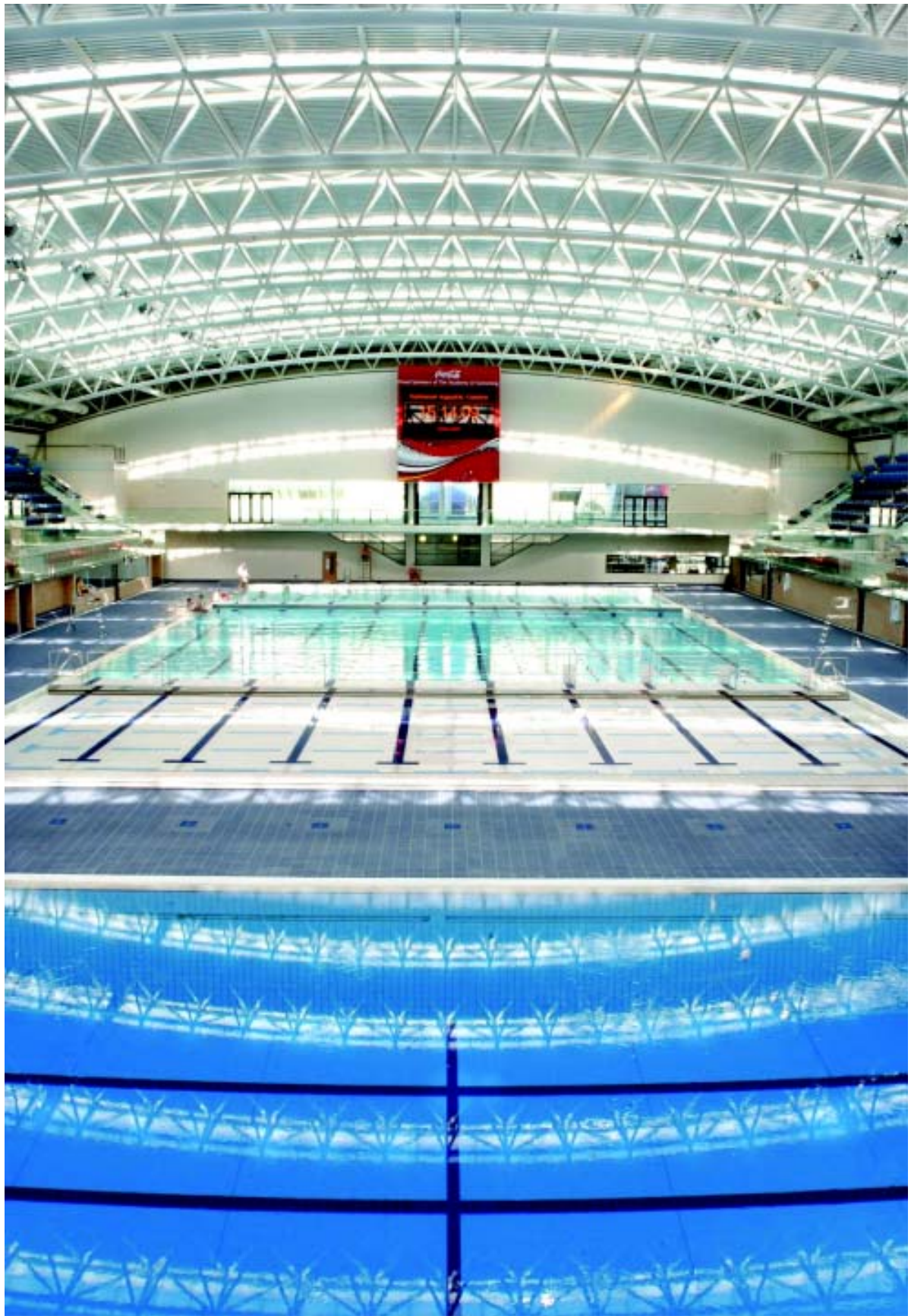


# Natural Daylight Design Through Rooflighting

by



NATIONAL  
ASSOCIATION OF  
ROOFLIGHT  
MANUFACTURERS



# Natural Daylight Design Through Rooflighting

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# Introduction

The **National Association of Rooflight Manufacturers (NARM)** represents a complete cross section of rooflight design and material type manufactured in the UK, and together with their Associate Members, they are able to provide a knowledge base second to none on all matters relating to providing good quality natural daylight into all non-domestic buildings.

Daylight design will be influenced by the building size and its usage. For smaller buildings vertical glazing will generally be adequate but only for areas within 6m of a window. For larger buildings, rooflighting or a combination of both roof and wall glazing will be needed.

The manufacturers within **NARM** offer a complete range of product and material types including in-plane profiled rooflights, continuous barrel vaults, modular domes and pyramids, panel glazing systems and architectural glazing systems for skylights, lantern lights and atria.

There are three principle types of material used to provide natural light into buildings:

- **Glass**

Used widely in large span rooflights such as atria, this readily recycled glazing media benefits from the low cost availability of low emissivity coatings and improved cavities such as argon gas filled. Very low U-values are therefore simply achieved with the same glazing systems and depth of sections without the need for triple glazing.

- **GRP (Glass Reinforced Polyester)**

A translucent thermoset material under the general heading of plastic that once formed into the required shape can never be reshaped after curing. A very tough and durable material that in opaque format is used for yacht hulls, aircraft nose cones and mine sweeper hulls.

- **Polycarbonate and Other Thermoplastics**

Polycarbonate is a clear thermoplastic formed

under heat and fixed in shape by cooling. It can be recycled by reheating to a liquid state. When correctly processed and handled it can provide excellent impact resistance and good resistance to UV and weathering.

Other thermoplastics include PVC which is largely used in DIY and agricultural markets, but rarely in industrial or commercial applications due to its fragility. Acrylic has good UV resistance but is not used in the UK as it does not meet the required standards for either impact or fire resistance.

Natural Daylight is a vital element in our daily life. The general pattern of life for humans is to sleep at night and work and play during the daylight hours. Our brain functions and responds to the stimulus of daylight. Providing natural daylight into the working environment is of fundamental importance for the well being, efficiency and safety for the people in that environment. The electric light bulb is a poor substitute to the fulfilment of the human requirements.

Legislation issued in 2002 recognises this need and now requires buildings to have adequate natural daylight as part of the design, **minimum 20% of the wall area** or **minimum 10% of the roof area**, being composed of light transmitting elements.

This document demonstrates how natural daylighting can best be incorporated into the building design. It looks at the various material options, giving their advantages and limitations, highlighting fixing needs, durability requirements and legislation issues.

Many of the members of this Association have been making rooflights since the 1950s and 1960s and have a wealth of knowledge that is available to be tapped. The Association's aim is to impart their knowledge to designers and contractors to achieve excellent natural daylight design in buildings, so that people who work in them or who visit them have that feel good factor.

## Daylight Design

Daylight is a vital natural resource that will significantly improve the environment within any building. Rooflights provide three times more light than the same area of vertical glazing. They can also provide a much more even distribution of light, particularly in larger structures. Where vertical glazing exists, the effective area for natural lighting will only be within 6m of the wall containing the window. These facts are well understood by most people involved in building design. However the huge potential of rooflights to provide exactly the amount, type and distribution of natural light required to meet any given specification is not always appreciated. Rooflights can help to provide natural light with qualities appropriate to the use of the building.

## Benefits of Natural Daylight

Daylight is an essential natural asset. For those of us living in temperate Northern climates, the beneficial effect of sunlight is easy to recognise; a couple of sunny days seem to lift everyone's spirits. Research also shows that suicide rates are considerably higher in parts of the world where daylight is very limited for significant parts of the year. On a slightly less dramatic but equally significant level, there is also a growing body of evidence to suggest that buildings enjoying high levels of natural light are literally more successful than those more reliant on artificial light. In all environments the eye and brain functions respond better to natural light, so people perform better, while passive solar gain can reduce energy costs.

## Education

Research demonstrates a clear correlation between classrooms with good natural light and improved student performance and even attendance. This is because in natural light children concentrate better so are more focused and less easily distracted. Some studies suggest that health is also enhanced helping to explain the improved attendance.

## Health

In the UK we are used to hearing of SAD, Seasonal Affective Disorder, a clinically diagnosed condition in which the lack of sunlight in winter makes people feel ill. Natural light helps people to feel better but it can also aid the healing process. In hospitals, studies have proven that the recovery rate of patients is accelerated where levels of natural light are increased.

## Business

Daylight improves concentration so that working environments, be they factories or offices with natural light, tend to achieve increased productivity. Research into retail environments suggests that in many situations sales tend to be better in naturally lit locations; colours are more vivid and true, making goods appear attractive and encouraging customers to spend more time in these areas. A number of the UK's leading retail organisations include large areas of rooflights in specifications for all new build projects to ensure a high percentage of evenly distributed natural light within the interior.

## Recreation

People like bright naturally lit environments, evidenced by the huge popularity of domestic conservatories and sunrooms. It is therefore logical that in their leisure time people prefer facilities enjoying high levels of daylight. Most sporting and recreational facilities today try to maximise natural daylight in recognition of this.

## Legal Requirements

The revised Building Regulations Approved Document L, for the first time acknowledges the well proven benefits of natural light, and the effectiveness of rooflights in providing daylight into a structure. In industrial and commercial buildings revised Document L of the Building Regulations recommends a minimum rooflight area of 10%, and a notional Standard based on 20% rooflight area. For full details of compliance to achieve natural daylight levels with thermal insulation requirements, see **Section 4 - Legal Requirements - Thermal Performance**.

# Daylight Design

## Energy Efficiency

On top of its many other benefits, natural light also offers passive solar gain i.e. a free heating source. Even in a rather dull climate such as the UK, passive solar gain provides significant potential to reduce energy usage. Buildings that enjoy high levels of natural light evenly spread throughout the structure, will be heated naturally for a considerable percentage of the year. If the structure includes thermal mass in the form of solid walls and floors, these will act as a heat store, collecting heat during the day and releasing it as the temperature drops in the evening, thereby reducing the need for artificial sources of heat throughout the entire day. If window and rooflight openings are maximised on the sunnier southern aspects of a building, and minimised on the cooler northern aspects, and this is combined with a well insulated, airtight structure containing reasonable thermal mass centrally located within the building, dramatic reductions in heating costs can be achieved. A reduction in the level of artificial light required in naturally lit buildings also helps to reduce energy usage. Designers should also take care to avoid solar overheating - see Pages 16-18 Sections 5 and 6.

## Type of Light

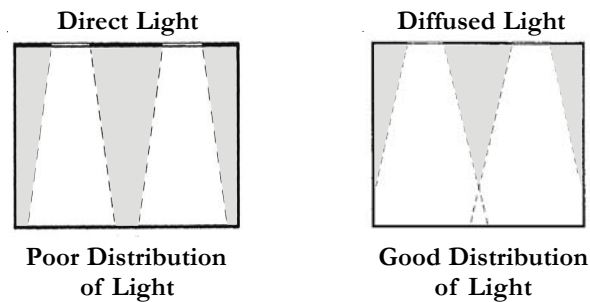
Rooflights are not only the most effective way of allowing natural light into a building, they can also determine the type and amount of light entering the building.

