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# GGF Glazing Manual

## Contents



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# Plastics Glazing Sheet Materials – Basic Products

1.2 FEBRUARY 2000

## Scope

The scope of this Data Sheet is to give information on Transparent and Translucent Thermoplastic and Glass Reinforced Plastic (GRP) Glazing Sheet materials and to present general product information to the specifier, on the main types of Plastics Glazing Sheet material that may be used in a vertical application.

## Foreword

The Data Sheet gives information on the types of material that are available and some basic information on their Physical Properties.

The Glass and Glazing Federation issues this Data Sheet to Specifying Authorities in all industries. It is intended for use by designers of new buildings as well as for maintenance engineers and estate managers.

This Data Sheet is not intended to offer recommendations on the specific material to be used in any given application. For guidance on methods of installation, specifiers should observe the recommendations in GGF Data Sheet 4.5 "Glazing with Plastics" and the relevant recommendations in BS 6262.

## Definitions

a) **Thermoplastic Material.** A material based on an organic polymeric substance of high molecular weight that may be used either in its raw material state or in combination with other chemical additives to modify the properties of the raw material to suit particular applications.

b) **Thermoplastic Film.** Any plastics material less than 1mm in thickness.

c) **Thermoplastic Sheet.** Any plastics material 1mm or greater in thickness.

d) **Thermoplastic Glazing Sheet Material.** Plastics material consisting of a single sheet or a combination of sheets laminated together or as profiled extruded multiskin sheet.

e) **Thermoplastic.** A type of Plastic material which softens physically when heated but does not undergo chemical change.

f) **Thermoset Plastic.** A type of Plastic material which has undergone a chemical change during manufacture and does not soften under the action of further heating. An example of this material would be GRP flat sheet.

## Classifications

Thermoplastics glazing sheet materials are of various 'types'. The types marketed differ in their chemical composition and structure, or they may be a combination of two or more different types. Whilst different types are normally available under their proprietary brand names, the five basic types most commonly used for exterior and interior flat glazing applications are generically:-

a) Polycarbonate

b) Polymethyl Methacrylate (PPMA) or "Acrylic"

c) Polyvinyl Chloride or "Rigid PVC" (unplasticised PVC or PVCu)

d) Multiskin extruded profiles in polycarbonate, polymethyl methacrylate and polyvinyl chloride (See Note A).

e) Reinforced multiskin extruded PVC panels.

Other Plastics materials or profiles suitable for specialised glazing applications include:

f) Glass fibre reinforced plastics (GRP) flat sheet.

In all cases the manufacturer should be consulted as to suitability and recommended uses.

*Note (A)*

**Multiskin Hollow Sheet.** For Multiskin sheeting it is important to note that the profile cross section (the number of skins and the overall thickness) will affect the properties, weight, performance and method of use of the specific material and therefore it is essential that manufacturer's data is consulted for all applications.

## Types

Plastics Glazing Sheet materials are available in some of the following forms other than standard. Colours (including Clear Transparent) - Textured - UV Surface Protected - Hard Coated - Mirror Surfaces. For details of availability, reference should be made to the supplier.

## Physical Properties

### Weight

Solid Sheet Material weight per square metre (Shown in kg) based on an sg of 1.20 for Polycarbonate, 1.38 for PVC & 1.19 for Acrylic.

Table 1

| Thickness in mm | Polycarbonate | PVC | Acrylic |
|---|---|---|---|
| 3 | 3.60 | 4.14 | 3.57 |
| 4 | 4.80 | 5.50 | 4.76 |
| 5 | 6.00 | 6.90 | 5.95 |
| 6 | 7.20 | 8.28 | 7.14 |
| 8 | 9.60 | 11.04 | 9.52 |
| 10 | 12.00 | 13.80 | 11.90 |
| 12 | 14.40 | 16.56 | 14.28 |

For Multiskin Hollow Sheet (See Note A).

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**Light Transmission**

Light Transmission Solid Sheet. Clear Transparent (%)

**Table 2**

| Thickness in mm | Polycarbonate | PVC | Acrylic |
|---|---|---|---|
| 4 | 88 | N/A | 92 |

For Light Transmission Multiskin Clear Transparent See Note A

**Footnote**

Coloured Transparent & Translucent forms of solid sheeting and PVC are available which will offer different Transmission values.

**Heat Transference**

The Heat Transference (measured in W/m $2^2$K, U values) for Solid Sheet material.

**Table 3(a)**

| Thickness in mm | Polycarbonate | PVC | Acrylic |
|---|---|---|---|
| 4 | 5.3 | N/A | 5.3 |

The Heat Transference (measured in W/m $2^2$K, U values) for Hollow Sheet Material.

**Table 3(b)**

| Typical U Value for | Polycarbonate | PVC | Acrylic |
|---|---|---|---|
| (16mm Triple Wall section) See Note A | 2.4 | N/A<br>See Foot Note | 2.4 |

**Footnote**

For 60mm Triple wall PVC the corresponding U value is 1.4 W/m$^2$K.

**Impact Strength**

The impact strength of solid sheet material is classified in compliance with the soft body impact test specified in BS 6206 and the manual impact strength tests specified in BS 5544. Typical results are shown in Table 4(a).

**Table 4(a)**

| Test & Thickness | Polycarbonate | PVC | Acrylic |
|---|---|---|---|
| BS 6206 3mm+ | Class A | N/A | Class C |
| BS 5544 4mm+ | Pass at high Energy Level | | N/A |

+ = Upwards

The impact strength of Hollow section materials are classified in compliance with the soft body impact strength tests specified in BS 6206/ Typical results are shown in Table 4(b) for 10mm thick material.

**Table 4(b)**

| BS 6206 | Polycarbonate | PVC | Acrylic |
|---|---|---|---|
| 10mm<br>Refer also to Note A | Class A | N/A | N/A |

**Linear Thermal Expansion**

For all materials, solid and hollow, for a total 60°C overall change, the materials reversibly expand and contract as shown in Table 5.

**Table 5**

| | Polycarbonate | PVC | Acrylic |
|---|---|---|---|
| Movement shown in mm per metre for both width and length. | 4.0 | 4.8 | 5.0 |

It should be noted that the colour of all materials influences their rate of expansion.

**Sevice Temperature Range**

The service temperature range for both solid and hollow materials are given in Table 6.

**Table 6**

| | Polycarbonate | PVC | Acrylic |
|---|---|---|---|
| Service Temperature Range upper & lower limits | +115 -40°C | +65 -40°C | +80 -40°C(Cast)<br>+70 -40°C (Extruded) |

*Note (B)*

Machining, cutting etc should be carried out on material that has reached room temperature throughout its whole core. This may take up to 24 hours to reach (Approx. 18° to 23°C) dependent upon ambient workshop and storage conditions.

**Weatherability**

Table 7 gives typical performance guides for Ultra Violet (UV) Surface protected sheets. This table is based upon the Delta Yellowness Index ASTMS 1925 (1977).

**Table 7**

| Performance | Polycarbonate | PVC | Acrylic |
|---|---|---|---|
| Excellent<br>Good<br>Poor | Good | Good | Excellent |

It should be noted that the method of UV protection can vary.

*Note (C)*

No Additional surface protection is necessary for Acrylics.

**Reaction to Fire Properties**

Typical examples of reaction to Fire properties are given in Table 8.

However in every case the manufacturers should be consulted regarding the type of material to be used.

**Table 8**

| | BS 476 Part 6 | BS 476 Part 7 Class 1 | BR Class O | BR TP (a) | BR TP (b) |
|---|---|---|---|---|---|
| **Solid** | | | | | |
| Polycarbonate | Some | Most | Some | 3mm + | N/A |
| PVC | Some | Most (Class 1) | Some | All | N/A |
| Acrylic | - | (3 cast) | - | N/A | All |
| **Multi Skinned** | | | | (If Class 1) | |
| Polycarbonate | Some | Some | Some | Some | All |
| PV C | - | Some | - | Some | All |
| Acrylic | - | - | - | - | - |

BR = Building Regulations England & Wales    BS = British Standards

1991 Approved Document B

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# Window and Door System U-Values: Provision of Certified Data

2.2 November 2014

**Contents**



## Foreword

This datasheet has been prepared by the GGF after consultation with other trade organisations.

It describes methods of assessing and reporting the thermal performance of windows and doors. This version supersedes the earlier (March 2002) edition. Changes have been incorporated to relate to the window U-value requirements of Building Regulations Approved Documents for England, Wales, Scotland and Northern Ireland. As these regulations are regularly updated, care should be taken to ensure that the current minimum criteria are met.

The datasheet has two objectives;

1. To enable interested parties to establish whether windows and doors satisfy the U-value requirements of Building Regulations Approved Documents for England, Wales, Scotland and Northern Ireland.

2. To provide a fair means by which comparisons can be made between the performances of different window and door systems.

## 1. Scope

This Datasheet describes how to provide data on;

- The thermal performance of the component parts of windows and doors, which will enable subsequent calculation of U-values of complete window and door assemblies to be determined by simple arithmetical operations.
- Reference U-values for different types of windows and doors, enabling them to be compared on a fair basis.

The data sheet defines the methods of calculation, simulation and measurement available, and describes the circumstances in which each method is to be used.

Curtain walling and other structural glazing are not within the scope of this document.

The effects of thermal bridging at the interface with the building envelope, solar radiation and heat transfer by air leakage are excluded.

## 2. Definitions

**2.1 Calculation** – A simple procedure based on mathematical process that may be carried out without a computer. The result is conservative.

**2.2 Simulation** – A procedure designed for use on a computer, in which a mathematical process is made to represent the physical behaviour of a body. The results are comparable to measured values.

**2.3 Method** – An orderly prescribe procedure.

**2.4 System** – A coherent group of frame sections and associated component parts from which complete windows and doors may be assembled.

**2.5 Window Assembly** – A window with single or multiple lights, or a coupled window including the sub-frame when it is part of the normal construction.

**2.6 Door Assembly** – A door leaf and door frame, which may also include multi leaf doors, sliding patio, French and sliding / folding doors. A door leaf without a frame is treated as a component part.

**2.7 Reference Window or Door** – A reference window or door is a defined typical design and size, which is used for comparison with other products manufactured from alternative window and door systems.

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### 3 Overview of techniques for determination of U-values

**3.1** Determination of thermal transmittance (U-Values) of window and door components. The thermal transmittances of frames, glazing / infill panels and ψ (linear thermal transmittance) can be obtained as follows;

**3.1.1** BS EN 673 is a method for calculating the centre pane U-value of glazing (Ug) or infill panels. Measurement of U values can be undertaken in accordance with BS EN 674, BS EN 675.

**3.1.2** Simple calculation to BS EN ISO 10077-1 allow the determination of frame members U-values, glazing U-values and ψ values from basic frame dimensions and tabulated values (see section 4).

**3.1.3** BS EN ISO 10077-2 gives a method for determination of frame member U-values and ψ values by means of simulation method (see section 6). The ψ values of the glazing edge includes the effect of the spacer bar, glazing or infill panel by linear method. [Note: for condensation assessment, it is necessary to use the model complete with glazing system and spacer bar, otherwise the minimum surface temperature will not be representative of the glazed window condition)

**3.2** Determination of thermal transmittance (U-value) for window and door assemblies

**3.2.1** BS EN ISO 12567-1 is the measurement method for the determination of U-value for window and door assemblies

**3.2.2** The U-value for a complete window or door assembly can be calculated from the component U-values using BS EN ISO 10077-1 and BS EN ISO 10077-1+2.

**3.3** Windows and door samples for system reference U-value determination: When a reference U-value is required for trade comparisons, or to represent the product system performance for Building Regulation purposes.

### 4 Simplified Methods of Calculation.

#### 4.1 BS EN ISO 10077-1

The complete window and door assembly overall U-values can be calculated, for assemblies of any construction, from the component U-values as specified in 3.1.1 to 3.1.4, using the procedures defined in the standard:

**4.1** Thermal transmittance of the frame (Uf)

**4.1.2** Thermal transmittance of the central area of glazing (Ug) is taken from table C2 of BS EN ISO 10077-1

**4.1.3** Linear thermal transmittance of glazing (ψ) is taken from table E1 of BS EN ISO 10077-1.

**4.1.4** Linear thermal transmittance of the infill panel is calculated in accordance with BS EN ISO 10077-2.

The contents of the report shall comply with the requirements of section 7 of BS EN ISO 10077-1.

### 5 Simulation and Calculation.

Simulation is a complex computer procedure, normally based upon finite element analysis, but in some circumstances finite difference analysis may be adequate. This enables accurate representation by mathematical processes to be made of the temperature and heat flux in the window or door system components.

This simulation programme used shall comply with BS EN ISO 10211-1

#### 5.1 BS EN ISO 10077-2

Two simulations for each frame construction detail are undertaken. The simulations enable the following to be determined.

- Frame thermal conductance L2D, when glazed with an insulation panel with thermal conductivity of 0.035W/mK, which allows the derivation of Uf.
- Linear thermal transmittance ψg of the glazing, representing the interaction between the frame and the edge construction of the glazing or infill panel by the linear method.

#### 5.2 Whole window U-Value.

The U-value of any size or design in a product system is determined by summing arithmetically the component values according to the appropriate formula

$$U_w = \frac{\Sigma A_g \times U_g + \Sigma A_f \times U_f + \Sigma l_g \psi_g}{\Sigma A_g + \Sigma A_f}$$

Where

$U_w$ is the thermal transmittance of the window

$U_g$ is the thermal transmittance of the glazing

$U_f$ is the thermal transmittance of the frame

$\psi_g$ is the linear thermal transmittance due to the combined thermal effects of glazing, spacer and frame

Result are reported in accordance with the requirements of section 7 of BS EN ISO 10077-2

### 6 Measurement methods.

**6.1** Summary of procedure and methods: complete window U-values are measured in accordance with BS EN ISO 12567-1. The specimen is fabricated to a specified size and design. The thermal transmittance is measured to the specified procedures and conditions in a hot box.

**6.1.1** Individual window and door samples; the size and design of the sample is chosen according to the specified requirement in accordance with the requirements of BS EN 14351-1.

**6.2** Measurement. U-values and other thermal properties of the product assemblies, and the thermal properties of product components such as insulating glass units, shall be measured only by organisations accredited by the relevant nationally accredited notified body for the measurement of thermal transmittance.

**6.3** Calculation. Reference U-values of window and door assemblies shall be determined only from thermal transmittance values obtained by methods described above.

**Appendix A** – Reference Samples

For the purposes of U value declarations for CE marking of windows, refer to table E1 of BS EN 14351-1.

For the purposes of U value declarations for CE marking of external pedestrian doorsets, sliding patio, French and sliding / folding doors refer to table E2 of BS EN 14351-1.

In order to demonstrate compliance with national building regulations it may be necessary to declare U-values using the standard size and configurations as set out in GGF Datasheet 2.3.

**Bibliography** – Reference Samples

Unless otherwise stated, the latest edition of all documents is to be referred to

BS EN 673:2011. Glass in Building – Determination of thermal transmittance (U-value). Calculation method

BS EN 674:2011. Glass in Building – Determination of thermal transmittance (U-value). Guarded hot plate method

BS EN 675:2011. Glass in Building – Determination of thermal transmittance (U-value). Heat flow meter method

BS EN ISO 8990:1996. Thermal Insulation – Determination of steady state thermal transmission properties. Calibrated and guarded hot box

BS EN ISO 10077-1:2006. Thermal performance of windows, doors and shutters. Calculation of thermal transmittance. General

BS EN ISO 10077-2:2012. Thermal performance of windows, doors and shutters. Calculation of thermal transmittance. Numerical method for frames

BS EN 10456: 2007. Building Materials and products. Hygrothermal properties – tabulated design values and procedures for determining declared and design thermal values.

BS EN ISO 12567-1: 2010. Thermal performance of windows and doors. Determination of thermal transmittance by hot box method. Complete windows and doors

BS EN ISO 12567-2: 2005. - Thermal performance of windows, doors. Determination of thermal transmittance by hot box method. Roof windows and other projecting windows.

BS EN 14351-1 – Windows and doors – Product standard, performance characteristics.

GGF Datasheet 2.3 – Guide to the calculation of energy ratings for windows, roof windows and doors.

# A Guide to the Design of Fire Resistant Glazed Screens and Partitions to comply with the Requirements for Impact and Crowd Loads

2.9 JANUARY 2001

Contents



## Foreword

The Fire Resistant Glazing Group of the Glass and Glazing Federation has prepared this Data Sheet.

The Data Sheet has two objectives.

(i) To enable designers and specifiers to ensure that fire resistant glazed screens or barriers are strong and robust enough to withstand impact and crowd pressure.
(ii) To provide relevant guidance and recommendations to designers and specifiers of fire resistant glazing.

## 1. Scope

This Data Sheet is designed to provide information for the successful performance in service of fire resistant glazed screens and partitions with respect to impact and crowd loads.

## 2. References

The designer shall comply with the Building Regulations Approved Documents Part K and Part N.

Part K : Protection from falling, collision and impact.

Part N : Glazing – Safety in relation to Impact, Opening and Cleaning.

The design shall also comply with British Standards.

**BS 5234:1992 Partitions**

Part 1 Code of Practice for Design and Installation.

Part 2 Specification for performance requirements for strength and robustness including methods of test.

**BS 6180:1999 Code of Practice for Barriers in and about Buildings**

**BS 6262:Part 4:1994 Code of Practice for Glazing for Buildings Safety related to Human Impact.**

**BS 6399:Part 1:1996 Code of Practice for dead and imposed loads**

This data sheet highlights the need for compliance with BS 5234 and BS 6180 by partitions and barriers.

Extracts of British Standards are reproduced with permission of BSI but are no substitute for reference to the full standards which are available from BSI, Customer Services, 389 Chiswick High Road, London W4 4AL.

## 3. Definitions

The definitions for this document are as described in the British Standards, detailed above.

## 4. Fire Resistant Partitions to BS 5234

Grades of Partition.

BS 5234 grades partitions by their categories of duty. These can be assessed against performance criteria when tested for strength and robustness.

Table 1 Partition grades by categories of duty (from BS 5234:Part 2:Table 1)

| Grade | Category of duty | Examples |
|---|---|---|
| Light duty (LD) | Adjacent space only accessible to persons with high incentive to exercise care. Small chance of accident occurring or of misuse. | Domestic accommodation |
| Medium duty (MD) | Adjacent space moderately used primarily by persons with some incentive to exercise care. Some chance of accident occurring and of misuse. | Office accommodation |
| Heavy duty (HD) | Adjacent space frequently used by the public and others with little incentive to exercise care. Chances of accident occurring and of misuse. | Public circulation areas<br>Industrial areas |
| Severe duty (SD) | Adjacent space intensively used by the public and others with little incentive to exercise care. Prone to vandalism and abnormally rough use. | Major circulation areas<br>Heavy industrial areas |

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Partitions should be sufficiently robust to withstand:

a) Bending caused by people leaning on the partition or by a person standing on a ladder against it (see stiffness test).

b) Impact caused by people falling against the partition (see soft body impact test).

c) Impact caused by trolleys, wheelchairs and equipment (see hard body impact tests). Not appropriate for glazed partitions.

d) Door slamming caused by wind or people closing a door energetically (see door slam test).

The performance criteria are set out in Table 2:

Table 2
Summary of grade requirements and principal test performance levels

| Requirement | Units | Grade (see table 1) | | | | Criteria | | Test Method |
|---|---|---|---|---|---|---|---|---|
| | | LD | MD | HD | SD | BS 5234: Part 2 Clause | Summary | |
| Stiffness | mm<br>mm | 25<br>5 | 20<br>3 | 15<br>2 | 10<br>1 | 1.6.1 | Maximum deflection<br>Maximum residual deflection | Annex A |
| Small hard body impact: | | | | | | | | |
| Surface damage | Nm | 3 | 3 | 6 | 10 | 1.6.2 | Judgement of indent | Annex B |
| Perforation | Nm | [1] | 5 | 15 | 30 | 1.6.4 | No perforation of facing | Annex D |
| Large soft body impact: | | | | | | | | |
| Damage | Nm | 20 | 20 | 40 | 100 | 1.6.3 | 2mm maximum deformation | Annex C |
| Structural damage | Nm | 60 | 60 | 120 | 120 | 1.6.5 | No collapse or dislocation | Annex E |
| Door slam | No. | 20 | 20 | 100 | 100 | 1.6.6 | No damage and 1 mm maximum displacement | Annex F |

1) No requirements for this grade

Where a partition is liable to be subjected to the pressure of crowds, consideration should also be given to a sample being tested for resistance to collapse or dangerous damage.

**5.** Criteria for Acceptance of Fire Resistant Partitions to BS 5234

**5.1** Methods of Test and Criteria for Acceptance

Part 2 Annexes A to G specify the methods of test, and section 1.6 details the criteria for acceptance.

**a.** Stiffness: a horizontal load of up to 500 N is applied via a 150 mm diameter plate. There shall be no damage other than superficial cracking. Deflection and deformation shall not exceed specified limits.

**b. Surface damage by small hard body impact:** this test using a 3kg impactor, with its head being a 50 mm diameter steel sphere, is inappropriate for glazed areas of partitions. The impact performance requirement of glass to reduce the risk of injury from glass breakage is determined by testing to BS 6206. Safety glass is classified A, B or C when it either does not break or breaks safely under impactor drop heights of 1219 mm, 457 mm or 305 mm. Building Regulations Approved Document N and BS 6262:Part 4 designate where safety glass should be used.

