Technical Note No. 62

Specification of insulating glass units

This Technical Note replaces TN12. It describes the construction of insulating glass units, their performance and the relevant standards.

This Technical Note is one of eight describing the use and performance of glass. They are:

TN61 Glass types
TN62 Specification of insulating glass units
TN63 Glass breakage
TN65 Thermal fracture of glass
TN66 Safety and fragility of glazed roofing: guidance on specification
TN67 Safety and fragility of glazed roofing: testing and assessment
TN68 Overhead glazing
TN69 Selection of glass to prevent falls from height

This Technical Note should also be read in conjunction with:

TN35 Assessing the appearance of glass
TN38 Acoustic performance of windows
TN48 U-values of windows
TN49 U-values of curtain walls

Introduction

An insulating glass unit (IGU) comprises two or more panes of glass spaced apart and sealed in a factory with dry air or gas between the glass panes. A range of gases may be used to improve thermal performance. The specification of insulating glass units is not always a straightforward matter; there are many issues in the design and manufacture of IGUs that are often overlooked or simply misunderstood. The appropriate British Standard is BS EN 1279 which is concerned with manufacturing and production control. It is not a guide to the Specifier in any meaningful way. This note lists the items that the Specifier might need to consider and possible alternatives.

Configuration

IGUs comprise the following components:

- Glass (any type may be used including wired and patterned);
- Spacer bar - maintains the space between the panes and contains desiccant to keep the air or other gas dry;
- Desiccant - absorbs any small amount of residual moisture from the air space;
- Seal(s) - prevents moisture from entering the unit cavity and holds the unit together;
- Dried air or other gas - lack of moisture vapour eliminates the risk of condensation in the cavity; dry gases are better insulators than moist ones.

Almost any combination of glass panes may be used to form an IGU.

Curved IGUs can be manufactured.
BS EN 1279 allows the manufacture of IGUs with radius greater than 1000mm without the need for further type testing. However, not all IGU manufacturers will give warranties on curved IGUs. It is not possible to give a safety classification to curved glass in accordance with BS EN 12600.

IGUs are available with cavity widths upwards of 3mm. Vacuum glazing units have narrower cavities with small glass pillars to hold the glass panes apart. For air or gas filled cavities there is an optimum cavity width depending on the construction and gas fill. Generally the optimum cavity width for thermal performance of an IGU with a single cavity lies in the range 15-20mm when assessed in accordance with BS EN 673. Other cavity widths may be required if there are multiple cavities or if the overall depth of the unit is limited. Some frames will only accommodate

thin IGUs with narrow cavities and the resulting performance may be compromised.

Safety and wind loading requirements must always be considered and the glass thickness, area and type selected accordingly. BS 6262-3 gives guidance on selection of glass.

The IGU manufacturers may have dimensional limits to the size of IGU they will assemble depending on the thickness and type of glass.

Performance

IGUs are used primarily to manage energy transmission into and out of a building. The thermal performance of a window depends on the performance of the frame as well as that of the glass.

The thermal performance of an IGU depends on the width of cavity, whether the cavity is filled with air or gas, and the type of glass. Table 1 shows approximate centre pane U-values for a range of glazing units. Clear float glass is assumed except where indicated otherwise. The U-values given in Table 1 are the centre pane U-values. CWCT TN48 and CWCT TN49 cover the assessment of U-values for glazing frames.

As well as reducing heat loss, double glazing:

- Reduces internal condensation, which can occur when warm, moist air inside a room comes into contact with a cold window pane;
- Improves comfort by reducing downdraughts from windows and heat loss from occupants by radiation.
- Reduces noise transmission, depending on; the thickness and relative thicknesses of the panes. The cavity width and gas filling has little or no effect on the acoustic performance of an IGU. CWCT TN38 covers the acoustic performance of windows.