### Direct or Diffused

**Direct Light** - As the name suggests light passes through the rooflight without any disruption or interference, entering the structure as a straight beam. It therefore gives strong light in a given area but less general light in the surrounding area. It is useful where strong light is required in an area for close detailed work such as painting, or in situations where a very natural environment is desired, or the designer wants people in the building to see the sky through the roof. Direct light will result in shadows and glare on sunnier days.

Polycarbonate, PVC and glass in clear and most tinted options provide direct light.

**Diffused Light** - As the light passes through the rooflight it is scattered giving a much more even distribution of light into the structure below. It is useful when the requirement is for ambient lighting over a large area with minimal shadows. Most industrial, commercial and sporting facilities prefer diffused light for these qualities.



GRP in all forms, Polycarbonate, PVC, and Glass in patterned and opal tinted forms provide diffused light.

If a material providing direct light and one providing diffused light into the building have the same light transmission, they will let the same amount of light into the building, it is simply distributed differently.

## Amount of Light

Different materials and different tints of materials provide varying amounts of light into the building. In clear format most single skin rooflight materials will have a light transmission of 80%-90%. This must however be checked for the specific rooflight being used; material thickness, diffusing or colour tints, and number of skins can all affect overall light transmission.

In some situations the amount of light entering the building needs to be controlled, usually to prevent overheating. Tinted materials will limit the light entering the building. It is impossible to give a general guide to the light transmission achieved through the various tinted options available, as these vary not only from material to material but also from manufacturer to manufacturer.

# Daylight Design

## Rooflight Areas to Achieve Adequate Natural Lighting Levels

The Part L regulations state that wherever rooflight area is less than 20% the building designer must show there is adequate natural light, and also that rooflight area must always be a minimum of 10% for a space to be regarded as daylit (see **Section 4 Legal Requirements - Thermal Performance**). However adequate is a vague term, and the regulations do not give any clear guidance on how much daylight or rooflight area is needed for different applications.

The building designer should select the light level most appropriate for the building use, and whether this should

be measured horizontally or vertically; these are usually dictated by the use of the building.

It is important that designers also consider possible future change of use of a building when determining rooflight area, and ensure that daylight levels are sufficient for all likely future uses.

The **CIBSE Guide A** recommends that standard maintained illuminances are appropriate to the task(s) generally carried out in the building. A selection from **CIBSE Guide A (Table 1.12)** are listed below:

**Table A: Examples of Activities/Interiors Appropriate for Each Maintained Illuminance**

Standard Maintained Illuminance (Lux)	Characteristics of Activity/Interior	Representative Activities/Interiors
50 - 100	Interiors used occasionally, with visual tasks confined to movement, limited perception of detail.	Corridors, Bulk Stores
150 - 200	Continuously occupied interiors, visual tasks not requiring perception or detail.	Loading Bays, Plant Rooms
300 - 500	Moderately difficult visual tasks, colour judgement may be required.	Packing, General Offices, Engine Assembly, Retail Shops
750 - 1000	Difficult visual tasks, accurate colour judgement required.	Drawing Offices, Chain Stores, General Inspection, Electronic Assembly, Supermarkets
1500 - 2000	Extremely difficult visual tasks.	Precision Assembly, Fabric Inspection

For manufacturing environments (and office spaces), the tasks being illuminated are usually in a horizontal plane, viewed from above, and it is usually more appropriate to measure light levels horizontally. For some applications (e.g. storage facilities and racking), the illumination of vertical surfaces may be more relevant, and light levels should then be analysed vertically. Note that inside any given building, the vertical illuminance levels are generally lower than horizontal - but lower light levels are often acceptable for tasks viewed vertically (such as storage facilities).

The possible shading effects of large obstructions inside the building should also be considered, as should rooflight layout to minimise this effect.

Independent research\* submitted to the Building Regulation Advisory Council and being considered for

\*The independent research was carried out by the Institute of Energy and Sustainable Development, De Montfort University in 2003, and the results published as **Daylighting and Solar Analysis for Rooflights**.

# Daylight Design



inclusion in future revisions to the Building Regulations, has predicted the daylight levels in the horizontal and vertical planes inside typical large span buildings (assuming even rooflight layout, without any significant obstructions) using the latest computer modelling techniques.

This research does not define a definitive rooflight area for a particular application. Selection of exact rooflight area depends on the level of natural lighting desired, the percentage of a working year that lower natural light levels are acceptable, and the level of use of auxiliary lighting which is acceptable; these are more subjective, and should be determined by the building designer, although it is recognised that rooflight area should not be less than 10% in any daylit space, as specified in Part L2.

The research provides data on how often during a year rooflights of various area will provide any selected lighting level (and hence how often auxiliary lighting may be required). In general, if relatively small increases in rooflight area result in significant reduction in time that auxiliary lighting is required, they should be seriously considered; conversely, reductions in rooflight area can be justified where they do not result in significant increases in the time that auxiliary lighting is required.

**Tables B and C** taken from this research, provide recommendations for rooflight area to achieve desired lighting levels, on this basis, assuming overall light transmission of 67%; for rooflights with lower or higher light transmission, the figures should be adjusted accordingly.

**Table B : Recommended Minimum Rooflight Area for Desired Illuminance Level (Horizontal)**

Illuminance Level Required in the Horizontal Plane (Lux)	Recommended Min Rooflight Area (% of Floor Area)
100	10
200	10
300	13
500	15
750	17
1000+	20

**Table C : Recommended Minimum Rooflight Area for Desired Illuminance Level (Vertical)**

Illuminance Level Required in the Vertical Plane (Lux)	Recommended Min Rooflight Area (% of Floor Area)
100	10
200	14
300	17
500+	20



# Rooflight Construction, Configuration and Material Type

## Rooflight Construction

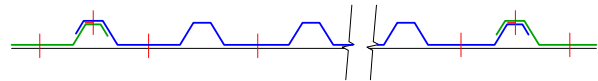
There is a wide range of metal and fibre cement roof cladding systems and flat roof membrane systems in the market. The type of system, building design and usage will influence the choice of rooflight.

Rooflights are very effective options for delivering natural daylight deep into the interior areas of industrial, commercial, recreational and agricultural buildings.

In its simplest form the rooflight is made to the same profile shape as the metal or fibre cement sheet, and simply replaces the opaque sheet as an in plane rooflight. In some cases the metal sheet design is not ideal to replicate in rooflight material, and a better solution is to raise the rooflights out of plane from the rest of the roof. For all flat roof systems, out of plane rooflights will be the norm.

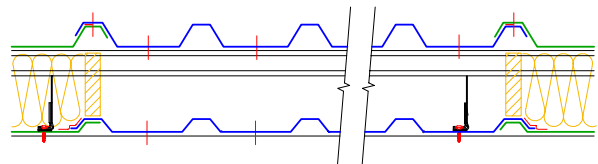
## IN PLANE ROOFLIGHTS

### 1. Single Skin Rooflight



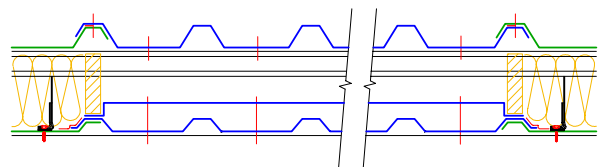
### 2. Site Assembled Double Skin Rooflight

This type of construction consists generally of a shallow profiled rooflight sheet to match the metal liner, a spacer system, perimeter closure and an outer rooflight sheet matching the metal weather sheet. This fully compliments the assembly of the metal roof.



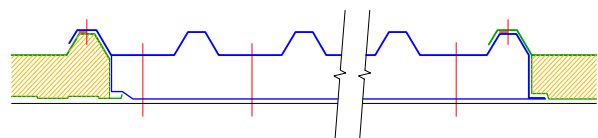
### 3. Site Assembled Triple Skin Rooflight

A typical assembly of three site assembled rooflight sheets, where the internal sheet could be replaced with a transparent insulation core.



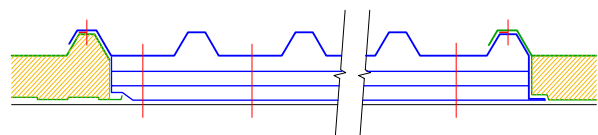
### 4. Factory Assembled Double Skin Rooflight

A factory made and assembled unit using purpose designed box assembly of rooflight sheeting. It incorporates a rigid spacer at the purlin line to provide a secure fixing assembly. The units are designed to match and compliment metal composite panels.



### 5. Factory Assembled Triple and Multi Skin and Insulated Core Assembly

A typical unit of outer skin and lining panel to match the metal composite, with one or multiple layer or transparent insulation internal to the box, of various designs to provide the requisite U-value.

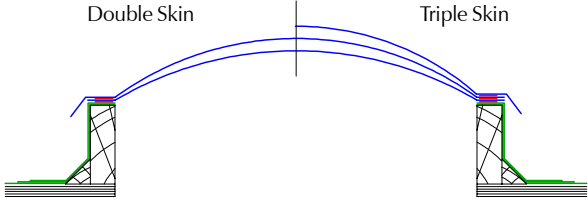


# Rooflight Construction, Configuration and Material Type

## OUT OF PLANE ROOFLIGHTS

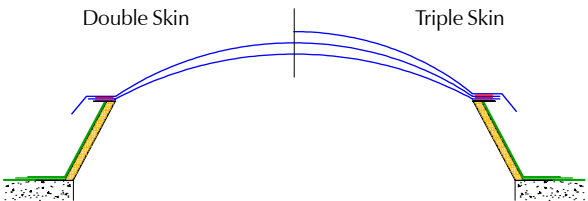
### 6a. Dome Rooflight

A dome or pyramid in double or triple skin format manufactured from standard sizes, but can also be purpose made to suit existing upstand dimensions



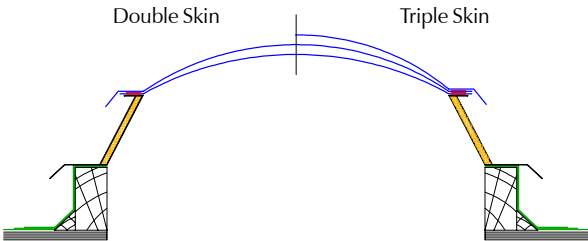
### 6b. Dome Rooflight with Manufacturer's Curb

A dome or pyramid with integral upstand manufactured to standard sizes, but can also be purpose made to suit exiting opening roof sizes. Other upstand heights can be supplied to accommodate various depths of roof insulation. Ventilator options not shown.



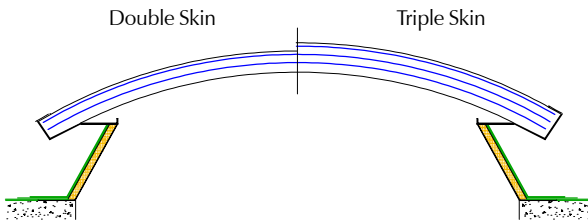
### 6c. Dome Rooflight with Manufacturer's Adaptor Curb

A dome or pyramid with integral adaptor curb usually manufactured to suit existing upstands. Ventilator options not shown.



### 6d. Barrel Vault Rooflight

A low profile or semi circular barrel vaulted rooflight in solid or multi-wall, double or triple skin format and normally manufactured to suit specified dimensions. Can be supplied to suit builders upstand or with other upstand heights to accommodate various depths of roof insulation. Ventilator options not shown.



