



# **TECHNICAL MANUAL**

Light Transmission



LOW CARBON DAYLIGHT SOLUTIONS

# Light transmission

The benefits of the use of natural daylight in buildings in respect of health & well-being, safety, productivity and energy savings are well documented.



## LIGHT TRANSMISSION

Light that has travelled through a medium without being absorbed or reflected.



This is further reinforced by statements in Workplace (Health, Safety and Welfare) Regulations 1992 and HSG38 - Lighting at Work where suitable and sufficient lighting is required, and as far as reasonably practicable, by natural light.

Rooflights can provide up to three times more light than vertical glazing elements, and can provide a more even and useable distribution of natural light into a building, particularly in large structures where light is required deep into the building or in enclosed areas that cannot be lit through an external wall.

The light that enters a building can be direct light such as that which passes through clear or transparent materials, or diffused light that is created by surface textures designed to create diffusion by surface refraction, or by materials that are translucent and naturally diffusing. Glass Reinforced Polyester (GRP) rooflights are manufactured using clear

polyester resins reinforced with transparent glass fibres. As the light passes through the combination of materials, the light is scattered by refraction to create a diffusing medium.

### Direct light

Light that enters through a window or rooflight with minimal disturbance through transparent type materials, such as glass and polycarbonate, provides a strong and direct light path that can create high localised levels of illumination, where required, as part of the building design and provide clear vision to the outside of the building.

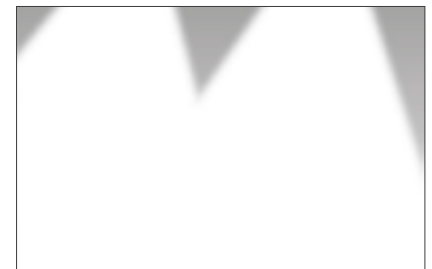


Poor distribution & glare

For some applications, direct daylighting can offer positive benefits particularly in window applications, however in periods of strong sunlight it can create

high contrasts between light and dark, undesirable shadows and glare.

### Diffused light



Good, even light distribution

When light is scattered as it passes through translucent diffusing materials such as GRP, or transparent materials that are modified to produce diffused light transmission, it does not necessarily reduce the levels of light transmission. It makes more efficient use of the available light by spreading it over a far greater area. This significantly reduces the apparent difference between light and shade and minimises the creation of shadows, thereby creating a more consistent and evenly lit space.

## Daylight design

Different materials and high levels of diffusion can all provide different levels of light transmission into the building, and it is important that all elements of the rooflight assembly are taken into consideration, particularly when they are made up of multiple layers or incorporate different insulating layers to improve the thermal performance.



## Recommended light levels

It is important that designers consider the intended use of the building, and in some cases, possible future changes to the use or internal layout of the building. Windows and wall lights generally become ineffective at distances of over 6m into the building and therefore daylight illumination through rooflights becomes the most effective method.

Light levels - or 'illuminance' - is measured in Lux, and the following table provides minimum illuminance levels recommended for various activities.

Activity	Recommended Illuminance (lux)	Typical building type
Continuously occupied with visual tasks but not requiring perception of detail	200	General warehousing and storage facilities, reception areas
Moderately difficult visual tasks	500	General retail and manufacturing areas
Difficult visual tasks requiring accurate colour judgement or perception of movement	1000	Clothing and furniture retailing, sports halls
Precise detailed work requiring accurate perception of intricate detail	2000	Engineering facilities, craft and design studios (good background plus specialist task lighting)

Source: CIBSE SLL Code for Lighting

### Design considerations

To optimise the internal illumination, it is necessary to consider the position, numbers and total rooflight area required. This should take into account internal obstructions caused by items such as racking, services, equipment etc.; however light reflection from internal walls and installations can further improve the distribution of already well diffused light.

The design should also consider at what height or plane, horizontal or vertical, the appropriate illuminance is required. Illumination of a vertical plane will generally require greater rooflight areas to achieve the same level of illumination.