Type of glazing	U-value (W/m^2K)
Single	5.7
Double 6mm air cavity	3.3
Double 12mm air cavity	2.9
Double 16mm air cavity	2.65
Double 20mm air cavity	2.8
Double 16mm argon cavity	2.7
Double low E glass 16mm air cavity	1.4 – 1.7
Triple 12mm air cavities	1.9
Triple low E glass 12mm air cavities	0.9 – 1.4
Triple low E glass 12mm argon cavities	0.7 – 1.2

The above figures assume 4mm glass and ninety per cent argon filling where appropriate.

Where a range of U-values is given the exact value depend on the coating performance.

Table 1 Centre pane U-values of different glazing units in accordance with BS EN 673

Components

Edge seals

A key part of any IGU is the edge seal, which must provide a hermetic seal and:

- Have low moisture vapour transmission;
- Have high adhesion to glass and spacer bar;
- Be compatible with the glass, spacer bar and glazing materials;
- Have good resistance to water, service temperature and ultraviolet radiation if exposed to the sun once glazed;
- Be sufficiently flexible to allow for differential expansion and contraction of the panes in response to temperature fluctuations and bowing in response to pressure variations.

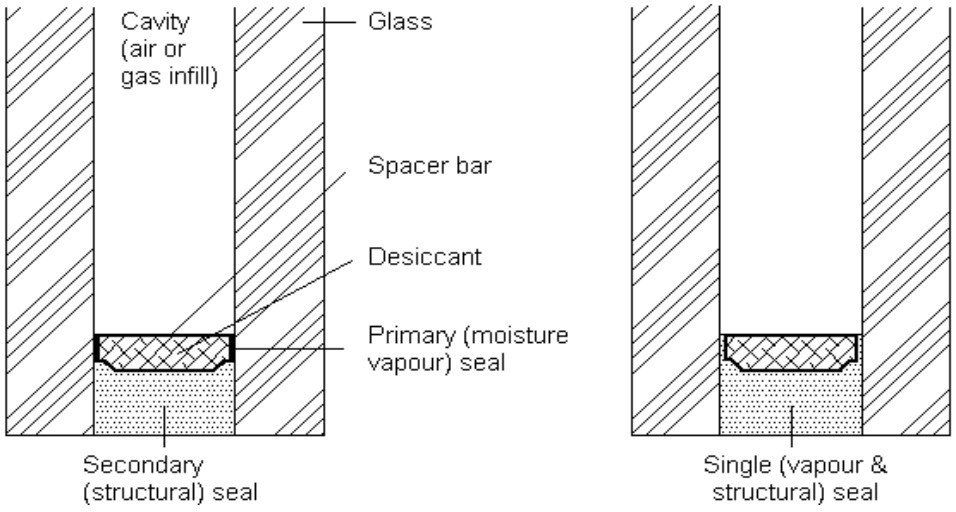
Edge seal configuration

There are two edge seal configurations:

- Single seal systems
- Dual seal systems

Generic edge details are shown in Figure 1. Single seals are normally used only in domestic window installations. For a more durable product to be used in higher quality work it is normal to use a dual seal.

Single seal units rely on the edge sealant to act both as the vapour seal for the unit and as an adhesive bond to hold the panes of glass together. The seal can be provided by chemically curing sealants, for example polysulfides, or by hot melt materials (butyls). A high standard of application and sufficient depth of sealant (of low moisture vapour transmission) are particularly important to the life of a single seal unit.



a) Dual seal b) Single seal

Figure 1 Generic edge seals

Dual seal units have two seals:

- The inner (primary) seal is the main control for the moisture vapour transmission rate into the unit, and also holds the unit together while the secondary sealant is applied and cures; the primary seal may be a liquid material (butyl) or a preformed tape (PIB). Wet-applied sealants are normally used as they accommodate irregularities in the glass or spacer bar whereas tapes may not. However, tapes ensure a uniform width of seal which may be important in applications where the edge of the glazing is visible;
- The outer (secondary) seal holds the glass tightly against the spacer bar, minimising the moisture vapour transmission path. The seal is produced from chemically curing sealants (e.g. silicone, polysulfide, polyurethane, or from hot-applied butyl materials) which have excellent adhesion to glass and the spacer bar.