# Rooflight Construction, Configuration and Material Type

## Rooflight Configuration

The factors to consider when designing the rooflight configuration are :

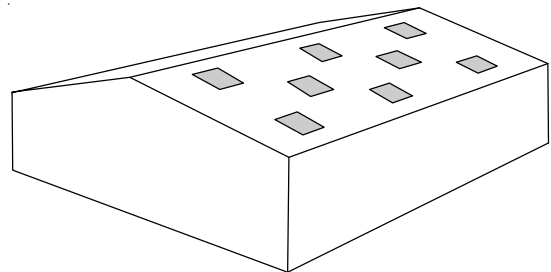
- a) Is there sufficient general lighting to create a pleasant and suitable internal environment?
- b) Is there a requirement for increased or controlled light levels in specific areas of the building e.g. play area in a sports hall?

- c) The relationship between the height of the building and the diffusing quality of the rooflights to provide good general light at ground level.
- d) Degree of roof maintenance and roof access envisaged.
- e) Weatherability and minimising laps, especially between dissimilar materials.

There are a number of possible configurations for the rooflights.

### 7. Chequerboard Rooflights

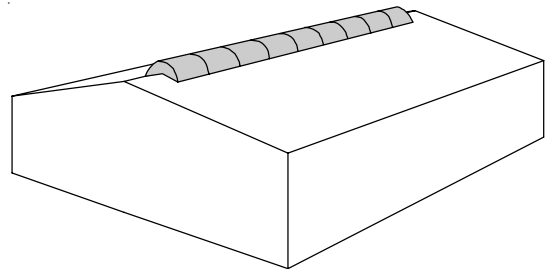
This allows for individual rooflight units, both in plane and out of plane, and provides the most uniform distribution of light. The rooflight is fixed to the metal cladding or roof deck on all four sides and is therefore well supported.



This design has the maximum number of end laps or flashings and therefore requires the maximum attention to the sealing details by the roofing contractor with resultant increased costs.

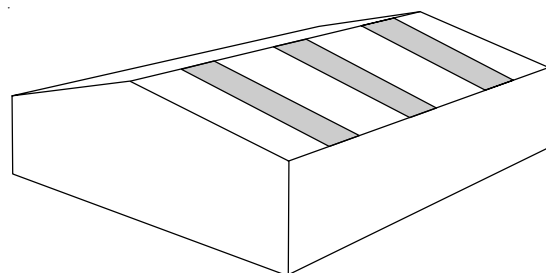
### 8. Ridge Lights - Barrel Vault Rooflights

Using a barrel vault rooflight along the ridge can provide an aesthetically pleasing design and a relatively uniform distribution of light only if the roof slope is short. The major advantage over the chequerboard arrangement is that they reduce the number of metal/translucent junctions to be fixed and sealed. However, at the ridge they are subject to high wind loads. Since it is recommended that rooflights should not be walked on at any time, where roof access is expected and frequent, ridge lighting provides a safer option.



### 9. Ridge to Eaves - In Plane or Barrel Rooflights

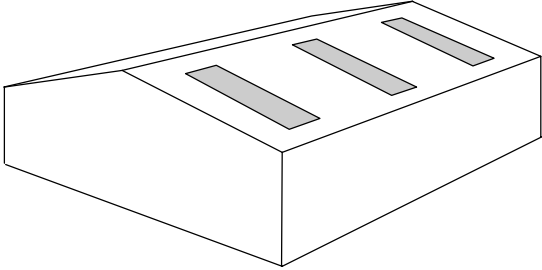
Both profiled and barrel rooflights can be fixed from ridge to eaves or from ridge downslope. They minimise the number of metal/translucent junctions and could eliminate rooflight end laps, thereby improving reliability and servicing. However, since the rooflight industry does not recommend walking on rooflights at any time, a ridge to eaves layout will limit access across the roof.



# Rooflight Construction, Configuration and Material Type

## 10. Mid Slope Rooflights

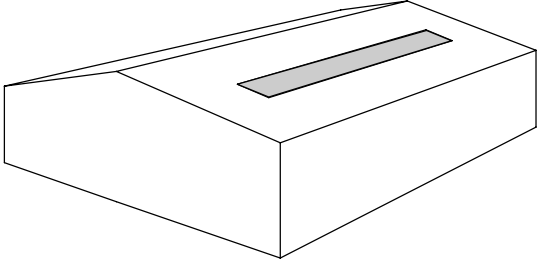
This configuration is only possible with rooflights which match the roof profile. It provides a compromise between chequerboard and ridge to eaves in terms of light distribution and buildability. It avoids all areas with high wind uplift and allows general roof access if the metal roof is suitable for walking on. This design is now very popular on new build work.



## 11. Continuous Run - In Plane Rooflights

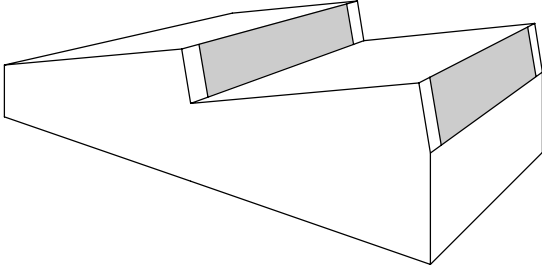
Good levels of lighting achieved but less used on modern design. Care needs to be given to manufacturing and fitting tolerances of the metal sheets and rooflights to avoid a build up of tolerance difference.

Replacing old reinforced glass fixed in T bars with modern profiled rooflights or panel systems is common practice and very effective.



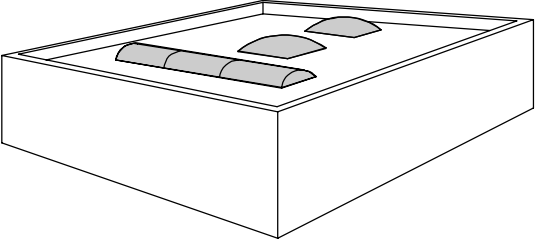
## 12. North Lights - In Plane Rooflights

This configuration could be viewed as a continuous run as above but is not subject to tolerance difference between metal sheets and rooflights. North lights on new build is no longer common practice but refurbishment with modern rooflights or panel systems is easily achieved.



## 13. Random Design on Flat Roofs - Barrel and Dome Rooflights

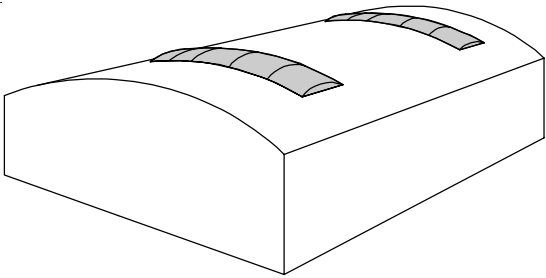
Used on flat or low pitch roofs, the rooflights are placed according to need and roof design on purpose designed upstands.



# Rooflight Construction, Configuration and Material Type

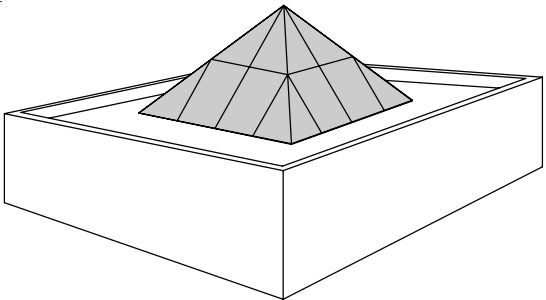
## 14. Curved Roof - Barrel Vault Rooflights

Placed on an upstand that curves to the roof, barrel vault rooflights can be applied to run over the crown of the roof and stopping either mid slope or down to the eaves. Ideal for metal standing seam system roofs and single ply membranes.



## 15. Structural Glazing

Bespoke structures of almost any shape and design, normally constructed from aluminium or steel sections and glazed with polycarbonate or glass units of varying specifications. These custom built structures are generally detailed by the rooflight manufacturer to an architects brief and allow immense freedom of design.



# Rooflight Construction, Configuration and Material Type

## Material Types

Rooflight materials must allow light through, satisfy all durability, thermal, safety and fire requirements, and work with the roof covering material and/or the glazing system being used. The main rooflight materials in the UK are GRP, polycarbonate and glass, and to a far lesser extent PVC.

### GRP

GRP remains the most versatile and commonly used profiled glazing material. Available to match virtually any metal or fibre cement sheet profile and ideal for barrel vault design. GRP offers excellent performance properties and provides high levels of diffused light into the building. In most industrial, sporting and commercial situations diffused light, which minimises glare and distracting shadows, is preferable. GRP sheets are produced in almost all profiles, and modern high quality GRP sheets incorporate UV absorbing surface protection which can virtually eliminate long term discolouration. In a very budget conscious world GRP is a very cost effective rooflight material.

### Polycarbonate

Polycarbonate is a versatile material used extensively as a rooflight glazing. It has three sheet forms :

- **Solid - Flat or Domed**
- **Profiled**
- **Multiwall**

The key properties of polycarbonate are common to all forms - exceptional impact resistance, high levels of light transmission, good workability and good fire rating. All are commonly available in clear and tinted options, with clear and most tints providing direct light, while clear patterned and opal tint provides diffused light and gives a **soft** quality to the light. Co-extruded UV protection eliminates up to 99% of UV radiation, protecting materials and people beneath it. Each form also has its own particular characteristics and properties.

Solid polycarbonate offers good optical clarity and superb workability. It can be cold curved on site, is suitable for use with a variety of glazing bar systems and can be moulded into various shapes such as domes and pyramids.

Profiled polycarbonate matches profiled roof cladding and allows the sky above to be seen through a corrugated material, a feature popular with many designers. It has

very good profile accuracy and is available in a growing profile range. Extrusion and vacuum forming techniques allow a huge variety of profiles to be produced.

Multiwall polycarbonate is an insulating glazing material. Thicker sheets with more walls achieve the highest thermal performance, typically  $1.6W/m^2K$  for a 25mm five wall sheet. Structured polycarbonate is most commonly used in most domestic and many commercial conservatories. Like solid polycarbonate it can be cold curved on site, although to a much lesser degree, it can be used in a variety of glazing bar systems, and has a very high strength to weight ratio making it ideal for the creation of glazing features.

### Safety Glass

Most visibly used as roof glazing in large shopping centres but used widely in the more up market commercial sector and significantly in traditional pitched roofs. Flat glazed rooflights in typical flat roof applications are currently very fashionable.

Glass has excellent fire properties, good impact performance, very high light transmission and provides the mark against which the optical clarity of all other glazing media is commonly compared. It is widely acknowledged as having a very long life expectancy with no discolouration from UV degradation, and laminated versions provide a good level of reduction in UV transmittance. Glass can also be curved for use in barrel vault rooflights and supplied with various coatings, interlayers and surface treatments to provide coloured or textured surfaces to achieve obscure or diffused glazing, solar control and total UV protection to areas beneath the glazing.

### PVC

PVC was used for industrial rooflight applications in the 1970s and 1980s, but has poorer impact resistance and weathering performance than other alternatives. PVC will not meet the non-fragility requirements without the addition of extra safety measures in the rooflight construction. It is now used very rarely in industrial or commercial applications, although it is a very popular DIY material. It is not expensive, has a reasonable strength to weight ratio and is straight forward to work with, thereby deserving its success as a DIY material for small, lowrise domestic projects.