**c. Resistance to damage to impact from a large soft body:** the partition shall be capable of withstanding impact energies of 20 Nm, 40 Nm or 100 Nm according to grade, applied by swinging against it a 45kg bag and suffering no permanent deformation in excess of 2 mm or any damage.

**d. Resistance to perforation by small hard body impact:** this test uses the same apparatus as b, and is likewise inappropriate for glazed partition areas for which BS 6206 determines impact resistance.

**e. Resistance to structural damage by impact from a large soft body:** the partition shall be capable of withstanding impact energies of 60 Nm or 120 Nm according to grade, applied by swinging against it a 45kg bag from heights of 122 mm or 245 mm, without collapsing or dislocating the partition or its fixings.

**f. Door slamming:** when installed in a test rig a 35 kg door leaf is slammed 20 times for light or medium duty, a 60kg door leaf is slammed 100 times for heavy or severe duty. The partition shall not be damaged, nor shall frame fittings come loose. The frame closing jamb shall not be displaced by more than 3 mm after an initial 3 slams and thereafter by any more than a further 1 mm.

**g. Crowd pressure:** a continuous load is transmitted through a 2.5 m horizontal beam at a height of 1.2 m for 2 minutes. A choice of load 0.75 kN, 1.5 kN or 3 kN per metre length of beam is made by the test sponsor. There shall be no collapse or damage that could cause injury.

**6. BS 6180:1999 Barriers in and about buildings**

This British Standard is relevant to the design and construction of fire resistant glazed screens which act as barriers to protect persons from various hazards, including falls from stairs, landings, ramps, edges of internal floors, external walls and external balconies. As a general rule barriers should be installed where there is a difference in adjacent levels greater than 600 mm. Barrier considerations apply to screen areas up to 1100 mm above floor level.

**Building use categories**

In the assessment of the need for a barrier and the type of barrier to be provided, the designer should give consideration to the building use and the risks to building users. BS 6180 invokes BS 6399:Part 1:Table 4 for building use categories or occupancy types, inserted here as Table 3.

**Design loads**

The design loads should be chosen in accordance with the appropriate building use category and barrier location. Barriers should be designed to resist the more onerous loads arising from the separate consideration of the uniformly distributed and point loads given in Table 3.

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Table 3 Occupancy types and minimum horizontal imposed loads (from BS 6399:Part 1:Table 4)

| Minimum horizontal imposed loads for parapets, barriers and balustrades, etc. | | | | |
|---|---|---|---|---|
| Type of occupancy for part of the building or structure. | Examples of specific use. | Horizontal uniformly distributed line load (kN/m) | A uniformly distributed load applied to the infill (kN/m2) | A point load applied to part of the infill (kN) |
| **A.** Domestic and residential | (i) All areas within or serving exclusively one dwelling including stairs, landing, etc, but excluding external balconies and edges of roofs (see C3ix) | 0.36 | 0.5 | 0.25 |
| | (ii) Other residential (but also see C) | 0.74 | 1.0 | 0.5 |
| **B** and **E.** Offices and work areas not included elsewhere including storage areas | (iii) Light access stairs and gangways not more than 600 mm wide | 0.22 | N/A | N/A |
| | (iv) Light pedestrian traffic routes in industrial and storage buildings except designated escape routes | 0.36 | 0.5 | 0.25 |
| | (v) Areas not susceptible to overcrowding in office and institutional buildings, also industrial and storage buildings except as given above | 0.74 | 1.0 | 0.5 |
| **C.** Areas where people may congregate<br><br>**C1/C2.** Areas with tables or fixed seating. | (vi) Areas having fixed seating within 530 mm of the barrier, balustrade or parapet | 1.5 | 1.5 | 1.5 |
| | (vii) Restaurants and bars | 1.5 | 1.5 | 1.5 |
| **C3.** Areas without obstacles for moving people and not susceptible to overcrowding. | (viii) Stairs, landings, corridors, ramps. | 0.74 | 1.0 | 0.5 |
| | (ix) External balconies and edges of roofs. Footways and pavements within building curtilage adjacent to basement/sunken areas. | 0.74 | 1.0 | 0.5 |
| **C5.** Areas susceptible to overcrowding. | (x) Footways or pavements less than 3m wide adjacent to sunken areas. | 1.5 | 1.5 | 1.5 |
| | (xi) Theatres, cinemas, discotheques, bars, auditoria, shopping malls, assembly areas, studios. Footways or pavements greater than 3 m wide adjacent to sunken areas. | 3.0 | 1.5 | 1.5 |
| | (xii) Designated stadia (see note 1) | See requirements of the appropriate certifying authority | | |
| **D.** Retail areas | (xiii) All retail areas including public areas of banks/building societies or betting shops. For areas where overcrowding may occur, see C5. | 1.5 | 1.5 | 1.5 |
| **F/G.** Vehicular | (xiv) Pedestrian areas in car parks including stairs, landings, ramps, edges or internal floors, footways. | 1.5 | 1.5 | 1.5 |

Note 1. Designated stadia are those requiring a safety certificate under the Safety of Sports Ground Act 1975

## 7. Deflection limits

A barrier that is structurally safe should not possess sufficient flexibility to alarm building users. The horizontal displacement of any part of the barrier should not exceed 25 mm.

In a full height glazed barrier with an opening window, where there is an unrestricted opening below the level of 800 mm, a barrier or rail should be provided not more than 800 mm from the floor.

Glass in a fully framed fire resistant screen is normally treated as an infill panel subjected to the concentrated point loads given in Table 3. Its deflection should not exceed the smaller of 12.5 mm or L/125, where L is the longest dimension of the glass. For fire rated glazing systems that are supported on two edges only, additional structural calculations are necessary.

The frame section should give adequate edge cover to give the desired fire resistance to the glass.

Table 4 indicates sizes of glass panes for different types and thicknesses of glass which will withstand the design criteria of this standard. Significantly larger sizes may be possible depending on the shape of the pane and whether it is an insulating glass unit.

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Table 4 Sizes of fully framed single glass panes which will be in accordance with the design criteria given in BS 6180: Table 2

| Design criteria from Table 3 | Nominal glass thickness mm | Area for glass type ($m^2$) | | |
|---|---|---|---|---|
| | | Laminated glass | Toughened glass | Safety wired glass |
| Line load 0.36 $kN/m^2$ + UDL 0.5 $kN/m^2$ + concentrated load 0.25 kN | 6 | 3.6 | 3.8 | 3.4 |
| | 8 | 5.8 | 6.0 | - |
| | 10 | 8.4 | 8.6 | - |
| | 12 | 11.6 | 11.7 | - |
| | ≥15 | No limit | No limit | - |
| Line load 0.74 $kN/m^2$ + UDL 1.0 $kN/m^2$ + concentrated load 0.5 kN | 6 | 2.2 | 2.4 | 0.2 |
| | 8 | 4.2 | 4.3 | - |
| | 10 | 5.8 | 6.0 | - |
| | 12 | 7.8 | 8.0 | - |
| | 15 | - | 11.4 | - |
| | 16 | 12.9 | - | - |
| | ≥19 | No limit | No limit | - |
| Line load 1.5 $kN/m^2$ + UDL 1.5 $kN/m^2$ + concentrated load 1.5 kN | 6 | Not applicable | Not applicable | Not applicable |
| | 8 | Not applicable | 1.8 | - |
| | 10 | 0.2 | 4.2 | - |
| | 12 | 3.4 | 6.2 | - |
| | 15 | - | 9.0 | - |
| | 16 | 9.9 | - | - |
| | 19 | - | 13.5 | - |
| | 20 | 14.4 | - | - |
| | ≥24 | No limit | No limit | - |

## 8. Impact Resistance

In addition to resisting the design loads, the materials used should also be appropriate to resist impact forces. Glass should be in accordance with the safety glazing recommendations given in BS 6262:Part 4.

BS 6262 recommends a class of safety glazing with respect to "free path" criteria. The impact energy level will vary according to the position of the barrier relative to the unhindered distance a body can travel in a direction perpendicular to the surface of the protective barrier (the free path). The impact classes recommended with respect to free paths are:

Less than 1500 mm class C
Greater than 1500 mm class A

but these are not normally applied to "full height barriers" such as fire resistant screens, which should simply comply with BS 6262:Part 4.

## Conclusion

The designer of fire resistant glazed screens and partitions must not only establish the appropriate level of fire performance to ensure a safe building, but also assess building use and duty rating for resistance to impact and crowd pressure.

Members of the Fire Resistant Glazing Group are aware of the relevant British Standards and Codes of Practice. In conjunction with technical consultants, they are ready to advise specifiers on the supply and installation of constructions, as required by Building Regulation 7, that are appropriate for their use, and that perform the functions for which they are designed.

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# Basic Putty Fronting Glazing Techniques for Single Glass

4.1 June 2012

## 1 Introduction

This Data Sheet has been produced to enable the correct products to be selected for putty fronting single glass into timber, and steel windows that are coated with a variety of coatings.

The method of application is the same for all products. The performance of the products is dependent on the rebate dimensions of the frame, the selection of the correct materials, correct painting procedure and adequate maintenance. If more detailed information on the life expectancy of a product is required than is given in this Data Sheet, then the reader should contact its manufacturer.

## 2 Scope

The detail given in this document covers the glazing of the following glasses into vertical frames using a putty fronting technique:-

Clear float and sheet glass

Polished plate wired and unwired glass

Rough cast wired and unwired glass

Patterned glass

Toughened glass

**Note:**

Basic glass products are covered in BS EN 572, Parts 1-9.

Glazing techniques for insulating glass units are covered in GGF Data Sheet 4.2.

The glazing of fire resistant glass is covered in GGF Data Sheet 2.8.

For information on glazing techniques for other glasses, consult the glazing material manufacturer and the glass manufacturer. Information on plastics glazing sheet materials can be found in GGF Data Sheet 4.5.

## 3 Frame materials and coatings

The combinations of frame material and coatings covered in this document are:-

- Primed or base coat stained softwood, or hardwood to be site painted or stained after glazing.
- Galvanised steel to be site painted after glazing.
- Powder coated steel where no coating is to be applied after glazing.

For information on other frame materials, such as durable hardwoods where no coating is to be applied to the frame, or correctly prepared metal frame materials such as aluminium, bronze or ungalvanised mild steel, contact the glazing material supplier. Any evidence of frame material deterioration should be investigated.

## 4 Glazing materials

All fronting glazing materials are classified as setting glazing compounds, and are usually referred to as putties for site painted frames and plastic glazing compounds for site stained frames. The main components of putties are chalk and vegetable oil. The amount of each depends on the use of the putty; small quantities of polymeric additives provide different properties to the putty.

Putties 'set' through a combination of oxidation of vegetable oils together with loss of volatile material in steel frames, or absorption of oils into timber frames in the presence of moisture.

Linseed oil putty is manufactured solely from chalk and linseed oil using a very small amount of wetting agent to give a uniform product.

All the other putties and plastic glazing compounds are made from blends of vegetable oils, drying and non drying oils with solvents and/or polymers together with alternative fillers.

All the glazing materials form a skin, which is essential for the successful painting of the product.

Good performance of the glazing material is only achieved if the front fillet has a thickness and width within the range specified by the manufacturer for the product. If the dimensions are smaller the material will crack prematurely; if the dimensions are larger the material will not set and will remain soft. In extreme cases this will lead to oil seepage from the material.

The following materials are available and cover almost all the situations where a fronting product is requried.
With the exception of some of the Rapid Set putty types the following putties are only suitable for use in externally applied putty fronting techniques. Depending upon individual manufacturer claims, some of the Rapid Set putties may be used for internal putty fronting.

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### 4.1 Linseed oil putty

Linseed oil putty is designed for fronting into softwood frames coated with a primer made to BS 5082 or BS 5358. Site painting after glazing is required.

In order to achieve good setting, some of the oil from the putty must be absorbed by the timber. The primers specified allow the correct amount of oil to be absorbed by the timber. Multiple coats of primer or primer plus undercoat will prevent the oil being absorbed by the timber, and will result in poor setting of the putty.

### 4.2 Metal casement or steel sash putty

These are designed for use in steel or non-porous hardwood frames where oil cannot be absorbed by the frame. Good setting is achieved by the choice of vegetable oil blend and a small percentage of solvent. Also, a small percentage of non-drying polymeric component forms part of the compound which allows the putty to accommodate the thermal movement of the steel frame after it has set. These putties require painting after glazing.

### 4.3 Plastic glazing compound

Traditional putties such as linseed oil putty and metal casement putty require painting and will only accommodate the limited movement that occurs in a frame coated with traditional undercoat and gloss. Plastic glazing compounds are designed to be used either in steel frames which are factory painted and where no painting will be carried out after glazing, or in base coat stained timber frames to be coated with microporous stains after glazing. These stains allow moisture vapour to pass through the coating into the wood, which results in significantly more movement of the wood than in a painted frame.

The initial set of plastic glazing compounds is by loss of solvent followed by reaction with oxygen in the air.

They should be used in sealed rebates, as loss of oil into the frame material will result in shrinkage and cracking of the compound.

### 4.4 Multipurpose or dual purpose putty

These are suitable for glazing into either primed or steel frames where painting is to be carried out after glazing.

Good setting is achieved by the correct choice of vegetable oil blend in the formulation, which will also usually contain non-drying polymer elements and solvents. Putties formulated in this way accommodate the thermal movement of a steel frame after it has set.

### 4.5 Rapid set putty types

Some manufacturers offer rapid set putty types. As the name indicates, these materials are suitable for use in situations where an accelerated skinning time, rate of set and overpainting are required over the range of more traditional putties. Depending upon the claims of the individual putty manufacturer, these materials are suitable for glazing most single glass types into a selection of painted softwood, hardwood or steel frames. Like all vegetable based putties and to ensure good service life these materials also require overcoating after application.

These putty types tend to be two part materials (base putty and a hardener) and tend to owe their inital skinning and cure characteristics to an accelerated chemical reaction rather than the slower skinning, oil absorption and volatile loss processes employed by more traditional putties.
These putty types can typically be overcoated within 4 to 7 days after application and set through considerably quicker than traditional putties.

In addition, due to the accelerated skinning and setting characteristics, some of these putty types are also suitable for internal fronting techniques where traditional puttties cannot be successfully used.

## 5 Frame storage, fitting and preparation

### 5.1 Storage and fitting of frames

Do not allow frames to be stored without adequate protection against mechanical damage or exposure to rain. Care must be taken during frame installation to avoid undue stress around the rebate joints. Excessive moisture content before installation will result in shrinkage of the timber and the opening up of joints, which can lead to water ingress through the joints. Follow manufacturers' instructions on both storage and installation.

### 5.2 General points applicable to all frames

- Check that the frames have not been damaged.
- Check that the moisture content of a timber rebate/frame is not excessive. High moisture contents at the time of glazing may lead to shrinkage of the timber, followed by subsequent opening of joints or loss of adhesion of glazing putties, which can result in water ingress.
- Ensure that the rebate surfaces are clean, dry and free from dust, grease and cement spatters. Wipe clean with a paper towel.
- Check that the frames are ready for glazing, and that any specific sealers or primers required for a product have been applied.
- Where a primer or base coat stain has weathered considerably, the frame should be recoated before glazing.

### 5.3 Timber frame preparation

#### 5.3.1 Softwood to be painted

Softwood frames to be painted are usually supplied with a paint priming coat. If supplied uncoated, consult the paint manufacturer for any appropriate primer system. It is important to ensure that the priming paint is sufficiently dry and hardened.

### 5.3.2 Softwood to be stained

Softwood frames to be stained are usually supplied with one coat of a base coat stain. If supplied uncoated, consult the stain manufacturer for an appropriate base coat stain.
Apply two coats of the sealer recommended by the plastic glazing compound manufacturer to the surfaces of the rebate that will be in contact with the compound.

### 5.3.3 Hardwood to be painted or stained

Apply two coats of the sealer recommended by the glazing material manufacturer to the surfaces of the rebate that will be in contact with the glazing material.

### 5.4 Steel frame preparation

### 5.4.1 Galvanised steel and painted steel

Where the rebate has been primed, check that the primer has fully hardened by gently rubbing its surface with a cloth soaked in white spirit. The primer should not be removed by the white spirit if it has fully hardened.
**Note:** Galvanised steel does not require priming if the galvanising has become weathered.

### 5.4.2 Powder coated steel

Powder coated steel does not need priming before glazing.

## 6 Glazing material

### 6.1 Selection of glazing materials

The table below gives the products to use for various combinations of frame material and coating.

| | **Coating** | | |
|---|---|---|---|
| **Frame Material Coating** | **Paint** (Site applied) | **Stain** (Site applied) | **Powder** (Factory applied) |
| Softwood | Linseed Oil Putty or Multipurpose Putty | Plastic Glazing Compound | |
| Hardwood | Metal Casement Putty or Multipurpose Putty | Plastic Glazing Compound | |
| Steel | Metal Casement Putty or Multipurpose Putty | | Plastic Glazing Compound |

### 6.2 Storage of glazing materials

Store materials in the dry, out of direct sunlight and at temperatures not exceeding 25°C.

### 6.3 Preparation of glazing materials before glazing

Immediately before glazing, prepare putty for use by working to a smooth consistency, which is free from lumps and with separated oils thoroughly mixed in.

## 7 Glazing procedure

**7.1** Apply putty to rebate and insert setting blocks.

**7.2** Place pane on setting blocks, centralise, press into putty to give a back bedding of 1-2mm throughout and secure pane with metal sprigs or clips. The use of glazing blocks may be required for certain types of opening window.

**7.3** Apply further fronting putty and knife off at an angle finishing about 2mm below sight line.

**7.4** Brush putty with soft brush to seal to glass.

**7.5** Knife off back bedding, sloping away from glass.

## 8 Painting of fronting glazing materials

All fronting glazing materials, except for the plastic glazing compound for powder coated steel should be painted with either white spirit or water based paints.

DO NOT USE PAINTS WITH STRONG SOLVENTS SUCH AS XYLENE.

The fronted material should have a strong skin and should be firm enough to take the paint before it is applied. If this is not the case brush marks or wrinkling will occur on the surface.

The initial set of putties in painted softwood frames occurs as a result of both oil absorption from the putty into the timber and the formation of a skin.

The initial set of plastic glazing compounds in a stained timber frame occurs as a result of loss of volatile material from the compound followed by the formation of a skin.
The initial set of putties and plastic glazing compounds in steel frames is by loss of volatile material from the compound followed by the formation of a skin. Early application of a paint system may trap volatile material and/or slow down the oxidation of vegetable oils which may result in a slow or poor setting putty.

After the initial set the putties can be painted. The recommended painting times are as follows:-

| **Glazing material** | **Minimum time for first coat (days)** | **Maximum time for first coat (days)** |
|---|---|---|
| Linseed Oil Putty | 7 | 28 |
| Metal Casement Putty | 7 | 21 |
| Multipurpose/Dual Purpose Putty | 7 | 28 |
| Plastic Glazing Compound | 7 | 90 |
| Rapid Set Putty | 4 *Depending upon manufacturer recommendations* | 28 |

**Note:**

- Glazing material must have formed a strong skin and be firm enough to take the paint before application.
- In cold weather the minimum painting times should be increased, in hotter weather the maximum times should be reduced.
- For small fillets the maximum painting times should be reduced, for larger fillets the minimum time should be increased.
- If the surface skin is disturbed before painting, this can result in problems with both the paint and the set of the putty.

## 9 Further setting of putties

After painting the glazing material will continue to set as a result of further oxidation of the vegetable oil. The rate of a set of putty depends on the size of the fillet, how quickly the putty was painted, the porosity of the coated timber and ambient conditions.

In general, slower setting occurs with larger fillet sizes, earlier painting and the porosity of the coated timber.

Warmer ambient conditions will give faster skinning times. Information on recommended fillet sizes and painting times are given in the manufacturer's literature.

The further setting is relatively slow, taking about a year to become hard. However under certain conditions it is possible to make an indentation in the surface of a putty with finger pressure one to two years after glazing.

Putty fronting without glazing pins or clips is not recommended, and in terms of current British Standards, is not a secure method of glazing until the putty has set hard. This period can be up to about two years.

It is possible to improve the security of windows glazed with single glass using a fronting system. For information on the options available consult the glazing material manufacturer.

## 10 Maintenance

### 10.1 Introduction

It has been assumed that adequate provision for suitable and safe access for the maintenance of the glazing systems is either incorporated into the design of the building or otherwise allowed for.

Be sure to provide written advice to the homeowner to check periodically the condition of the frame coating and glazing system.

The coating on the frame protects and stabilises the frame and joints. Failure to maintain the coating will lead to excessive movement of the frame, putting extra stress on the glazing, resulting in a reduction of its service life.

Distortion of the frame can also be caused by a failure to insert glazing blocks correctly. In extreme cases reglazing will be necessary.

### 10.2 Maintenance of the frame finish

Site applied frame finishes require regular maintenance. The coating on the horizontal surfaces will deteriorate more rapidly than on vertical surfaces.

Similarly the coating on a south elevation (which is subjected to greater levels of sunlight) will deteriorate more rapidly than other elevations.