While daylight illumination of buildings has mostly positive effects, consideration should be given to limiting rooflight areas to around 20% of the floor area, depending upon rooflight specification, to minimise the risks of overheating during hot weather and prolonged periods of strong direct sunlight. In large buildings this can generally be controlled with considered ventilation strategies rather than necessitating the introduction of cooling equipment and the associated energy consumption.

### Daylight factor

The daylight factor is the illuminance on a horizontal surface inside a building expressed as a percentage of the illuminance on a horizontal surface under an unobstructed grey sky. It is a measure of how bright or gloomy the inside of a



*No artificial light required*

building will generally appear, when naturally lit and is used to overcome the problem of the extreme variability of natural lighting.

A daylight factor can be measured for a specific point or expressed as an average.

For many situations, the CIBSE Code for Interior Lighting suggests a daylight factor of 5% or more for a well-lit appearance, whilst a factor of less than 2% does not look well lit and electric light will be in use usually throughout the day.

The daylight factor is used to overcome the problem of the extreme variability of natural lighting. In an attempt to use ordinary light meters to measure the daylight factor there will be an inevitable delay between taking the illuminance measurements inside the building and those outside. It is therefore probable that there will have been a significant change

in conditions in this interval leading to inaccuracies. There are light meters that allow the readings to be taken, and if necessary repeated, without delay by switching from the outside to the inside; they are also convenient to use, as the daylight factor can often be read directly as a percentage.

- A daylight factor can be measured for a specific point or expressed as an average.
- Daylight factor (percentage)
- Illuminance - The amount of light per unit area, measured in lux (1 lux = 1 lumen/m<sup>2</sup>)
- Luminance – The intensity of light emitted from a surface per unit area, usually in a given direction, measured in candela (Cd/m<sup>2</sup>)

Daylight factor	Appearance
< 2%	Room looks gloomy, artificial lighting required for most tasks
2% to 5%	Predominantly day-lit appearance, but supplementary artificial lighting is needed..
> 5%	Room appears strongly day-lit, minimising the need for artificial lighting

### Daylight factor considerations

- Distribution of daylight into the building immediately creates variations of the daylight factor within.
- The Sky Component (SC) – the direction of the opening and angle of the sky (more relevant to wall window design).
- The Externally Reflected Component (ERC) – the light entering the building reflected from external objects and surfaces (less of a consideration for windows in flat or low pitched roofs).
- The Internally Reflected Component (IRC) – the light that is reflected internally from all ceiling, wall and floor surfaces and fixtures and fittings within the building. This is very complex and is affected not only by the elements within the building, but by the way that the light enters the building.
- Other influences can include the diffusion properties of the light transmitting element, the nature and extent of any framing and dirt or contamination on the surfaces of the glazing material both internally and externally.
- The influence of light entering the building from sources other than the rooflights.



### Energy saving

Artificial lighting is generally essential in all occupied buildings and particularly in the winter months or in areas where localised specific or constant lighting levels are required. However, in new buildings where excellent levels of insulation are now being achieved, some of the most significant savings in energy can be achieved by the use of the free resource that is natural daylight.

The energy consumed by artificial lighting where inefficient lighting systems are used, or where artificial lighting is turned on and left on irrespective of need, far exceeds the relatively small amounts of heat energy that are lost through increasing the rooflight area which is a very small part of the whole building fabric. Generally, the amount of energy required to light a building is greater than the amount of energy required