# Rooflight Construction, Configuration and Material Type

**Comparison Chart**

Material	GRP	Polycarb'te Flat	Polycarb'te Multi Wall	Safety Glass	PVC
Transparency	Medium	Excellent	Medium	Excellent	Excellent
Untinted Translucency	Excellent	Good	Good	Medium	Medium
Strength	Excellent	Excellent	Excellent	Medium	Poor
Fire Rating	Class 0,1,3,4	Class 0,1(Y)	Class 0,1(Y)	Class 0,1	Class 1(Y)
UV Resistance	Good	Good	Good	Excellent	Medium
Temperature Resistance	Excellent	Good	Good	Good	Medium
Thermal Insulation	Good	Good	Good	Good	Good
Sound Insulation	Good	Good	Medium	Good	Good
Rigidity	Excellent	Good	Excellent	Excellent	Good
Patterns	No	Yes	No	Yes	No
Colours	Yes	Yes	Yes	Yes	Yes
Cold Curving	Good	Excellent	Good	No	Good
Formability	No	Excellent	No	No	Excellent



# Legal Requirements - Thermal Performance

## Introduction

The Government is committed to the reduction of greenhouse gases as a result of the Kyoto accord on Climate Change. The Building Regulations for England, Wales and Scotland, which cover **Conservation of fuel and power**, have been updated accordingly. The revised Regulations require buildings to:

- Have more insulation in the building envelope.
- To limit heat loss from pipes and ducts.
- To provide more energy efficient lighting, heating, cooling and ventilation systems.

In the drive for energy efficiency the revised Regulations set minimum acceptable levels for natural daylighting and refer to CIBSE LG10 for additional guidance. That publication explains the value of natural daylight on human performance and thus on energy efficiency in its widest sense. Widespread research links natural daylighting to tangible work place benefits: improved retail sales, lower staff absenteeism, faster hospital recovery rates, and improved school exam results.

Natural lighting should be provided in all buildings. Windows can provide daylight to areas within 6 metres of a window, but rooflights are the only practical means of introducing daylight to any wider buildings. An appropriate area of rooflights - **see Pages 4 and 5** - should be included on all roofs, including curved and flat roofs, standing seam and any other steel and fibre cement roofs.

## Regulations

The Building Regulations 2000 (England and Wales) Approved Document L (2002 edition) came into force on 1st April 2002 in England and Wales, in two parts:

- L1: Conservation of fuel and power in dwellings.
- L2: Conservation of fuel and power in buildings other than dwellings.

The above documents are referred to simply as **Part L** in this document.

The Building Standards (Scotland) Regulations 2001 Part J: Conservation of fuel and power, which has similar requirements, came into force in Scotland on 4th March 2002. In this document all general comments and any specific reference to Part L will equally apply to Part J unless indicated otherwise. Paragraph references are specific to Part L unless otherwise stated.

## Daylighting

Workplace (Health Safety and Welfare) Regulations 1992 state, "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**.

The most effective method of providing even, consistent daylight particularly in large buildings, is through rooflighting – up to three times more efficient than windows of similar area. 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. However it does offer good psychological benefits and must not be ignored.

The existing regulatory requirements are now reflected in the revisions to Part L. 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 artificial 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 does not include definitive guidance on how to determine adequate daylight levels. It does define minimum glazing levels; para 1.45 says: "... a daylight space is defined as any space within 6m of a window wall provided that the glazing area is at least 20%... Alternatively it can be roof-lit, with a glazing area at least 10% of the floor area... "

This means that for any building space which is more than 6m from a window, roof lights should be provided to a minimum of 10% of the floor area. Greater areas may be required in many applications.

No further guidance is given in Part L about the absolute daylight levels needed, but information is provided in this document in **Section 2, Page 4 - Daylight Design - Rooflight Areas to Achieve Adequate Natural Lighting Levels**.



## General Design

There are three alternative methods in the Regulations to demonstrate compliance with the requirement for the conservation of fuel and power.

### 1. Elemental Method

This method considers the performance of each element of the building envelope individually. To comply, a minimum level of thermal performance should be achieved in each of the elements. This is stated as U-value; a lower U-value indicates less heat transfer per square metre, i.e. better insulation.

The simplest method for the designer to demonstrate compliance is to ensure that the U-value of all exposed elements meets the minimum level of thermal performance required and does not exceed the maximum allowable area for any element.

Some flexibility is also provided for trading off between elements of the construction. For example, a designer may choose to use less than the permitted maximum rooflight area (provided it can be demonstrated that daylight levels will remain adequate) which will result in a **heat credit** which can be used to justify use of less well insulated rooflights, or traded off against performance of other elements such as doors, windows or thermal bridges. Compliance would be achieved providing that the overall heat loss from the proposed building does not exceed that from a notional building of the same size and shape.

### 2. The Whole Building Method

This considers the performance of the whole building, and applies to offices, schools and hospitals but not to industrial or storage buildings. Environmental design guidance issued from other authorities is also referenced. Performance of all environmental systems is considered – including heating, lighting, air conditioning and ventilation.

For example, for schools DfEE Building Bulletin 87 is the referenced source. The bulletin provides a holistic

approach to school design encompassing acoustic, lighting, ventilation, heating, and thermal performance standards. An energy rating method is defined.

Building Bulletin 87 refers back to Part L for minimum acceptable rooflight U-values and glazing areas, so rooflight limits as defined in the elemental method above still apply. As in Part L the recommendation for daylight provision also applies: “Priority should be given to daylight as the main source of light in working areas, except in special circumstances. Wherever possible a daylight space should have an average daylight factor of 4-5%”.

### 3. Carbon Emissions Calculated Method

This method also considers the whole building performance including building services. 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. A variety of software modelling tools are available – since these are 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

The simplest method for a designer to demonstrate that rooflights comply with Part L is to ensure that:

1. The rooflights achieve a U-value of  $2.2 \text{ W/m}^2\text{K}$  or lower.
2. The rooflight area on the building is no more than 20% of the roof area.

However these values may be varied by the designer using:

3. heat credit trade off calculations.

Other requirements relate to:

4. Air leakage.
5. Solar overheating.
6. Thermal bridging.

Well designed triple skin rooflights will normally meet the standard U-value requirement of  $2.2 \text{ W/m}^2\text{K}$  and

# Legal Requirements - Thermal Performance

are available from most rooflight manufacturers. They offer a significant reduction in heat loss through the rooflights compared with double skin rooflights and is a recommended method of fulfilling the requirements of the new legislation.

## 1. Standard U-values

To show compliance the building envelope has to provide certain minimum levels of insulation. Part L defines standard U-values for each constructional element as given in **Table D**.

**Table D: Standard U-values of Construction Elements**

Exposed Element	U-Value (W/m <sup>2</sup> K)
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*	2.20
Windows translucent wall areas	2.00

\* 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.

U-values should be determined by physical test or by finite element analysis in accordance with BS EN ISO 10211 Part1 :1996 as specified in L2 Para 0.15.

## 2. Maximum Glazed Areas

To show compliance the total area of windows, doors and rooflights should not exceed the values given in **Table E**, unless compensated for in some other way.

**Table E: Maximum Areas of Openings Unless Compensating Measures are Taken**

Building Type	Windows* Doors as % area of wall	Rooflights as % area of roof
Residential buildings	30	20**
Places of assembly, offices and shops	40	20**
Industrial and storage buildings	15	20**

\* For the purposes of this calculation dormer windows in a roof may be included in the rooflight area.

\*\* L2 Para 1.14 states that if the rooflight area is to be reduced below 20% of the roof, the designer must ensure that the natural daylight levels are sufficient for the building purpose - see **Pages 4 and 5**.

Rooflights that achieve a U-value of 2.2 W/m<sup>2</sup>K, at areas up to 20% of the roof, thus fully meet the requirements of the new Regulations.

## 3. Trade Off

Area of rooflights, doors and windows, and their respective U-values, can be varied from standard values given in **Tables D and E** so long as total heat loss meets allowable limits. A notional building is used to demonstrate that a design meets the energy conservation objectives of Part L whilst allowing these elements to deviate from standard allowable U-values or areas.

A notional building is a theoretical building of the same size as the building under design, with maximum areas of rooflights, doors and windows and with each element meeting its standard U-value. To achieve compliance, the total heat loss from this notional building must not be exceeded by the building being designed.

## Legal Requirements - Thermal Performance

Care should always be taken that rooflight area is sufficient to provide adequate daylight - see **Pages 4 and 5** -, but this may be less than the maximum permitted area of 20%. If rooflights with a U-value of  $2.2\text{W}/\text{m}^2\text{K}$  are fitted to a reduced area, there will be a heat credit, which can be traded off against the performance of other elements such as doors, windows and thermal bridges.

This heat credit can also be used to compensate for the use of less well insulated rooflights, and **Table F** shows the maximum rooflight U-value at different areas, if the entire heat credit is traded against rooflight U-value. However, it should be noted that use of rooflights with a U-value of at least  $2.2\text{W}/\text{m}^2\text{K}$  is encouraged by ODPM and supported by NARM.

**Table F: Maximum Rooflight U-values per Roof Area**

Rooflight area (% of roof)	Rooflight U-value ( $\text{W}/\text{m}^2\text{K}$ )
30%	1.5
20%	2.2
15%	2.8
12%	3.5
10%	4.1

### Constraints to Trade Off

L2 para 1.14 states that care must be taken to confirm that levels of daylight are adequate. If the rooflight area is to be reduced below 20% the designer must ensure that natural daylight levels are sufficient for the building purpose.

L2 Para 1.16(c) states that no more than half of the allowable rooflight area can be converted into increased areas of windows (vertical) and doors. There is no provision for converting vertical openings into increased rooflight areas in the roof.

L2 Para 1.16(b) states that if the area of rooflights is less than the values shown in **Table E** the respective U-values of roof, wall and floor cannot exceed the appropriate values given in **Table D** by more than  $0.02\text{W}/\text{m}^2\text{K}$ . Thus however much notional heat loss

saving is made by reducing the rooflight area the U-value of the insulated roof cannot exceed  $0.27\text{W}/\text{m}^2\text{K}$ .

### 4. Air Leakage

Air leakage requirements do not apply to Building Standards (Scotland): Part J and for Part L1 – Dwellings – only reasonable provision is required.

Under Part L2 buildings should be reasonably airtight to avoid unnecessary space heating and cooling demand. There is a requirement that the permeability of the envelope (which includes the total area of the perimeter walls, roofs and ground floor area) should be no worse than  $10\text{m}^3/\text{h}/\text{m}^2$  at an applied pressure of 50 Pascals. All buildings that exceed  $1000\text{m}^2$  of gross floor area must be air tested on building completion to show compliance.

Buildings of less than  $1000\text{m}^2$  gross floor area will be deemed compliant providing evidence that appropriate design detail and construction techniques have been used.

Provided that rooflights are correctly fixed and sealed, rooflight assemblies will usually comply easily with this requirement. Association members strongly recommend that Contractors take care in the fixing and sealing of rooflights in accordance with their recommendations, since subsequent air test failure will generally require extensive remedial work which could prove to be expensive.

### 5. Solar Overheating

Solar Overheating legislation is not included in the Building Standards (Scotland): Part J.