The period between maintenance will vary from as little as 1 to 2 years for south facing horizontal surfaces coated with dark coloured, low build microporous stains, up to 6 years for long life coatings in less severe exposures.

The specification of the actual coating on the frame is important, and details of suitable maintenance for coatings should be obtained from the manufacturer.

### 10.3 Maintenance of the glazing system

Maintenance schedules consist of regular inspections of the glazing systems and, when necessary, the replacement of defective glazing material.

To give a weathertight seal, a glazing material must adhere well to all the surfaces with which it is in contact. The movement that occurs between the frame and the glass, together with the effect of the weather can, over a period of time, break down the adhesion of the glazing material. This loss of adhesion results in the formation of a fine split between the glazing material and the glass.

When such splits first form it is difficult to see them with the naked eye. Some materials, particularly those applied by hand, can shrink and set hard on ageing. Cracks will appear, initially in the paint, and then through the glazing material.

It is possible to re-seal fine splits between the glazing material and either the glass or the frame with paint or stain, without having to recoat the whole frame. Where splits have widened and are too large to seal with paint – or where cracks have formed in the glazing material – the defective length should be replaced with the same type of glazing material.

# System Design and Glazing Considerations for Insulating Glass Units (IGUs)

4.2 December 2009

**Contents**



GGF

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## Part 0 General

### 0.1 Introduction

The overall purpose of the data sheet is to provide up to date information aimed at achieving the longest possible service life from installed Insulating Glass Units (IGUs).

In order to achieve the optimum service life from IGUs they must be well designed and constructed to meet the requirements of BS EN 1279, and glazed into well designed frames using durable glazing materials with good on site or factory workmanship followed by adequate maintenance.

This data sheet is intended to provide information for architects, specifiers, builders, frame manufacturers glazing companies and IGU manufacturers. This should lead to a more knowledgeable selection of frames and frame finishes, improvement in glazing specifications, and more efficient on site supervision and workmanship.
For ease of reference the data sheet has been divided into the following sections;

- General considerations
- IGU design
- Frame design
- Glazing Systems; including selection; workmanship and maintenance

A glazing company and or supplier of IGUs may not have control over all the factors affecting service life of the IGUs. It is hoped that by providing more information on all the important factors, the people who do have control will understand their responsibilities and take appropriate action.

### 0.2 Scope

This data sheet gives the principles underlying the correct glazing of IGUs into windows and doors for UK exposure conditions, and includes descriptions of the glazing methods recommended by the Glass and Glazing Federation. The document is applicable to both site glazing and factory glazing.

The following applications are excluded from the scope of this data sheet, although the principles of glazing of IGUs set out in this data sheet should generally be applied for all situations.

- Curtain walling
- Structural glazing
- Sloped glazing
- Stepped IGUs
- Special Applications such as explosion resistant glazing, bullet resistance, fire resistance, etc

### 0.3 Definitions

- **Bedding.** The glazing material which seals IGUs and beads in the rebate.
- **Back bedding.** The glazing material between the face of the glass and the rebate upstand after the IGU has been pushed into position.
- **Front bedding.** The glazing material between the face of the glass and the bead.
- **Capping.** A sealant applied to fill the gap above a strip glazing material positioned between the IGU and the rebate upstand and/or bead.
- **Cavity.** The space between the panes of glass in an IGU.

- **Cellular Adhesive Sections:** Rectangular or profiled closed cell synthetic rubber or polymeric section with self-adhesive backing
- **Clearances (see fig 1):-**
- Edge clearance. The distance between the edge of the IGU and the rebate platform.
- Back clearance. The distance between the IGU and the rebate upstand.
- Front clearance. The distance between IGU and bead.
- **Flush edged IGU.** An IGU in which the panes are of equal size.
- **Load bearing strip sealant.** A strip sealant capable of withstanding the wind pressure exerted on an IGU without distortion. Strip sealant suppliers should advise the maximum IGU sizes that can be glazed for different exposure conditions, and edge covers.
- **Organic Spacer.** An organic material containing desiccant used to create the space between the glass panes.

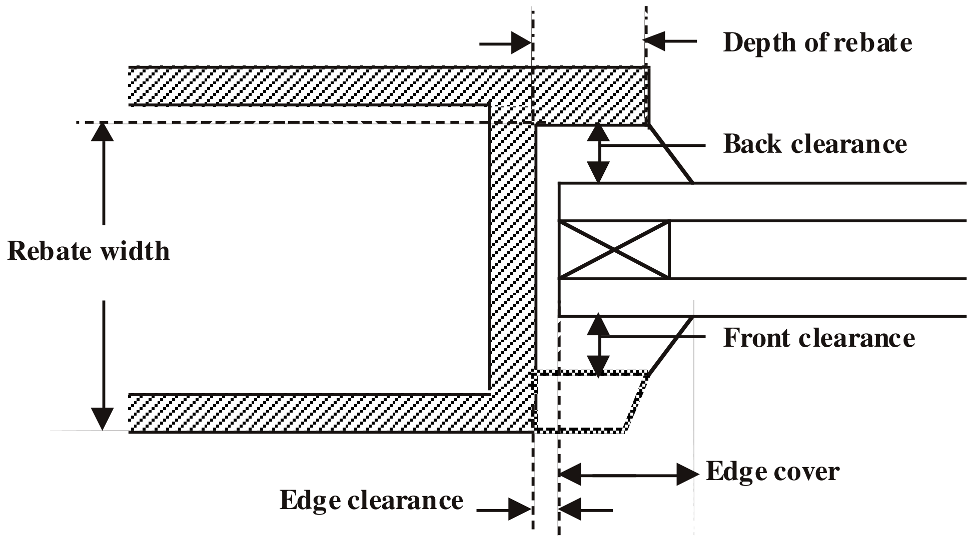



**Figure 1**

- **Edge cover (see fig 1).** The distance between the edge of the IGU and the sight line.
- **Glazing:-**
- External glazing. Glazing where one face is exposed to the outside of the building.
- Internal glazing. Glazing where neither face is exposed to the outside of the building.
- Outside glazing. External glazing in which the glass is inserted from outside the building.
- Inside glazing. External glazing where the glass is inserted from inside the building.
- **Glazing material.** A material which provides a bedding for the glass and forms a joint between the glass and frame. The term includes glazing compounds, sealants, putties, glazing strips and tapes, and gaskets.
- **Heel bead/Toe bead.** A bead of sealant applied between the edge of the IGU and the rebate angle, or between the edge of the IGU and the glazing bead.
- **Inner Sealant** (Also known as The Primary Sealant in a dual seal IGU). A sealant which, when applied, is in contact with the cavity of the IGU.
- **Insulating Glass Unit (IGU).** An assembly consisting of at least 2 panes of glass, separated by one or more spacers, hermetically sealed along the periphery, mechanically stable and durable.
- **Outer Sealant** (Also known as The Secondary Seal in a dual seal IGU) a sealant which, when applied, is in contact with the environment outside the IGU.
- **Primer.** A coating applied to a surface to improve the adhesion of compounds or sealants.
- **Rebate upstand.** The face of the rebate which is parallel to the faces of the IGU.
- **Rebate platform.** The face of the rebate which makes an angle with the upstand to form the complete rebate.
- **Sealer.** A coating applied to a porous surface to prevent migration from compounds or sealants subsequently applied to that surface.
- **Sizes (see figure 2):-**
- **Sight size.** The actual size of the opening which admits daylight, as measured between the sight lines.
- **Tight size.** The actual size of a rebate opening, as measured between the rebate platforms.
- **Sight line.** The perimeter of the opening which admits daylight.
- **Spacer.** A component used to separate the panes and control the width of the gap at the edge of the IGU.
- **Tolerance.** The difference between the nominal dimensions and the actual dimensions. Tolerances are given as positive and negative differences from the nominal dimensions.

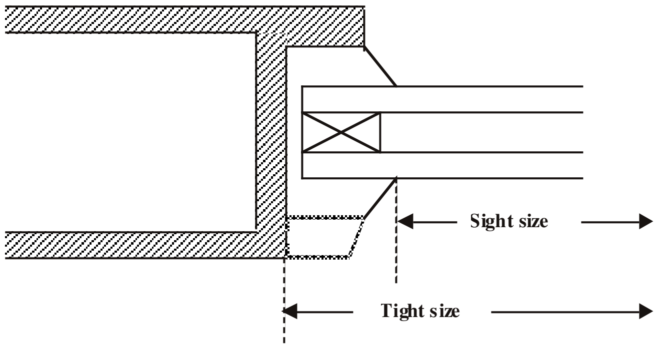



**Figure 2**

### 0.4 Principles of glazing

### 0.4.1 General principles

The fundamental principles underlying glazing of IGUs in order to achieve a long service life are:

- Prevention of prolonged contact of moisture with the edge seal of the IGU
- Compatibility between the edge seal and other components of the IGU, the glazing materials and, if applicable, coatings on the glass and on the frames
- Protection of the edge seal of the IGU against direct sunlight
- Quality of workmanship
- Suitable frame design
- Accommodation of frame movement

**Note:** IGUs are fundamentally different from single glasses, in that they have an edge seal. However well they are glazed, IGUs cannot be expected to have the same life expectancy as single glass.

### 0.4.2 Prevention of prolonged contact of moisture

The major cause of IGU failures is associated with water. If liquid water is trapped against the edge seal of a IGU failure of the adhesive bond of the sealant to the glass may result. This will allow water and/or moisture vapour to pass between the edge sealant and the glass, leading to excessive moisture vapour in the IGU cavity and ultimately to condensation on internal glass surfaces.

Even if failure of the adhesive bond of the sealant does not occur the presence of liquid water in the glazing rebate may lead to premature failure of an IGU.

Water in the form of moisture vapour is able to permeate through the edge sealant into the IGU cavity. The rate of permeation of moisture vapour is dependent on the properties of the edge sealant(s), and on the concentration of moisture vapour. However low the rate of moisture vapour permeation, it is inevitable that, after a period of time, excess moisture vapour in the IGU cavity will occur, and condensation on the internal glass surfaces will result.

Moisture can penetrate into the glazing rebate, either through or around the glazing system, or through the frame joints, from a variety of sources such as:-

- Rainwater
- Window cleaning operations
- Condensation within frame sections
- Condensation on the room side or outside glass surfaces

All glazing systems must protect the edge seal of the IGU, either, by ensuring that any water which penetrates as far as the edge seal is soon removed by drainage and ventilation of the rebate area, or by preventing access of water to the seal.

Glazing methods for IGU fall into two groups, known as (1) drained methods, and (2) solid bedding methods.

1) Drained methods are based on the principle that some water may penetrate the glazing rebate; and while this is kept to a minimum, provision is made in the design of the frame to ensure that any water that does penetrate is removed by drainage and ventilation.

2) Solid bedding methods protect the seal of the IGU by embedding the edge of the IGU in compound or sealant to prevent moisture coming into contact with the edge seal.

### 0.4.3 Compatibility

Edge seals have different levels of compatibility with different glazing materials. Edge seals and glazing material are considered to be compatible if, when they are in direct contact with each other, or in close proximity, the performance of either is not reduced in any way as a result and there is no adverse effect to the performance of the IGU.

When using glazing methods where there is likely to be contact between the edge seal and the glazing material, it is essential to check that the edge seal and the glazing material are compatible. (See GGF data sheet 4.9 Compatibility of Glazing Sealants and Compounds with Insulating Glass Units.).

Some IGUs are provided with an edge tape. In such cases it is essential that a check is made to confirm that the tape is compatible with the proposed glazing system and the outer seal of the IGU and has long term adhesion. (see also Part 1 Clause 1.1.3, and Part 3 Clause 3.2.1).

### 0.4.4 Exposure to sunlight

The seals on some IGUs can degrade if exposed to direct sunlight. It is important, therefore, to ensure that the rebates provide full cover of the seal of the IGU. (Ref to later section 2.4.4 & 2.4.5)

### 0.4.5 Quality of Workmanship.

See Part 3 section 3.2 Workmanship.

### 0.4.6 Suitable Frame Design.

See Part 2.

### 0.4.7 Frame Movement.

All frame materials will move during their service life as a result of climatic conditions and therefore should be considered during the design process.

# PART 1. IGU DESIGN

## 1.1 Design considerations

Reference should be made to the European standard BS EN 1279 for IGUs, and to the relevant parts of the Building Regulations. In order to conform with the Construction Products Directive (CPD), to CE mark and to legally place products onto the market, conformance to BS EN 1279 must be demonstrated.

There are many component parts used in the manufacture of IGUs. The selection, design and assembly of these individual components play a major role in the performance of the IGU, and the correct combination of these materials will improve the long-term durability of the IGU. It is important to ensure that all materials used in the construction of the IGU are compatible and, when assembled, meet the requirements of BS EN 1279. A brief review of the major components used in the manufacture of IGUs follows.

### 1.1.1 Glass

A wide variety of glass types is available for IGU manufacture. These should be checked for compatibility with the edge sealant(s) and other components. The sealant(s) should have excellent adhesion to un-primed glass as defined in part 4 of BS EN 1279, In the case of some coated glasses, it may be necessary to remove the coating from those surfaces to which the edge sealant has to adhere, and the advice of the glass manufacturer should be obtained.

The glass must also be compatible with the glazing materials used. For instance, if a laminated glass is used in the construction of a IGU then care should be taken to ensure that the glazing materials do not affect the appearance or performance of the interlayer e.g. acid-cure glazing materials, or those containing oil or solvents, are known to affect interlayer materials adversely and therefore should not be used to glaze laminated glass.

### 1.1.2 Edge sealant

A wide variety of sealants is used in the manufacture of IGUs.

The manufacturer should always carry out a full evaluation of any new sealant to confirm its performance with the proposed IGU design (in accordance with BS EN 1279)

Performance features of the sealant (or combined sealants in a dual seal system), which need to be considered include:-

- Compatibility with glazing materials
- Moisture vapour transmittance
- Compatibility of inner and outer sealants
- Adhesion qualities
- Resistance to service temperature

### 1.1.3 Edge tapes

Self-adhesive edge tapes are sometimes applied by the IGU manufacturer to the perimeter of the IGU.

The purpose of the edge tape is usually to improve the aesthetic appearance of the IGU or to facilitate handling and should always be removed prior to glazing, unless it is a functional part of the design, and included in the initial type test to BS EN 1279. In this case the use of edge tape will be included in the manufacturers' system description and therefore must remain in place when the IGU is glazed. If edge tapes are used they should be applied after quality control final inspection.

The application of edge tapes may reduce the life expectancy of the IGU especially in cases where the tape is badly applied or is damaged during handling. Water may enter between the tape and the glass and be trapped against the edge seal for prolonged periods, particularly in the case of drained glazing systems. The adhesives on some edge tapes are water-sensitive and may suffer loss of adhesion to the glass, thereby increasing the likelihood of water entering between the tape and the glass. Certain adhesives used on the tapes may be incompatible with the outer seal of the IGU.

In cases where an edge tape is wrapped around the edge of the IGU onto the face of the glass, and where the glazing material is required to adhere to the glass, the edge tape will reduce the effective bonding area depending on the distance by which the tape extends onto the face of the IGU.

### 1.1.4 Spacer

There are many materials, shapes, sizes and surface finishes used in the manufacture of spacers. Commonly these are hollow tubes. The IGU manufacturer should always check the suitability, compatibility and adhesion of the edge sealant(s) to the spacer. If for any reason the spacer or its surface treatment is changed, then testing of the new spacer with the edge sealant(s) should be carried out according to BS EN 1279.

The spacer frame can be manufactured in several ways. The way in which the corners are formed may affect the life of the IGU. Corners may be formed using corner keys, or by welding, or by bending the spacer.

When using hollow spacers of various widths, the IGU manufacturer must ensure sufficient desiccant is held within the spacer frame system to ensure long-term performance of the IGU.

In some IGU constructions, rather than being a hollow tube, the spacer is a desiccant filled organic sealant which may be pre-formed. The pre-formed sealant spacer may contain an impermeable barrier in the form of a metal strip or other material. The desiccant is blended into the sealant by the sealant manufacturer rather than being filled at the time of IGU manufacture.

### 1.1.5 Desiccant

Desiccants principally adsorb moisture vapour from the IGU cavity to prevent condensation on the cavity surfaces of the IGU. They are produced in a variety of forms and blends, ranging from silica gel to pure molecular sieve of various granule sizes. Selection will depend on specific requirements.

The IGU manufacturer should always ensure the suitability of the desiccant system, including the quantity required. For example, if a component of the IGU contains a volatile material, then a specific desiccant blend, that will adsorb both water and solvent, should be selected.

Certain desiccants have the capability to adsorb nitrogen from the IGU cavity particularly at low temperatures. This can result in excessive glass deflection and, with certain combinations of edge sealant and spacer design, can lead to glass breakage.

### 1.1.6 Edge seal

The edge seal system is designed to adhere to the glass panes and spacer, to prevent moisture from penetrating the unit cavity, and where appropriate to retain gases within the cavity.

In principal there are two basic edge seal configurations:-

- Single seal systems
- Dual seal systems

**Single seal** systems rely on the sealant to act as the vapour and gas barrier, and as the adhesive to hold the panes of glass together. This single seal can be provided by chemically curing sealants, or by hot-applied, butyl-based sealants (commonly known as hot melt butyls), or can be in the form of a preformed organic spacer, which may contain an impermeable barrier - see figure 3.

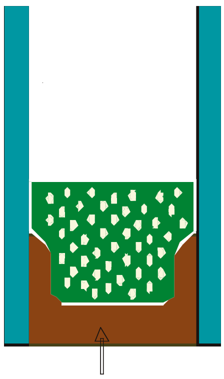



**Figure 3**

With single seal systems, production aids such as adhesive tapes may be used to hold the spacer frame in position on the glass while the edge sealant is applied and allowed to cure. These tapes do not increase the life expectancy of the IGU.

**Dual seal** systems are produced using an inner or primary seal and an outer or secondary seal.

The primary seal is normally produced from polyisobutylene (PIB), which is the main moisture vapour barrier of the IGU or can be in the form of a preformed organic spacer, which may contain an impermeable barrier. During assembly it firmly holds the glass and spacer together while the secondary sealant is applied.

The outer or secondary seal is either produced from chemically curing sealants, such as. silicones, polysulfides, polyurethanes, or from hot-applied butyl materials. These sealants must have excellent long term adhesion to the glass and spacer frame in order to hold these components together during the service life of the IGU. (See Figure 4).

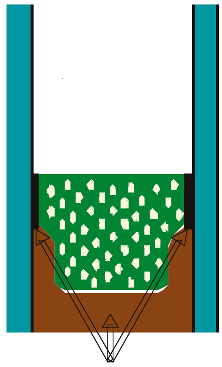



**Figure 4**

It is critical in the manufacture of IGU that the edge sealant is applied correctly, in accordance with the manufacturer's system description. Some defects can dramatically reduce the service life of the IGU and may include amongst other things, gaps in the primary sealant, voids in the secondary sealant and uncured secondary sealant.

### 1.1.7 Gas filling

To improve the thermal, and in some cases acoustic, properties of the IGU the air in the cavity is sometimes replaced, either partially or wholly with specialist gas(es) such as argon, krypton etc.

### 1.1.8 Other components

A variety of other components may be incorporated in the IGU design (e.g. self-adhesive lead strip, Georgian bar inserts, coloured films), which could have an effect on the performance of the IGU. The component manufacturer should be consulted regarding their use.

## 1.2 Sizing the IGU

Tolerances from the nominal dimensions of the IGU and the frame tight size should be taken into account, to enable the required minimum edge clearance given in Clause 2.4.3 to be achieved. Refer to BS EN 1279: Part 1 for information relating to tolerances of IGU

The IGU length or height = F - C - du - df,

Where **F** = nominal frame tight size,

**C** = sum of the two edge clearances,

**du** = maximum IGU tolerance,

**df** = maximum frame tolerance.

An example using this calculation procedure is given in Appendix 1.

## PART 2. FRAME DESIGN

### 2.1 Introduction

This section details the important features of a frame which have a significant effect on the performance of the glazing system, and ultimately on the service life of the IGU that is glazed into the frame.

In order to be suitable for the glazing methods described in Part 3 of this data sheet, frames must meet the requirements detailed in this section of the data sheet.

### 2.2 Frame selection

When selecting a window frame the specifier should ensure that:-

- the materials used are suitable for the proposed method of glazing
- the rebate height is sufficient to give adequate edge cover and edge clearance for the IGU.
- the rebate platform is of sufficient width to allow for the required thickness of glazing material each side of the IGU, and for the correct positioning and fixing of the beads;
- the beads have the required dimensions to enable them to be positioned and fixed correctly.
- the design of any drainage/ventilation system is adequate for the rapid removal of any water that may enter the glazing rebate.

### 2.3 Traditional frame materials and construction

#### 2.3.1 Steel frames

Steel frames should be made from hot rolled sections in accordance with BS EN 10025 S235JR, manufactured to meet the requirements of BS 6510.

The coating on the surface of the steel can affect the choice of glazing material (see 2.3.5.1 Frame finishes).

#### 2.3.2 PVC-U frames

PVC-U frames are made from extruded hollow profiles which should conform to the appropriate standards (BS EN 12608, and BS 7722). The frames should be fabricated from these profiles in accordance with the recommendations of the system designer and in the case of white frames conform to BS 7412.

