CWCT
CURTAIN WALL INSTALLATION HANDBOOK

Chapter 7 Glass

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University of Bath

Centre for Window and Cladding Technology

November 2001

ISBN 1 874003 96 3

Published by
Centre for Window and Cladding Technology, University of Bath, Claverton Down, Bath BA2 7AY

This handbook was part-funded by the Department of the Environment, Transport and the Regions under research contract number 39/03/272 cc 862.

This handbook was written by the Centre for Window and Cladding Technology (CWCT) as part of its training programme to improve the standard of curtain wall installation.

It will be of benefit to all those installing, or supervising, the installation of curtain walling and other glazed building elements.

This is one of eight chapters from the CWCT Installers' handbook.

Introduction

The installation of facades and façade elements is one of the more complex operations on a construction site. It requires a range of skills and knowledge yet has not been recognised as a particular skill or trade. Façade failure, particularly water leakage, is the most common cause of failure in new buildings.

This handbook brings together advice on installation of curtain walling including all the major components: frames, gaskets, sealants, finishes, glass and fixings. It is based on experience gained by CWCT in setting up training centres for installers and in training main contractors' site supervisors.

The book explains why things should be done and highlights those things that are most critical to the success of curtain wall and window installation.

This Handbook is a guide to achieving better curtain wall installation. However, it is not a substitute for care and diligence, nor should it be a substitute for proper training. Full details of CWCT's training programme are available at http://www.cwct.co.uk/installers.

7 Glass

- **Types**

Glass is available in many types, thicknesses, patterns and finishes. The glass is selected for reasons of safety, appearance and the way it controls the internal environment of the building.

Glass may be grouped into categories by considering:

- Strength and safety
- Appearance
- Environmental control

Strength and safety
Glass in a building will be subject to mechanical loads in the form of wind load and impact. It may also be subject to stresses due to environmental conditions such as temperature changes. The strength properties of glass can be varied by increasing the thickness, heat treatment and combining the glass with other materials to form composites. The strength of glass must be sufficient to resist the loads it is likely to be exposed to. Safety of glass is related to its strength but also takes into account the risk of injury from the failed glass.

- Annealed glass
Annealed glass is the basic form of glass produced in float glass plants. It has no special properties of strength or safety and on breaking it forms large shards with sharp edges.

- Heat strengthened glass
Annealed glass may be strengthened by controlled heating and cooling. Heat ***strengthened glass is not a safety glass*** but is roughly twice as strong as annealed glass. When broken it behaves like annealed glass and breaks into large shards with sharp edges.

- Wired glass
Wired glass fractures in the same way as annealed glass but remains in place with the shards held together by the wire mesh. Wired glass is not stronger than annealed glass before failure. After failure the strength of the pane will depend on the thickness of the wires. Wired glass is available as ordinary wired glass and safety wired glass which contains stronger wires.

- Toughened glass
Annealed glass is toughened by heating it to 650^{o}C and rapidly cooling the surfaces. This compresses the surfaces and increases the strength of the glass. Toughened glass is roughly five times as strong as annealed glass.

An important property of toughened glass is the way in which it breaks. Any cracking of the glass leads to a rapid release of the surface compression and toughened glass always breaks into small pieces of glass Figure 7.1. Toughened glass complying with BS6206 is a safety glass.

Toughened safety glass should be kitemarked and installed with the kitemark visible.

Toughened glass cannot be cut or drilled after toughening and must therefore be cut to size before toughening.

- Heat soaked toughened glass
Toughened glass may fail due to the presence of nickel sulfide crystals in the glass. To reduce the risk of nickel sulfide failure, the glass may be subjected to a process known as heat soaking. To be effective the heat soaking process must be strictly controlled.

- Laminated glass
Annealed, heat strengthened or toughened glass can be laminated in any combination to make a safety or security glass. Two or more pieces of glass are laminated together to give the required

properties. The glass may be laminated as a sandwich with a layer(s) of polyvinyl butyral (PVB) between the sheets of glass. Glass can also be laminated by pouring a resin between two sheets of glass. PVB laminates are best suited to flat glass while poured resins are best suited to curved glass.

Laminated glass is not as strong as a single pane of glass of the same type and thickness but after failure the broken pieces of glass will be held together by the interlayer.