There is an important distinction between solar overheating and solar gain. Most windows and rooflights are likely to generate solar gain under normal daylight conditions. Solar gain is beneficial in that it reduces heating requirement during daytime hours when buildings are usually occupied. In some cases, such as use of unheated atria, solar gain may play a major role in energy efficiency strategies by reducing the effective exposed wall area of the building and offering a buffer zone between external and internal climates.

# Legal Requirements - Thermal Performance

However improperly designed glazing may result in solar overheating and the workplace environment becomes unpleasant.

Buildings should be constructed so that occupied spaces are not likely to overheat when subject to a moderate level of internal heat gain, and so that excessive cooling plant is not required to maintain the required conditions.

There are various ways of achieving this:

- Appropriate specification of glazing performance.
- Incorporation of passive measures such as sun-shading.
- Mechanical ventilation without excessive use of cooling plant.
- Use of exposed thermal capacity combined with night ventilation.
- By calculation ref Part L para 1.23.

If none of the above are suitable alternatives then:

- By limiting the area of glazing facing only one orientation to the opening areas shown in **Table G**.

**Table G: Maximum Allowable Area of Glazing**

Orientation of opening	Maximum allowable area of opening (%)
N	50
NE/NW/S	40
E/SE/W/SW	32
Horizontal	12

**NARM** has obtained an interpretation from BRE that **Horizontal** will be applied to all roofs below 75° pitch.

Thus in England & Wales compliance is only demonstrated if at least one of the above six requirements to minimise solar overheating is adopted. If rooflight area at 12% is the chosen method to achieve compliance, then the designer needs to ensure that the daylight levels are adequate for the purposes of the building. If they are not, then the designer could chose to obtain compliance by adopting the **Calculation Method (Part L para 1.23)**.

## 6. Avoidance of Solar Overheating by Calculation Method

Part L Regulations state that where the rooflight area is less than 12%, solar overheating will not be a problem and no further action is required. Wherever higher rooflight areas are specified, it must be shown that solar overheating will not occur by calculation or adoption of alternative measures.

Independent research carried out by the Institute of Energy and Sustainable Development, De Montfort University, has been submitted to the Building Regulation Advisory Council and being considered for inclusion in future revisions to the Building Regulations, has predicted the levels of solar overheating which will occur inside typical large span buildings using the latest computer modelling techniques.

The Part L Regulations are met if the overall internal gain does not exceed 40W/m<sup>2</sup>; they assume an internal gain of 15W/m<sup>2</sup>; thus allowing a maximum solar load of 25W/m<sup>2</sup>; but the research demonstrates this assumption does not apply to many large span buildings, depending on the building use.

For typical activities in large span buildings, the heat emitted per person (male) ranges from 140W (seated light work) to 256W (medium bench work). Standing, light work or walking produces about 160W of heat.

**Table H** (extracted from the independent research) shows the maximum rooflight area which will avoid solar overheating, from various levels of internal gain.

**Table H: Maximum Rooflight Area to Avoid Overheating**

Internal gain (W/m <sup>2</sup> )	Max rooflight area (% of floor area)
0	23
5	20
10	17
15	14
20	11

# Legal Requirements - Thermal Performance

This table shows that where internal gains are  $15\text{W}/\text{m}^2$ , rooflight area can be up to 14% of floor area without risk of causing solar overheating; where internal gains are lower then rooflight area can be higher.

For example, in storage buildings, occupant densities are generally very low and can often be ignored; the main gains are from artificial lighting, typically only  $5\text{W}/\text{m}^2$ . It can be seen from **Table H** that rooflight areas up to 20% will not cause solar overheating.

Any large plant or process facility may produce considerable local heat gains. Where these are envisaged, it is recommended that localised heat extraction/removal and/or cooling is used to prevent overheating. Where these are known to be effective in eliminating the localised heat gain, the sources can be excluded from the internal heat gains for the assessment of overheating.

In retail outlets occupant density can be significant (typically around  $4\text{W}/\text{m}^2$ ), and retail outlets are usually well lit, with internal gains due to lighting around  $15\text{-}20\text{W}/\text{m}^2$ . However, the period of highest solar gain is simultaneous with highest daylight illuminance, and provided rooflight area is sufficient, the internal gains due to electric lighting can be greatly reduced or eliminated by switching off the lights either manually or more reliably, by daylight-linked controls. Total internal gains may therefore be around  $4\text{W}/\text{m}^2$  and **Table H** again shows that rooflight areas up to 20% will not cause solar overheating.

## 7. Thermal Bridging

The building fabric should be constructed so that there are no significant thermal bridges or gaps in the insulation layer within any elements, at the joints between elements and at the edges of elements such as those around rooflights or windows (para 1.9).

Part L2 refers to BRE IP17/01 and MCRMA Technical Report No 14, which details how thermal bridges should be assessed, and the limiting factors. Thermal bridges have two effects: there is a heat loss per linear metre (measured by the  $\Psi$ -value), and an increased risk of surface condensation due to localised cold spots (measured by the f-factor)

In practice heat loss through thermal bridges can be treated in the same way as that through any other element of the building. The maximum allowed heat loss through thermal bridges is a further 10% of the total heat loss allowed from the notional building described in 3 above.

In addition, the trade off principle can be used so any heat credits (e.g. a rooflight with a higher insulation specification) can be traded off, and thus compensate for correspondingly greater heat loss through thermal bridges in other areas of the building.

To avoid condensation risk in different building types, IP17/01 specifies that the f-factor for every detail must always be greater than a minimum permissible value, as shown in **Table J**.

**Table J: Minimum Permissible f-factors**

Types of areas	Minimum f-factors
Storage Buildings	0.3
Office, Retail premises	0.5
Sports Halls, Kitchens, Canteens, etc.	0.8
Swimming Pools, Laundries, etc.	0.9

In plane rooflights do not usually give any additional cold bridge compared to surrounding metal cladding; the same insulated support brackets and thermal barriers should be used as necessary. Whilst there is no direct thermal bridge, these rooflights still have a defined f-factor associated with the insulation value. Double skin rooflights will usually not have an f-factor higher than 0.7, whilst well insulated rooflights could have an f-factor of 0.8 to 0.9.

Individual and continuous out of plane rooflights may have cold bridges via aluminium or steel frames and this should be factored into the thermal bridging calculation to demonstrate compliance. These may also affect the f-factor of these products, which should be confirmed with the manufacturer.

# Legal Requirements - Thermal Performance

## 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 rooflights are acceptable.

A low-level heated building with a heating requirement no more than 25W/m<sup>2</sup> could typically be a warehouse used for storing goods to protect them from condensation or frost.

A cold store building is one where insulation is required to a level that will be determined by operational needs.

## Roof Refurbishment

The Regulations apply to both new buildings and refurbishing old buildings, however if a single component is defective and needs replacing it is 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 described above. However 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 the requirements if it is feasible to do so.



## Legal Requirements - Non-Fragility and CDM

**When specifying rooflights, designers should consider carefully the potential to eliminate or reduce known or predictable hazards.** The decision on how best to specify rooflights should take account of the risks associated with temporary gaps during construction, and the risks when access to the roof is needed later e.g. during maintenance or cleaning.

As in all building work good safety standards are essential to prevent accidents. In accordance with the **Health and Safety at Work Act and the Construction (Design and Management) or CDM Regulations 1995**, the building should now be designed with safety in mind, not only for the construction period but throughout the normal life of the building. This must include considering the safety of people involved in maintenance and repair, and even demolition. It might mean providing permanent access to the roof, walkways and parapets, for example. The HSE document **HSG 33 Safety in Roof Work** refers specifically to fragile rooflights as an example of a potential hazard to be considered and to be avoided as far as possible.

Construction of the roof is one of the most hazardous operations because of the potential for falls or material dropping onto people below. The roofing contractor must plan and document a safe system of work before starting construction. This must take the fragility of the cladding systems into account. Whilst fully fixed metal sheeting is generally regarded as non-fragile, many rooflights and metal lining panels must be treated with more care.

Where specifying rooflights designers should consider the following options :

- Specifying in plane rooflights that are non-fragile.
- Fitting rooflights designed to project above the plane of the roof, and which cannot be walked on (these reduce the risk but they should still be capable of withstanding a person falling onto them).
- Protecting rooflight openings e.g. by means of mesh or grids fitted below the rooflight or between the layers of a built-up rooflight.
- Specify rooflights with a design life which matches that of the roof, taking into account the likely deterioration due to ultraviolet exposure, environmental pollution, and the internal and external building environment.

When properly fixed, most GRP and polycarbonate double skin in plane rooflights can be classified as non-fragile (usually Class B), using the industry accepted test procedure **ACR[M]001:2000**. (for more information refer to **NARM Guidance Note:2003/1**). All in plane units (even non-fragile) should be identifiable when installed, (for example by the use of poppy red fixing heads) to identify the rooflight location.

PVC, which is an inherently brittle material, always requires extra safety reinforcement. However, even non-fragile rooflights are likely to be damaged by impact; they are usually not intended to support foot traffic and crawling boards must be used at all times.

Out of plane rooflights (including modular rooflight units, barrel vault and patent glazing derivatives, etc.) should also be classified to the requirements of **ACR[M]001:2000**. Consideration should also be given to the requirements of **prEN1873** using an energy rating of 1200 joules.

On completion of the building, designers should provide a Health and Safety File to the building owner. The following information should be included in respect of the roof and rooflights

- No person should have access to the roof, unless under the direct supervision of a competent person who is to assess and take action to minimise risks.
- Access to the roof should be avoided when it is wet or in slippery conditions.
- The rooflight specification, including the weight (thickness) of the rooflights, the non-fragile test method and classification when new, and the expected non-fragile life of the roof and rooflights.
- A schedule for cleaning and maintenance for both performance and longevity of the specific rooflights.
- **Never** walk on rooflights, irrespective of their non-fragility classification. Even rooflights that are designed to be non-fragile for the life of the roof could be damaged by foot traffic, and this may affect both the non-fragility performance and the light transmitting quality of the rooflight in the long term.

# Legal Requirements - Fire Performance

## Existing UK Building Regulations

**Building Regulations Approved Document B (2000 edition)** sets out the rules for fire safety of buildings. Section B2 covers internal fire spread, and applies to the linings of both the roof and walls of buildings. In general these are surface spread of flame requirements to BS476 Part 7 (typically Class 1 and Class 3). Section B4 covers external fire spread and applies to external coverings or roofs and walls; in general these are fire resistance requirements to BS476 Part 3 (typically AA and AB).

Thermosetting materials (GRP) can be tested to BS476 Parts 3 and 7, and a variety of grades are usually available offering alternative fire ratings to meet the main requirements.

Thermoplastic materials cannot be tested to BS476 Part 3, as the material melts during the test. Building Regulations define an alternative classification method for these materials :

- Polycarbonate at least 3mm thick, PVC (any thickness), and any thermoplastic materials, which are rated Class 1 to BS476 Part 7, are given the rating Tp(a).
- Other thermoplastic materials can be tested to BS2782, and given ratings of Tp(a) or Tp(b).
- Polycarbonate or PVC which achieve Class 1 when tested to BS476 Part 7, can also be regarded as having AA designation.

