Technical Note No. 12

SPECIFICATION OF HERMETICALLY-SEALED GLASS UNITS

CENTRE FOR WINDOW AND CLADDING TECHNOLOGY

Introduction

An insulating glass unit is two or more panes of glass spaced apart and sealed in a factory with dry air in the unit cavity. The air may then be flushed out and replaced with a range of other gases to improve thermal or acoustic performance. The specification of hermetically sealed glass units is not always a straightforward matter; there are many issues in the design and manufacture of these components that are often overlooked or simply misunderstood. The appropriate British Standard, BS 5713, fails to guide the specifier in any meaningful way. This note lists the items that the specifier might need to consider and possible alternatives.

Performance

Glass units are now used primarily to limit heat loss from a building - Approved document L of the Building Regulations, which limits glazed areas according to the thermal transmittance coefficient ('U' value) of the glazing, virtually necessitates their use.

The thermal performance varies with the width of cavity, whether the cavity is filled with air or gas and the type of glass. Table 1 shows approximate U values for a range of glazing units. Plain float glass is assumed except where indicated otherwise.

As well as reducing heat loss, double glazing:

- Reduces condensation, which can occur when warm, damp air inside a room comes into contact with a cold window pane;
- Reduces noise transmission, depending on, for example, the thickness and relative thicknesses of the panes, and cavity width.

Type of glazing	U value (W/m^2K)
Single	5.4
Double 6mm air cavity	3.2
Double 12mm air cavity	2.8
Double 16mm air cavity	2.65
Double 20mm air cavity	2.7
Double 12mm argon cavity	2.6
Double low E glass 12mm air cavity	1.9
Triple 12mm air cavities	1.85
Triple low E glass 12mm air cavities	1.15
Triple low E glass 12mm argon cavities	0.95

Table 1 U-values of different glazing units

Components

Glass units comprise the following elements:

1. Glass (any type can be used including wired and patterned);
2. Spacer bar - maintains the space between the panes and contains desiccant to keep the air or other gas dry;
3. Desiccant - absorbs any small amount of residual moisture from the air space;
4. Seal(s) - prevents moisture from entering the unit cavity and holds the unit together;
5. Dried air or other gas - lack of moisture vapour eliminates condensation.

Edge sealant

A key part of the hermetically sealed unit is the edge seal, which must:

1 Have low moisture vapour transmission (M.V.T.);

2 Have high adhesion to glass and spacer bar;

3 Be compatible with the glass, spacer bar and glazing materials;

4 Have good resistance to water, service temperature and ultraviolet;

5 Be sufficiently flexible to allow the unit to expand or contract in response to temperature or pressure fluctuations.

Edge seal configuration

There are two edge seal configurations:

- Single seal systems
- Dual seal systems

Generic edge details are shown in Figure 1.

Single seal

Single seal units rely on the edge sealant to act both as the vapour barrier 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.

Dual seal

Dual seal glazing units rely on two seals:

- The inner (primary) seal controls the moisture vapour transmission rate into the unit, and also holds the unit firmly while the secondary sealant is applied and cures; the primary seal may be a hot-melt material (butyl) or a preformed tape (PIB). Wet-applied sealants accommodate irregularities in the glass or spacer bar whereas tapes may not, but do ensure a uniform width 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.