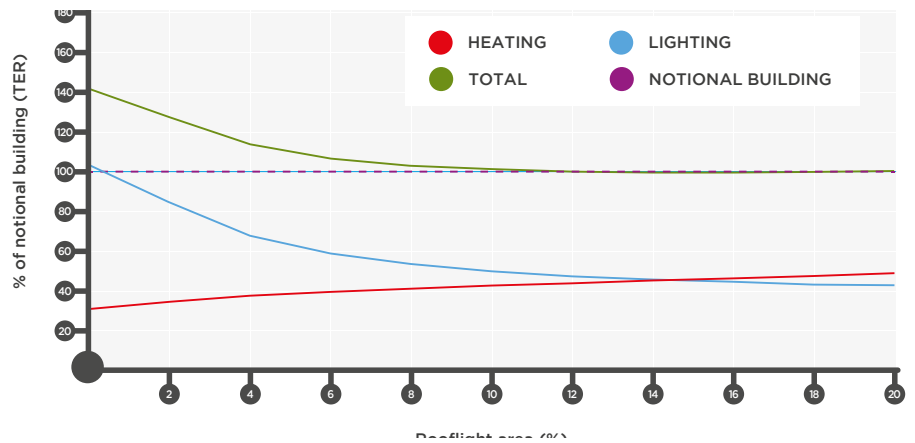
to heat it and can be the greatest single energy use in operating the building.

Research by De Montfort University and published by the National Association of Rooflight Manufacturers (NARM) demonstrates the savings that can be made by the introduction of rooflights and at larger than previously considered optimum areas.

Each building and building design should be considered on its own merits, and with regard to the existing or intended use.

The research also demonstrates the importance of incorporating appropriate automated lighting controls using sensors that monitor and control the artificial light use.

The graph reproduced above using SBEM results shows the relatively small increase in heating energy required as the rooflight area increases, compared to the dramatic reduction in energy consumption by artificial lighting typically reaching an optimum level at around 18%. This figure will vary from



Source: NARM NTD06.2 2014 Designing with Rooflights

building to building in respect of both design and operation of the building, but clearly demonstrates the value of natural daylight.

### Rooflight properties

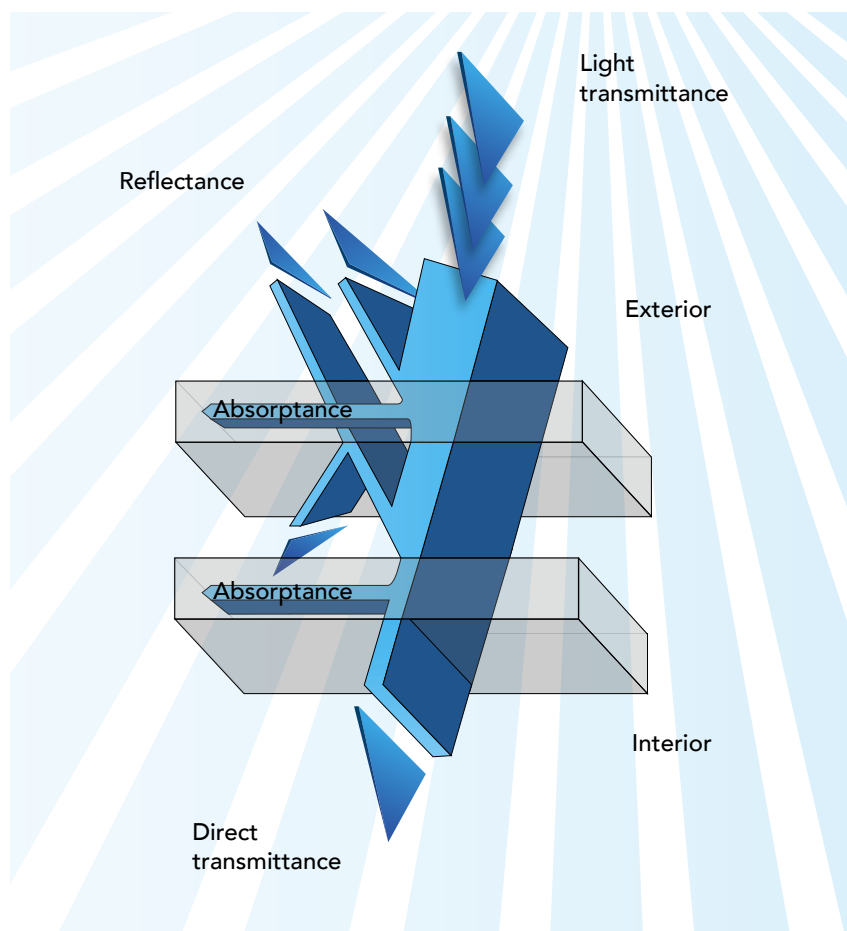
Light that passes directly through a transparent or translucent material is referred to as 'direct transmittance',

however not all available light passes directly through any glazing or rooflight medium.