The performance of a laminated glass depends on the type of interlayer used. Some are designed to resist penetration and others solely as safety glasses.

- Tempered glass
Tempering is the American term for strengthening and toughening. Tempered glass is roughly equivalent to heat strengthened glass and is not a safety glass. Only fully tempered glass has similar properties to toughened glass. Fully tempered glass used as a safety glass should conform to BS6206.

- Plastics
Polycarbonates are sometimes used as glazing materials. They are used for safety glazing as they are less prone to breakage. Plastics are more flexible than glass of the same thickness. They may be sprung out of a glazing frame and are not always suitable as security glazing. Plastics are less scratch resistant than glass.

Appearance

- Patterned
Glass may be patterned by rolling a relief onto one surface while it is still hot and soft. This is done to obscure vision or to change the appearance of the facade. Patterned glass has the same strength and safety characteristics as annealed glass and is not normally a safety glass however it is possible to toughen patterned glass. Some patterned glasses - those that do not have deeply embossed surfaces - may also be laminated.

- Printed
It is possible to print patterns on to glass. This may be done to make people aware of the glass for safety reasons. In this case the patterning has to be in the correct position. Note that company logos and other signage may be used for this safety purpose.

- Fritted and etched
The surface of glass may be etched or otherwise altered to achieve the same effect as printing. Again this may be done for safety reasons.

Environmental control
Environmental control glasses are used to limit the heat and light passing through a window.

- Tinted
Glass may be tinted to reduce light transmission and prevent glare within a building.

- Coated
Glasses are coated to change the properties of the glazing. Coatings are used to reflect light and/or heat. Increasing the amount of reflected light may be required for aesthetic reasons (giving a mirror effect) or to restrict the view into the building. Reflection of heat may be required to reduce solar gain or to retain heat within the building. The type of coating will differ depending on its purpose.

Low emissivity (low-E) coatings are among the most widely used and are provided to reflect heat from inside the building back to the inside and therefore reduce heat loss. They do not reflect solar radiation in the same way due to the different wavelength. They are not visible to the eye.

- Printed
Patterns may be printed or etched onto the surface of the glass to obscure vision or prevent glare.

- Double and multiple glazing
Glass is frequently used as insulated glazing units (double glazing). This is normally done to reduce heat loss from the building but it can also help to reduce noise levels inside a building. In some cases triple glazing is used to reduce noise levels or further reduce heat loss.

Insulated glazing units may be made using any of the glasses described above and different glasses may be used for the inner and outer panes. The panes are separated by a spacer bar. The units may be constructed with a primary airtight seal between the spacer bar and the glass and a secondary structural seal outside the spacer bar holding the glass panes together Figure 7.2. Alternatively a single structural and air tight seal may be used Figure 7.3.

- Gas filled
Insulated glazing units may be gas filled to reduce energy loss through the window. Any units that are broken or damaged should be replaced with equivalent units.

• Safety glazing and fire rated glazing

The Building Regulations make specific requirements for the use of safety glazing and fire rated glazing under certain circumstances. The design of the facade will have taken account of these requirements. It is essential that safety glazing and fire rated glazing are installed as specified.

Safety glazing
Glass in critical locations (adjacent to doorways and pedestrian areas and in windows with low sills) has to comply with part N of the Building Regulations Figures 7.4 and 7.5.

The glass has either to break in a safe manner or resist impact. It is normal to use toughened, laminated or wired glass in these locations. Plain annealed glass may be used provided no single pane exceeds 0.5 m^2 in area, the smaller dimension is no more than 250mm and the thickness is not less than 6 mm.

Substitution with glass of different performance in a critical zone may be unsafe and should only be approved by the specifier.

Fire rated glazing systems
Fire rated glazing systems will have been tested to show that they can resist fire for the required period of time.

The performance of a fire rated screen depends on the exact replication of the test sample on every contract. No substitution of any framing, glazing or other components is permitted.

In the UK FIRAS maintain a register of trained installers and approved specialist contractors.

CDM Regulations
The Construction, Design and Management Regulations require all people involved in the construction of a building to ensure that it is safe during construction and use. Glass is a potentially hazardous material and care will be required to ensure the safety of the workforce, occupants of the completed building and any future maintenance workers.

