

# Glass Rooflights - Specification Guide



## Contents

|  |         |
|--|---------|
| <b>Introduction</b>  | Page 03 |
| <b>Common types of glazing</b>   | Page 04 |
| <b>Safety:</b> <i>safety for building users; non-fragility; fire regulations</i> | Page 05 |
| <b>Reducing heat loss</b>  | Page 07 |
| <b>Limiting excessive solar gain</b>   | Page 07 |
| <b>Light diffusion</b>   | Page 08 |
| <b>Walk-on rooflights</b>  | Page 08 |
| <b>Framed systems</b>  | Page 09 |

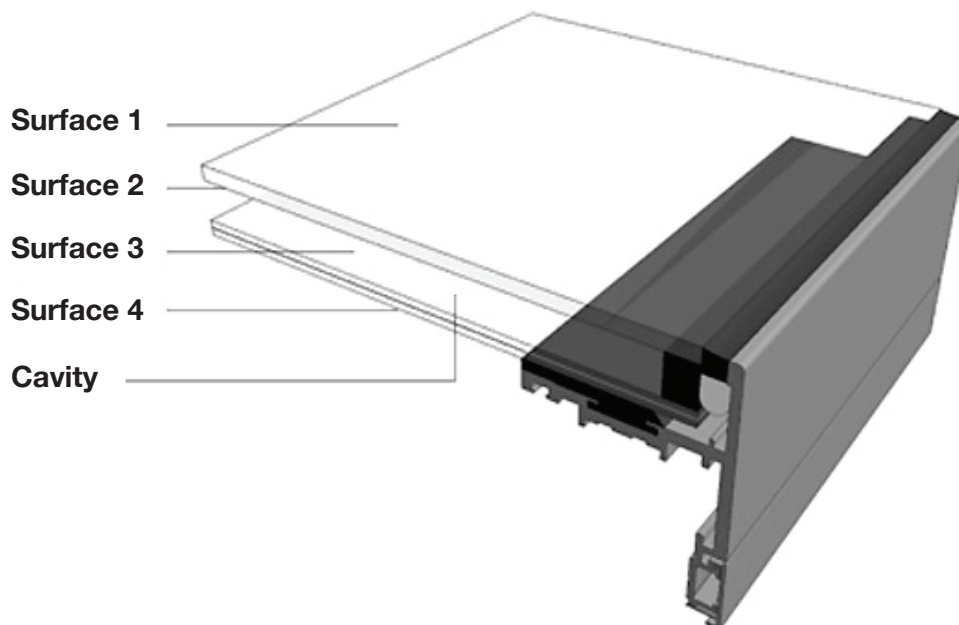
## Introduction

Glass is used throughout buildings for its optical clarity, longevity and structural properties; it can offer unobstructed views out of a building, or if specified so, can provide natural light into rooms where privacy is required.

Glasses are amorphous, non-crystalline, solid materials and are typically brittle. The most common glass used in windows for many years is soda-lime glass, composed mainly of silica. There are also many modern thermoplastic materials used as glasses, such as polycarbonate and acrylics, which are lighter and possess different properties to common silica glasses.

In the majority of external envelope applications, glass is fitted as a Double Glazed Unit (DGU), or increasingly, as a Triple Glazed Unit (TGU), in order to provide improved resistance to the passage of heat, thus improving energy efficiency and comfort to building users. These sealed units of differing pane numbers are collectively known as Insulated Glass Units (IGU).

A typical hermetically sealed DGU mounted within a rooflight frame would comprise a toughened outer pane, argon filled cavity, and preferably a laminated inner pane; although under certain circumstances a toughened pane may be considered acceptable. The DGU assembly may look similar to the image shown below:-



## Common types of glazing

### Annealed glass

Annealed glass is the initial product produced in glass making, and is often processed further to create other infill materials (listed below). It is the least expensive, most readily available glass, and is relatively easy to cut to shape. Annealed glass is the weakest form of glass infill available (45 N/mm<sup>2</sup> bending strength), and when broken, produces large shards of sharp glass; as a result, monolithic annealed glass can never be referred to as 'safety glass'.