#### 2.3.3 Aluminium frames

Aluminium frames are made from extruded profiles. The frames should be fabricated from these profiles in accordance with the recommendations of the system designer, and should conform to BS 4873.

The finish on the surface of the aluminium can affect the choice of glazing material (see 2.3.5.2 Frame finishes).

#### 2.3.4 Timber frames

The basic design, in terms of the requirements for materials (including preservative), profile design, workmanship, construction, security and safety, weather-tightness, and operation and strength performance, should be in accordance with BS 644.

The coating on the surface of the timber can affect the choice of glazing material (see 2.3.5.3 Frame finishes).

NB Other frame materials may be available that are not covered here

#### 2.3.5 Frame finishes

##### 2.3.5.1 Steel frames

Steel frames are usually finished with a factory applied coating, or if not, may require painting on site. Some glazing materials may not be compatible with the various finishes used, and advice should be sought.

##### 2.3.5.2 Aluminium frames

Aluminium frames are finished with a factory applied coating or an anodised finished which requires no further treatment. Advice should be sought regarding the suitability and compatibility of glazing materials.

##### 2.3.5.3 Timber frames

Timber frames are manufactured from a variety of types of wood (hard and soft) and supplied with various types of treatment or coatings. Advice should be sought regarding the suitability and compatibility of glazing materials and finishes.

##### 2.3.5.4 PVC-U frames

PVC-U frames are supplied ready for use and do not require surface finishing.

### 2.4 Glazing rebate and bead requirements

#### 2.4.1 General principles

The upstand of the glazing rebate must have sufficient height to provide sufficient edge cover, plus edge clearance.

Glazing rebate widths must allow for the thickness of the IGU; plus the thickness of the glazing materials; to ensure that beads can be securely fixed.

#### 2.4.2 Specific requirements for drained or drained and ventilated glazing systems

These systems should be designed to minimise the amount of water that may enter the glazing rebate. The drainage system of the frame must ensure the rapid removal of any water from the rebate platform.

The rapid removal of water from the glazing rebates to the outside is best achieved for timber frames by the incorporation of a sloping platform.

A slope of 1 in 10 (6°) is recommended for the bottom platform of a timber frame. Alternatively, gutters with holes may be used for aluminium or PVC-u frames (see Figure 5 for examples). A typical system should include drainage holes at least 8mm in diameter, or slots at least 25mm x 5mm to ensure the passage of water.

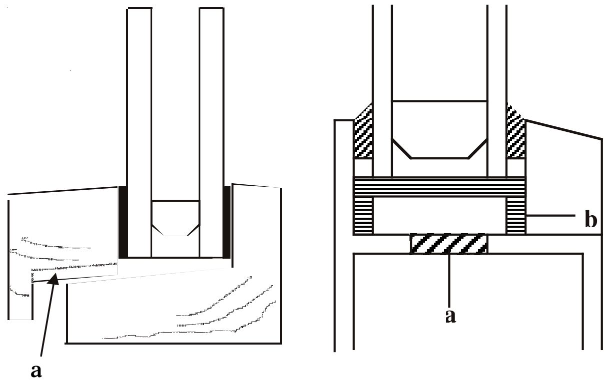



**Figure 5**

**Figure 5. Drained glazing system – a Drainage hole or slot – b**

It is difficult to ensure the removal of all water from the glazing rebates by drainage alone. Water may be trapped, or may be held by surface tension, either as droplets or between opposing surfaces, even though the design should prevent this happening. Ventilation may be necessary to dry out these areas. This is particularly true of frames with horizontal platforms, or where moisture may collect on the top edge of an IGU. The degree of ventilation achieved is not only dependent upon the size of the ventilation holes or slots, but also upon their position and accessibility to prevailing winds. Slots of 20mm x 3mm can be adequate for ventilation in exposed parts of the window, but further ventilation is probably necessary in more protected parts.

To prevent wind-driven water being carried into the frame section, all exposed holes and slots should be protected, either by fitting hoods, or by forming the slots in a position in the frame where they are not subject to direct wind and weather.

### 2.4.3 Edge clearance

Edge clearance is necessary to prevent frame-to-glass contact, to ensure drainage and allow for differential thermal expansion of the IGUs and frames.

For drained/ventilated glazing systems edge clearance is necessary to prevent water from bridging between the rebate platform and the edge seal of the IGU. The edge clearance should be sufficient to allow for thermal movement, and the recommended minimum is 5mm. For very well drained and ventilated frames, the clearance can be reduced for the side and top rebates, to a minimum of 3mm in the case of glass lengths up to 2m.

For solid bedded glazing systems there should be sufficient edge clearance to enable the perimeter of the IGU to be fully bedded to the rebate platform. If any voids are left around the perimeter of the IGU, there is a possibility that water entering through open corner joints in the frame will pass through the voids to the perimeter of the IGU, and cause premature failure. For IGUs less than 18mm thick and up to 2m long a minimum edge clearance of 3mm is required; for IGUs over 2m long or over 18mm thick, a minimum edge clearance of 5mm is required.

### 2.4.4 Edge cover

This is required around the edge of an IGU, to provide adequate mechanical support, and to protect the edge sealant from attack by sunlight. In some cases, for example with steel frames, further protection of the edge seals can be obtained from the glazing material which can be sloped to finish several millimetres above the frame sight line.
Mechanical support is provided by the rebate upstand and bead.

Typically for IGUs made with a spacer and edge sealant, a minimum edge cover of 12mm is required to keep the spacer below the sight line and to protect the edge sealant. However other spacers may be available to allow for reduced edge cover.

### 2.4.5 Rebate height

The rebate height should provide sufficient edge clearance and edge cover for the IGU to meet the requirements described above, and should take account of the sight and tight size tolerances for both the IGU and the frame

For example with an IGU that requires 12mm edge cover and a minimum 5mm edge clearance when glazed into a timber or metal frame, a rebate height of 20mm will ensure that adequate edge clearance is achieved for most combinations of IGU and frame tolerances. However this will not give complete cover to the spacer where the frame tolerances approach the maximum, and the IGU tolerances approach the minimum.

For PVC-U frames, where manufacturing tolerances may be larger, the minimum rebate heights will need to be 22mm for the bottom rebate and 20mm for the top and side rebates.

An example rebate height calculation is given at Appendix 1.

### 2.4.6 Rebate platform

The width of the rebate should be sufficient to provide the required front and back clearances and to provide sufficient contact of the glazing beads onto the platform. The width of the rebate platform should be equal to the sum of the front and back clearances, the nominal thickness of the IGU, the width of the bead, and an allowance for the tolerances on IGU and bead thicknesses.

For example, in order to achieve 3mm of glazing material (to fill the front and back clearances) each side of the IGU, for a 24mm IGU the rebate platform should be 24mm + 6mm + the width of the bead + a typical allowance for the tolerances on IGU thickness, say 1mm, making a total of 31mm plus the width of the bead.

### 2.4.7 Beads

Timber beads for timber frames should have an installed height equal to the rebate height, and a width in contact with the rebate platform greater than the height, to enable firm fixing of the bead to be achieved. Normally external, top and side beads should not project beyond the face of the frame, and are flush with the face. If top beads project, this could encourage water penetration which could lead to reduced life of the IGU. Additional sealing of a projecting top bead is required.

The bottom bead should run the full tight size width of the frame. The bottom bead should not be recessed in from the frame face, and may project beyond the face.

If timber beads are fixed with screws these must be at no more than 75mm from each corner and at not more than 200mm centres. If pins are used they must be twice as long as the bead height and fixed no more than 50mm from each corner and at not more than 150mm centres.

Beads for metal and plastics frames should have a height equal to the rebate height, and must be designed to be fixed to ensure they cannot move or distort, and to securely retain the IGU and the glazing seals.

## PART 3. GLAZING SYSTEMS FOR IGUs

### 3.1. Glazing system selection

The following factors should be considered in selecting the glazing system:-

#### 3.1.1 Frame design

The selected glazing system must be appropriate for the frame design.

Consideration should be given to whether drainage and ventilation provision is adequate where required. (See Clause 2.4.2 above).

#### 3.1.2 Compatibility

The glazing materials should be compatible with each other and with the edge seal of the IGU , glass components and the frame finish.

#### 3.1.3 Glass type

Special glazing system requirements may be necessary for some glass types, e.g. self cleaning glass.

#### 3.1.4 Special environments

Special environments must be taken into account e.g. swimming pools, chemical plant.

#### 3.1.5 Factory glazing / site glazing

Factory glazing provides a controlled environment and better control of workmanship than site glazing.

#### 3.1.6 Site Glazing

In the case of site glazing, account must be taken of whether the IGUs are to be inside or outside glazed. For inside glazing, special care should be taken in the selection of drained frames.

#### 3.1.7 Access

The availability of temporary or permanent access to the outside of the building must be considered for maintenance purposes, (see clause 3.5)

#### 3.1.8 Colour

If desired the glazing material colour should be selected to compliment the frame colours.

### 3.2 Workmanship

In order to achieve the maximum service life of an IGU it is important that the frame design is correct and it is also important to follow the specified glazing procedure.

Glazing contractors should be properly trained and conversant with good glazing practice as described in this document.

#### 3.2.1 IGU handling and storage

All IGUs must be handled with care. IGUs delivered in cases should be unpacked on arrival and checked that they conform to the specification. If IGUs are found to be wet they must be dried. All IGUs must be stored inside away from sunlight (or, if outside, under an opaque cover and not under transparent sheeting) to avoid thermal stress. All IGUs must be stored with both panes supported and in dry conditions with adequate support to prevent distortion or bowing. Suitable soft surface supporting blocks should be used to prevent edge damage.

Where IGUs are supplied with self adhesive edge tapes unless advised by the manufacturer they should be removed and adhesives cleaned from the glass before IGUs are installed, (See Clause 1.1.3).

See also BS 8000 - Part 7. Section 2 "Material handling and preparation

#### 3.2.1a Handling factory glazed IGUs

Frames which have been factory glazed will need care in handling due to the weight of the glazed frame. It is advisable to label the windows and to issue instructions to indicate how they should be handled to avoid distortion

#### 3.2.2 Glazing check list

The following features are critical and should be checked before glazing

- Frames should be checked to ensure that they are ready for glazing, have not been damaged, that the rebates are free from obstruction, and that the rebate and bead surfaces are clean, dry and free from any dust, cement spatters, etc.
- Strippable coatings, protective tapes, etc, should be removed from glazing rebates and beads to ensure that they do not encroach on to the glazing surfaces of frames prior to glazing.
- Timber frames and porous surrounds should be checked to ensure that they are dry. Excessive moisture in the frame or porous surround may prevent adhesion of primers, sealers and glazing materials or may cause discolouration.
- If problems are encountered in this respect, glazing should be suspended until the frames have dried out sufficiently (clean and re-prime before glazing with sufficient time being allowed for the primer to dry).
- The condition of any wood primer or base coat previously applied to a timber frame should be checked. Where the primer or base coat has weathered considerably, the frame should be re-treated before glazing.
- The IGU size should allow adequate clearance all round in accordance with the minimum values given in Clauses 2.4.3.2 and 2.4.3.3 of the data sheet relating to frame design. The rebate height should be such that achievement of the edge clearance is consistent with the edge seal and spacer of the IGU.The rebate height should be such that it completely covers the edge seal and spacer(see clause 2.4.5)
- Edge tapes should be removed unless otherwise recommended by the IGU manufacturer (see clause 1.1.3).
- Ensure that all the glazing materials are suitable for the glazing method being used.
- Although most of the above checks are required for both solid bedding systems and drained systems, the following additional checks should be made when glazing into drained systems.

- The frames should be checked for the presence of drainage and ventilation holes or slots, and that they are of a suitable size, and are free from obstructions such as fabrication swarf, etc.

- Ventilation and the free flow of water to holes and slots must not be impeded by setting and location blocks, external bead retention lips, or glazing materials.

- As water can be present in the glazing rebate (and, in some designs, in other areas of the frame) it is essential with the exception of holes and slots for drainage that all vulnerable details should be adequately sealed e.g. screw fixing holes. Similarly, unless this is intentional as part of the drainage system, all frame joints should be adequately sealed.

- The external glazing seals should limit water penetration into the rebate as much as possible, and should shield the edge seal of the IGU against the effect of sunlight.

- Where gaskets or strip materials are supplied cut to size, these should be the correct length to ensure that there are no gaps at the corners.

### 3.3 Location of IGUs in frames

It is essential that the IGUs are correctly positioned in the frames. This is achieved by the use of setting blocks and, where appropriate, location blocks and distance pieces. The use of the correct components, in terms of material type and dimension, and the correct positioning of the components, is essential in achieving a successful installation. Full details of the correct location of the glazing blocks are given in figures 6, 7 and 8, and information relating to setting block materials and sizes is given in Table 1.

#### 3.3.1 Setting blocks

Setting blocks (see Figure 6) are used between the bottom edge of the IGU and the frame or surround, to support and centralise the IGU in the opening.

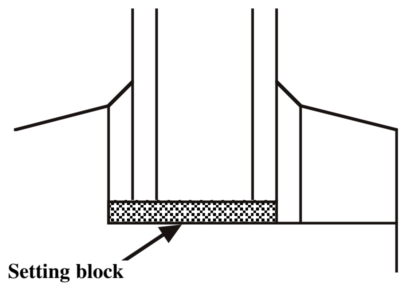



**Figure 6**
Setting blocks

**Setting blocks should be of resilient, non-absorbent rot-proof, compatible materials such as those indicated in the table below**

Setting blocks are required in different positions depending on the frame type. Positions for setting blocks for all types of frame are shown in Figure 7.

For fixed windows, blocks are usually positioned as near the quarter points as possible. Where it is necessary to avoid undue deflection of the frame, the window manufacturer should specify the position of setting blocks as being either:-

a) not less than 30mm from the corner, or;

b) in positions to coincide with the window fixing points if these are between 30mm from the corner and the quarter points.

For designs where the actual positions are critical, or where blocks are required in additional positions, these should be stated by the window manufacturer.

In order to ensure that both panes of glass are supported, the width of the setting block should, in general, be equal to the sum of the IGU thickness plus the back clearance. In cases where a gasket or strip material is of such a dimension as to prevent positioning of the setting block against the upstand, the width of the setting block should be the same as the width of the IGU.

The thickness of the setting block is determined by the minimum edge clearance required at the bottom of the IGU, or by the actual edge clearance when the IGU is centralised.

The length of the setting block is determined by the area of the IGU and the material of the block. For handling purposes the minimum length of each setting block should be 25mm. In cases where setting blocks are required at two positions, the length of setting block for different sizes of IGUs is given below:-

**Table 1.** Materials suitable for setting blocks, and block length required for different areas of IGUs. (Each of 2 blocks at bottom of unit).

| Block Material | IGU size | | | | |
|---|---|---|---|---|---|
| | Up to 1m² | Up to 2.5m² | Up to 5m² | Up to 7.5m² | Up to 10m² |
| Sealed hardwood e.g. teak, mahogany | 25mm | 25mm | 50mm | 75mm | 100mm |
| Rigid plastics e.g. un-plasticised PVC-U, nylon | 25mm | 63mm | 125mm | 188mm | 250mm |
| Plasticised PVC (with a softness number of 35 to 45 - see BS 2571) or neoprene (74 to 80 IRHD - see BS ISO 2921) | 30mm | 75mm | 150mm | 225mm | 300mm |

**Note:** For vertically pivoted, side-hung and projected side hung windows, and for doors where a single setting block is required, the block length must be twice that given in the table.

### 3.3.2 Location blocks

Location blocks are in essence the same as setting blocks but must be used between the edges of the IGU (other than the bottom edge - called setting blocks) and the frame or surround at positions shown in figure 7. The purpose of location blocks is to prevent movement of the IGU within the frame when the window or door is opened or closed, and to prevent the weight of the glass from causing the frame to become out-of-square. For designs where the actual positions are critical, these should be stated by the window manufacturer. To prevent movement of the IGU in the frame prior to, and during, installation of factory glazed windows, additional location blocks may be necessary.

Location blocks should be at least 25mm long for all opening windows, except for those at the top edge of horizontally pivoted windows which are reversible

In this case the length of these location blocks should be determined as if they were setting blocks.

Location blocks should be of a thickness to suit the edge clearance. It is preferable for location blocks to be positively located in order to prevent them becoming displaced during installation or service. The width of the location blocks should in general be equal to the sum of the IGU thickness plus the back clearance. In cases where a gasket or strip material is of such a dimension as to prevent positioning of the location blocks against the upstand, the width of the location blocks should be the same as the width of the IGU.

**Note:** Attention should be paid to the compatibility of the setting and location blocks with the glazing materials and the edge seal of the IGU. In the case of PVC-U frames, compatibility with the frame material should also be considered.

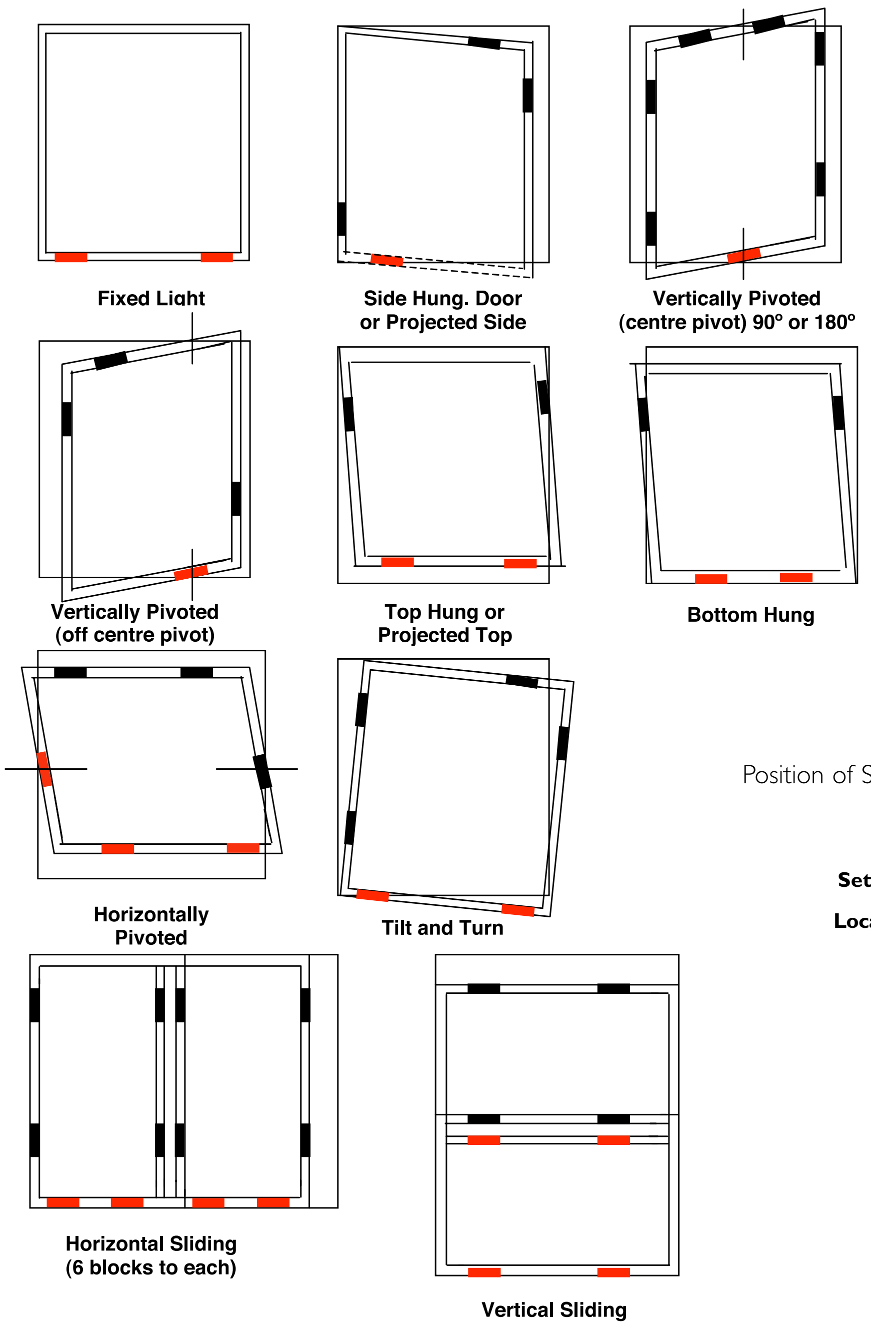



**Figure7**

Position of Setting and location blocks

### 3.3.3 Distance pieces

Distance pieces (positioned between the glass faces and rebate and bead upstands) (see Fig 8) are necessary to prevent displacement of glazing compounds or sealants by loading e.g. wind pressure on the glass.

Distance pieces should be of a resilient, non-absorbent material. They should be 25mm long and of a height to suit the depth of the rebate and the method of glazing; and they should be of a thickness equal to the actual back and front clearances, to retain the IGU firmly in the frame so that it cannot be displaced in service conditions.

- Distance pieces are available in various sizes and shapes.
- Distance pieces should be used in all cases, except where a load bearing strip material is used.
- Distance pieces on both sides of the IGU should be placed opposite each other.
- Where beads are fixed by screws or over studs, distance pieces should coincide with the bead fixing points.