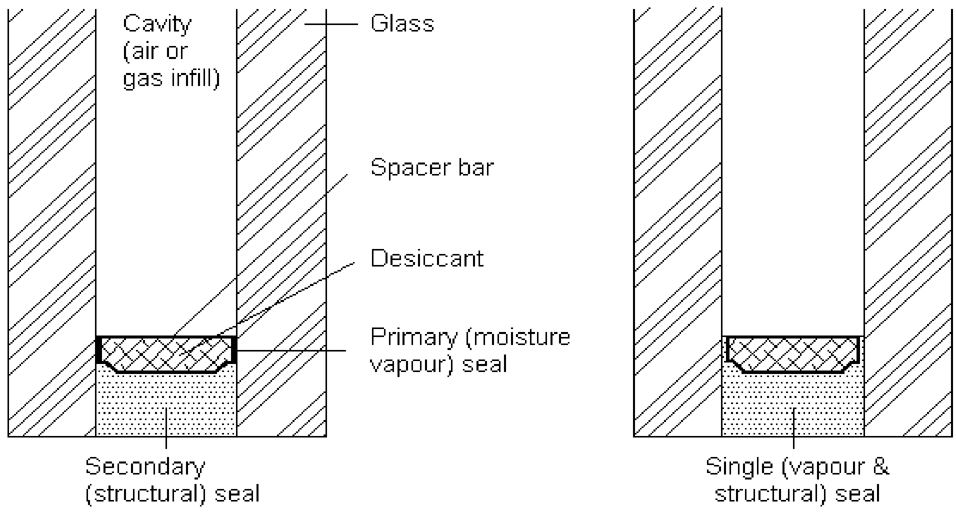
The combined properties of primary and secondary sealants give high quality glass units. As with single seal units, it is critical that the edge sealant is applied correctly with no voids or adhesion defects, since either will dramatically reduce the life of the unit. The primary and secondary seals must be compatible with each other and with the spacer bar and any corner pieces.

Spacer bar

The primary purpose of the spacer bar is to control 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 the spacer frame can be manufactured in several ways, which can affect the life of the unit:

- Four pieces of extrusion joined at the corners with nylon or metal corner keys;
- Single extrusions folded into a rectangle and joined at mid-length of one side;
- Single extrusions folded into a rectangle and welded end-to-end.

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.



a) Dual seal b) Single seal

Figure 1 Generic hermetic seals

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 long-term performance of the unit. 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.

Glass unit size limitations

Glass units are available with gas-space widths upwards of 3mm. The maximum area depends on the glass thickness and ranges from 2.4m^2 for 3mm thick glass to nearly 16m^2 for 12mm thick glass (BS 5713). These size limits are to ensure effective sealing; safety and wind loading requirements must always be considered and the glass thickness, area and/or type selected accordingly (BS 6262).

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:

1 Compatibility of glazing materials and coatings with the perimeter seal of the glass unit;

2 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);

3 Protection of the edge seal against ultraviolet radiation.

Moisture attack

Water is the major enemy of glass units; 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. In other words, under prolonged contact with liquid water, the unit can fail prematurely. Water attack can be encouraged by poor tooling of the sealant, allowing water to penetrate between the glass and seal. Note that the use of tapes to 'protect' the edge of the glass unit prevents proper examination of the quality of the edge seal and should 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.

Water in the form of moisture vapour is able to permeate through the edge sealant into the unit. The rate depends on the properties of the sealant and on the concentration of moisture vapour; manufacturing defects such as voids in the seal will increase the rate of moisture vapour permeation. However low the rate of moisture vapour permeation, it is inevitable that after a period of time excess moisture vapour in the unit will occur and result in condensation on the internal glass surfaces. Fogging of the glass unit, when the dew point temperature is reached, will reduce the insulating efficiency of the unit. It is the poor water vapour resistance of some sealants which requires a dual edge seal detail - one of the seals is a barrier to water vapour, the other holds the unit together. Well constructed glazing units will last for 25 years. However the life can be seriously shortened by poor installation.

Glazing system

All glazing systems must protect the edge seal by preventing water from entering the glazing rebate and preferably by also ensuring that any water that does penetrate as far as the edge seal is soon removed by drainage or evaporation.

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 are unable to be periodically inspected, they are not recommended for glazing insulating glass units, although fully bedded systems which allow the edge of the glass unit to 'breathe' are being promoted.

With face-sealed glazing systems any water that bypasses the outer seal can drain away only within the framing system. In drained-and-ventilated systems, small holes or slots fabricated in the underside of transoms or sloping glazing platforms 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.

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.

Exposure to ultra-violet

Some edge seal materials can degrade if exposed to solar radiation (particularly ultraviolet). It is important to ensure that glazing rebates provide full cover of the seal, unless the sealant is known to be resistant to solar radiation.

