GEORGE BARNSDALE
Est. 1884

The Magic (and science) of Glass

A Specifiers Guide

The purpose of this guide is to help specifiers and architects unravel some of the mysteries of glass that my ancestors and I have been uncovering since we began making timber windows and doors in 1884. We have never been content to churn out mass produced products, that perform "well enough" and look "good enough" but still cost the earth.

As an Engineer with a background in high tech vehicle manufacturing, I joined the Barnsdale family business with the same hunger for refining and redefining the classic timber window that my ancestors displayed when they helped develop the British Standard BS644 for windows in the 1930s. We have always pushed the boundaries, invested in research and development (including our own onsite centre), taken part in pan-European research projects and developed innovative patented designs to ensure we really do know windows inside and out.

Being true window geeks, we are always happy to talk technical if you need any help or advice, regardless of whether it is related to a project we are working on or not.

Hope you find this guide helpful!

Tom Wright
Managing Director

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Enlightenment

A brief history of glass

The need for light and ventilation in our buildings/ habitats was recognised by our earliest ancestors. Before glass, there was animal hyde, translucent animal horn, cloth, wood and even thin slices of alabaster (fengite). And then…

Alchemy

Man learnt how to turn silica (essentially ultra pure sand) into glass and the world instantly became a brighter place.

Glass is wonderfully weird

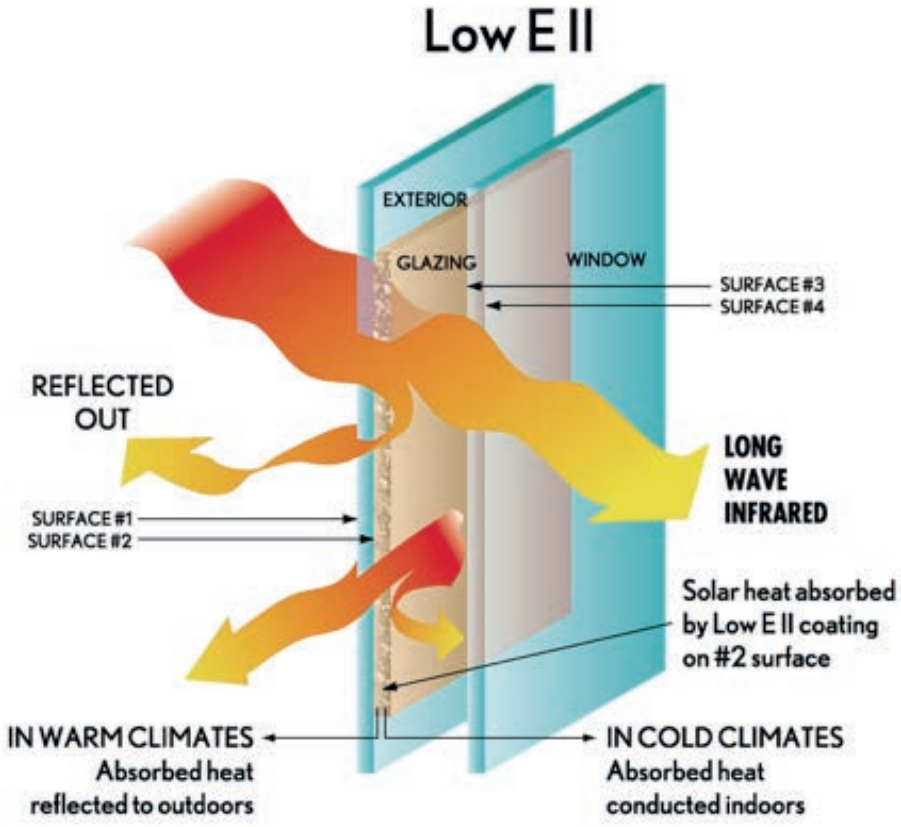
Scientists are still trying to work out what glass actually is. Described as a non crystalline amorphous solid, it lacks the ordered molecular structure of true solids, yet its irregular structure is too rigid for it to qualify as a liquid. According to the New Scientist it would "take a billion years for just a few of the atoms in a pane of glass to shift at all."

Glass affects light in numerous ways, for example it slows it down (Refraction) bending it to magnify, create prisms and rainbows. Without glass, we would never have discovered the spectrum and the fact that daylight is made of different wavelengths of coloured light.