Where beads are pin fixed or fit into grooves, the first distance pieces should be at approximately 50mm from each corner, and the remainder should be located at approximately 300mm centres.

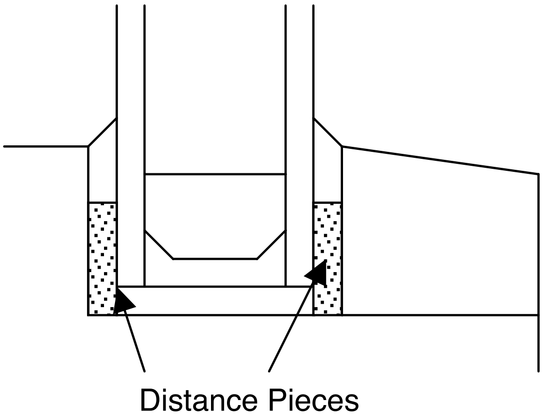



**Figure 8**

Distance pieces

### 3.3.4 Fixing of beads

Where timber beads are fixed with screws these must be at no more than 75mm from each corner and at not more than 200mm centres. If pins are used they must be twice as long as the bead height and fixed no more than 50mm from each corner and at not more than 150mm centres. Pins should be fixed so as to avoid contact with the glass edge.

Beads for metal and plastic frames should have a height equal to the rebate height, and must be designed to be fixed to ensure they cannot move or distort, and to securely retain the IGU and the glazing seals.

## 3.4 GLAZING SYSTEMS

The glazing systems described below are systems that are suitable for glazing IGUs in normal situations into new frames, or for replacing IGUs in existing frames.

The following illustrations of glazing systems are intended to indicate the design principles and the use of glazing materials. For clarity, setting and location blocks, distance pieces, bead fixings and covers to holes or slots have been omitted from the illustrations.

The illustrations of glazing methods show the most commonly used frame material. Providing the design of the rebate and beads is suitable, frames of other materials may also be appropriate.

### 3.4.1 System IG 1: Gasket glazing

This is a drained system – see Figure 9.

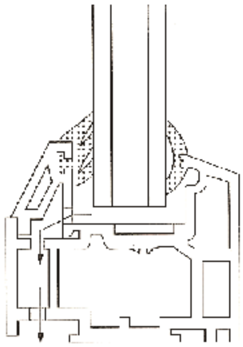


**Figure 9**

System IG 1

**Frame type:** Aluminium, or PVC-U with channels and/or nibs to accommodate a gasket profile, with drainage .

**Procedure:** Ensure the frame rebate surfaces and the beads are clean. If the frame is mechanically jointed, apply sealant to the frame joints if this is specified by the frame manufacturer.

If the gasket sections have not been supplied pre-cut to size, cut them to the correct length. Where possible, gaskets should go round the frame in one piece, being nicked in the corners to ease bending, and with the joint at the top of the frame. Cut the gaskets slightly oversize to ensure that they are not under tension when assembled, which would result in creep-back in service.

Fit the gaskets to the beads and to the frame upstand where appropriate to the frame design.

Place the setting blocks in the frame ensuring that they do not obstruct drainage. Clean the perimeter of the IGU with a dry cloth. Insert the IGU into the frame, centralise, and insert location blocks as required.

Apply pressure, either by insertion of the beads, or by applying the beads and inserting the wedge-shaped gasket. The wedge-shaped gasket should be inserted at the corners first, then by working outwards from the centre. Check that there are no gaps at the corners of the frame.

### 3.4.2 System IG 2: Cellular adhesive sections or strips; or load bearing mastic tapes; or pre-shimmed mastic tapes.

This is a drained system - see Figure 10

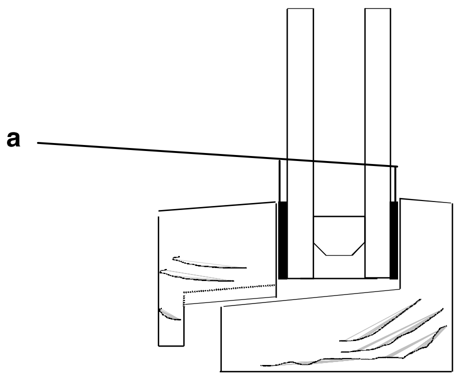



**Figure 10**

System IG 2 (Wood frame shown)

**Front and back bedding (a)**

Profiled closed cell synthetic rubber or polymeric section with self-adhesive backing; or load bearing mastic tapes; or pre-shimmed mastic tapes.

**Frame Type:** Timber, metal or PVC-U, with drainage .

**Procedure:** Ensure the frame rebate surfaces, the beads and the areas of the IGU which will be in contact with the glazing material are clean. If the frame is mechanically jointed, apply sealant to the frame joints if this is specified by the frame manufacturer.

Apply self-adhesive cellular section or the mastic tape or pre-shimmed mastic tape to the rebate upstand. In the case of the cellular sections, these should be applied in line with the sight line. In the case of the mastic tapes these should be applied slightly above the sight line. Tapes or cellular sections should be at least 2.5mm thick after compression.

Place setting blocks in the frame ensuring that they do not obstruct drainage. Insert the IGU into the frame, centralise, and insert locations blocks as required. Apply pressure to bed the IGU against the section or tape.

Apply the glazing material to the beads. Cellular sections should be applied in line with the sight line. Mastic tapes should be applied slightly above the sight line. Bed the beads to the glass by applying pressure to compress both the inside and outside glazing materials, and fix the beads in position. With pre-shimmed mastic tapes the compression should be sufficient to ensure that the shims are in compression between the glass and the bead and rebate upstand.

If timber beads are fixed with screws, these must be at not more than 75mm from each corner and at no more than 200mm centres. If pins are used, they must at least twice as long as the bead height, and fixed at no more than 50mm from each corner and at no more than 150mm centres.

In the case of load bearing and pre-shimmed mastic tapes, trim the excess material which has been compressed above the sight line using a sharp knife. Where possible trim to form a chamfer to shed water.

### 3.4.3 System IG 3: Load bearing or pre-shimmed mastic tapes or cellular adhesives strips, and sealant capping.

This is a drained system – see Figure 11.

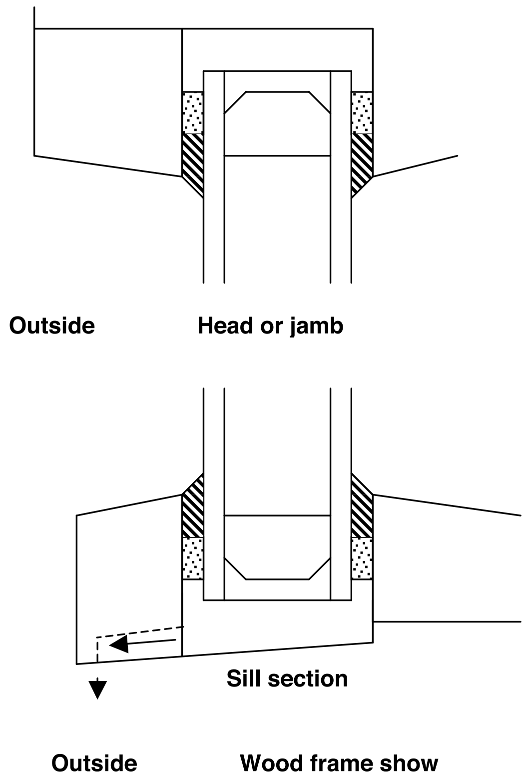



**Figure 11**

System IG 3 (Wood frame shown)

**Frame suitability: Timber or metal, with drainage**

Procedure: Ensure the frame rebate surfaces, the beads and areas of the IGU which will be in contact with the glazing materials are clean. If necessary prime the appropriate frame, bead and IGU surfaces with sealant primer. If the frame is mechanically jointed, apply sealant to the frame joints if this is specified by the frame manufacturer.

Apply the self adhesive cellular strip or mastic tape to the rebate upstand with the top edge set approximately 6mm below the sight line. Tapes or cellular strips must be at least 2.5mm thick after compression.

Place setting blocks in the frame, ensuring that they do not obstruct drainage. Insert the IGU into the frame, centralise, and insert location blocks as required. Apply pressure to bed the IGU against the tape or strip.

Apply self adhesive cellular strips or mastic tapes to the face of the bead or the face of the IGU, set approximately 6mm below the sight line, taking care that the drainage or ventilation is not obstructed.

Bed the beads to the glass, compressing both inside and outside strips or tapes, and fix the beads in position. If timber beads are fixed with screws, these must be at no more than 75mm from each corner and at no more than 200mm centres. If pins are used, they must at least twice as long as the bead thickness, and fixed at no more than 50mm from each corner and at not more than 150mm centres.

Apply the sealant capping internally and externally, ensuring that the channels between the glass and the frame/beads above the tape/cellular strips are completely filled. Tool the sealant to a smooth chamfer to shed water.

### 3.4.4 System IG 4: Moisture vapour permeable (MVP) sealant bedding.

This is a solid bedding system – see Figure 12.

**Frame suitability:** Timber or metal.

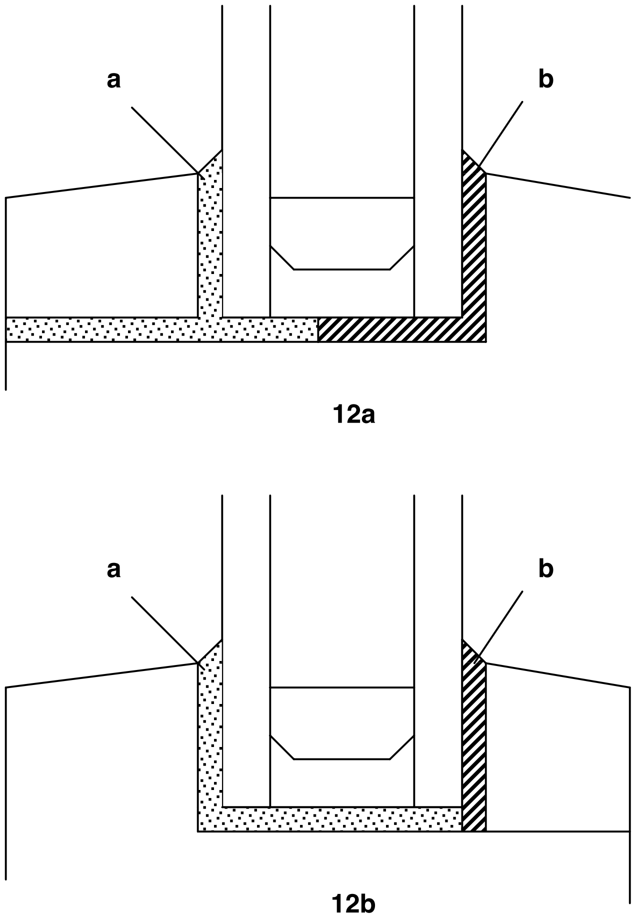



**Figure 12**

MVP sealant bedding

**Outer Bedding (a)**

Moisture vapour permeable sealant e.g. silicone.

**Inner Bedding (b)**

Low permeability glazing material e.g. load bearing or pre-shimmed mastic tape, polysulfide sealant or non-setting compound.

**Note:** Inner bedding should always be less permeable than the outer bedding.

**Procedure:**

**Outside glazing (Figure 12a)**

Ensure the frame rebate surfaces, the beads and areas of the IGU which will be in contact with the glazing materials are clean. If necessary prime the appropriate frame, bead and glass surfaces with sealant primer. Apply the back bedding to the rebate upstand. In the case of mastic tapes, apply slightly above the sight line and apply a heel bead of sealant (this can be high or low permeability) beneath the tape to provide a bedding for the back edge of the IGU.

Insert the setting blocks and distance pieces as required. Centralise the IGU in the frame, insert location blocks as required, and apply pressure to bed the IGU against the back bedding so that the distance pieces (where used) are tightly held between the rebate upstand and the IGU.

Apply moisture vapour permeable sealant around the edge of the IGU to completely fill the perimeter void ensuring that the seal is continuous and in full contact with both the IGU and rebate platform. Then apply a substantial fillet of sealant around the perimeter of the IGU to form the bedding between bead and glass.

Insert distance pieces of the required thickness opposite those against the rebate upstand. Bed the beads to the glass, squeezing the sealant up between the beads and the glass, and between the bottom of the bead and the rebate platform. Press the beads back until the distance pieces are firmly held between beads and glass.

Fix the beads in position. If timber beads are fixed with screws, these must be at no more than 75mm from each corner and at no more than 200mm centres. If pins are used, they must be at least twice as long as the bead height, and fixed at no more than 50mm from each corner and at not more than 150mm centres.

Apply further sealant to fill any residual voids between bead and glass, and tool to a smooth chamfer to shed water.

Finish the internal bedding. In the case of mastic tapes, trim with a sharp knife, where possible forming a watershed. In the case of glazing compound, form a smooth chamfer to shed water.

**Inside glazing (Figure 12b)**

The system is reversed, bedding the IGU in the moisture vapour permeable sealant, and bedding the bead to the glass with the less permeable sealant.

### 3.4.5 System IG 5: Single sealant

This is a solid bedding system – see Figure 13.

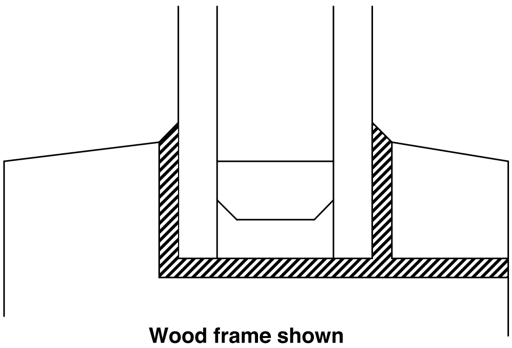



**Figure 13**

System IG 5

**Frame suitability:** Timber or metal.

**Bedding:** Suitable 1 or 2 part curing glazing sealant,

**Note:** Non-setting glazing compounds and putties are not suitable as the single sealant material for glazing IGUs.

**Procedure:** Ensure the frame rebate surfaces, the beads and areas of the IGU which will be in contact with the glazing materials are clean. If necessary prime the appropriate frame, bead and glass surfaces with sealant primer.

Apply a generous fillet of sealant around the perimeter of the frame to the angle between the rebate upstand and the platform. Insert setting blocks and distance pieces as required.

Centralise the IGU in the frame, insert location blocks as required, and apply pressure to bed the IGU against the back bedding so that the distance pieces are tightly held between the rebate upstand and the IGU.

Apply sealant around the edge of the IGU to completely fill the perimeter void ensuring that the sealant is continuous and in full contact with both the IGU and rebate platform. Then apply a substantial fillet of sealant around the perimeter of the IGU to form the bedding between beads and glass. Insert distance pieces of the required thickness opposite those against the rebate upstand. Bed the beads to the glass, squeezing the sealant up between the beads and the glass, and between the bottom of the bead and the rebate platform. Press the beads back until the distance pieces are held firmly between the beads and glass.

Fix the beads in position. If timber beads are fixed with screws, these must be at no more than 75mm from each corner and at no more than 200mm centres. If pins are used, they must at least twice as long as the bead thickness, and fixed at no more than 50mm from each corner and at not more than 150mm centres.

Apply further sealant on both sides of the glass to fill completely any residual voids between glass and rebate and glass and bead. Tool the sealant to smooth chamfers to shed water.

### 3.4.6 System IG 6: Load bearing or pre-shimmed mastic tapes, or cellular adhesive strips, and sealant capping.

This is a solid bedding system – see Figure 14.

**Frame suitability:** Timber or metal.

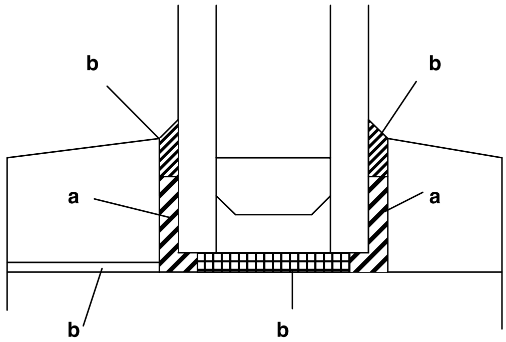



**Figure 14**

Wood frame shown System IG 6

**Back and front bedding (a)**

Load bearing mastic tapes; or pre-shimmed mastic tapes; or closed cell synthetic rubber strips with self-adhesive backing.

**Capping,** perimeter filling, and bead-to-platform bedding (b)

Suitable one or two-part curing sealant e.g. silicone, polysulfide.

**Procedure:** Ensure the frame rebate surfaces, the beads and areas of the IGU which will be in contact with the glazing materials are clean. If necessary prime the appropriate frame, bead and glass surfaces with sealant primer.

Apply the mastic tape or cellular strip to the rebate upstand, with the top edge approximately 6mm below the sight line, and apply a heel bead of sealant beneath the tape to provide a bedding for the back of the IGU. Tapes and cellular strips should be at least 2.5mm thick after compression.

Place setting blocks in the frame and insert the IGU. Centralise the IGU in the frame, insert location blocks as required, and apply pressure to bed the IGU against the strip or tape.

Apply sealant around the edge of the IGU to completely fill the perimeter void, finishing flush with the face of the IGU ensuring that the sealant is continuous and in full contact with both the IGU and rebate platform.

Apply mastic tape or cellular strip to the face of the bead or to the face of the IGU, with the top edge approximately 6mm below the sight line, and the bottom edge approximately in line with the edge of the IGU.

Apply a fillet of sealant to the rebate platform, against the perimeter filling to form a sealant heel bead. Bed the beads to the glass, applying pressure to compress both the inside and outside tapes or strips, and to bed the beads to the platform.

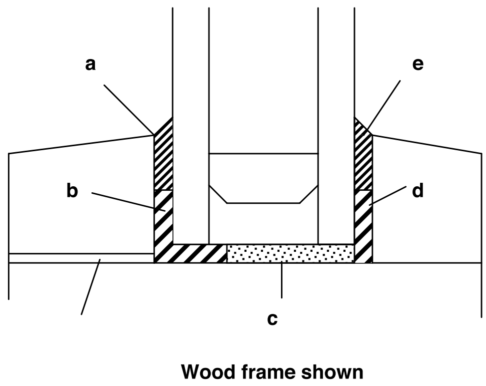
Fix the beads. If timber beads are fixed with screws, these must be at no more than 75mm from each corner and at no more than 200mm centres. If pins are used, they must at least twice as long as the bead height, and fixed at no more than 50mm from each corner and at not more than 150mm centres.

Apply the sealant capping internally and externally, ensuring that the channels between the glass and the frame/beads above the tape/cellular strips are completely filled. Tool the sealant to smooth chamfers to shed water.

### 3.4.7 System IG 7: Heel bead seal

This is a solid bedding system - see Figure 15.

**Frame suitability:** Timber or metal.




**a and e can be of the same type**
**b, c & d can be of the same type**

**Figure 15**

System IG 7

#### a. Back and front bedding (a & e)

Load bearing mastic tapes; or pre-shimmed mastic tapes; or closed cell synthetic rubber strips with self-adhesive backing.

#### b. Heel beads and perimeter filling (b, c & d)

One or two-part curing sealant.

**Procedure:** Ensure the frame rebate surfaces, the beads and areas of the IGU which will be in contact with the glazing materials are clean. If necessary prime the appropriate frame, bead and glass surfaces with sealant primer.

Apply self-adhesive closed cell rubber strip or the mastic tape or pre-shimmed mastic tape to the rebate upstand (a). In the case of the closed cell rubber strip, this should be applied in line with the sight line. In the case of the mastic tapes these should be applied slightly above the sight line. Tapes or cellular sections must be at least 2.5mm thick after compression. Apply a heel bead of sealant (b) beneath the tape or strip to provide a bedding for the back edge of the IGU.

Place setting blocks in the frame. Insert the IGU, centralise it in the frame, insert location blocks as required, and apply pressure to bed the IGU against the tape or strip and the sealant.

Apply sealant around the edge of the IGU to completely fill the perimeter void (c), finishing flush with the face of the IGU ensuring that the sealant is continuous and in full contact with both the IGU and rebate platform.

Apply a fillet of sealant to the rebate platform against the perimeter filling to form a sealant heel bead (d).

Apply the glazing material to the beads (e). Closed cell rubber strip should be applied in line with the sight line. Mastic tapes should be applied slightly above the sight line. Bed the beads to the glass by applying pressure to compress both the inside and outside glazing materials, and fix the beads in position. With pre-shimmed mastic tapes the compression should be sufficient to ensure that the shims are in compression between the glass and the bead and rebate upstand.

Fix the beads. If timber beads are fixed with screws, these must be at no more than 75mm from each corner and at no more than 200mm centres. If pins are used, they must at least twice as long as the bead thickness, and fixed at no more than 50mm from each corner and at not more than 150mm centres. In the case of mastic tapes trim with a sharp knife, where possible forming a watershed.

### 3.5 Maintenance

### 3.5.1 Glazing materials

Materials used for the glazing methods described in this GGF Data sheet should be selected for their suitability in respect of maintenance and service life. However, inspections should be carried out after approximately one year, and periodically thereafter, as deterioration could take place as a result of incorrect application, vandalism, or damage.