Thermal performance

The thermal insulation properties of glass units can be enhanced by a variety of means, as described below.

Gas fills

The gas-space contains a large uniform layer of gas with a significant temperature difference. The heat loss 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. However, the use of gas has led to some concern about the long-term efficiency of the unit, 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.

The unit cavity is usually filled with gas via a special corner key following assembly of the unit with the primary seal. The unit must be filled at a steady rate to ensure proper flushing of air out of the unit. Manufacture is completed by applying the peripheral (secondary) seal.

Spacer bars

Aluminium spacer bars increase the overall U value of the glass unit and glazing frame, owing to the creation of a thermal bridge at the unit edge, and give rise to local, low temperatures at the edge region, often causing condensation on the glass. New spacer materials and designs with low thermal conductivity are available to improve overall thermal performance and minimise condensation caused by aluminium spacer bar cold bridging. 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.

Air space convection

Further reductions in the U value of the unit can be gained by separating the air space into two or more cells using a very thin, transparent plastic film. The film can also be coated to reduce its emissivity. The only difficulty with this technique is ensuring that the films remain taut (they quickly become visible if allowed to wrinkle).

Appearance/visual acceptance

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 below the sight line of 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 glass units, although the glass can be treated at the edge to obscure the sealant.

Edge tapes

As stated above edge tapes should not be used. The tape may conceal defects in the unit edge seal and will reduce the life of the unit if water is trapped between it and the seal.

Desiccant

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

Glass cut edge condition

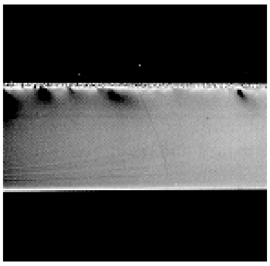
There are no standardised visual acceptance criteria for the edge condition of glass. However, glass with edges that are severely feathered or have deep, pointed shells/vents are generally unacceptable, especially in glass types that absorb a high percentage of solar energy (Figure 2). Edge damage will promote thermal cracking and premature failure.

Glass condition

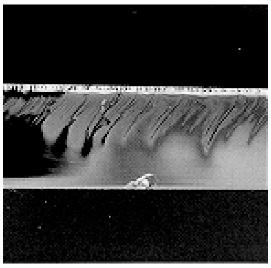
Some forms of glass may contain small bubbles or marks due to processing and handling (toughened glass may have roller wave or tong marks). It is important to decide how the glass is to be viewed when assessing its condition since viewing at a shallow angle may exaggerate small defects.

Bowing

Glass will bow due to temperature variations (the glass and the air or gas-fill will both expand as temperature increases) and pressure variations (the unit will have been sealed at a specific barometric pressure). Bowing of the external pane of glass (which is most observable) can be reduced by using asymmetric units - thicker glass to the outside. Assembly in the vertical plane can reduce elastic deformation of large panes.


Acceptable clean cut edge


Acceptable good edge with little feather


Just acceptable severely feathered edge


Unacceptable vented edge

Figure 2 Degrees of edge damage and their acceptability

Labelling

Often the date of manufacture and name of manufacturer can be marked on the glazing spacer or glass as a means of identification. Where safety glass is used, the glass type and British Standard number or Kitemark should be etched on the glass and visible after glazing.

Quality control

Unit design/manufacture

Units should conform to BS 5713 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 in accordance with the manufacturer's instructions.

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.

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:

1 Integrity of seals (sealant cappings, compression gaskets) is not impaired;
2 Drainage paths in drained systems are unobstructed;
3 Units remain supported over their full width.

Summary

Glass units have become commonplace in almost all modern, habitable buildings because of the continuous, 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. Advances in certain components have made available a number of innovations, which can improve the appearance, and ease of manufacture of units.

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CWCT
The Studio, Entry Hill, Bath, BA2 5LY

T: +44 (0) 1225 330945
cwct@cwct.co.uk
www.cwct.co.uk