> "It would take a billion years for just a few of the atoms in a pane of glass to shift at all."

Magic in the making

Moving from hand blown panes to machine drawn floating glass over molten tin was a huge breakthrough in glass innovation. Developed by Pilkington in 1957, later followed by Insulated Glass Units , there is now a vast range of options to consider when specifying.



After the development of float glass came coatings which have helped impact hugely on reflectance, heat and light. Low E, hydrophilic and many other coatings are available and it can be a mine field when it comes to choosing what's right for a given project.

Toughening and tempering

The toughening process is to heat glass to around 600˚C and then to rapidly cool it. This increases the strength by approximately 5 times as well as causing it to shatter into small pieces when struck making it ideal as safety glass applications.

Heat strengthening

An alternative to tempering, this process uses a cooling cycle that is twice as long and a glass that is 2 x as strong as annealed glass vs 5 x as strong for tempered. Unlike tempered glass that shatters into small pieces, heat strengthened glass breaks into larger pieces that usually remain in the unit.

Heat soaking

Heat soaking is a stress test of the glass to ensure it doesn't have any weaknesses or imperfections that will cause it to fail. Break now not later is the concept here. This can be very expensive when using laminates as the unit needs to be manufactured in a different order to normal.

Laminated glass

A laminated piece of glass consists of at least two panes of glass with a polymer layer between them. The purpose of this is to increase security, improve safety (comply with part K) or increase acoustic performance.

Coatings can do magical things

Recent developments in high performance coatings have helped to overcome some of the issues with the earlier coatings like Pilkington's K glass. Whilst it had a major impact on the thermal performance of the unit, it had a blue haze and an odd reflection.

Modern coatings include solar control which aims to achieve significant solar reduction whilst maximising light transmittance (and a neutral colour and reflectance).

Self cleaning coatings are also possible but they don't currently perform well in a vertical plan and are more suited to roof lights and glass roofs.

Many of the new "soft coat" types can now also be toughened.

Specification Tip:

On south/south western elevations it is generally preferable to block sunlight as the cost of cooling is likely to be more than heating!

Pure but far from simple

The Glass and Glazing Federation publishes a "Quality of Vision" standard that sets out to ensure glass is as flawless as possible. However, there is no such thing as 100% flawless glass due to the nature of what it is made of - molten sand.

If you've ever wondered why glass viewed from the side has a green tinge, it is due to the level of iron content. Low iron glass is much clearer and allows more light in. Standard float glass has a much reduced iron content than was the case 5-10 years ago but a low iron specification is possible, although less cost beneficial on complicated units particularly if volumes are small.

Did you know?

Glass that has been toughened will always have a slight rippled effect which shows more on larger units.

Specification Tip:

Ask for low iron glass on high value projects with thick acoustic glass where users demand clarity as well as high performance.

Mind the gap!

Definition of U value - The amount of energy lost watts per m² kelvin (w/m²K)

An IGU is two or more units of glass with a sealed perimeter usually filled with a noble gas (argon or krypton).

The performance of the IGU is affected by the number of panes and the gap between the units. If the gap is too big, internal convection occurs with the gas which transfers heat between the units.

When it comes to filling the gap:

- Xenon has the best thermal performance for very narrow units, but it only makes up 87 parts per billion of the earth's atmosphere so the cost to the environment can never be recovered by the energy saved.
- For narrow units, krypton has good performance and is a good environmental option (1 part per million of the earth's atmosphere) however it is expensive.
- For normal units argon is the best option. With a concentration of nearly 1% of the atmosphere it is much cheaper to obtain.

Specification Tip:

Think of the environmental cost compared to very small thermal performance gains.

One aspect of design that can result in the dreaded steamed up IGU is the depth of the secondary seal. Historic units with shallow seals usually fail the EN1279 tests. The best manufacturers' historic units are well tested and have great performance. A solution for historic projects is vacuum glass (see page 16).

Did you know?

EN1279 series (Glass in Building) was developed to ensure the units are made to last. Part II tests for moisture penetration and part III for gas leakage.