The combined properties of primary and secondary sealants give high quality IGUs. As with single seal units, it is critical that the edge sealant is applied correctly with no voids or adhesion defects, since either may dramatically reduce the life of the IGU. The primary and secondary seals must be

compatible with each other and with the spacer bar and any corner pieces.

Seal integrity

Durability of any glass unit is dependent on maintaining a good perimeter seal, which is mainly achieved by a high standard of glazing in terms of:

- Compatibility of glazing materials and coatings with the perimeter seal of the glass unit;
- Proper sealing and drainage of the glazing system to minimise water entry, and retention within, the glazing rebate including provision of adequate clearance between the glass unit and the frame (BS 8000:Part7);
- Protection of the edge seal against ultraviolet radiation after installation.

Well-constructed glazing units with a dual seal can last for 25 years. However the life can be seriously shortened by poor installation or maintenance. The service environment will also affect the service life of an IGU.

The National House Building Council (NHBC) Standard for glazing requires all IGUs with area greater than $1m^2$ to be constructed as either:

- A dual sealed unit
- A single sealed unit with a hot melt butyl seal

Compatibility

It is essential to check with the unit manufacturer that the edge seal and glazing materials are chemically compatible. This includes checking any sealant or adhesive that may be used to join lengths of any glazing gasket.

Many sealants emit chemicals during curing which can migrate through other materials, or diffuse across an air gap, and attack products used in the edge seal of the IGU. It is important to assess the compatibility of all sealing products used in the vicinity of the IGU edge seal, even if there is no direct contact.

The choice of edge sealant is often restricted when using IGUs as structural sealant glazing. In this case the use of an inappropriate edge sealant could lead to a breakdown of the structural sealant.

Moisture attack

Water is the major enemy of IGUs; if liquid water is trapped against the edge of a unit for a long period, failure of the adhesive bond between the sealant and glass will occur. This will allow liquid water and/or water vapour to penetrate the edge seal, leading to excessive moisture vapour and ultimately to condensation on the internal glass surfaces.

Poor tooling of the sealant may allow water to penetrate between the glass and seal and make the IGU more prone to edge seal failure.

The use of tapes to ‘protect’ the edge of the glass unit prevents proper examination of the quality of the edge seal and should generally be avoided. Claims that these tapes are to protect the glazier are false; glass should only be handled by individuals with proper lifting equipment and personal protective equipment.

Some IGU warranties are conditional on any tapes being removed from the IGU prior to installation.

Some fire resistant IGUs require a tape to be left in position to protect materials essential to the fire performance of the glass and should be left on.

Moisture ingress

Water in the form of moisture vapour is able to permeate through the edge sealant into the unit. The rate of moisture transfer depends on:

- The vapour resistance of the edge seal
- The concentration of moisture vapour

Water vapour passing the edge seal is initially taken up by the desiccant. However, it is inevitable that after a period of time the desiccant becomes saturated and excess moisture vapour in the unit leads to condensation on the internal glass surfaces.

Vision through the IGU may be impaired by fogging once the dew point temperature is reached. A secondary effect of increased moisture in the cavity is the resulting change in thermal efficiency of the IGU.

Ultimately free water may begin to collect within the IGU cavity.

Adhesion

The integrity of an IGU depends on a good seal between the glass and the spacer bar. This is important to prevent moisture ingress and particularly important for IGUs used in structural sealant glazing systems. Soft coatings applied to glass to create an environmental control glass may not have adequate adhesion to the glass and may have to be removed so that the spacer bar can be bonded directly to the glass. The removal of the coating around the perimeter of the glass is known as 'edge deletion'. Hard coatings do not normally have to be deleted but in the case of doubt the glass supplier should be consulted. Edge deletion may result in a thin visible band of light at the perimeter of an IGU unless the glazing gaskets provide adequate cover.