Depending upon the material type, thickness and composition, there will always be a part or component of the light that is reflected from the surface, referred to as 'reflectance', and a part that is absorbed by the material, known as 'absorptance'.

Light reflectance occurs at the surface of a material and tends to be dependent on the nature and surface of the material, rather than its thickness. Even the most transparent materials can have high levels of reflectance, for example sunlight reflecting from a window or windscreen.

The light that is absorbed by the material is converted to heat and re-radiated from the material internally and externally. The greater the mass of the glazing or rooflight material generally, the greater is the capacity for heat build-up and re-radiation. This is referred to as the 'secondary' component in solar heat gain.

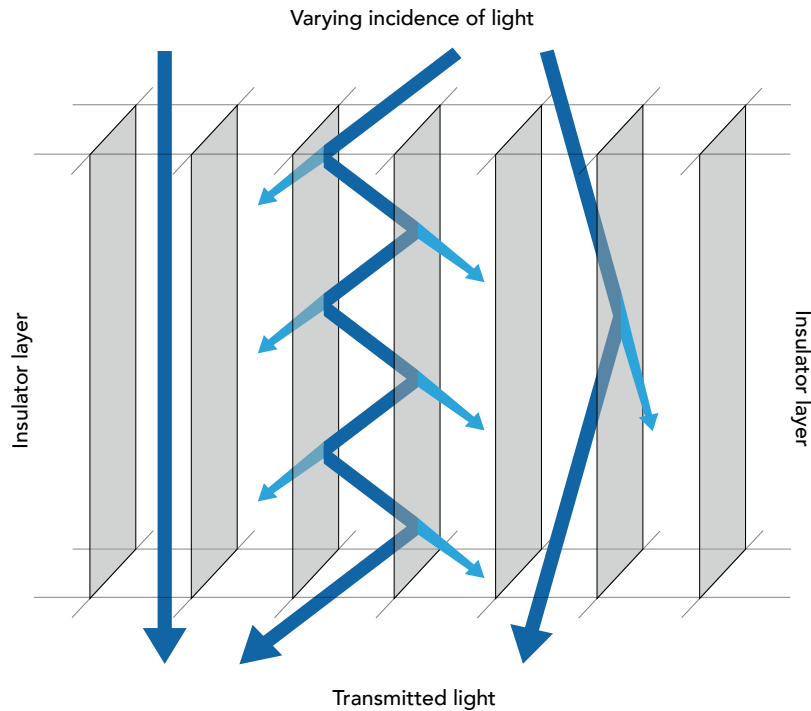


Light transmittance, reflectance and absorptance

## Insulated rooflights

To provide better insulated rooflights, the fundamental requirement is to reduce heat loss through that element of the building. For the majority of the building envelope where there is no requirement for any light transmission, the choice of insulating materials and methods are varied, but all ultimately rely on reducing conduction, convection and radiation.

Reducing radiation through rooflights invariably results in reducing light transmission. Therefore the primary focus for improving the thermal performance of rooflights is to reduce the materials in the rooflight that can facilitate the conduction of heat through the rooflight, and inhibit the convection currents of air that can carry heat from the inside layer of the rooflight to the outer weather exposed layer. This is most commonly achieved by simply increasing the number of layers of insulating material and minimising the amount of any physical connection between these layers. This is effective up to a point where the increasing numbers of layers begins to have a significant impact on the total light transmission due to increasing levels of reflectance and absorptance at each layer.