A tight fit

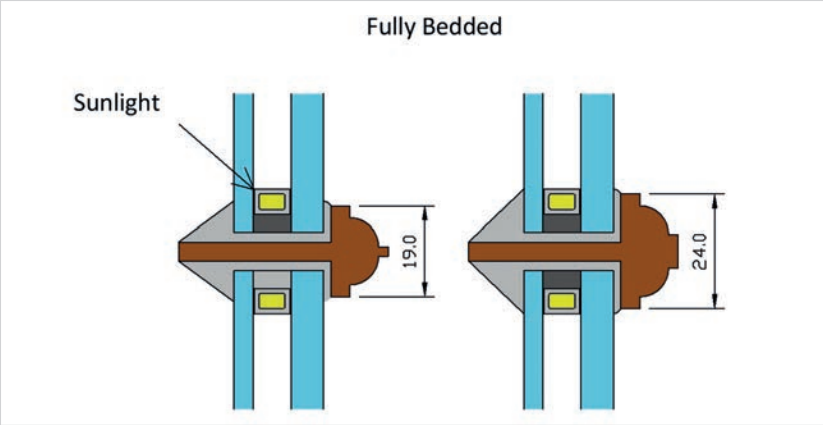
Innovative frame design is the key to whole window performance

No matter how well an IGU is made, the design of the installation detail into the frame has a major impact on the long term performance. It is not inevitable that IGUs need to be replaced after 10-15 years with all the associated environmental damage that can do, providing the whole window performance and design is understood and considered at the outset.

"You can specify the highest performing IGU, but if it isn't installed correctly, it won't perform how it should." Hayden Darley, Technical Director, George Barnsdale.

So what is the secret to installing IGUs into the frame to ensure long lasting performance?

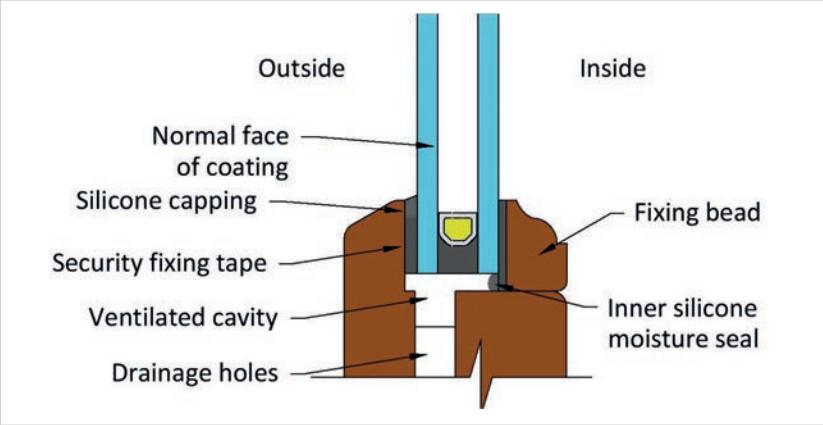
Traditional systems saw the unit fully bedded either with or without an external bead.



Theoretically, the fully bedded method where sealant surrounds the unit should provide a better barrier to water penetration than the drained and ventilated system below. However, in time (10-20 years) it is likely that the sealant will degrade, making the units prone to failure.

It is vital to protect the primary and secondary seals from UV exposure. Any part that is exposed is vulnerable and will fail.

Drained and ventilated



The George Barnsdale solution is the drained and ventilated system. The design of the glazing interface is just as important as the quality of the glazing unit seal itself. This system was designed and fully tested by BRE Scotland at the end of the last century and has performed exceptionally well. Very few units have failed since the system was introduced.

Specification Tip:

Ask for drained and ventilated glazing interface, unless you need an historic window.

The humble spacer bar has come a long way

Spacer bars used to be aluminium and filled with desiccant to help absorb moisture in the IGU. Since aluminium is such an effective conductor of heat, it reduces the thermal performance of the unit compared to other options. On a cold day it is often possible to see condensation on the inside around the edge of the unit caused by this.

A word of warning – there has been a big problem in the spacer bar industry over the last decade with false performance claims based on test data that has been tampered with. As a result the Bundersverband Flachglas, a German Glass Association has provided a certification scheme to provide quality assurance.

Swissspacer Ultimate was the top of all leading foiled warm edge spacers for thermal performance in official tests by ift Rosenheim (WA-17/1 & WA-08/3).

A warm edge spacer bar has to achieve the best thermal performance but it also has to maintain that performance for years by preventing insulating gas leaking out and moisture vapour getting into the sealed unit.