For the majority of industrial buildings, the requirements can be summarised as follows:

- The lining of a roof or wall should normally be rated Class 1 to BS476 Part 7 or Tp(a).
- A concession allows the lining to be rated Class 3 or Tp(b) if the area of each rooflight is less than 5m<sup>2</sup>, and there is a clear space of 1.8 metres in all directions between each rooflight.
- There are no restrictions on use of roof outer sheets rated at least AC to BS476 Part 3.
- Rooflights with outer skin fire ratings less than AC should not be used within 6 metres of a boundary.
- A single skin sheet must meet the requirements for both the inner ceiling and outer roof surfaces.

- The only requirement for greater protection of wall outer sheets is where the building is within 1 metre of a boundary or is over 20 metres tall or is a building to which the public have access, when some areas will require sheets rated Class 0.

## Forthcoming European Regulations

New European classification systems are not directly comparable to existing UK tests. They will measure reaction to fire and resistance to fire. Reaction to fire is measured by a classification system giving rating A to F. It is unlikely that any plastic rooflight materials would ever achieve an A classification. Ratings B to F are determined by a small flame test and the SBI test. Resistance to fire may be measured by one of four tests (based on original French, Nordic, UK and German tests) to EN1187.

A European supplement to Approved Document B, will detail which new European tests and ratings will be required to replace existing UK tests in various applications. At the time of writing, the latest version of this supplement specifically excludes rooflights. Existing UK tests, as detailed above, are currently the only means of complying with Building Regulations.



## In Plane Rooflights

### Fixings

The mechanical properties of plastic rooflights differ from metal and fibre cement sheets. They are more flexible and can have a lower fastener pull through value (i.e. Suction loadings which pull the rooflights over their fasteners).

The pull through performance values of fastener assemblies should be determined in accordance with Annex B: BS5427: Part 1: 1996.

Fasteners are required to be watertight and to restrain the rooflights without damage when subjected to wind loads determined in accordance with BS6399: Part 2: 1997 - **Code of Practice for Wind Loads**, and support the design snow loadings described in BS6399: Part 3: 1988 - **Code of Practice for Imposed Roof Loads**.

When required, rooflight manufacturers can provide guidance for calculating wind and snow loads covered by the above Code of Practices. Load calculations outside the scope of the above documents should be provided by a structural designer.

Assembled rooflights are also required to meet the HSE non-fragility requirements as detailed in **Section 5**. The number of fixings, the size of washer, purlin centres and location of fixings will have a bearing on the non-fragile performance of the rooflights.

To meet the above design loadings and the non-fragility requirements, washers of at least 29mm diameter should be used in conjunction with 5.5mm diameter primary fasteners. The preferred location of the fasteners is usually in the bottom flat troughs of profiles (see below), except for continuous sinusoidal profiles which have no flat area where crown fixings should be employed.

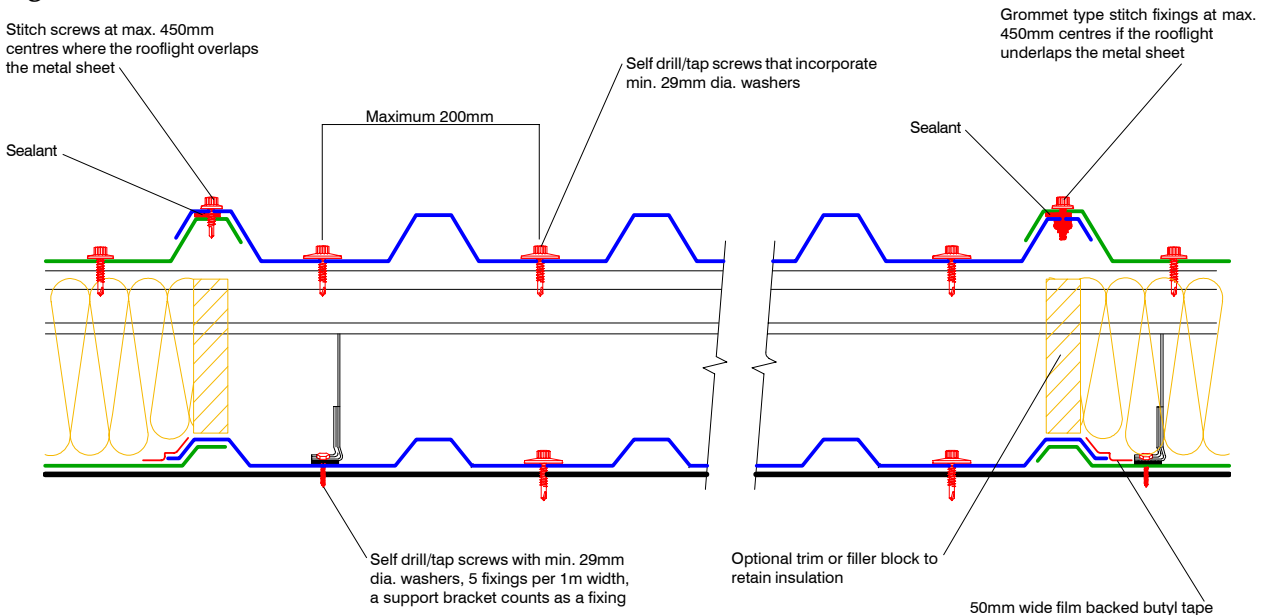
To prevent build up of rainwater behind the fasteners, the washer diameters should be at least 10mm less than the trough width. Wide troughs may require more than one fixing in each trough.

When sheets are fixed through the crown of the corrugation, rigid profile shaped supports are required between rooflights and supporting members to enable the fasteners to be correctly tightened without distorting the profile.

Roof purlins must have a level face parallel to the roof plane, otherwise if twisted the rooflight liners will deform.

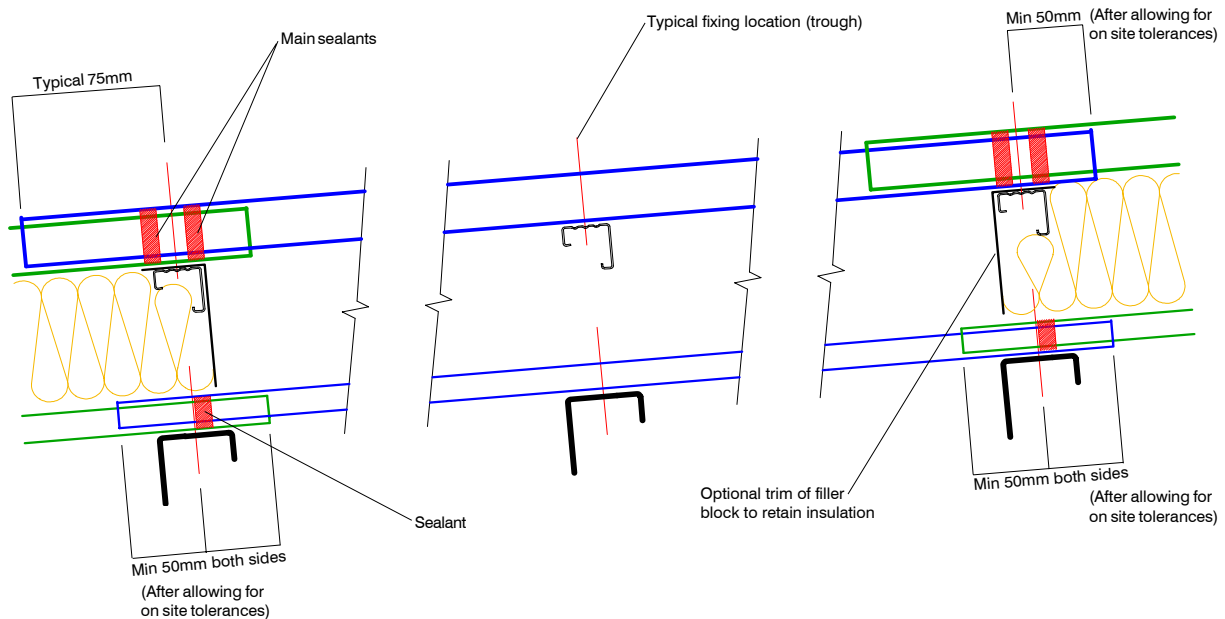
NB: With the new Thermal Performance Regulations, the additional weight of insulation and accessories may be an issue regarding roof purlin design.

**Fig.1 - Site Assembled Double Skin - Cross Section**



# Assembly and Accessories

**Fig.2 - Site Assembled Double Skin - Longitudinal Section**



Where buildings are in non-exposed locations, less than 10 metres high, and have limited permeability, wind loading is usually less than  $1.2\text{kN/m}^2$  in general roof areas. GRP rooflights in 32mm deep trapizoidal profiles of weight  $1.83\text{kg/m}^2$  and  $2.44\text{kg/m}^2$  can be used at purlin centres of 1.8 metres and 2.0 metres. Similarly profiled polycarbonate rooflights of thickness 1.2mm can be used at purlin centres of 1.5 metres. In all cases the rooflight should be fixed at all purlins with 29mm diameter washers on fasteners, and a minimum of five fasteners across the sheet width.

Heavier or thicker rooflights, or reduced purlin centres will be required when rooflights are located in areas of high local suction wind loading adjacent to roof verges and ridge.

Provided that rooflights, located in the general roof area, are installed to meet the design wind and impact loadings, they will support the snowloads likely to occur in the UK. When rooflights are used in zones where :

- exceptional high loadings may occur
- on high buildings
- adjacent to abutments
- where valleys abut parapet walls
- other obstructions where snow drifts are likely; then heavier weight rooflights will probably be needed.

Plastic rooflights are more flexible than metal and fibre cement sheets. Whilst this allows these sheets to deflect to a greater extent without damage the following criteria should be adhered to:

- Limit wind load deflection to 1/15th span or up to 100mm total deflection, to prevent excessive wear around the fasteners.
- Snow loadings should not deflect the rooflights to more than 1/15th span or never more than 50mm, to avoid disruption of sealants which may cause end laps to birdmouth.

On built up site assembled rooflights, it is recommended that the liners and the top sheet assembly is fitted progressively across the roof. If lining out only, contractors must be fully aware of CDM non-fragility requirements for both rooflights and opaque sheets. To prevent any distortion of liners, always fix progressively from one end. Do **not** secure each end prior to fixing at intermediate purlins.

Stitch side laps at centres not exceeding 450mm. On exposed sites and roof pitches below  $10^\circ$ , reduce centres to 300mm. Stitch rooflight to rooflight with roofing bolts or proprietary fasteners, which provide adequate support on the undersides. Where rooflights overlap metal sheets, self tap screw fasteners may be used.

# Assembly and Accessories

When drilling for side lap fasteners, where the rooflight underlaps care must be taken not to push down the underlap with the drill. When the drill bursts through the outer sheet, the drill should be lifted to allow the liner to recover and then continue drilling with care.

Primary fasteners should not be fixed within 50mm of the end of the rooflight, after allowing for on site tolerances, unless provision is made to reinforce the edge of the rooflight, (a typical example is the built up/end upstand on factory assembled units).

Where rooflights extend to the bottom of the downslope (e.g. at eaves or valley) the overhang should not exceed 150mm.

Due to high thermal expansion coefficient of PVC and polycarbonate rooflights, over sized holes are required around the primary fasteners to accommodate the thermal movement without stress. On such rooflights up to 3 meters long over size holes should be 10mm diameter. On sheets up to 4 metres long over size holes should be 12mm. Due to high thermal movement, the length of PVC and polycarbonate rooflights should not exceed 6 meters and at this length a very high standard of workmanship at installation is required.