Damaged sealant should be cut out, and replaced with the same or compatible sealant.

Where gaskets have been displaced or damaged, or where there are gaps, the gaskets should be refitted or replaced as appropriate.

With drained glazing systems, inspections should be carried out to check that the drainage/ventilation holes or slots have not become blocked. Any blockages should be cleared.

### 3.5.2 Window frames

Window frames should be well maintained. Many frames have protective coatings which not only protect the frame material but also help to stabilise the frame components, particularly where timber frames are used.

Failure to ensure that the finishes on timber frames are maintained in good condition may lead to excessive movement occurring, due to swelling, shrinkage and distortion. This movement can put the glazing components under stress which may exceed their design capability resulting in failure of the glazing system., resulting in premature failure or the IGU.

Hinges, catches and stays should also be examined. If such components are damaged, they may induce racking and distortion of the frames, which in turn will place stresses on the IGU, and may also render draught seals and weather seals ineffective.

Maintenance information can be obtained from the current edition of the GGF booklet "Windows and Doors, a Homeowners Manual"

### 3.6 IGU Replacement

Where replacement of an IGU is required work should generally use a glazing system as described in this document.

Where replacement glazing work is to be undertaken all traces of old glazing compounds and sealants must be removed from the glazing rebates, and rebates must be thoroughly dry. Following preparation of the rebates glazing should be carried out in accordance with the systems described in this document. Any components damaged during replacement glazing work must be replaced.

## BIBLIOGRAPHY

This Data Sheet contains references to the following publications. The current versions must always be used:


- BS 644: Timber windows. Factory assembled windows of various types. Specification.
- BS 1186-2: Timber and workmanship in joinery. Specification for workmanship.
- BS 2571: Specification for general purpose flexible PVC compounds for moulding and extrusion.
- BS 4873: Aluminium alloy windows.
- BS 5589: Code of practice for preservation of timber.
- BS 6262: Code of practice for glazing for buildings.
- BS 6262: Parts1to 4 and 6 to 7: Glazing for buildings. Code of practice for glazing for buildings.
- BS 6399: Part 2: Loading for buildings. Code of practice for wind loads.
- BS: 6510: Steel framed windows and glazed doors.
- BS 7412: Plastics windows made from unplasticised polyvinylchloride (PVC-U) extruded hollow profiles. Specification
- BS 7722: Surface covered PVC-U profiles for windows and doors. Specification.
- BS 8000: Part 7: Workmanship on building sites. Code of practice for glazing.
- BS EN 942: Timber in joinery. General classification of timber quality.
- BS EN 1279:Parts 1 to 6: Glass in building. Insulating glass units.
- BS EN 10025: Parts 1 to 6: Hot rolled products of non-alloy structural steels. Technical delivery requirements.
- BS EN 12608: Unplasticised polyvinylchloride (PVC-U) profiles for the fabrication of windows and doors. Classification, requirements and test methods.
- BS ISO 2921: Rubber, vulcanised. Determination of low temperature characteristics. Temperature-retraction procedure. (TR test).
- BS ISO 9000: Quality management and quality assurance standards. Generic guidelines for the application of ISO 9001, ISO 9002 and ISO 9003.
- BS ISO 11600: Building construction. Jointing products. Classification and requirements for sealants.
- GGF data sheet 4.9 Compatibility of Glazing Sealants and Compounds with Insulating Glass Units.


## APPENDIX 1

### Example calculation of required rebate height

The following example for glazing into a timber frame illustrates how the actual edge clearance, and hence the required rebate height is affected by the tolerances of the frame tight size and of the IGU size.

For a 20mm thick IGU of less than 3m$^2$ the required minimum edge clearance is 5mm, and typical edge cover required is 12mm, so the minimum rebate height required will be 17mm.

However, to take account of tolerances of frame size and of IGU size it is necessary to increase the rebate height to ensure that all combinations of frame size and IGU size can be glazed to meet minimum edge clearance and minimum edge cover requirements.

The nominal size of a IGU is calculated from the nominal tight size of the frame, with allowances for tolerances, using the following formula:-

**Nominal IGU length or height = F - C - du - df**

Where: F is the nominal frame tight size

C is the sum of the two required edge clearances

du is maximum IGU tolerance

df is maximum frame tolerance

Hence, for a nominal tight size of frame of 1000mm with tolerances of ±2mm, and using an IGU with length and width tolerances of ±1.5mm the nominal size of IGU is given by:- 1000 - 10 - 1.5 - 2 = 986.5mm

If IGUs are manufactured to this nominal size then there will be a minimum 5mm edge clearance even when a IGU at maximum positive tolerance (988mm) is glazed into a frame with maximum negative tolerance (998mm).

However, at the opposite extreme condition, with a frame at maximum positive tolerance (1002mm) and a IGU at maximum negative tolerance (985mm) there will be edge clearances of 8.5mm. (1002 - 985 × $^1/_2$)

If rebate heights are only 17mm then edge cover will be reduced to 8.5mm rather than 12mm, so that part of the spacer and edge seal may be visible above the top of the rebate. To compensate it is necessary to increase the rebate height by 3.5mm - the difference between the maximum possible edge clearance and the minimum possible edge clearance. (8.5mm - 5mm).

Hence to allow for all possible combinations of IGU sizes and frame sizes resulting from tolerances, the rebate height should be increased to 20.5mm (17mm + 3.5mm) for a timber frame for glazing a 20mm thick IGU of less than 3m$^2$ in area.

Similar calculations can be made for other frames and other tolerances of frames and IGUs.

# GGF Datasheet for the Quality of Thermally Toughened Soda Lime Silicate Safety Glass for Building

4.4 February 2011

**Contents**



## 1. Scope

This datasheet defines the products and specifies the characteristics and associated measurement procedures and test methods for thermally toughened soda lime silicate safety glass that is in compliance with BS EN 12150.

Dimensional characteristics i.e. length, width, thickness and flatness, and their applicable tolerances are specified for thermally toughened soda lime silicate safety glass. Recommendations are also made on the dimensions and tolerances of holes/cut-outs. Details of acceptable edgework are also given.

NOTE: Tolerances etc. specific to the vertical tong hung process are given in annex A.

A test method is described for assessing the fragmentation of thermally toughened soda lime silicate safety glass to show how the quality and consistency of manufacture can be controlled.

Other requirements, not specified in this datasheet, may apply to thermally toughened soda lime silicate safety glass which is incorporated into assemblies, e.g. laminated glass or insulating glass units, or undergo an additional treatment, e.g. coating. The additional requirements are specified in the appropriate product standard. Thermally toughened soda lime silicate safety glass, in this case, does not lose its mechanical or thermal characteristics.

This data sheet does not apply to curved thermally toughened soda lime silicate safety glass.

NOTE: GGF Data Sheet 4.12.3 covers these products.

## 2. Definitions, characteristics and manufacturing processes

Where appropriate these definitions have been taken from EN 12150-1.

### 2.1 edge deformation

Deformation of the edge caused by the tong marks.

### 2.2 edge lift

(also referred to as edge dip)
Distortion produced in horizontal toughened glass, at the leading and trailing edge of the plate. This is a distortion produced by a reduction in surface flatness

### 2.3 enamelled thermally toughened soda lime silicate safety glass

Thermally toughened soda lime silicate safety glass which has a ceramic frit fired into the surface during the toughening process. After toughening the ceramic frit becomes an integral part of the glass

NOTE 1: Also known as opaque thermally toughened soda lime silicate safety glass.

NOTE 2: The application of the ceramic frit may be by a continuous process or discontinuous application, e.g. screen printing. The enamelled surface could be partially or wholly covered.

### 2.4 flat thermally toughened soda lime silicate safety glass

Thermally toughened soda lime silicate safety glass which has not been deliberately given a specific profile during manufacture

### 2.5 thermally toughened soda lime silicate safety glass

Glass within which a permanent surface compressive stress, additionally to the basic mechanical strength, has been induced by a controlled heating and cooling process in order to give it greatly increased resistance to mechanical and thermal stress and prescribed fragmentation characteristics

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NOTE: The mechanical properties, i.e. thermal durability and mechanical strength, and safety properties, i.e. fragmentation characteristics, are generated by the level of surface compression. These properties are not size dependent.

**2.6 horizontal process**
Process in which the glass is supported on horizontal rollers

**2.7 local distortion**
Local deformation of vertically toughened glass underneath the tong marks

NOTE: The mechanical properties, i.e. thermal durability and mechanical strength, and safety properties, i.e. fragmentation characteristics, are generated by the level of surface compression. These properties are not size dependent.

**2.6 horizontal process**
Process in which the glass is supported on horizontal rollers

**2.7 local distortion**
Local deformation of vertically toughened glass underneath the tong marks

**2.8 overall bow**
deformation of the whole pane of horizontally and vertically toughened glass caused by the heating and cooling process

**2.9 roller wave distortion**
distortion produced in horizontal toughened glass as a result of the glass being in contact with the rollers during the toughening process. This is the surface distortion produced by a reduction in surface flatness

**2.10 vertical tong hung process**
process in which the glass is suspended by tongs

NOTE: This process is now of very minor importance.

## 3 Glass products

Thermally toughened soda lime silicate safety glass is made from a monolithic glass generally corresponding to one of the following standards:

— soda lime silicate glass products according to EN 572-1 including;

— float glass according to EN 572-2;

— drawn sheet glass according to EN 572-4;

— patterned glass according to EN 572-5;

— supplied and final cut sizes according to EN 572-8;

— a coated glass, with a substrate as above, that is in accordance with EN 1096-1.

Glass of nominal thicknesses other than those covered in the above standards is possible.

## 4 Fracture characteristics

The fracture characteristics of glass are directly related to the amount of surface compression, these properties are not size dependent.

When the glass is manufactured with an appropriate degree of surface compression then in the event of breakage the glass fractures into numerous small pieces, the edges of which are generally relatively harmless.

NOTE: The degree of surface compression required is dependent upon glass type and thickness. The fragmentation test described in clause 11 is undertaken on unrestrained test specimens.

The fragmentation in service may not always correspond to that determined during the fragmentation test due to the imposition of other stresses, i.e. from fixing or from reprocessing (e.g. laminating).

## 5 Dimensions and tolerances

### 5.1 Nominal thickness and thickness tolerances

The nominal thicknesses and thickness tolerances are those given in the relevant product standard (see clause 4), some of which are reproduced in Table 1a and b.

**Table 1a** — Nominal thicknesses and thickness tolerances – float and patterned glass. Dimensions in millimeters

| Nominal Thickness d | Thickness tolerance for glass types | |
|---|---|---|
| | Float | Patterned |
| 3 | ±0,2 | ±0,5 |
| 4 | ±0,2 | ±0,5 |
| 5 | ±0,2 | ±0,5 |
| 6 | ±0,2 | ±0,5 |
| 8 | ±0,3 | ±0,8 |
| 10 | ±0,3 | ±1,0 |
| 12 | ±0,3 | ±1,5 |
| 14 | NM | ±1,5 |
| 15 | ±0,5 | ±1,5 |
| 19 | ±1,0 | ±2,0 |
| 25 | ±1,0 | NM |

NM = not manufactured

**Table 1b** — Nominal thicknesses and thickness tolerances for drawn sheet and new antiques sheet glass.
Dimensions in millimeters

The limits of squareness are described by deviation between diagonals. Limits are given in Table 3

| Nominal Thickness d | Thickness tolerance for glass types | |
|---|---|---|
| | Drawn Sheet | New Antique Sheet Glass |
| 3 | ±0,2 | NM |
| 4 | ±0,2 | ±0.3 |
| 5 | ±0,3 | NM |
| 6 | ±0,3 | ±0.3 |
| 8 | ±0.5 | NM |
| 10 | ±0.6 | NM |

NM = not manufactured

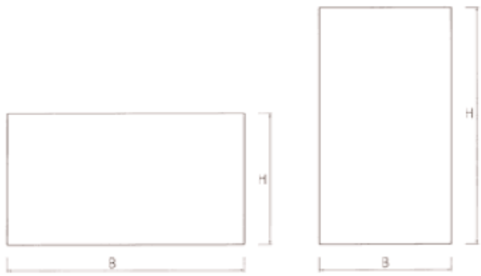
The thickness of a pane shall be determined as for the basic product. The measurement shall be taken at the centres of the 4 sides, and away from the area of any tong marks (see Figure 3), which may be present.

## 5.2 Width and length (sizes)

### 5.2.1 General

When thermally toughened soda lime silicate safety glass dimensions are quoted for rectangular panes, the first dimension shall be the width, B, and the second dimension the length, H, as shown in Figure 1. It shall be made clear which dimension is the width, B, and which is the length, H, when related to its installed position.

**Figure 1** — Examples of width, B, and length, H, relative to the pane shape



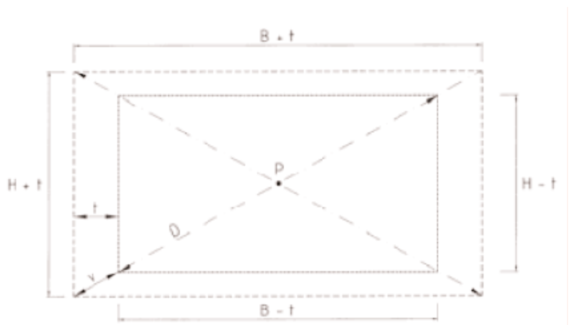

### 5.2.2 Maximum and minimum sizes

For maximum and minimum sizes, the manufacturer should be consulted.

### 5.2.3 Tolerances and squareness

The nominal dimensions for width and length being given, the finished pane shall not be larger than a prescribed rectangle resulting from the nominal dimensions increased by the tolerance, t, or smaller than a prescribed rectangle reduced by the tolerance, t. The sides of the prescribed rectangles are parallel to one another and these rectangles shall have a common centre. Limits are given in Table 2.

**Figure 2** — Tolerance limits for dimensions of rectangular panes




**Key:**

**B – width**
**H – length**
**T – tolerance limits for dimensions**
**D – diagonals**
**V – deviation between diagonals**
**P – common centre of rectangles**

**Table 2 — Tolerances on width, B, and length, H**

| Nominal dimension of side B or H | Tolerance t | |
|---|---|---|
| | Nominal glass thickness d ≤ 8 | Nominal glass thickness d > 8 |
| ≥ 2000 | ±2,0 | ±3,0 |
| 2000 <B,H≤≥ 3000 | ±3,0 | ±4,0 |
| > 3000 | ±4,0 | ±5,0 |

Dimensions in millimeters

**Table 3 — Limit deviations for the difference between diagonals**

| Limit deviation v on the difference between diagonals | | |
|---|---|---|
| Nominal dimension of side B or H | Nominal glass thickness d ≤ 8 | Nominal glass thickness d > 8 |
| ≥ 2000 | 4 | 6 |
| 2000 <B,H≤≥ 3000 | 6 | 8 |
| > 3000 | 8 | 10 |

Dimensions in millimeters

### 5.2.4 Edge deformation produced by the vertical process

See Annex A.

## 5.3 Flatness

### 5.3.1 General

By the very nature of the toughening process, it is not possible to obtain a product as flat as annealed glass. This difference in flatness depends on the type of glass, e.g. coated etc., glass dimensions, i.e. the nominal thickness, the dimensions and the ratio between the dimensions, and the toughening process employed, i.e. vertical or horizontal.

There are four kinds of distortion:

— overall bow (see Figure 4);

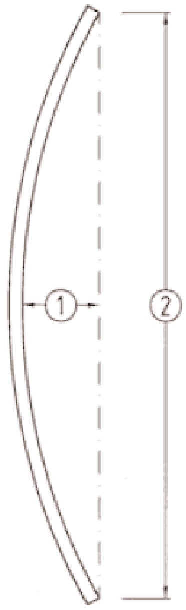
— roller wave distortion (for horizontal toughened glass only) (see Figure 5);

— edge lift (for horizontal toughened glass only) (see Figure 6);

— local distortion (for toughened glass produced by the vertical tong hung process only) (see Figure A1).

NOTE: Local distortion needs to be allowed for within the glazing materials and the weather seals. For special requirements the manufacturers should be consulted.

**Figure 3 — Representation of overall bow**

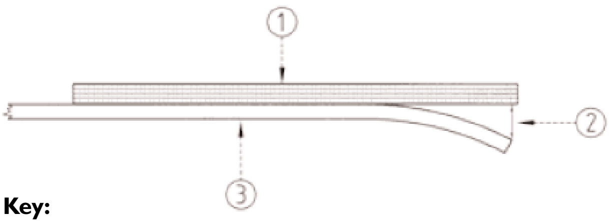



**Key:**

**1 – deformation for calculating overall bow**
**2 – B, or H, or diagonal length**

**Figure 4 — Representation of roller wave distortion**

**Figure 5 — Representation of edge lift**




**Key:**

**1 – straight edge**
**2 – edge lift**
**3 – thermally toughened glass**

### 5.3.2 Measurement of overall bow

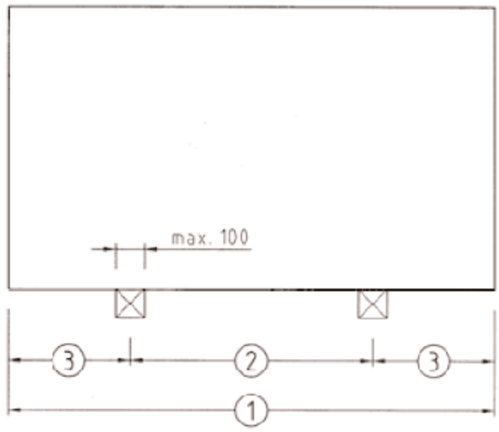
The pane of glass shall be placed in a vertical position and supported on its longer side by two load bearing blocks at the quarter points (see Figure 6).

The deformation shall be measured along the edges of the glass and along the diagonals, as the maximum distance between a straight metal ruler, or a stretched wire, and the concave surface of the glass (see Figure 4).

The value for the bow is then expressed as the deformation, in millimetres, divided by the measured length of the edge of the glass, or diagonal, in meters, as appropriate.

The measurement shall be carried out at room temperature.

**Figure 6 — Support conditions for the measurement of overall bow**




**Key:**

**1 – B or H**
**2 – (B or H)/2**
**3 – (B or H)/4**

### 5.3.3 Measurement of roller wave

#### 5.3.3.1 General

The roller wave is measured by means of a straight edge, or equivalent, being placed at right angles to the roller wave and bridging from peak to peak of the wave (see Figure 7).

NOTE: This section deals with measurement using a straight edge and feeler gauges. An alternative method is described in Annex B.

#### 5.3.3.2 Apparatus

A straight edge: - length of between 300 mm and 400 mm.

NOTE: The actual length of straight edge required will depend upon the wavelength of the roller wave.

Feeler gauges: - various thicknesses in units of 0,05 mm.

#### 5.3.3.3 Method

Place the straight edge so that it bridges across adjacent peaks. Insert the feeler gauge between the glass surface and the straight edge. Increase the thickness of the feeler gauges until they just fill the gap between glass surface and the straight edge. Record the thickness of feeler gauge(s) to an accuracy of 0,05 mm.

Repeat the measurement at several places over the glass surface.

The measured roller wave distortion is the maximum value measured. The maximum values are given in Table 4.

#### 5.3.3.4 Limitations

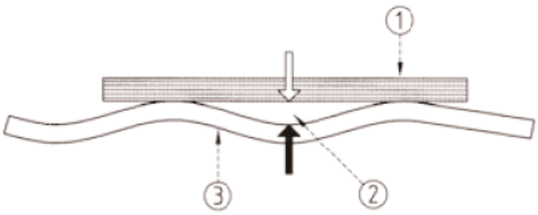
The following limitations apply:

— The roller wave can only be measured panes with a dimension greater than 600 mm measured at right angles to the roller waves.

— The roller wave cannot be measured in an exclusion area that is 150 mm from the edges of the pane. The apparatus should not be used in the exclusion area.

— Panes with an overall bow shall be laid on a flat support. This will allow gravity to flatten out the overall bow and hence give a truer result for the roller wave.

**Figure 7 — Measurement of roller wave distortion**




**Key:**

**1 – straight edge**
**2 – roller wave distortion**
**2 – thermally toughened glass**

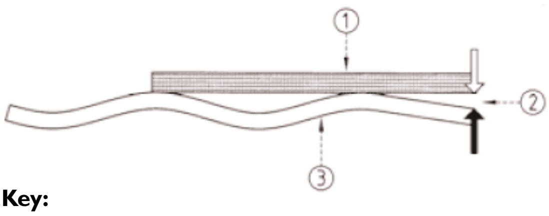
### 5.3.4 Measurement of edge lift (for horizontal toughened only)

The glass shall be placed on a flat support with the edge lift overhanging the edge of the support by between 50 mm and 100 mm. The straight edge is placed on the peaks of the roller waves and the gap between the ruler and the glass measured using a feeler gauge (see Figure 8).

The maximum values for edge lift are given in Table 5.

The values in Table 5 only apply to thermally toughened glass having edgework complying with Figures 9 to Figure 12. For profiled edges or other types of edgework contact the manufacturer.