*Light transmittance and reflectance through the Zenon Insulator core*

## Zenon Insulator

To overcome the problem of significantly diminishing light transmission with the addition of each layer of insulant, Hambleside Danelaw developed the Zenon Insulator transparent tessellated core system. This system of insulation operates by trapping the air within the rooflight cavity and inhibiting the convection currents that carry the heat through the rooflight panels.

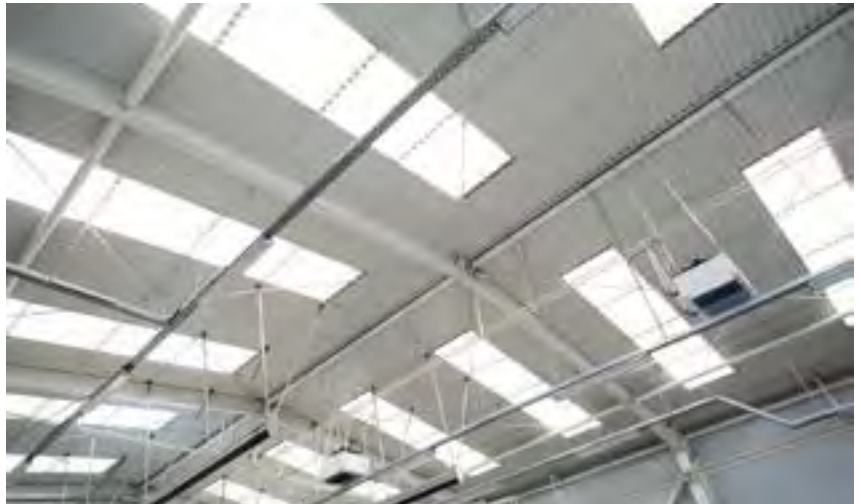
It benefits from a transparent 'honeycomb' cell structure perpendicular to the plane of the rooflight that directs the reflectance component of the daylight into the building through the rooflight with minimal effect on the overall light transmission. The cell structure is of a lightweight high gloss material designed to maximise reflectance and minimise absorptance to best effect, creating a 'lens' type effect that provides a better, wider spread of diffused light irrespective of angle of incidence.



*A close up of the Zenon Insulator honeycomb layer*

### Light transmission values

The standard insulation layer thicknesses, when using simple structured polycarbonate (PC) inserts for both site assembled rooflight applications for built-up cladding systems or Factory Assembled Insulated Rooflights (FAIRS) for use with composite cladding systems, are 4mm twin-wall or 10mm four-wall panels.



The Zenon Insulator core is available for both site assembled rooflights or FAIRS. There are three standard thicknesses available, depending upon thermal performance requirements, that can also be used in layer combinations where very low U-value rooflights are required.

Rooflight sheet	Pro 18	Pro 24	Pro 30	Pro 36	Pro 54	Evolution LC1	Evolution LC2
Light %	81	80	79	78	70	64	62

Insulation system	4mm PC	10mm PC	20mm Insulator site	20mm Insulator FAIR	40mm Insulator site	40mm Insulator FAIR	80mm Insulator site	80mm Insulator FAIR
Light %	79	62	83	91	83	91	82	91

*Transmission data from physical testing by National Physical Laboratory*

### Rooflight surface protection

As well as being protected by UV stabilisers and absorbers, GRP rooflights that are manufactured in the UK are also protected from UV degradation and discolouration by the application of a special surface layer.

At one time this would have been a clear surface coating, however this has long since been superseded by the application of a special transparent surface protective film for the external surface of the outer rooflight sheets.

Hambleside Danelaw uses the Zenon Shield, a highly durable UV protective surface film for extended performance.

The long term UV exposure and weathering of all surface films results in some degradation of the outer surface of the film giving a slightly dulled surface appearance or 'hazing'.

This change to the surface layer is sufficiently thin that there is minimal effect on overall light transmission levels.



*Zenon Shield protective surface film*

Zenon, a comprehensive range of low carbon rooflights for the metal building envelope from Hambleside Danelaw

**Hambleside Danelaw**  
Rooflights



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