GRP rooflights do not normally require any special provision to allow for the thermal movement.

## Application

To comply with the statutory requirements discussed in **Section 4**, rooflights used on insulated and heated buildings should be double or triple skin construction. They may be assembled on site as a built up system or fabricated as a single component under factory conditions.

Use site assembled rooflights with in situ insulated double skin roofing systems. Factory assembled rooflights are used in conjunction with composite panels or under purlin lining systems.

Rooflights assembled on site, consist of top sheets and liners to match the profiles of the adjacent opaque roofing systems. On low U-value rooflight systems, proprietary profiled sheets or other insulating layers are installed between the top sheets and the liners.

On factory manufactured insulating units, flat or profiled liners with upstands to form a box are bonded to the underside of the external sheet. Also, low U-value assemblies incorporating additional insulating components between the sheet skins are available.

## Sealants

Seal end laps on external weather sheets with two runs of preformed sealants applied within 15mm on each side of the primary fasteners. Ensure that sealants are well bedded into the corrugations prior to the application of the overlapping sheets.

When rooflights overlap rooflights or overlap metal, an additional seal close to the end of the lap will restrict dirt and moisture ingress.

Seal weather sheet side laps with at least one strip of preformed sealant tape located out board of the side lap stitchers (sealant laid in line with side lap fasteners can twist and become distorted when drilled through).

On built up assemblies, translucent liners form an integral part of the vapour sealed lining system. It is recommended that each side of the translucent liners should overlap the metal liners, and be sealed with 50mm wide film backed butyl tape applied over the joints between the translucent and metal liners. Seal end laps with a similar tape or a single run of sealant fixed above the fasteners.

Where the vertical upstands of factory assembled rooflights abut composite panels, they may be effectively sealed with closed cell, foam plastic strip.

Although adequate sealing will control moist air entering the rooflight in new build, some temporary misting may occur on the underside of the external sheet, particularly on cold, clear, frosty nights. This is normal and the misting will disappear as the structure dries out.

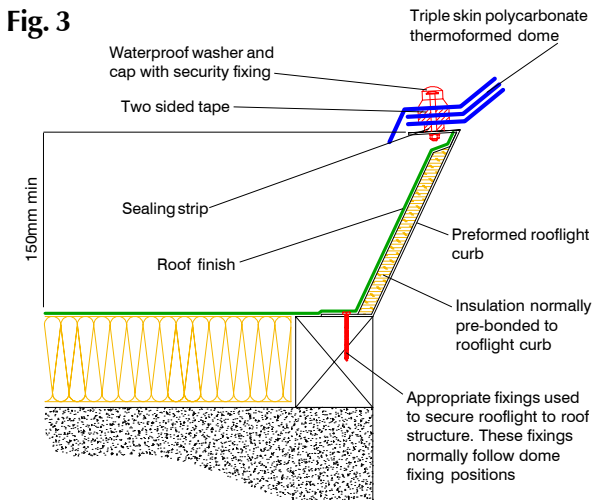
Polycarbonate rooflights should not come into contact with plasticisers, and barrier tape (not PVC) should be used to prevent contact with plastisol coatings on steel sheets.

## Out of Plane Individual and Continuous Rooflights

### Fixing Requirements and Weather Tightness

Fixing requirements vary slightly between rooflight manufacturers but the general curb/dome arrangement remains the same. However, the curb installer must follow the instructions supplied with each particular type of rooflight.

When using a preformed metal, plastic or GRP curb - **Figure 3**, this must be fixed squarely to the roof structure which surrounds the rooflight opening using appropriate fixings e.g. wood screws in the case of a timber structure.



An allowance will need to be made within the roof construction for the height of the roof insulation, in order that a 150mm clearance can be achieved from the top of the finished roof weatherings to the top of the rooflight curb. It is important to continue the roof weatherings to the top of the preformed curb, thus providing a continuous weathertight seal. Where vents are incorporated into the side of the curb, the clearance must be at least 150mm to the underside of the vents before a break in the weatherings.

If no allowance is being made within the roof construction for the thickness of the roof insulation, an extra high preformed curb should be specified as necessary in order to maintain the 150mm minimum installation of the dome above the roof surface.

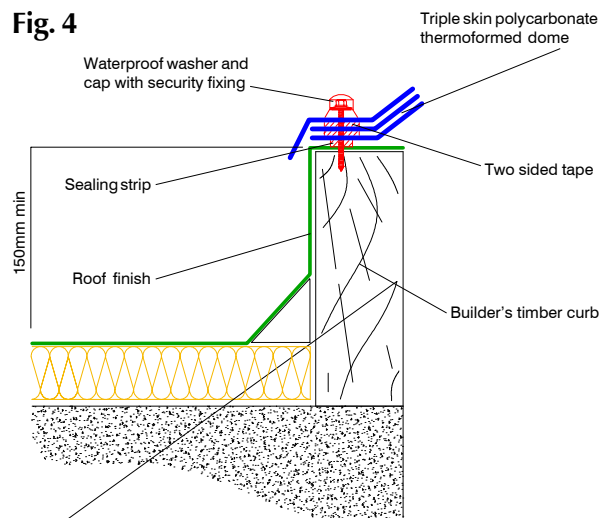
When domes are supplied complete with preformed curbs, the fixing holes in the domes are normally pre-drilled. Should it be necessary to drill fixing holes, these must be oversized to allow for thermal movement.

Care should be taken when bonding torch applied membranes and flashings to a preformed curb, and this should be completed prior to the installation of the dome. Many single ply membranes can be cold bonded to the preformed upstand, therefore, is possible to apply these following installation of the dome.

Prior to fitting the dome, it is important to fit a sealing strip around the entire perimeter of the fixing flange and fixing washers must be compressed onto dome, again maintaining a weather tight seal.

Many intermediate sections are available for fitting between the preformed curb and dome, such as ventilators, access hatches and smoke vents. These are normally factory fitted to the preformed curb, however, should site assembly be necessary, the installer must follow the particular manufacturers instructions.

Where a dome is to be installed directly to a builders timber curb - **Figure 4**, an allowance must be made within the roof construction in order that a 150mm clearance is maintained between roof weatherings and the top of the finished curb. It is advisable to continue the flashings over the top edge of the curb.



# Assembly and Accessories

Many intermediate adaptor sections, vents, etc., are available for installation between the builders timber curb and dome, and these should be fixed in accordance with the manufacturers instructions.

The sealing strip, which must be continuous, is applied to the top of the builders curb prior to the installation of the dome, which will normally allow for overlap of the flashings assuming the curb is level and fixed squarely.

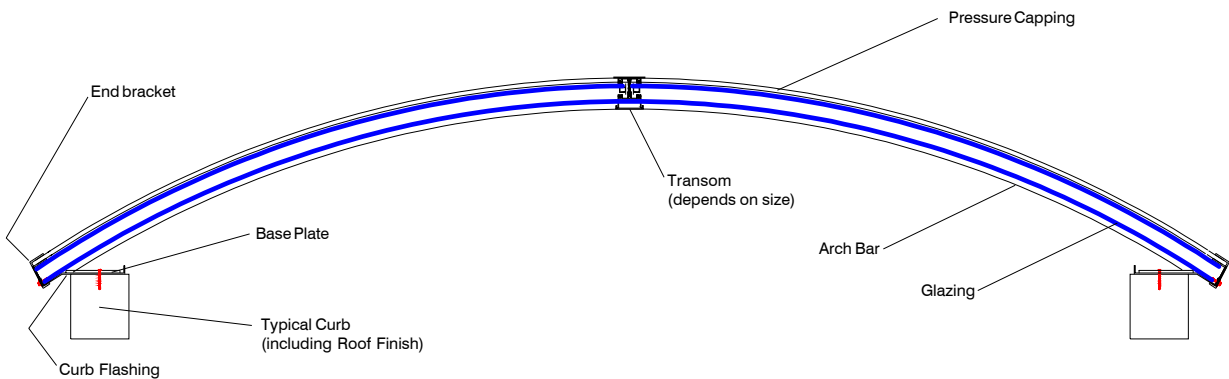
Barrel vault rooflights are available in all rooflight materials to suit standing seam systems, secret fix systems, flat and curved roofs. There are numerous

designs which employ different methods of construction although all types are normally fixed to a curb support structure or similar.

The manufacturers fixing and sealing recommendations must be followed to ensure that weather tightness, impact resistance, durability and insulation requirements are maintained.

**Fig.5** illustrates a typical cross section of a barrel vault rooflight. These are available in a range of widths to match the system that the rooflights are used with. Barrel vault rooflights can provide varying lengths and widths as required.

**Fig.5 Barrel Vault Rooflight - Cross Section**



# Durability

Durability is the ability of a building and its parts to perform its required function over a period of time (BS7543). Virtually all materials will change physically when subject to UV radiation, moisture and atmospheric pollution. This change may well affect both their performance and appearance. The designer must therefore ensure that, not only will the materials and details used be suitable initially, but also that they will have a satisfactory life if the necessary maintenance requirements are met.

## Materials

When considering **in plane** rooflights, the materials selected for both the roof cladding and rooflight can have a significant effect on the durability of the rooflights, and the amount of maintenance that will be necessary during their life. Components which are exposed to the weather and sunlight are particularly important.

The type of rooflight materials and roof sheeting colour must both be considered. Generally light coloured roof sheets are preferable because they do not absorb as much sunlight as dark colours, and they are therefore cooler. This means they will have less effect on the rooflight laps, which tend to deteriorate more quickly at higher temperatures. Similarly light coloured seals and fillers should always be used. This is particularly important with thermoplastic rooflights, and generally it is not an issue for GRP thermosets. Lighter roof sheet colours also have the best life and they optimise the thermal performance of the roof. The performance might also depend on the shape and orientation of the building and the environment.

**Out of plane** rooflights are generally not affected by the surrounding and adjacent materials, being isolated from them by the upstands, curbs and isolating systems. They are however, similarly subject to the same rules regarding fillers, seals and other components. Normally however, the rooflight will be delivered in a condition such that it can be incorporated directly into the roof assembly.

All rooflights are subject to gradual deterioration which will cause fading, discolouration and embrittlement, with some PVC being particularly susceptible. Plastic rooflights are generally resistant to normal pollution in the atmosphere, provided the products have been protected with UV light inhibitors, and suitable surface protection.

With the use of special coatings and films the products can be used in aggressive chemical environments. Resistance to discolouration, surface degradation and embrittlement depends, to a large extent, on the surface protective treatment used by the manufacturer.

## GRP

Most GRP rooflights will remain structurally sound for 30 years or longer. UV light and weathering could cause discolouration and surface erosion (thinning), but does not cause embrittlement or weakening of the sheets. Long term performance depends on environment, quality of sheets and surface protection, and maintenance. Discolouration of unprotected sheets can begin within 5 years, but good quality sheets incorporating UV absorbing surface protection (as supplied by all NARM members) will usually prevent significant discolouration for at least 20 years with the right maintenance program, and can virtually eliminate UV discolouration throughout their life. Higher fire resistant sheeting discolours more quickly when exposed to UV light due to the effect of the fire retardant additives.