Exposure to ultra-violet

Some edge seal materials can degrade if exposed to solar radiation (particularly ultraviolet). It is important to ensure that either:

- The seal material is known to be resistant to solar radiation (e.g. silicone).
- The glazing rebates provide full cover of the seal,
- The edge of the glass is opacified to shield the edge seal. This may be achieved by printing or fritting the edge of the glass.

Spacer bar

The primary purpose of the spacer bar is to control the width of the air gap between the panes of glass. It also acts as the container of the desiccant and to control the depth of the perimeter sealant (Figure 1). Spacer bars are available in a variety of materials, shapes, sizes and finishes and may be profiles formed by extrusion or folding. The spacer frame can be manufactured in several ways:

- Four pieces of profile joined at the corners with nylon or metal corner keys;
- Lengths of profile folded into a rectangle and joined away from the corners;
- Lengths of profile folded into a rectangle and welded end-to-end. However, this is rarely available.

The method of manufacture can affect the life of the IGU. To help maximize life expectancy, it is recognised good practice to minimize the number of spacer bar joints. Most spacer bars are supplied in 6 metre lengths and thus the minimum number of joints will depend on the length of the IGU perimeter. If using spacer bars that can be folded at corners, it is common practice to position joints randomly along the straight thus avoiding material wastage. It is not normally practicable to ensure that all joints appear on the straight in the same position. Whilst the specifier can specify joints at corners only, this can result in an unwelcome increase in the number of joints. When spacer bars are jointed at corners, manufacturers may be tempted to use surplus off-cuts in short lengths joined together. The specifier should state clearly whether this is acceptable or not.

The top surface of the spacer bar is normally visible to building occupants. Aluminium spacers painted in a range of RAL colours or colour anodised are available from specialist manufacturers to enhance appearance.

Metal spacer bars increase the overall U value of the window, owing to the creation of a thermal bridge at the edge of the IGU, and give rise to local, low temperatures at the edge region. This can lead to condensation on the perimeter zone of the glass. New spacer materials and designs with low thermal conductivity are available to improve overall thermal performance and minimise condensation formation in the perimeter zone. These include thermally broken aluminium, polycarbonate and stainless steel spacers. Some combine pre-extruded sealant, spacer and desiccant into one flexible product to facilitate unit manufacture. Where plastic spacer bars are used the compatibility of the spacer with sealants should be checked even if there is no direct contact.

Desiccant

Desiccant is incorporated within the spacer bar, which, if metal, is hollow and perforated with holes or slits to allow the desiccant to be in permanent contact with the trapped air and so remove any residual moisture. Desiccant comes in a variety of forms and blends, ranging from silica gel and pure molecular sieve of various granular sizes to blends of materials, depending on specific requirements. If the edge sealant contains solvent, a specific desiccant blend that will absorb both water and solvent must be used to prevent solvent vapours remaining inside the unit.

Whichever form/blend of desiccant is used it must be of sufficient volume to ensure the moisture is taken up by the desiccant. Desiccant can absorb 20 per cent by weight of moisture, and for a normal 12mm wide cavity, should at least fill the spacer bar along the two longest sides of the unit. For gas filled units, the desiccant has to be compatible with the gas. The volume of desiccant alone does not determine the life expectancy of the unit.

Glazing system

All glazing systems must protect the edge seal by limiting water ~~from~~ entering the glazing rebate and preferably

by also ensuring that any water that does penetrate as far as the edge seal is effectively removed by drainage or evaporation.

Drained-and-ventilated glazing systems have small holes or slots fabricated in the face or underside of transoms or sloping glazing platforms that drain out any water that bypasses the outer seals. In addition, ventilation can remove small amounts of water by evaporation, helping to maintain the glass unit and glazing seals in a dry condition. This is the best way to glaze IGUs. Note that a 6mm gap below the IGU is necessary to allow drainage to occur and care is needed to ensure that drainage paths are not obstructed by setting blocks.