**Figure 8 — Measurement of edge lift**




**Key:**

**1 – straight edge**
**2 – edge lift**
**2 – thermally toughened glass**

### 5.3.5 Measurement of local distortion (for vertical toughened glass only)

See Annex A.1.2

### 5.3.6 Limitation on overall bow, roller waves and edge lift for horizontal toughened glass

The maximum allowable values for the overall bow, when measured according to 5.3.2, for roller waves, when measured according to 5.3.3 and edge lift, when measured according to 5.3.4 are given in Tables 4 and 5. The values only apply to thermally toughened soda lime silicate safety glass without holes and/or notches and/or cut-outs.

| Glass Type | Maximum value for distortion | |
|---|---|---|
| | Overall bow mm/m | Roller wave mm |
| Uncoated float glass in accordance with EN 572-1 and EN 572-2 | 3,0 | 0,3 |
| Others (a) | 4,0 | 0,5 |
| (a) For enamelled glass that is not covered over the whole surface the manufacturer should be consulted. | | |
| Note: Dependant upon the wave length of the roller wave an appropriate length of gauge has to be used | | |

**Table 4 — Maximum values of overall bow and roller wave distortion for horizontal toughened glass**

Dimensions in millimeters

| Glass Types | Thickness of glass | Maximum Value |
|---|---|---|
| Uncoated float glass in accordance with EN 572-1 and EN 572-2 | 3,0 | 0,5 |
| | 4 to 5 | 0,4 |
| | 6 to 25 | 0,3 |
| Others (a) | all | 0,5 |
| (a) For enamelled glass that is not covered over the whole surface the manufacturer should be consulted. | | |
| Note: Dependant upon the wave length of the roller wave an appropriate length of gauge has to be used | | |

**Table 5 — Maximum values for edge lift for horizontal toughened glass**

### 5.3.7 Limitation on overall bow and local distortion for vertical toughened glass

See Annex A.1.3.

### 5.3.8 Other distortions

The incorporation of holes and/or notches in a plate gives the possibility of distortions being produced during the toughening process as a result of the absence of glass and/or an increase in unsupported edges. The magnitude of these distortions will generally be less than edge lift in horizontally toughened glass or the local distortion in vertically toughened glass.

## 6 Edge and/or surface work, holes, notches and cut-outs

### 6.1 Warning

Thermally toughened soda lime silicate safety glass should not be cut, sawed, drilled, edge worked or surface finished (e.g. sandblasting, acid etching) after toughening because the risk of breakage is increased or the glass can be destroyed immediately.

### 6.2 Edge working of glass to be thermally toughened.

The simplest type of edge working is the arrissed edge (see Figure 9). Common types of edge working are shown in Figures 9 to Figure 12.

For specialist edge work, such as 'water jet cutting', the manufacturers should be consulted.

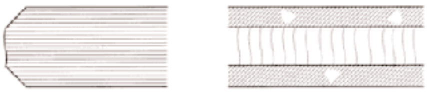


**Figure 9 — Arrissed edge (with blank spots)**

**Figure 10 — Ground edge (with blank spots)**

**Figure 11 — Smooth ground edge (no blank spots)**

**Figure 12 — Polished edge**

### 6.3 Profiled edges

Various other edge profiles can be manufactured with different types of edgework. This kind of product is not covered by Table 5. Corners need not to be treated unless required by the customer.

### 6.4 Round holes

#### 6.4.1 General

This standard considers only round holes in glass that is not less than 4 mm nominal thickness. The manufacturers should be consulted about edge working of holes.

This edge work applies only to the perimeter

#### 6.4.2 Diameter of holes

The diameter of holes, Ø, shall not, in general, be less than the nominal thickness of the glass. For smaller holes, the manufacturers should be consulted.

#### 6.4.3 Limitations on position of holes

In general, the limitations on the positions of holes either relative to the edges of the glass pane, the corners of the glass pane or to each other depends on:

— the nominal glass thickness (d);

— the dimensions of the pane (B, H);

— the hole diameter (Ø);

— the shape of the pane;

— the number of holes.

The recommendations given below are those which are normally available and are limited to panes with a maximum of 4 holes.

1) The distance, a, of the edge of a hole to the glass edge should be not less than 2d.

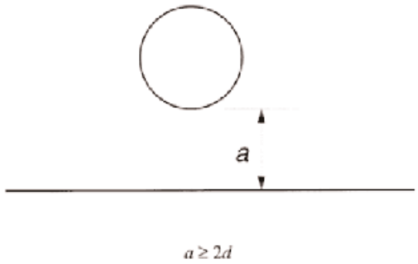



**Figure 13 — Relationship between hole and edge of pane**

2) The distance, b, between the edges of two holes should be not less than 2d.

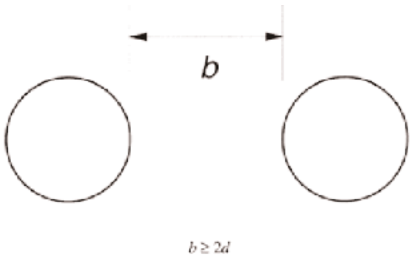



**Figure 14 — Relationship between two holes**

3) The distance, c, of the edge of a hole to the corner of the glass should be not less than 6d.

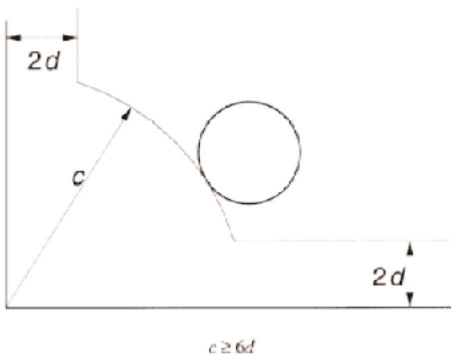



**Figure 15 — Relationship between hole and corner of pane**

NOTE If one of the distances from the edge of the hole to the edge of the glass is less than 35 mm, it can be necessary to position the hole asymmetrically with respect to the corner. The manufacturers should be consulted.

### 6.4.4 Tolerances on hole diameters

The tolerances on diameters of holes are given in Table 7.

| Nominal hole diameter Ø | Tolerance |
|---|---|
| 4 = Ø = 20 | ± 1,0 |
| 20 < Ø = 100 | ± 2,0 |
| 100 < Ø | consult the manufacturer |

**Table 7 – Tolerances on hole diameters**

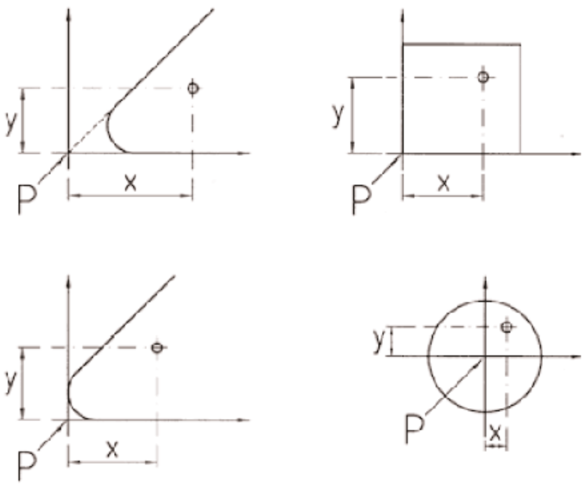
### 6.4.5 Tolerances on position of holes

The tolerances on positions of holes are the same as the tolerances on the width, B, and the length, H (see Table 2). The positions of holes are measured in two directions at right angles (x- and y- axes) from a datum point to the centre of the holes. The datum point is generally chosen as a real or virtual corner of the pane (see Figure 16 for examples).

The position of a hole (X,Y) is (x ± t, y ± t),

where x and y are the required dimensions and t is the tolerance from Table 2.

NOTE: Manufacturers should be consulted if tighter tolerances on hole positions are required.



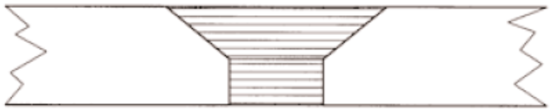

P – datum point

**Figure 16 — Examples of the positioning of holes relative to the datum point**

### 6.5 Holes/others

There are available countersunk holes, see Figure 17.
The manufacturer shall be consulted for the tolerances on hole position, hole shape/dimensions and edge work.

**Figure 17 — Countersunk hole**



### 6.6 Notches and cut-outs

Many configurations of notches and cut-outs can be manufactured, for examples see Figures 18a and 18b.

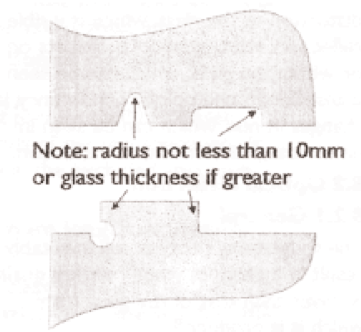



**Figure 18a — Examples of notches**

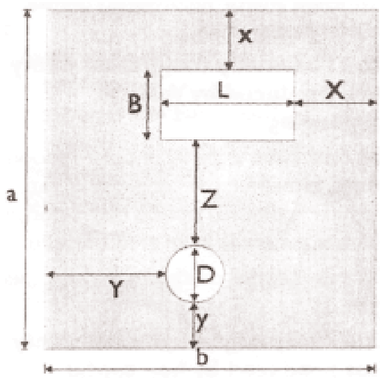



**Figure 18b — Examples of cut-outs**

Limitations on cut outs as shown in figure 18b:

- B, L and D < a/3 or b/3 whichever is the smaller;
- X and x not less than the smaller of L/2 or B/2;
- Y and y not less than D;
- Z not less than the larger of B/2, or L/2 and D/2

The manufacturer should be consulted about edge working of notches and cut-outs.

## 7 Shaped panes

Many non-rectangular shapes can be manufactured and manufacturers should be consulted.

## 8. Visual appearance

### 8.1 General

This section covers optical quality i.e. distortion of the glass which is visible in reflection; visual quality, i.e. defects on or within the glass, which can be seen in transmission; and colour consistency, i.e. changes in hue, which can be seen in either transmission and/or reflection.

### 8.2. Optical distortion

#### 8.2.1 General

The toughening process will inevitably result in a product whose optical quality is lower than that of the glass from which it is produced.

Surface distortion is produced by a reduction in the surface flatness, which can be seen particularly in reflection. This can be exacerbated when the glass used is body tinted, surface coated (including post-toughening coating) or enamelled and/or incorporated into insulating glass units.

#### 8.2.2 Thermally toughened soda lime silicate safety glass produced by vertical toughening

(see Annex 2.1)

#### 8.2.3 Thermally toughened soda lime silicate safety glass produced by horizontal toughening

While the hot glass is in contact with the rollers during the toughening process, a surface distortion is produced by a reduction in surface flatness, known as roller wave. Roller wave is generally noticed in reflection.

Thermally toughened glass, may show signs of small imprints in the surface (roller pick-up/pluck). This is a result of the length of time the glass spends in the furnace. Therefore the thicker the glass the more pronounced this could be.

NOTE: Toughenable low-e glass requires longer in the furnace.

#### 8.2.4. Roller wave

On toughened sheet glass, or toughened patterned glass, it is not possible to measure roller wave, due to the inherent distortion of the basic glass.

Method of measuring roller wave distortion is given in clause 5.3.3 and limits for acceptance in Table 4. An alternative measurement method is given in Annex B

### 8.3 Anisotropy (iridescence)

The thermal toughening process produces areas of different stress in the cross section of the glass. These areas of stress produce a bi-refringent effect in the glass, which is visible in polarised light.

The viewing of thermally toughened soda lime silicate safety glass under polarized light results in areas of stress showing up as coloured zones. These zones are, known as "leopard spots". Polarised light occurs in normal daylight. The amount of polarized light depends on the weather and the angle of the sun.
The bi-refringent effect is more noticeable either at a glancing angle or through polarized spectacles.

### 8.4 Visual quality

#### 8.4.1. Body faults, e.g. seeds, bubbles

The number, size and distribution of seeds, bubbles, etc. are defined for the glasses under consideration in the appropriate parts of EN 572.

No change will occur as a result of the toughening process.

Assessment of body faults should be undertaken using the method/criteria given, for the basic glasses in the appropriate parts of EN 572.

#### 8.4.2 Surface faults e.g. scars, scratches

Toughened safety glass shall be deemed acceptable if the following phenomena are neither obtrusive nor bunched: hairlines or blobs; fine scratches not more than 25mm long; minute imbedded particles. Obtrusiveness of blemishes shall be judged by looking through the glass, not at it, when standing at right angles to it on the room side at a distance of not less than 3 metres in natural daylight and not in direct sunlight. The area to be viewed is the normal vision area with the exception of a 50mm wide band around the perimeter of the glass.

Pattern ghosting can occur on glasses with a textured finish.

### 8.5 Colour consistency

#### 8.5.1 Clear glass

Clear glass from different manufacturers may show differences in hue.

#### 8.5.2 Body tinted glass

Toughening will not produce any significant variation in colour. However, if a piece of toughened body tinted glass is placed next to a piece of annealed body tinted glass there may be a discernible difference.

A far larger problem will occur if different thicknesses of body-tinted glass are placed side by side as the colour is throughout the glass thickness. This can occur in those areas where toughened safety glass is required and an attempt is made to use the increased strength of the toughened safety glass by reducing the thickness of the glass. Body tinted glass from different manufacturers, or from different batches from the same source manufacturer can show different shades.

#### 8.5.3 Surface coated glass

As a general rule those surface coated glasses which can be toughened may exhibit different visual characteristics or a slight colour variation as a result of toughening. Care should be taken to ensure that the coated surface is not contaminated before toughening by, for example oil, grease, sweat, etc, as these materials may be burnt in during the toughing process. This could produce patches on the coating where there is a significant colour variation.

Glass, which is coated after toughening, will be within the same manufacturers colour tolerance as coated annealed glass.

#### 8.5.4 Enamelled toughened safety glass

With this product the 'colour' results from the firing in of a ceramic frit. No colour variation will result from the toughening process itself.

However, the manufacturer should be consulted as to the likely tolerances on the colour and the possible variation between batches of ceramic frit. There is also a possibility that a colour variation may be noticeable if panes of different glass thickness or from different basic glass supplies are placed side by side.

## 9 Properties

### 9.1 Thermal durability

The mechanical properties of thermally toughened soda lime silicate safety glass are unchanged for continuous service up to 250oC and are unaffected by sub-zero temperatures.
Thermally toughened soda lime silicate safety glass is capable of resisting both sudden temperature changes and temperature differentials up to 200 K.

NOTE: This property does not have any relationship to the fire resistance performance.

### 9.2 Mechanical strength

The value of mechanical strength can only be given as a statistical value associated with a particular probability of breakage and with a particular type of loading, i.e. four point bending test according to EN 1288 - 3.

The mechanical strength values apply to quasi-static loading over a short time, e.g. wind loading, and relate to a 5 % probability of breakage at the lower limit of the 95 % confidence interval.
The values for different types of glass are listed in Table 8.

| Type of glass | Minimum values for mechanical strength $N/mm^2$ |
|---|---|
| Float – clear, tinted, coated | 120 |
| Enamelled Float* | 75 |
| Others | 90 |
| *Based on the enamelled surface in tension | |

**Table 8 — Minimum values for the mechanical strength of thermally toughened soda lime silicate safety glass**

### 9.3 Classification of performance under accidental human impact

Thermally toughened soda lime silicate safety glass can be classified, as to its performance under accidental human impact, by testing in accordance with EN 12600.

The classification determined will be as follows:

1(C)_

Where the value of _: is dependent upon the glass having a no-break performance at one of the three drop heights, i.e. 190mm, 450mm and 1200mm.

This means the classification could progress from:

*__1(C)0;__ where a test specimen broke at 190mm,*

*to __1(C)3;__ where no test specimens broke at 190mm but a test specimen broke at 450mm,*

*to __1(C)2;__ where no test specimens broke* at 190mm and 450mm but a test specimen broke at 1200mm, to **1(C)1;** where no test specimens broke

## 10 Glazing and fixing

### 10.1 General

Glazing should be in accordance with BS6262, BS 8000 Part 7, Glass and Glazing Federation Glazing Manual or other appropriate standard.

Appropriate edge clearances must always be allowed taking into account glass type, e.g. clear or solar control and either single or double-glazed. Suitable insulation or cushioning should be used to prevent contact with hard materials.

### 10.2 Use of mechanical fixings

Glass to metal contact must be eliminated at all times by the use of gaskets, bushes, linings and setting blocks. These should be of appropriate material, which has been approved by the thermally toughened soda lime silicate safety glass manufacturer.
All fittings to which the glass is to be clamped must be free from high spots and/or burrs. Care should be taken to ensure that when the glass is being clamped the clamping pressure is evenly distributed. For more information see BS 6262-6: 2005.

## 11 Fragmentation test

### 11.1 General

The fragmentation test determines whether the glass breaks in the manner prescribed for a thermally toughened soda lime silicate safety glass.

### 11.2 Dimensions and number of test specimens

The dimensions of the test specimens shall be 360 mm x 1100 mm, without holes, notches or cut-outs.

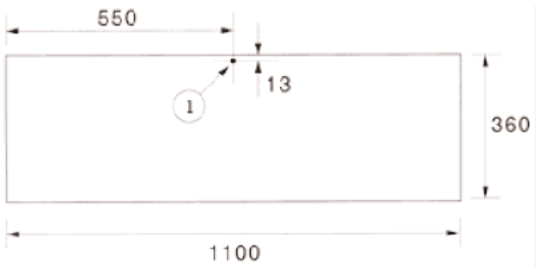
### 11.3 Test procedure

Each test specimen shall be impacted, using a pointed steel tool, at a position 13 mm in from the longest edge of the test specimen at the mid-point of that edge, until breakage occurs (see Figure 19).

NOTE: The fragmentation characteristics of thermally toughened soda lime silicate safety glass are unaffected by temperatures between – 50ºC and + 100ºC.

Examples of steel tools are a hammer of about 75 g mass, a spring loaded centre punch, or other similar appliance with a hardened point. The radius of curvature of the point should be approximately 0,2 mm.

The test specimen shall be laid flat on a table without any mechanical constraint. In order to prevent scattering of the fragments, the specimen shall be simply held at the edges, e.g. by a small frame, adhesive tape etc., so that the fragments remain interlocked after breakage yet extension of the specimen is not hindered.



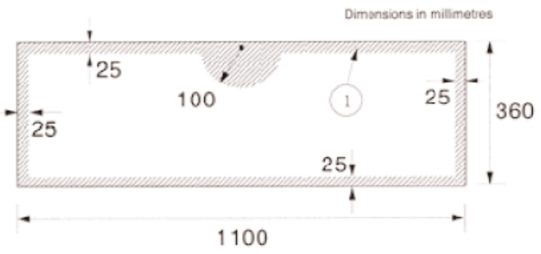

**Key:**
**1 - impact point**

**Figure 19 — Position of impact point**

For thermally toughened soda lime silicate safety glass manufactured by vertical tong hung process, the impact point shall not be on the tong mark edge.

### 11.4 Assessment of fragmentation

The particle count and measuring of the dimensions of the largest particle shall be made between 4 minutes to 5 minutes after fracture. An area of radius 100 mm, centred on the impact point, and a border of 25 mm, round the edge of the test specimen (see Figure 20), shall be excluded from the assessment.




**Key:**
**1 - excluded area**

**Figure 20 — Area to be excluded from the particle count determination and largest particle measurement**

The particle count shall be made in the region of coarsest fracture (the aim being to obtain the minimum value). The particle count shall be made by placing a mask of (50 ± 1) mm x (50 ± 1) mm on the test piece (see Annex C). The number of crack-free particles within the mask shall be counted. A particle is 'crack-free' if it does not contain any cracks which run from one edge to another (see Figure 21).

The examination shall be completed within 5 minutes of fracturing the glass.


**Figure 21 — Examples of crack-free particles and the assessment regarding the number**

In the particle count, all particles wholly contained within the area of the mask shall be counted as one particle each and all the particles which are partially within the mask shall be counted as 1/2 particle each (see Annex B).

### 11.5 Minimum values from the particle count

In order to classify a glass as a thermally toughened soda lime silicate safety glass, the particle count of each test specimen shall not be less than the values given in Table 9.

**Table 9 — Minimum particle count values**

| Glass type | Nominal thickness, d, mm | Minimum particle count number |
|---|---|---|
| Patterned | 3<br>4 to 19 | 30<br>40 |
| Float and Sheet | 3 to 12<br>15 to 25 | 40<br>30 |

### 11.6 Selection of the longest particle

The longest particle shall be chosen from the body of the test specimen. It shall not be in the excluded area (see 11.4).

### 11.7 Maximum length of longest particle

In order to classify the glass as thermally toughened soda lime silicate safety glass, the length of the longest particle shall not exceed 100mm.

### 12 Marking

According to EN 12150-1 the thermally toughened soda lime silicate safety glass shall be marked as follows:

Manufacturer's name or trade mark, number of the standard, i.e. EN 12150

To comply with UK building regulations covering accidental human impact the installed thermally toughened soda lime silicate safety glass must be indelibly marked and the marking must be visible after installation. The marking shall consist of the following:

Manufacturer's name or trade mark
Number of the standard, i.e. EN 12150

Classification in accordance with EN 12600, i.e. 1(C) as a minimum.

The full performance classification, i.e. 1(C) _, will be required when the glass is protecting a difference in drop.