• Terminology

The following terms relating to glazing are illustrated in Figure 7.6.

- Sight size
- Pane size
- Tight size
- Edge clearance
- Rebate depth

- Edge cover
- Back clearance

• Condition

The performance of glass is highly dependent on its condition. The use of damaged glass or insulated glazing units will impair the performance of the facade.

Glass should be inspected for:

Size
Glass that is undersize will not have sufficient cover in the glazing rebate. This can lead to an inadequate seal at the gasket and in the extreme loss of glass retention.

Glass that is oversize will reduce the clearance between the glass and frame which will limit the accommodation of relative movement of the glass and frame.

If thinner setting blocks are used to accommodate oversize glass this will reduce the cavity in the glazing rebate so that the lower edge of the glass is wetted. This may lead to the breakdown of seals of glazing units.

Ultimately the glass may not fit into the frame if it is too large.

Surface defects
Surface defects are uncommon with float glass. However when they do occur they are clearly visible. Surface defects are an obvious source of irritation to the client.

It is good practice to check all glass for surface defects at the time of installation. It is far easier to replace glass at this stage while the access scaffold is still in place.

Toughened glass may have a slightly rippled surface as a result of the toughening process. This is generally accepted but if particularly bad it may be unacceptable and the glass may have to be replaced.

If the cavity of an insulated glazing unit is at a different pressure to the surrounding air, the glass will dish and give distorted reflections.

Pressure differences can be caused by sealing the units at too high a temperature or at a different altitude from the site. This results in dishing of the glass as the cavity volume changes. Visual effects can be quite pronounced and unacceptable.

Changes in weather conditions will have a smaller effect that is normally acceptable.

Edge defects
Edge defects include:

- Feathering where the edge of the glass is not exactly square to the face and may not be plane
- Venting where the edge of the glass is clearly chipped to leave sharp edges around a depression

Feathering of the edge is acceptable up to a point. Venting is never acceptable Figure 7.7.

Edge defects cause stress concentrations which weaken the glass if it is subject to load. Thermal fracture of glass takes place if there is a large temperature difference between different parts of the glass. This can occur when most of the glass is heated by solar radiation but the edge is kept cool by shadows or the insulation of the frame. Stress concentrations at edge defects increase the risk of thermal cracking.

An edge tape may be used but this is not recommended as it provides little protection, hides edge damage, prevents inspection of the seal(s) and can even trap moisture causing breakdown of the seal.

Laminated glass
Laminated glass should be visually and optically acceptable. There should be no damage to the edge of any sheet of glass in the laminate.

Edge seals
Sealed units are made with either single or double edge seals to comply with BS5713.

Double edge seals are used to give a longer life to the unit. Any units replaced on site due to breakage or the presence of defects should be replaced with units of the same construction.

Edge seals should be free of any visible air bubbles.

• Identification

Identification of glass on site can present difficulty if it is part of a glazing unit, has invisible coatings or particular strength properties. The main methods of identifying glass are:

- Visual inspection with a gauge card held against the surface will identify the glass thickness using the reflection from the back face of the glass. A reflected flame will appear differently on coated surfaces.

- **Marking** of glazing units at the time of manufacture assists identification. Labels should show: type of glass, size, manufacturer, glazing position and orientation. Toughened safety glass should be kitemarked to BS6206. Glazing units may be kitemarked to BS5713.

- Gauges or meters may be used to determine glass thickness. Several commercial systems are available.

- DSR (differential surface refractometer) equipment can be used to determine the surface stresses in glass and the degree of toughening. This equipment is expensive and is unlikely to be available on site.

- **Ultrasonic** test equipment can be used to identify laminated glasses. These also sound differently when tapped.

Suitable methods of identification:

Glass types	*Methods*
Clear float	Visual or meter
Patterned	Visual
Wired	Visual
Tinted	Visual
Coated	Visual or meter
Heat-strengthened	DSR
Toughened	Mark, DSR or polarised light
Bent	Visual
Laminated	Mark, ultrasonic
Glazing unit	Mark on spacer
Printed	Visual
Off-line coated	Visual, meter, reflections

• Glass installation

The following standards apply to glass installation:

BS6262	Code of practice for glazing of buildings
BS8000 Pt 7	Code of practice for glazing on building sites
BS5516	Code of practice for design and installation of sloped and vertical patent glazing
BS8213 Pt 4	Code of practice for the installation of replacement windows and doorsets in buildings

Glazing materials should be installed in accordance with the manufacturer's instructions and BS6262. BS6262 gives general guidance applicable to most windows.