The ideal product design is a spacer bar material with outstanding thermal properties and a backing foil that is capable of stopping 100% of gas and moisture vapour transmission so it can maintain its energy saving performance over many years.

Ultimate's High Tech Gas Barrier is as good as metal backing foils such as steel or aluminium in preventing gas and moisture vapour transmission. It stops moisture getting in and insulating gas getting out of the sealed unit so performance doesn't drop.

Specification Tip:

Ask for swisspacer Ultimate. Unlike other products it still has a large cavity for the desiccant, has excellent thermal properties, looks very good and is available in different colours.

CERTIFICATE

Certified Passive House Component

Component-ID 1497sp01 valid until 31st December 2020

Passive House Institute
Dr. Wolfgang Feist
64283 Darmstadt
Germany

Category: Spacer for low-E-glazing
Manufacturer: SWISSPACER, Kreuzlingen, Switzerland
Product name: SWISSPACER ULIMATE

This certificate was awarded based on the following criteria:

Depending on the climatic region, the spacer prevents high surface temperatures, which can cause mould. At least 3 out of the 7 reference frames fulfilled the spacer hygiene criteria for the relevant climatic region.

Hygiene $f_{Rsi} \geq 0.80$

The specific resistance of the spacer's edges is greater than the climate-independent minimum requirement.

Efficiency $R_E = 5.10\,m\,K/W \geq 1.50\,m\,K/W$

Type: All-Plastic
Height Box 2: 6.50 mm
Thermal conductivity Box 2: 0.140 W/(m K)

arctic climate

phA

CERTIFIED COMPONENT

Passive House Institute

Passive House efficiency class: phE | phD | phC | phB | phA | phA+

www.passivehouse.com

A magical performance

There are many areas to consider in terms of the performance of glass units:

Thermal

Spot the g value – this is the amount of energy coming into the building, essentially free heat but can also lead to overheating

Thermal performance is affected by:

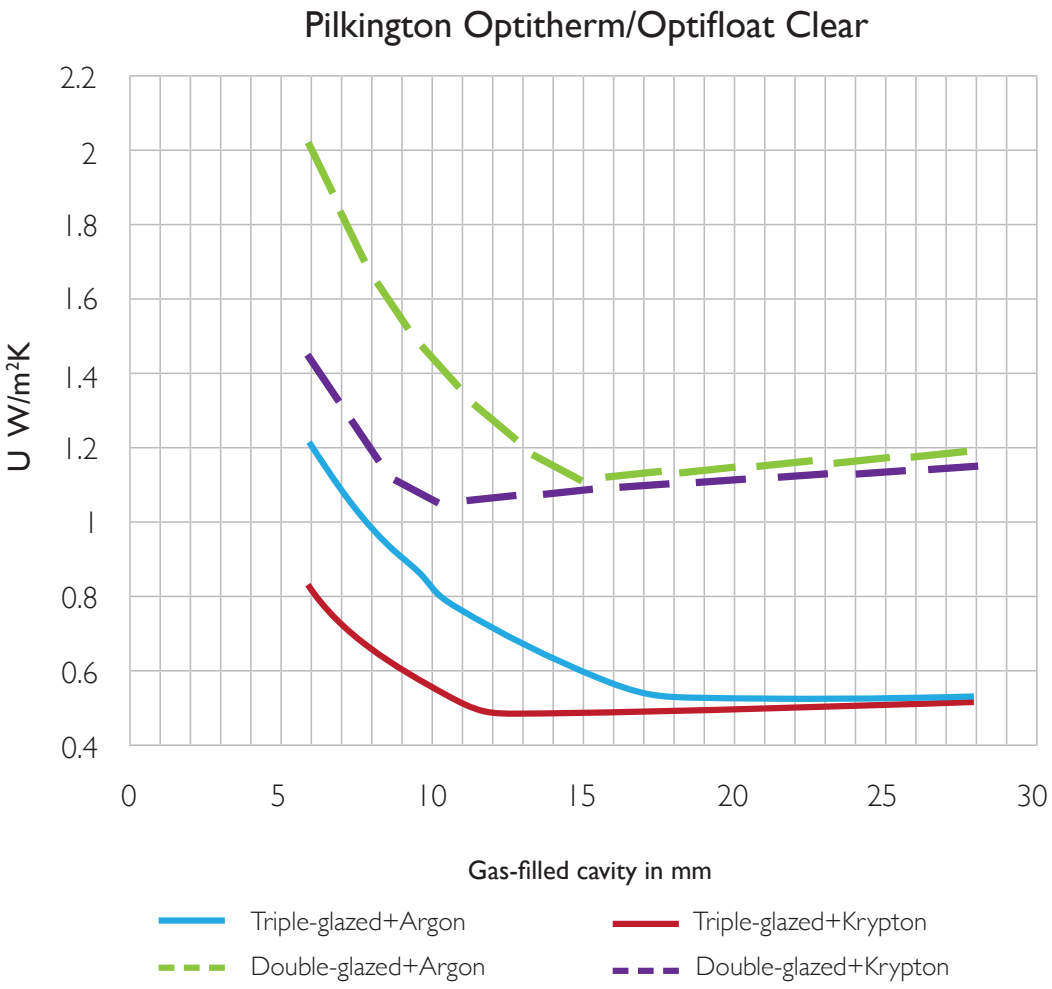
Gap between the units

The space between the panes of glass act in a number of ways to limit heat loss/transfer including limiting conduction by the high thermal resistance of the air or gas space between the panes. They also limit convection due to the air between the panes being unable to move and therefore transfer heat. Finally, they limit radiation because two panes interrupt the radiation of energy, especially when using low-E surface coatings.

The minimum space between glazing panes should ideally be 12mm, but can range from 10-16mm.

Number of panes

The best thermal performance of a double glazed unit is currently around 1.0 W/m²K and the best from a triple glazed unit is 0.5 W /m²K



If argon is used as a gas the unit would normally be around 24mm thick which can be an issue for historic products requiring a narrower unit.

Solar gain is measured in g value

Solar

Blocking solar heat reduces the need for air conditioning that is required to make a room comfortable in summer. On the other hand, increasing solar gain helps to heat a room in the winter and an energy rated window improves by increasing solar gain.

There are lots of examples of high rise buildings with a blue tinge which is a sign that the glass in those buildings has undergone "hardcoating" to block out the solar gain. The downside of this was that it also blocks natural light too. The blue tinge wasn't universally popular and manufacturers have worked hard to develop processes to deliver the same benefits with a clearer level of glass. The latest "softcoating" methods (using something called magnetron sputtering) leads to a clearer glass, allows a good level of natural light but also retains the ability to block solar gain.

Acoustic

Mass is the best way to absorb sound which means the thicker the glass the more sound that is absorbed. Windows and doors generally perform less well than walls and roofs and sound travels through any place where there is air leakage. This also means, of course, that a window that performs well in an air test should also perform well in acoustic tests. However, this is not always the case if that window or door has been badly fitted.

When it comes to glass, double and triple glazing provide effective soundproofing and argon is preferable to air in the cavity because it is a denser gas. The optimal gas is krypton but the difference in acoustic performance is marginal and should be offset against the environmental and cost implications. Very often, standard annealed glass is sufficient for most purposes but there is the option to upgrade to acoustic laminated glass. This is made by taking two layers of annealed glass and laminating them with a special acoustically absorbent plastic (PVB, polyvinyl butyral layer) to give the appearance of a single.

The way that sound waves behave is complex which is why architects often rely on acoustic engineers to assist in specifying acoustic performance requirements.

High performing timber windows and doors naturally perform well acoustically but there are incidents when a higher level of performance is required to overcome road or aircraft noise for example. Some specifiers request higher performance in the bedrooms of a property or where there is street noise pubs nearby.

Specification Tip:

Ask for whole window acoustic performance data not just glass values. We at George Barnsdale have an extensive range of test data.

The key to excellent acoustic performance is not necessarily down to specifying a high performance glazing unit, this can be undermined by poor frame design and installation of the glass into the window. Always ask for whole window performance data not just centre pane performance.