## Polycarbonate

The current generation of polycarbonate rooflighting products are manufactured from high quality extruded sheet material. With these materials, not only is there a high level of basic UV inhibitor but also co-extruded protective layer on both faces of the sheet. This is known as enhanced UV protection and always carries a manufacturer's warranty. Additionally, the sheet manufacturer often warrants the performance of the material, even after thermoforming.

Polycarbonate rooflights can be expected to be fit for the purpose, in excess of 15 years, with a slow (but documented) deterioration of light transmission and strength. Some enhanced UV protected high performance polycarbonate products have a life of 15 - 20 years. As with many high performance materials, care must be exercised with regard to compatibility with adjacent materials. Some roofing sheet finishes (for example plastisol coated steel) can, over time, affect the mechanical performance of the product and an appropriate isolating system should be applied.

## PVC

Most PVC darkens and embrittles under UV radiation providing a useful life of 5-10 years. Specially formulated and protected grades are available and, if properly fixed, can last over 20 years. PVC, especially in cold conditions, should always be treated as a fragile material and should therefore not be used on industrial/commercial buildings, unless additional means are provided in the design to prevent falls through the rooflight.

## Fasteners

### In Plane Rooflights

Both plated carbon steel and stainless steel fasteners are available. In most situations involving coated steel cladding and rooflights, plated steel fasteners provide acceptable performance as long as their heads are protected from the elements. Integral plastic heads are more reliable than push on caps, and the use of poppy red heads for rooflight fasteners is recommended. Stainless steel fasteners can be used for improved durability, and must be used when fixing to aluminium sheets to prevent bi-metallic corrosion.

The durability of the fixings will affect the non-fragile status of the rooflights, and care must be taken to ensure the fixings' durability is compatible with the specified or stated non-fragile life of the roof and rooflights.

### Modular and Vaulted Rooflights

Always use stainless steel fixings, grade A2 to BS6105, with the fixing type being chosen to suit the supporting substrates.

### Design Details for In Plane Rooflights

Rooflights must be assembled correctly in order to achieve the maximum durability. Avoiding water and dirt traps, by ensuring satisfactory slopes and end laps, is particularly important with in plane systems.

The frequency of fixings and the size of the washers, needed for rooflights and rooflight liners, will generally be different to that of the surrounding metal sheets.

Rooflights will also require side lap stitching. A full fixing specification must be obtained from the rooflight manufacturer to ensure long term durability and non-fragility.

### Design Details for Out of Plane Rooflights

Generally these rooflights are delivered in a format such that they can be incorporated directly into the roof construction. If site assembly is required, the component parts are prefabricated from suitable materials.

## Maintenance

The durability of any rooflight, regardless of the material from which it is made, is always dependent on regular maintenance. Maintenance regimes vary from manufacturer to manufacturer, and each should be approached for their specific recommendations according to their warranty, but in general terms, the requirements can be described as follows :

### Cleaning

Clean regularly to maintain the highest levels of light transmission, usually every 12 months. As well as affecting light transmission, surface contamination can affect the heat absorption of many glazing materials, and this in turn can affect the long term physical and optical properties.

The cleaning process is generally uncomplicated, consisting of washing down with warm water and mild detergent. Abrasive, caustic and chemical treatments are unnecessary, and may actually cause damage to the exposed surfaces of the rooflight. A soft cloth or brush may be used to remove persistent contamination. In the case of paint or bitumen splashes, white spirit or alcohol applied with a soft cloth may be used with care. A final rinse with clean water will complete the process. Pressure hoses should not be used as the high pressure water can penetrate the sealing systems.

## Inspection

Rooflights should be inspected at least once a year. This is often best combined with a cleaning process. The surface of the rooflights should be checked for damage, and any found should be repaired in accordance with the manufacturers' instructions. Any damage which penetrates the surface protection of the units will, in time, affect the ability of the unit to resist impact, and with the advent of non-fragile systems, this is particularly important.

Finally, all fixings should be checked for tightness and corrosion. Many non-fragile systems rely on the security of the fixings to achieve their impact performance potential. Any fixing found to be inadequate should be replaced.

Every second or third inspection should include a check of the sealing systems, replacing any that are showing signs of failure.

## Note :

Obviously, the frequency of inspection and maintenance must be tailored to suit the local environment conditions on the roof in question, with higher levels of aggressive atmospheres requiring shorter inspection periods.

## General

Although rooflight degradation can be minimised by careful specification, attention to detail during construction, inspection/repair and frequent cleaning, the rooflights are only likely to provide adequate daylighting for 20 to 25 years. Replacement must be anticipated during the life of the building. More detailed information can be obtained from individual manufacturers.

## Long Term Non-Fragility

Provided rooflight products are fixed in accordance with the manufacturers recommendations, rooflights manufactured by **NARM** members will be designed and produced to be non-fragile when installed, unless stated to the contrary. As with most other roof cladding materials, it must not be assumed that the non-fragility status will last the life of the building.

Good quality GRP rooflights have a service life in excess of 25 years, and polycarbonate 15 - 20 years, but resistance to impact relies heavily on the quality of the installation. Long term non-fragility could be affected by many external factors such as incorrect initial installation, corrosion of fasteners or supporting materials, fasteners which have worked loose, or seals which have hardened or perished, even when there is little UV degradation or weakening of the rooflight sheet itself. Mechanical damage to the sheet, including chafing around the fixings, which can be accelerated by failure to install additional fixings around areas of high wind load, will also affect non-fragility classification.

Manufacturers of rooflights are therefore only able to give guidance on expectations of non-fragility over long periods of time, and such guidance will vary dependant on the design specification of the rooflight. The likely affects of external factors means that no rooflights are likely to retain their non-fragile classification beyond that given. The possible early influence of these factors means non-fragility of the rooflights should never be guaranteed within the period given, and it is usually prudent to treat rooflights as if they were fragile after the construction phase is completed, unless otherwise indicated. For more information on this please refer to **NARM Guidance Note 2003/1**, where the recommendations on 25 years non-fragility are provided.

There are much stronger and safer rooflight options available which may retain their non-fragility classifications for longer periods. The designers, in line with their design responsibility, should determine the risks, the required life and period of non-fragility, and the extra margins to include in order to maintain longer term safety.



## Transport

Rooflights may be supplied loose, shrink wrapped, on pallets or crated to comply with customers requirements.

Sheet lengths up to 8m can generally be supplied but lengths in excess of 12m will require special transportation and special consideration on manpower and/or crane off loading facilities. It is normal practice for sheet unloading to be the responsibility of the contractor/client, and specific off loading requirements must be notified to the manufacturer/supplier prior to despatch.

## Storage on Site

Where possible store the rooflights indoors in cool dry conditions, avoiding direct sunlight.

If outdoor storage is unavoidable, store in secure locations where the rooflights are unlikely to be stolen, damaged by site vehicles or foot traffic.

Stack in plane rooflights on clean level battens at least 100mm wide. Curved barrel vault lights will require additional supports to prevent them spreading. Locate supports at 1.5m for GRP and 1.0m for thermoplastics, and limit stack heights for GRP to 1.5m and for thermoplastics to 1.0m.

If the sun's radiation, even on dull days, is allowed to pass unchecked through the layers of unprotected rooflight sheets, the pack of sheets could become a solar battery, where the infrared radiation is entrapped creating a continuous build up of heat. Any moisture entrapped between the sheets will then boil and the resulting vapour, now at high pressure, will discolour the sheets. Additionally, for the thermoplastic rooflights permanent sheet deformation could take place.

To prevent this problem, always protect the sheet stack with reflective opaque waterproof covers draped over timbers to avoid direct contact with the rooflights and allow air circulation round the stack. Secure the covers to prevent wind damage and water penetration.

Particularly in wet conditions, frequently check to ensure that water has not penetrated the stack.

## Note :

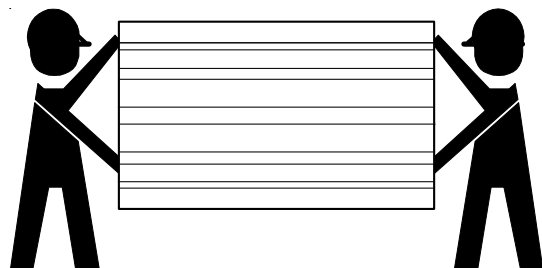
These comments are particularly relevant when sheet stacks are loaded out on to a pitched roof. Without full cover protection, the upslope sheet ends are very vulnerable to driving rain entering the pack of sheets, with capillary and gravity taking the water to the centre of the stack.

## Handling

Caution must be exercised when handling and installing rooflights in windy weather. Rooflights are frequently large, relatively lightweight, and when caught in gusting wind will endanger the personnel handling them and any person nearby.

When handling single skin rooflights they should be supported at 3 metre centres. Long length single sheets may be carried by rolling the sheets across their width to form a cylinder and roped at 1.5 metre intervals. Ensure that the down turn on the exposed sheet edge faces downwards to prevent ropes from snagging on the sheet edges.

When carrying multi skin factory assembled or barrel vault rooflights, care must be taken not to twist them. They should be carried at all time by two men, as illustrated, or more in the case of long units.



Always wear protective leather gloves to avoid cuts from sharp edges of sheets.

## Cutting and Drilling

Cut rooflights with a power saw having a 40/60 grit diamond blade operating at minimum speed. Alternatively, they can be cut with a hacksaw having 6 to 8 teeth per centimetre held at a shallow oblique angle.

Holes must never be punched through rooflights as this can cause cracking around the holes. This reduces the pull through performance of the fasteners (i.e. the force required to pull the rooflight over the fastener when subject to suction loadings).

Use standard metal drills for drilling GRP. Drill thermoplastics with masonry type drills, or metal drill bits having a point angle of 130°. To accommodate thermal movement in thermoplastic rooflights, the diameter of the holes where the primary fasteners are to be fixed, must be at least 10mm diameter.

## COSHH Regulations

For GRP, polycarbonate and PVC when cutting or machining with power tools, a non-toxic biological inert dust is produced. These dust levels should be kept as low as reasonably practical, and must not exceed the **Occupational Exposure Limit of 10mg/m<sup>3</sup> - 8 hour TWA value**.

When working outdoors, it is most unlikely that these levels could be reached. When working indoors or in confined areas, adequate ventilation should be provided. When extensive operations are necessary, suitable dust extraction equipment should be used.

When cutting sheets, operators should always wear suitable dust masks and goggles to avoid any irritation in the nose, throat, lungs and eyes. In isolated cases, dust may cause slight transient irritation. Should these effects be prolonged or any sign of rash occur, medical advice must be obtained.

All exposed skin must be thoroughly and frequently washed with soap and water. Any eye contamination must be washed with copious amounts of clean water.

Sheet edges can be sharp, always wear gloves when handling sheets.

Do not smoke in or near stores or working areas.

Whilst the use of long length rooflights may reduce the number of end laps and reduce material costs, site conditions must be considered. A long length rooflight (exceeding 7 metres) is relatively light in weight, and when handled on high exposed buildings, can be awkward to handle even in mild blustery conditions.

In the event of a fire involving rooflight material, the safe extinguishers to use are :

- Carbon Dioxide
- Water
- Foam
- Dry Powder

Noxious fumes may be produced which can contain carbon monoxide, carbon dioxide and soot particles. Breathing equipment is advisable in enclosed areas.



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