Where manufacturer's instructions differ from BS6262 the manufacturer's instructions should be followed.

Positioning

It is important that glazing units are correctly positioned. Units that include safety glass should be used in the correct openings and not swapped with non safe units.

Units that have different glasses for the inner and outer panes should be positioned with the correct face outermost. This may be required for reasons of safety, appearance or the effectiveness of energy efficient glazing.

Each glazing unit will contain two or more pieces of glass that will be of slightly different size due to manufacturing tolerances. Good quality glazing units are constructed with all glass aligned on two edges of the unit that are labelled 'bottom'.

Glass should be installed with the correct edge resting on the setting blocks so that all sheets of glass are equally supported.

Setting blocks and spacers

Setting blocks are used to support the glass and must support both panes of a glazing unit. They prevent glass to frame contact and centralise the glazing in the frame, Figure 7.8.

Setting blocks should support the glazing clear of any water that enters the glazing rebate.

Setting blocks should not block any drainage paths. Some systems require setting blocks that bridge the drainage channel. Use of sealant to locate setting and location blocks may also block drainage paths.

Setting blocks may be made from the following materials:

- Neoprene with Shore Hardness 80 to 90

- Plasticised PVC with softness of 35 to 45
- Extruded unplasticised PVC

Hammered lead is sometimes used in undrained systems and sealed hardwood may be encountered in some windows but should not be used in curtain walls.

Location blocks are used to prevent lateral movement of the glazing and give rigidity to opening lights and factory glazed products. They are made from the same materials as setting blocks.

Distance pieces are used to maintain the distance between the glass and the frame when using wet applied sealants Figure 7.9. They are made from the same materials as setting blocks.

Glass and frame support

The glazing material stiffens the frame of opening lights and doors and prevents them distorting or sagging in use. The setting block positions are selected to correctly stiffen the frames as well as support the glass. For windows that pivot on a horizontal axis the setting blocks at the top of the frame also support the glass.

The recommended positions for setting blocks for windows are shown in Figure 7.10 but the manufacturer's instructions should also be read.

Setting blocks should be at least 30mm and no more than 100mm from the corner of the glazing frame.

Curtain walling and glazing screens have to move to accommodate movement of the primary structure. Location blocks in curtain walling should be placed near the bottom of the glass to prevent lateral movement of the glass but allow racking of the frame Figure 7.11.

Edge clearance

Glass should be fitted into the frame with adequate edge clearance. This is necessary so that:

- The glass and frame can move without stressing the glass
- Water entering the frame can drain freely

Minimum edge clearances for glass are:

- 3mm for glass sizes up to 2m
- 5mm for glass sizes over 2m
- 6mm for all drained systems

Minimum edge clearances for plastic glazing materials are:

- 3mm for plastic sizes up to 1m
- 5mm for plastic sizes between 1 and 2m
- 7mm for plastic sizes between 2 and 3m

Drainage

Drain holes in the bottom or face of the frame must not be blocked by setting blocks, swarf or sealants.

• Storage and Handling

Glass weight

Typical glazing units are heavy and larger units require special consideration. It is always preferable to glaze windows at the factory. However for larger windows the completed weight is too great to be lifted manually and these windows have to be site glazed. Some windows have to be deglazed for fixing into the opening.

Glass weighs 2.5kg/m^2/mm. Weights of typical glass products are shown below;

6mm glass	15 kg/m^2
6 - 12 - 6 glazing unit	30 kg/m^2
7.3 - 12 - 6 laminated glazing unit	32.5 kg/m^2
15mm glass	37.5 kg/m^2

Consideration should be given to mechanical handling and lifting of larger glazing units and complete glazed windows.

Glass storage
Glass should be stored:

- In the dry
- Out of direct sunlight
- Stood on edge
- Protected from impact
- Protected from dirt

Glass should be stored on site in a protected location where it will not be damaged and does not become marked or unduly dirty.