Face-sealed glazing systems rely on a single outer seal. Unless they have drainage provision any water that bypasses the outer seal is retained in the glazing rebate adjacent to the edge seal of the IGU.

Fully-bedded glazing systems rely on the glazing rebate being completely filled with glazing compound to prevent the entry of water. Any voids in the bed will attract water, which may penetrate to the edge of the glass unit, become trapped and degrade the unit edge seal. Because fully-bedded glazing systems are prone to bad workmanship and cannot be periodically inspected, they are not recommended for glazing IGUs, although fully-bedded systems which allow the edge of the glass unit to 'breathe' are being promoted.

The NHBC standard for glazing systems requires that glazing frames for all IGUs of area greater than 1m^2 must be drained and ventilated. IGUs of smaller area may be fully bedded on three edges but the lower edge must always be drained.

Gas fills

The gas-space contains a large uniform volume of gas with a temperature difference across it. The heat transfer is governed by conduction heat transfer for a narrow gas-space, and convection heat transfer for a wide gas-space. The optimum gas-space width is the width at which the transition from conduction to convection occurs; wider gas-spaces can be used if the gas is inert with a high molecular weight and preferably with a low thermal conductivity. BS EN 673 defines a calculation method by which thermal performance can be established for a range of gas fills. The gas performance is determined by its specific heat capacity, density and viscosity.

There has been concern about the long-term efficiency of gas filled IGUs, particularly if the gas escapes, and there is also a question as to how the customer can prove the purity of the gas fill in the first place. Many of these concerns can be overcome by ensuring that the supplier has a BS EN 1279-3 certificate.

Vacuum glazing

There are now vacuum technology products on the market that have a very narrow cavity between the panes and these adopt a different approach to seal technology. They are intended for use in locations where conventional IGUs will not fit but low U-values are required. However, supply is limited.

Appearance/visual acceptance

Guidance on assessing the appearance of glazing is given in CWCT TN35. Some information relating to the specification of IGUs is given below.

Edge seals

The seals of dual seal glazing units normally differ in shade, and this emphasises any variations in depth of either seal, which may occur when applying the sealant or attaching the glass. This is not a problem, visually, with glazing systems that provide an adequate depth of edge cover because the edge sealant is concealed by the glazing bead, compound or gasket. However, in structural sealant glazing systems the beads of sealant - and any irregularities of depth - will be visible. There are currently no visual acceptance criteria for the edge seals of IGUs because they are purely functional and not designed for appearance. Where the seal will be visible the seals may be obscured under a ceramic border applied to the glass surface during manufacture.

Edge tapes

As stated above edge tapes should not generally be used. A wide tape applied around the edge of the glass may impair the gasket seal and in the extreme may be visible above the gasket.

Desiccant

Desiccant may spill into the cavity during unit manufacture, transportation or installation. The specifier should state whether this is acceptable, although significant spillage generally is not (spacer frames should be assembled and filled away from the glass).

Glass condition

Some forms of glass may contain small bubbles or marks due to processing and handling, heat-treated glass may have roller wave or may have picked up surface deposits. Damage may also occur during installation or may result from construction activities adjacent to the installed glass. It is important to decide how the glass is to be viewed when assessing its condition since viewing at a shallow angle may exaggerate small defects. CWCT TN 35 gives guidance on assessing the appearance of glass.

Bowing

Bowing of the glass panes may occur during manufacture. Some bowing movement will occur as a result of changes in ambient temperature and atmospheric pressure during use.

Bowing during manufacture may occur due to elastic sagging of the glass pane if the IGU is assembled in the horizontal plane and vertical assembly is preferred for larger IGUs. Bowing may occur immediately after assembly if the IGU is sealed at an elevated temperature and the gas in the cavity subsequently cools.

Bowing of IGUs due to variations of pressure and temperature in service is also noticeable as are the deformations that can occur at the time of manufacture.

The bowing of glass is most noticeable in the strong reflections from the outer surface of the IGU. The visual impact of bowing may be minimised by using an asymmetric glass configuration with a thicker glass as the outer pane. Most deformation will then occur in the thinner inner pane. Care should be taken to ensure that the thinner pane does not deflect so far that it touches the other pane.