Heat soaking

Temperature extremes can be created unwittingly by simple things like dark blinds on the inside of a window fitted close to the glass, stickers on glass or the two sashes of a sliding sash window being together as a result of being fully opened. These are all capable of causing spontaneous glass breakage and cracking in non toughened glass. However, toughened glass is also susceptible to spontaneous breaks. Here are a few things that can cause this:

- Minor damage during installation such as chipped edges later developing into larger breaks
- Binding of the glass in the frame, causing stresses to develop as the glass expands and contracts due to thermal change of deflects due to wind
- Internal defects within the glass such as nickel sulphide inclusions
- Inadequate glass thickness to resist wind load
- Thermal change due to wind

In order to overcome these issues, glass can be heat soaked, but this can be a costly addition. The process of tempering glass is to place it in a furnace and then rapidly cool with air as it exits. This can cause a slight ripple effect in the finish which is more noticeable on large units.

Security

The definitive standard for fenestration security is PAS24 enhanced security performance requirements for doorsets and windows in the UK. There are other standards that can be used but generally PAS24 is used. Part Q of the Building regulations requires compliance to PAS24 for "new dwellings only, this includes dwellings formed by a material change of use" such as barn conversions.

The minimum performance to comply with the requirements of the PAS24 standard (Secured By Design) is 6.8mm laminated glass. Most other tests require a more secure glass specification.

Specification Tip:

Appendix B of Part Q does allow for non-standard door-sets to be untested but the use is ambiguous and you can get your fingers burnt with Building Regs.

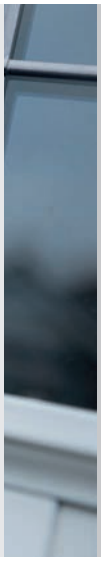
Safety

Part K 4 of the Building regulations is designed to provide protection against impact with glazing. Most doors require safety glazing as well as windows below 800mm from floor level. Glass that is used in areas where safety glass is required must be indelibly marked to indicate compliance. This can adversely impact on the aesthetics of windows or doors with a number of small units near to each other. It's useful to state that units in this situation should be fitted in a common orientation and it is also important to manage customer expectations.

Triple glazing

For architects with an eye on sustainability and zero carbon by 2050, triple glazing is definitely worth considering. Quality timber windows will last a minimum of 60 years and a lot longer with basic maintenance so it's worth incorporating it into your designs now.

There is no doubt that triple glazing performs much better thermally and acoustically than double glazing but some manufacturers are unable to offer the flexibility to supply the wider frame profiles required, those that can often lack the detailed whole window performance data.

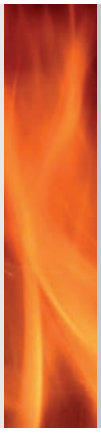


Specification Tip:

Ask for whole window test data when requesting triple glazing not just the glazing unit.

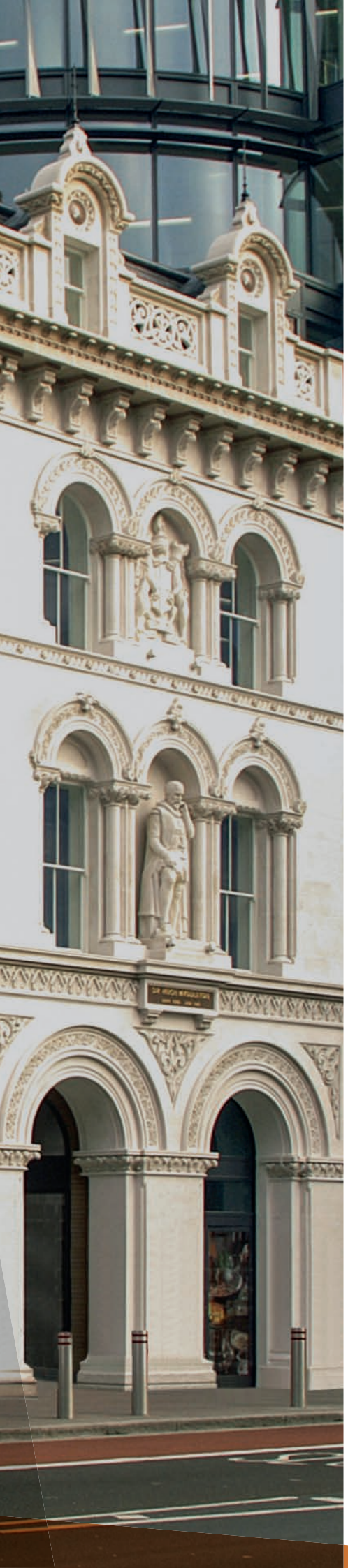
Fire

The Grenfell tragedy has put all aspects of building design under the microscope and glass is no exception. There are a number of glazing options with varying levels of protection that are measured in defined time periods (30, 60, 90, 120 and 180 minutes). As with any other performance aspect of a window, fire performance depends on the performance of the whole unit not just the glass. This restricts flexibility.