### Heat Strengthened Glass

The process involves applying a controlled heating and cooling process to annealed glass, inducing a permanent surface compressive stress, affording a vastly improved bending strength over annealed glass (70 N/mm<sup>2</sup>). However, heat strengthened glass exhibits a similar post breakage behaviour to annealed glass, giving a high potential to cause serious injury. As such, monolithic heat strengthened glass cannot be classed as 'safety glass'.

### Toughened Glass

Similar to heat strengthened glass, a controlled heating and cooling process is used to induce a permanent surface compressive stress (albeit higher than that experienced with heat strengthened), providing a bending strength of 120 N/mm<sup>2</sup>. When toughened glass is broken, it forms small, slightly rounded pieces of glass (known as 'dice'), which are less likely to cause injury; hence its classification as a 'safety glass'. However on rare occasions, these dice can clump together and fall as larger sections of glass. A risk assessment should be undertaken before considering a toughened inner pane of glass in an IGU. Unfortunately, due to the presence of nickel sulphide (NiS) inclusions, toughened glass can spontaneously shatter. This risk can be greatly reduced by specifying heat soaked toughened glass.

### Heat Soaked Toughened Glass

Subjecting toughened glass to a sustained high temperature allows unstable nickel sulphide inclusions which may be present, to return to a stable form. Unfortunately the reversion causes breakage in glass undergoing treatment, meaning that increased lead times can occur due to failing glass panes. However those which do survive are less likely to fail during service. Heat soaked toughened glass is used in the same applications as toughened glass, and demonstrates similar breakage behaviour.

### Laminated Glass

Laminated panes are produced by bonding a film, or interlayer (ionomer material, typically polyvinyl butyral - PVB) between two or more plies of glass (typically annealed or heat strengthened glass). Upon fracture, the interlayer holds the broken shards of glass, preventing injury to those immediately below the rooflight. The interlayer, depending on thickness, material and pane size, may also have the ability to hold a load lying on the glass, preventing falls from height through the rooflight.

## Safety

When considering the specification of overhead glazing for inclusion within rooflights, there are two parties to bear in mind; those above the glass (often maintenance staff), and those below it (general building users).

### Safety for building users

To protect those below rooflights, the first choice for the inner pane of a rooflight should usually be a laminated glass, as this generally minimises the risk of any glass falling into the room beneath and consequent injury, if the inner pane should break.

British Standards define that inner panes must always be laminated wherever rooflights are more than 5 metres above floor level (increased to 13 metres in limited circumstances) or are located over water (eg swimming pools). It is noted that British Standards do set out other circumstances and locations when a toughened inner pane can be used, subject to satisfactory risk assessment

However, NARM recommends that the inner pane should always be laminated glass, unless a stringent risk assessment has been undertaken which shows that use of a toughened glass inner pane does not give any additional risk to those below rooflights. If after a risk assessment a monolithic toughened inner pane is being considered, it should always be heat soak tested. Guidance on how to go about carrying out a glass risk assessment can be found in a document published by CIRIA (Construction Industry Research and Information Association); document C632 'Guidance on Glazing at Height'.

Note that a laminated inner pane does not necessarily mean a rooflight can also be classified as non-fragile (which may be required to protect those above the rooflight); if required non-fragility should be specified separately (see below).

Where an annealed inner laminated pane is proposed, careful thought should be given to the risk of Thermal Heat Stress failure which could affect the durability of a laminated inner pane. To avoid this risk, and should additional strength be required to the inner pane, a heat strengthened or toughened laminate can be specified (with care taken to ensure this does not affect non-fragility classification).

### Non-fragility

In addition to using a laminated inner pane to protect building users, rooflights can also be specified and designed to be non-fragile. This is intended to ensure that anyone accidentally walking or falling onto the rooflight will not fall through the rooflight, even if the glass is broken or the rooflight damaged.

CDM Regulations require that a risk assessment should be carried out for every construction project, and this should define the measures required to prevent significant risk of anyone falling through a rooflight.

## Safety (contd.)

If the risk assessment confirms that satisfactory measures have been taken to ensure there is no risk of anyone falling through a fragile rooflight then fragile rooflights can be specified, but otherwise rooflights should be specified to be non-fragile.