BS EN 1279 does not set limits for acceptable bowing of the glass and the specifier should state what is acceptable.

Labelling

Often the date of manufacture and name of manufacturer can be marked on the spacer bar as a means of identification. Where safety glass is used, the glass supplier and manufacturing standard should be marked on the glass and be visible after glazing. The impact classification from BS EN 12600 must also be marked on the glass. Guidance on marking of safety glass is given in BS 6262-4.

Quality control

IGU design/manufacture

IGUs should conform to BS 1279 in respect of:

- Dimensional accuracy
- Appearance/contamination
- Initial seal leakage
- Initial dew point condensation
- Fogging by UV exposure
- Weather cycling
- High humidity cycling

Warranties given by manufacturers of glass units are normally only valid provided the units are installed and maintained in accordance with the manufacturer's instructions. The warranty is for the integrity of the seal and not against glass breakage, etc.

Glazing workmanship

Workmanship for on-site glazing must conform to BS 8000: Part 7. During the installation/glazing process the durability of glass units can be maximised if they are:

- Handled with care to avoid damage to the glass or the edge seal;
- Kept clean, dry and free from contaminants;
- Stored on edge, in racks and on blocks of wood or felt, in dry, ventilated conditions, and out of direct sunlight to prevent thermal fracture;
- Checked for size against that of the glazing opening (a wrong-sized unit must not be glazed, nor should its size be modified by nipping or grinding as damage of the seal could occur). It should be noted that tight glazing, or glass with damaged edges, is more likely to fail due to thermal stress.

Factory glazing avoids site workmanship and is highly recommended for structural sealant bonding.

Maintenance

Periodic inspection should be carried out and maintenance undertaken as required or as specified. The frequency depends on the nature of the glazing materials, their level of exposure and the location of the building. Inspection should be carried out annually to check:

- Integrity of glazing frame seals (sealant cappings, compression gaskets) is not impaired;
- Drainage paths in drained systems are unobstructed.

Summary

Glass units have become commonplace in almost all modern, habitable buildings because of the increasing demands to reduce energy consumption. The life of units is directly dependent on maintaining the integrity of the unit edge seal, by correct selection of components, high standards of quality control during manufacture, and proper glazing in a well designed, constructed and maintained glazing system that allows drainage and ventilation.

References

BS 5713, 1979, *Specification for hermetically sealed double glazing units*, British Standards Institution.

BS 6262, 1982, *Code of Practice for Glazing for Buildings*, British Standards Institution.

BS 8000: *Workmanship on building sites.* Part 7, 1990, *Code of practice for glazing*, British Standards Institution.

BS EN 673, 1997, Glass in building - Determination of thermal transmittance (U value) - Calculation method, British Standards Institution.

BS EN 1279 Glass in building. Insulating glass units, British Standards Institution.

The following Building Regulations Approved Documents may be accessed at:
http://www.planningportal.gov.uk/england/professionals/en/

Building Regulations (Scotland) may be downloaded from: http://www.sbsa.gov.uk

Building Regulations (Northern Ireland) may be downloaded from:
http://www.dfpni.gov.uk/index/buildings-energy-efficiency-buildings/building-regulations/br-technical-booklets.htm

England & Wales Approved Document		**Scotland Technical Handbook**	**Northern Ireland Technical booklet**
B	*Fire safety*	Section 2	Part E
K	*Protection from falling collision and impact*	Section 4	Part H
L1A	*Conservation of fuel and power – work in new dwellings*,	Section 6	Part F
L1B	*Conservation of fuel and power – work in existing dwellings*,	Section 6	Part F
L21A	*Conservation of fuel and power – new buildings other than dwellings*,	Section 6	Part F
L2B	*Conservation of fuel and power – work in existing buildings other than dwellings*,	Section 6	Part F
N	*Glazing*	Section 4	Part V

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