If glazing seals become wet, particularly if water becomes trapped behind edge tapes, the seals will start to break down. If water is trapped between two pieces of glass for too long then the glass surfaces may be permanently marked.

If glass is stored in direct sunlight then heat passes into the stack and cannot escape. The glass within the stack can become very hot causing fracture.

Glass should be stored stood on edge and inclined against a rest to prevent it from falling. With glazing units both edges should be supported to reduce the risk of edge damage. A suitable arrangement is shown in Figure 7.12.

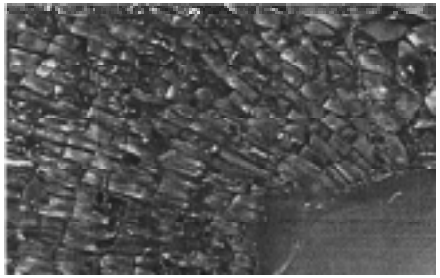

Figure 7.1 Fractured toughened glass

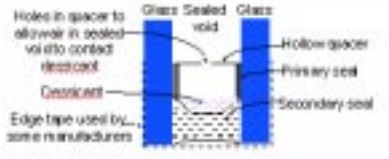

Figure 7.2 Dual seal edge detail

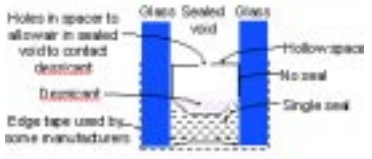

Figure 7.3 Single seal edge detail

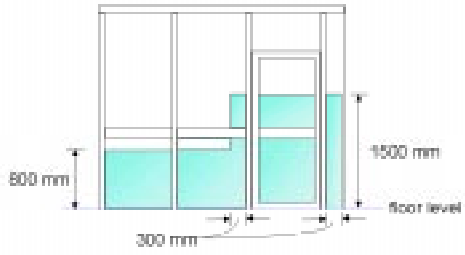

Figure 7.4 Critical areas in a glazed screen

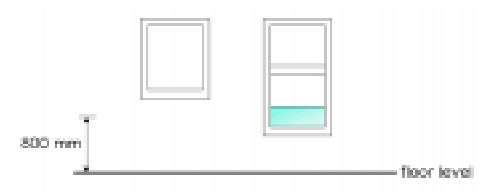

Figure 7.5 Critical areas in windows

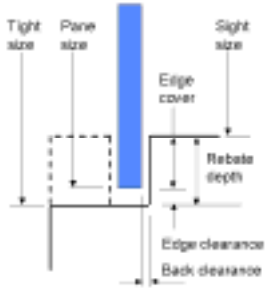

Figure 7.6 Glazing terms

Figure 7.7 Edge damage to glass

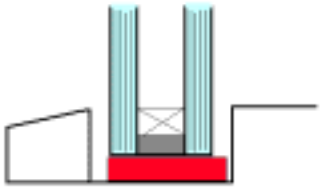

Figure 7.8 Setting block

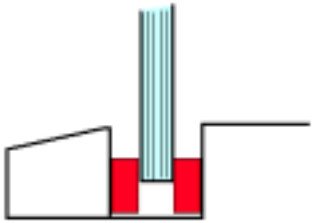

Figure 7.9 Distance pieces

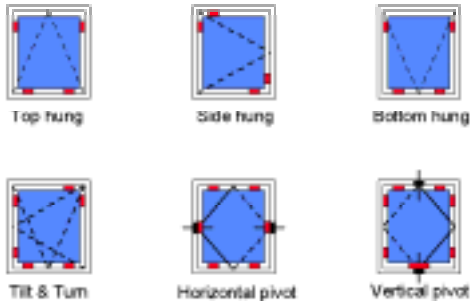

Figure 7.10 Setting and location block (windows)

Figure 7.11 Setting and location blocks (curtain wall)

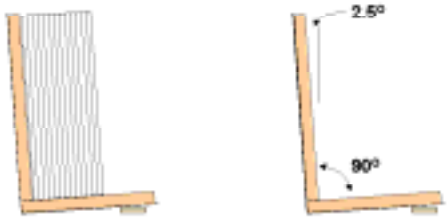

Figure 7.12 Storage of glass