Non-fragility for roofing products is generally defined by the “Red Book” ACR[M]001 issued by the Advisory Committee for Roof Safety, but for glass rooflights that document cross refers to documents issued by The Centre for Window and Cladding Technology: CWCT Technical Notes 66 and 67 “Safety and Fragility of Glazed Roofing: guidance on specification” and “testing and assessment” respectively, and CWCT Technical Note 92 “Simplified Method for Assessing Glazing in Class 2 roofs” which includes a simplified test method and a “deemed to satisfy” solution for rooflight applications in a Class 2 roof (one not intended for any foot traffic).

These CWCT documents should be used to define non-fragility of glass rooflights. They are based on the ACR[M]001 soft body impact test, together with an additional hard body impact test specifically relevant to glass, and a static load test to ensure that a broken IGU can retain an injured person who has fallen onto the glass. Pass criteria include ensuring the soft body does not fall through a broken pane of glass, and that no significant shards of glass drop.

Note that any non-laminated pane of glass is incapable of retaining a body once broken, and any rooflight with a toughened inner pane must therefore always be considered ‘Fragile’.

It should also be noted that not all laminated glass combinations will achieve a ‘Non-Fragile’ classification, and many rooflights with laminated inner panes may be fragile: an enhanced specification of laminated glass, and how it is secured in the framing system, may be necessary to achieve non-fragility. Rooflights should either be tested to CWCT TN 92 (or to TN 66 and TN67), or comply with the deemed to satisfy standards defined in CWT TN92 to be regarded as non-fragile.

Deemed to satisfy standards specify a minimum inner pane of 9.5mm or 11.5mm laminated glass (depending on size) comprising 2 plies of annealed or heat strengthened glass with a 1.5mm pvb or ionomer interlayer, continuously supported in a rebated frame with an edge cover of at least 15mm on all four sides.

### Fire Regulations

The Building Regulations Approved Documents B1 and B2 state that when used in rooflights, unwired glass a minimum of 4mm thick is deemed as having a  $B_{ROOF}(t4)$  classification. This information is found in paras 12.8 (AD B1) or 14.8 (AD B2), and there is therefore no restriction on the use of glass as an outer skin.

The inner skin should generally be C-s3, d2 (Class D for smaller spaces, or Class B in circulation spaces)

in accordance with Tables 4.1 (AD B1) or 6.1 (AD B2). These requirements exclude the framing according to paras 4.6b (AD B1) or 6.6b (AD B2). Where the inner skin is glass it can be considered as Class A (to EN 13501-1) according to the table in the Annex of EC Decision 94/611/EC which provides a Classification without further testing (CWFT) for the reaction to fire of a range of materials including glass, which includes heat strengthened, chemically toughened, laminated and wired glass.

It is possible to achieve fire resistance with glass rooflights but these require specialist fire resistant glass that has been tested in a horizontal orientation and in combination with the particular framing system in which it is proposed to be used.

## Reducing heat loss

### Low E glass

This is glass designed for low-emissivity (known as Low E) and is used to improve thermal insulation. The glass has a transparent metal oxide film applied normally to the top surface of the inner pane on a DGU (See diagram on page 3 - surface 3), which works by reflecting the radiation characteristic of heat generated within the building back into the internal space. External solar radiation however, can pass through the film into the building giving 'Solar heat gain' to the space. Thus by retaining internal heat and gaining external heat, Low E coatings in DGU's provide up to three times more insulation than glass without.

### Spacer Bars

The two panes of glass in a DGU are held apart by a frame or Spacer Bar around the edge. This frame is often made of aluminium and is seen as a bright edge between the panes of glass. However, this metal frame can act as a 'Thermal Bridge' between the panes, transmitting heat from inside the building to outside. This problem can be reduced by specifying a 'Warm edge' Spacer Bar made from a material that has low thermal conductivity; this improves the energy efficiency, and reduces the risk of condensation.

### Gas filled cavity

The two panes of glass in a DGU are sealed at the edges to create a cavity; this space adds to the thermal insulation of the unit. The space is hermetically sealed and can be filled with dried air or an inert gas. This dehydrated air or gas is chosen because it's molecular make up provides a barrier to the transfer of heat by normal convection, which would take place in the open air. Inert gasses such as xenon, krypton and, more commonly argon in conjunction with Low E glass are used in DGU's for their low thermal conductivity properties. Low E glass used in conjunction with an argon filled DGU typically gives a centre pane 'U' value of 1.1 W/m<sup>2</sup>K.