Specification Tip:

Fire glazing systems often rely on large section glazing beads with imtumescent glazing material that will only work with fixed lights.



The power of a vacuum and historic solutions

Historic solutions

- Only 7mm thick
- Thermal performance equivalent to triple glazing (W/m²K)
- Excellent acoustic performance
- Edge sealed with glass overcoming issues with slim IGUs and extending life expectancy

But…. It is very expensive, there are tiny dots at 25mm centres that act as spacers and there are also some safety and security issues.

There are a number of options for historic conservation projects which can vary depending on how rigid the conservation officer's ruling is. Old glass could only be made in small sections so all old windows had panes joined with lead or timber glazing bars. Single glazed units can still be produced today using hand or machine drawn glass for accurate replication.

The longest lasting and cheapest option is to have plant on bars but these are only acceptable on unlisted projects since some planners dislike them. Therefore, quality timber window manufacturers will offer a huge choice of glass and glazing profiles to replicate the original aesthetic. These usually require a solid glazing bar with a putty like finish and there are varying levels of performance depending on the type of putty system used. The most reliable is not the cheapest but uses glass that is properly tested, high quality authentic putty like material and skilled craftsmen to apply it. This means they will last as opposed to poorer systems that are known to fail within a few years.

Increasingly, planners are allowing narrow edge sealed doubled glazing units that are extra slim and provide better performance than single glazing though still not comparable to standard double glazed units.

Balancing historic design with thermal and acoustic performance can be challenging. One option is to use vacuum glass.

Vacuum glass is particularly well suited to historic buildings requiring slim glazing units. Only 7mm thick, the edge sealant is glass which deals with the performance problems of slim IGUs providing long life expectancy.

The old units used to have vacuum evacuation ports which were quite unpopular with consumers but our recommendation is to use a product like Fineo by AGC. These units deliver amazing energy performance, combined with exceptional thermal insulation and extreme durability. Thin and sleek, the unit is extremely elegant and particularly suited to historic projects requiring single glazing aesthetic.

Here are some of the benefits:

What's so special about it?	What does it mean for you?
Slim, sleek and aesthetical design	• An appearance similar to monolithic glass • No vacuum evacuation port • Suitable for retrofitting into existing windows
Outstanding thermal insulation	• U-value = 0.7 W/(m^2.K) • Regardless of inclination (e.g. sloped or roof glazing)
Sustainable investment	• Designed to perform for several decades
More natural daylight	• Slim design allows in more daylight
Harnessing more free solar energy	• Lower energy consumption • Lower emissions
Superb noise reduction	• Increased soundproofing • Reduced traffic noise
Lead-free and recyclable	• 100% Recyclable • Circular sustainability

Framing your specification

There are a number of considerations when it comes to specifying windows, the earlier an architect involves the manufacturer the better to avoid performance issues or additional costs from over specification.

In order to allow manufacturers like George Barnsdale to develop the best solution, it is really important for them to understand what you are trying to achieve with the project:

- **The vision** – what are your driving objectives regarding aesthetics, performance, sustainability etc. If we can understand how you see the project we can ensure that our input reflects that.
- **The purpose** – following on from the vision, it is important for us to understand the purpose of the building, its location, how it will be used, any planning constraints etc
- **Detail** - Manufacturers then need to know the detailed requirements:
  - Performance targets – thermal, acoustic, safety etc
  - Any specific requirements to meet the building regulations and any other standards (e.g. Secured by Design)
  - Aesthetics – any particular requirements

You may be in a position to provide this detailed information or you may want to discuss with a technician in order to allow us to develop the specification, utilising our experience and expertise.

Once the requirements are set out, we will be able to define the detailed specification of the glass and the other elements of the window/door. This ensures that you get a solution that is tested and certified to deliver your requirements and it is done in the most cost effective way by ensuring it isn't over specified. We can also, if desired, look at options that enhance the specification and provide a benefit at an acceptable cost.

Specification Tip:

The earlier a manufacturer is involved, the less likely it is that your project will be over-specified and cost prohibitive.