## Limiting excessive solar gain

Whilst considered an advantage in the winter months, excessive solar gain in summer can render a space uncomfortably hot, and in extreme cases, unusable without the use of air conditioning or similar equipment.

To limit the amount of heat transfer from the Sun into a building (Solar Gain), a Solar Controlled glass can be chosen and fitted as the outer pane of an IGU. Solar control can reduce glare and keep buildings cooler; this is achieved by tinting, applying metallic coatings or a combination of these dependent upon the glass manufacturer chosen. Solar values ('G' values) often correlate with an IGU's light transmission; as the quantity of radiated heat entering the building reduces, so too does the quantity of light entering a space. Building designers may wish to reap the benefits of solar gain during the winter, and counter excessive heat gains in summer through other means; brise soleil, deciduous landscaping et cetera.

## Light diffusion

A variety of light diffusing rooflight glazing materials are available. With these, as the light passes through the rooflight it is scattered giving a much more even distribution of light into the structure below. This 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. Diffused glazing may also be preferable where privacy is required, as is often in the case of 'walk-on rooflights'.

## Walk-on rooflights

Non-fragility of rooflights is a complex subject which can be influenced by many different factors, including material selection, design and the competence of the installer. For this reason, over the years, NARM has advocated that whatever the non-fragility rating or age of a rooflight, it should be considered as if it may be fragile and foot traffic on rooflights should always be avoided.

This advice does require a caveat, as there is a very specialised class of rooflights which are specifically designed for foot traffic. These are very high specification glass structures designed to floor loadings and installed in-plane with floors, usually on roof decks and roof terraces where pedestrian access is unrestricted. This type of specialist product has been available for many years, with notable examples providing tourist attractions on towers and other structures. In recent years these 'walk-on' rooflights have become more widely used, with many now providing a means by which homeowners are able to improve space utilisation offered by roof areas, as well as providing a means of allowing natural daylight to penetrate internal floors – into cellar areas for example.

These walk-on rooflights utilise strong laminates of toughened glass which produce glass, often with anti-slip treatments, as glass can become very slippery when wet.

As a minimum, walk on units should be designed for typical domestic floor loadings of 1.5kN/m<sup>2</sup>, with a concentrated load of 2.0kN as prescribed in BS EN 1991-1-1:2002; higher loadings can be achieved when required for non-domestic buildings through alternative glass specifications. Many rooflight companies now commonly offer 'walk on' glass in this way giving Architects a greater freedom of design in how light transfers through a building.

The member rooflight companies of NARM will be able to advise on a precise glass specification, taking into account the aspect ratio of the unit, the framing support system and site load conditions. The combinations of types of glass used in rooflights can allow the specification of a space that is lit by natural light, is safe and comfortable.

**Read More** For further information about walk-on rooflights, please refer to: *NARM Technical Document NARM NTD11 Understanding the differences between 'non-fragile' rooflights and 'walk-on' rooflights for deliberate foot traffic*". This can be downloaded from the narm website: [www.narm.org.uk](http://www.narm.org.uk).

## Framed systems

Bespoke structures of almost any shape can be designed using proprietary glazing systems. These usually comprise aluminium or steel glazing bars with polycarbonate or glass glazing.

Typical glazed skylight configurations include pyramids, pitched polygons, barrel vaults, ridgetlights, monopitch structures and vertical glazed panels. However, NARM member companies can work closely with architects and specifiers, to realise bespoke, individual design concepts if required.

Proprietary glazing systems are extremely versatile offering a wide range of profiles to suit many different applications. Internal water management systems, custom designed flashings and bespoke opening/ventilation systems can be incorporated.

The framing system makes a major contribution to the safety of the glazing, regardless of the glass type, and it is not satisfactory to determine the safety or non-fragility of a rooflight by considering the glass specification alone. The ability of the framing system to correctly retain the glass is key to its performance, so the glass engagement in the frame and the method of retaining it in the frame is just as important a consideration as the glass itself.

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