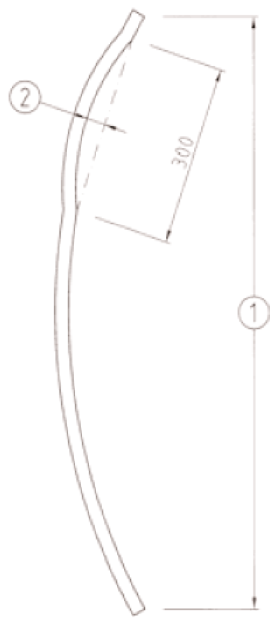
NOTE: The _ is dependent on glass type, thickness etc.

### Annex A Tolerances and distortions specific to thermally toughened soda lime silicate safety glass produced by the vertical tong hung process

### A.1 Distortion

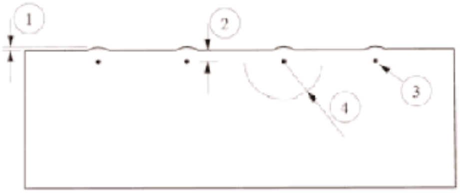
### A.1.1 Edge deformation produced by the vertical process (see 5.2.4)

The tongs used to suspend the glass during toughening result in surface depressions, known as tong marks (see Figure A.2). The centres of the tong marks are situated up to a maximum of 20 mm in from the edge. A deformation of the edge less than 2 mm can be produced in the region of the tong mark and there may also be an area of optical distortion. These deformations are included in the tolerances in Table 2.




**Key:**
**1 - B, or H, the side on which the tong marks occur**
**2 - local distortion**

**Figure A.1 — Representation of local distortion**




**Key:**

**1 - deformation**

**2 - up to 20 mm**

**3 - tong mark**

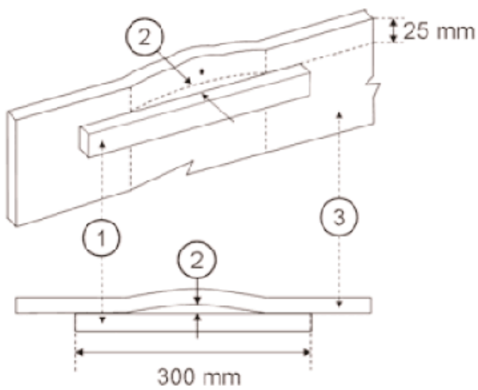
**4 - 100 mm radius maximum area of optical distortion**

**Figure A.2 — Tong mark deformation**

### A.1.2 Measurement of local distortion (for vertical toughened glass only) (see 5.3.5)

Local distortion can occur over relatively short distances on the edge of the vertical toughened glass that contains the tong marks (see Figure A.3).

Local distortion shall be measured over a limited length of 300 mm by using a straight ruler parallel to the edge at a distance of 25 mm from the edge of the glass (see Figure A.3). Local distortion is expressed as millimetres/ 300 mm length.




**Key:**

**1 - straight edge**

**2 - local distortion**

**3 - thermally toughened glass**

**Figure A.3 — Measurement of local distortion**

### A.1.3 Limitation on overall bow and local distortion for vertical toughened glass (see 5.3.7)

The maximum allowable values for the overall bow, when measured according to 5.3.2 and the local distortion, when measured according to A.2 are given in Table A.1. The values only apply to thermally toughened soda lime silicate safety glass without holes and/or notches and/or cut-outs.

| Glass type | Maximum value for distortion | |
|---|---|---|
| | Overall bow mm/m | Local distortion mm/ 300mm |
| All (a) | 5,0 | 1,0 |

(a) For enamelled glass that is not covered over the whole surface the manufacturer should be consulted.

**Table A.1 — Maximum values of overall bow and local distortion for vertical toughened glass**

### A.2 Optical distortion

### A.2.1 Thermally toughened soda lime silicate safety glass produced by vertical toughening (see 8.2.2)

The distortion is generally of a random nature. However, the tong marks can produce additional optical distortion, which is generally in an area of radius 100 mm centred on the tong mark (see Figure A.2)

## Annex B Alternative method of measuring roller wave

### B.1 Apparatus

This is a 350 mm long aluminium channel with a centrally mounted deflection gauge/dial gauge (Figure B.1).

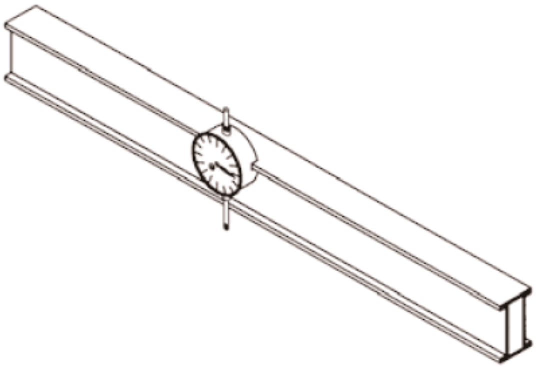


**Figure B.1 — Roller wave measurement apparatus**

### B.2 Method

The apparatus is placed on the glass at right angles to the roller wave, so that it can bridge from peak to peak of the wave (Figure B.2).

**Figure B.2 — Place the apparatus across the roller wave**

The apparatus is then moved along its axis until the dial gauge reads the highest value (Figure B.3).

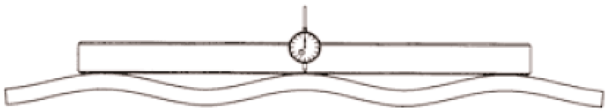


**Figure B.3 — Set the zero of the gauge on a peak of the roller wave**

At this point, the dial gauge is resting on a peak of the roller wave. The scale of the gauge is positioned (rotated) so that the needle points to 0 (zero) on the scale.
The apparatus is then moved again along its axis until the gauge reads the lowest value (Figure B.4). At this point, the dial gauge is resting in the lowest point of the trough.
The reading is then taken, and the depth of the roller wave is the difference between the zero point and the reading.

NOTE: The dial gauge scale is usually arranged so that a positive value is obtained by raising the post. Care should be taken to not misread the depth of the roller wave.

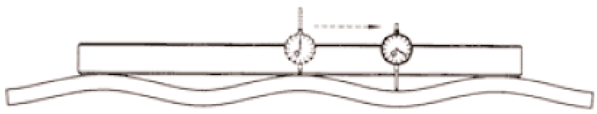


**Figure B.4 — Move the gauge to a trough**

The roller wave depth is recorded to the nearest 0,05 mm. y

The above procedure can be performed several times on the same pane, giving a variety of answers, since the roller waves are unlikely to be consistent. The worst roller wave of those recorded is the value of the pane.

### B.3 Limitations

The apparatus should only be used on panes with a dimension larger than 600 mm at right angles to the roller wave. There is an exclusion area, 150 mm from the edge of the pane, where the apparatus should not be used.

A true measurement of roller wave can only be obtained on an otherwise flat pane of glass. If the pane has an overall bow, this will contribute to the value measured by the roller wave and must be taken into account.

This can be reduced by laying the pane of glass flat on a table, which will reduce the overall bow in the pane due to the self weight of the pane, particularly with larger panes.

### B.4 Alternative use of apparatus

If the dial gauge is mounted on the end of the aluminium channel rather than at the centre then it may be used for the measurement of edge lift.

Lay the test sample over the end of a table with the edge lift overhanging the edge of the support by between 50 mm and 100 mm so that the edge lift is as shown in Figure 5 Move the apparatus towards the edge of the sample.

Measure the maximum deflection of the gauge from when sitting on a peak to touching the edge of the sample.

## Annex C Example of particle count

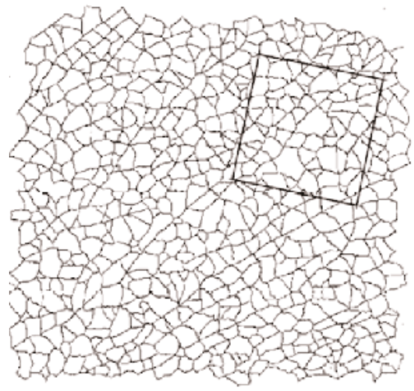
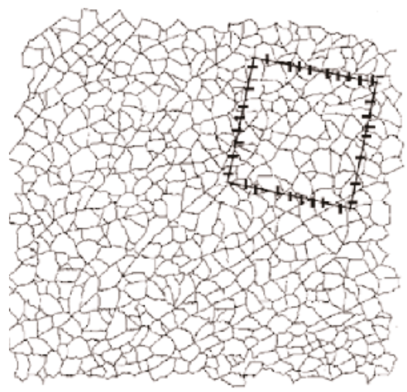


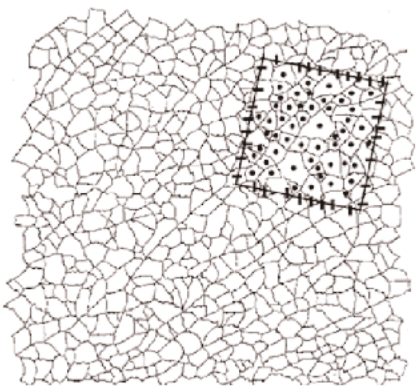
**Figure C.1 — Select the area of coarsest fracture, according to 11.4, place the template on the test specimen and draw round the template.**



**Key:**

**Number of perimeter particles = 32/2 = 16**

**Figure C.2 — Mark and count the perimeter fragments particles as 1/2 particle each**



**Key:**

**Number of central particles = 53**
**Total number of particles = 16 + 53 = 69**

**Figure C.3 — Mark and count the central particles and add these to the perimeter count to obtain the particle count for the specimen**

**Bibliography**

**BS EN 572-1:** *Glass in building - Basic soda lime silicate glass products - Part 1: Definitions and general physical and mechanical properties*

**BS EN 572-2:** *Glass in building - Basic soda lime silicate glass products- Part 2: Float glass*

**BS EN 572-4:** ***2005*** *Glass in building - Basic soda lime silicate glass products - Part 4: Drawn sheet glass*

**BS EN 572-5:** *Glass in building - Basic soda lime silicate glass products - Part 5: Patterned glass*

**BS EN 572-8:** *Glass in building .- Basic soda lime silicate glass products - Part 8: Supplied and final cut sizes*

**BS EN 572-9:** *Glass in building. Basic soda lime silicate glass products- Part 9: Evaluation of conformity/Product standard*

**BS EN 1096-1:** *Glass in buildin - Coated glass- Part 1: Definitions and classification*

**BS EN 1288-3:** *Glass in building - Determination of the bending strength of glass - Part 3: Test with specimen supported at two points (four point bending)*

**BS EN 12150-1:** *Glass in building – Thermally toughened soda lime silicate safety glass – Part 1: Definition and description*

**BS EN 12150-2:** *Glass in building – Thermally toughened soda lime silicate safety glass – Part 2: Evaluation of conformity/Product standard*

**BS EN 12600:** *Glass in building - Pendulum test - Impact test method and classification for flat glass*

**BS 6262-4:** ***2005*** *Glazing for buildings – Part 4: Code of practice for safety related to human impact*

**BS 6262-6:** *Glazing for buildings – Part 6: Code of practice for special applications*

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# GGF Data Sheet: Thermally Treated Soda Lime Silicate Glass Products - General

4.4.1 May 2016

**Contents**



## Introduction

Glass always breaks due to excessive tensile stresses being applied to the surface or/and edges of the glass and over stressing either the natural sub-microscopic "Griffiths Flaws" or larger flaws caused by damage to the glass.

The earliest discovery of a stronger form of glass was "Prince Rupert's Drops" which were made from tear drops of molten glass cooled rapidly. These were more entertaining than useful, but could resist hammer blows at levels of force which would shatter annealed (untreated) glass.

The physical reasons for this phenomenon was not known at the time of the discovery, but results from the fact that glass taken above a critical temperature contracts to a lesser extent if it is cooled more rapidly. The effect of quenching a glass panel cools the surface very rapidly, but the interior of the glass cools less rapidly and contracts to a greater extent than the surface layers. The heat treated product has a set of built- in stresses as a result of the different rates of contraction. The stresses are compressive at the surface with a balancing tensile stress in the central region.

The built-in compressive stress at the surface of the glass has to be overcome before the flaws in the surface become susceptible to over stressing. The effect is to provide a product which is more resistant to applied forces, be they of mechanical, impact or thermal origin.

There are three different types of thermally treated glass products available:

- Heat strengthened soda lime silicate glass – EN 1863
- Thermally toughened soda lime silicate safety glass – EN 12150
- Heat soaked thermally toughened soda lime silicate safety glass – EN 14179

## 1. Scope

This GGF Data Sheet examines, in general terms, the various types of thermally treated soda lime silicate glass products.

Thermally toughened soda lime silicate safety glass is covered in detail in the GGF Data Sheet 4.4 - Quality of Thermally Toughened Soda Lime Silicate Safety Glass for Building.

This GGF Data Sheet does not apply to:

1. Curved thermally treated glass products
2. Spontaneous breakage of thermally treated soda lime silicate glass products

NOTE 1: See GGF Data Sheet 4.12.3: Curved Glass – Part 3: Curved Thermally Treated Glass Products.

NOTE 2: See GGF Data Sheet 4.4.2: Thermally Treated Soda Lime Silicate Glass Products – Spontaneous Breakage.

## 2. Heat Strengthened Soda Lime Silicate Glass

### 2.1 Manufacturing stress levels

Heat strengthened glass is made from non-wired annealed glass which has been heated to a uniform temperature above 650 °C and cooled fairly rapidly, usually by blowing cold air evenly at both surfaces. Heat strengthened glass has a built-in stress as a result of this process, giving a surface compressive stress in the range of 25 N/mm² to 42 N/mm², i.e. 3,600 psi to 6,000 psi.

### 2.2 Strength characteristics

Heat strengthened glass will resist mechanical forces more than annealed glass, although it is sometimes not possible to make full use of this, because heat strengthened glass has only the same modulus of elasticity as annealed (untreated) glass. The design of a heat strengthened glass pane is often governed by deflection limitations rather than strength limitations.

### 2.3 Thermal characteristics

Heat strengthened glass will resist thermal stresses and thermal shock at levels more than two times higher than annealed glass. The figure quoted in EN 1863-1 is 100K. This should be sufficient to cope with most of the thermal stresses encountered in glazing in buildings. Heat strengthened glass has a maximum operating temperature of 200 °C.

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### 2.4 Fracture characteristics

Heat strengthened glass is designed to give some of the advantages of toughened glass, e.g. a proportion of the increased strength and thermal resistance, while retaining the fracture characteristics of annealed glass. In order for this to occur, the levels of built-in stresses must be sufficiently low to eliminate the possibility of violent crack propagation after a fracture is initiated.

The maximum compressive surface stress must be below 42 N/mm², i.e. 6,000 psi, to comply with this requirement.

Since the fracture characteristics of heat strengthened glass are similar to annealed glass, it should not be considered as a safety glass. Therefore a classification under the pendulum impact test, i.e. EN 12600, should not be claimed. However, if heat strengthened glass is used in a situation that requires a safety glass then it should be laminated to enable it to obtain an EN 12600 classification.

NOTE: The laminated product should conform to EN 14449.

### 2.5 Thickness limitations

The fragmentation requirement requires that the built-in stress are limited and this can lead to difficulties in providing uniform cooling at a sufficiently slow rate when the glass thickness is more than 10 mm. In practice heat strengthened glass can only be supplied 10 mm or thinner.

### 2.6 Optical distortion and bow

Heat strengthened glass is susceptible to optical distortion and bow in a similar manner to toughened glass (see 3.6), but the slightly less onerous processing regime and the lower levels of built-in stress make it possible that the amount of distortion and bow will be less than in toughened glass.

The possible reduction in bow and distortion means that heat strengthened glass may be a more visually pleasing product than toughened glass where opaque cladding panels or reflective glasses are required to have higher resistance to thermal stress than annealed (untreated) glass.

### 2.7 Nickel sulfide inclusions

See GGF Data Sheet 4.4.2: Thermally Treated Soda Lime Silicate Glass Products – Spontaneous Breakage.

### 2.8 Marking

The heat strengthened soda lime silicate glass in accordance with EN 1863-1 shall be marked as follows:

- Manufacturers trade mark or name
- The standard number, i.e. EN 1863

### 2.9 Compliance

Heat strengthened soda lime silicate glass that meets the requirements of EN 1863-1 shall be manufactured and approved to comply with EN 1863-2.

## 3. Thermally Toughened Soda Lime Silicate Safety Glass

### 3.1 Manufacturing stress levels

Toughened glass is made from non-wired annealed glass which has been heated to a uniform temperature above 650 °C and cooled rapidly, usually by blowing cold air evenly at both surfaces. Toughened glass has a high built-in stress as a result of the rapid cooling, giving a surface compressive stress in the range of 80 N/mm² to 150 N/mm², i.e. 11,600 psi to 21,700 psi.

A thermally toughened glass, suitable for safety glass applications is likely to have a surface compressive stress greater than 100 N/mm², i.e. 14,500 psi. To confirm that the thermally toughened glass can claim resistance to accidental human impact it must be classified for pendulum impact performance in accordance with EN 12600.

### 3.2 Strength characteristics

Toughened glass will resist mechanical forces more than 4 times higher than annealed glass, although it is often not possible to make full use of this, because toughened glass has only the same modulus of elasticity as annealed (untreated) glass. The design of a toughened glass pane is often governed by deflection limitations rather than strength limitations.

(See also GGF Data Sheet 4.4: Quality of Thermally Toughened Soda Lime Silicate Safety Glass for Building, Section 9.2: Mechanical strength).

The strength of toughened safety glass is sufficient to allow it to be used in a number of structural and semi structural roles. In particular, toughened glass has a usable and reliable strength for holes and notches, which make it suitable for bolted connections, provided these are suitably designed.

(See also GGF Data Sheet 4.4: Quality of Thermally Toughened Soda Lime Silicate Safety Glass for Building, Section 6: Edge and/or surface work, holes, notches and cut-outs and BS 6262-6: 2005).

### 3.3 Thermal characteristics

Toughened glass will resist thermal stresses and thermal shock at levels more than 5 times higher than annealed glass. The figure quoted in EN 12150-1 is 200K. It has a maximum operating temperature of 250 °C, above which it is possible for the built-in stresses to be gradually released.

### 3.4 Fracture characteristics

Due to the high levels of built-in stresses, once a fracture is initiated in toughened glass, it propagates violently due to the released energy. The effect is to disintegrate the glass into numerous small pieces, the edges of which are generally relatively harmless and are unlikely to cause cutting and piercing injuries like broken pieces of annealed glass

(See also GGF Data Sheet 4.4. Quality of Thermally Toughened Soda Lime Silicate Safety Glass for Building: Section 4: Fracture Characteristics).

It is because of this fragmentation after fracture that thermally toughened soda lime silicate safety glass when classified in accordance with EN 12600 is regarded as a safety glass. When it is classified as a safety glass it can then be used in critical locations (as defined in BS 6262-4: 2005). It is necessary to ensure that the toughened glass has sufficiently high built-in stress to provide the fragmentation characteristics required for a safety glass.

The fracture pattern, under controlled fracture conditions, can be used to assess the quality of toughened glass. When the glass is fractured under controlled conditions, the number of particles counted within a 50 mm square provides evidence of thermally toughened safety glass. The following minimum particle counts are detailed in EN 12150-1: 2015 Glass in building, Thermally toughened soda lime silicate safety glass. Definition and description, clause 8.5, table 10 - minimum particle count values.

| Glass type | Minimum thickness *d mm* | Minimum particle count *number* | Shower enclosures *see EN 14428* |
|---|---|---|---|
| All glass types | 2 | 15 | not applicable |
| All glass types | 3 | 15 | 40 |
| All glass types | 4 to 12 | 40 | 40 |
| All glass types | 15 to 25 | 30 | 30 |

*Extract from EN 12150-1: 2015*

(See also GGF Data Sheet 4.4: Quality of Thermally Toughened Soda Lime Silicate Safety Glass for Building: Section 11: Fragmentation test).

### 3.5 Thickness limitations

There are no practical limits on the thicknesses of non-wired annealed glass that can be thermally toughened. However, depending upon actual thickness and/or thickness variation certain products may not be able to be classified for resistance to pendulum body impact.

### 3.6 Optical distortion and bow

The heating of the glass softens it sufficiently to allow gravitational or other forces to cause minor distortions of the glass, leaving it optically less perfect than the annealed glass from which it was made. The toughening process may also cause some bow in the glass. While manufacturers make efforts to keep the distortion and bow to a minimum, it is inevitable that some will occur.

Any distortion or bow will be much more noticeable when the glass is viewed in reflection. This is particularly the case with opaque cladding panels and reflective coated glasses.

(See also GGF Data Sheet 4.4: Quality of Thermally Toughened Soda Lime Silicate Safety Glass for Building, Section 5.3: Flatness).

### 3.7 Nickel sulfide inclusions

See GGF Data Sheet 4.4.2: Thermally Treated Soda Lime Silicate Glass Products – Spontaneous Breakage

### 3.8 Marking

The thermally toughened soda lime silicate safety glass in accordance with EN 12150-1 shall be marked as follows:

- Manufacturers trade mark or name;
- The standard number, i.e. EN 12150,

And when used in critical locations, see BS 6262-4: 2005,

- EN 12600 classification

### 3.9 Compliance

Thermally toughened soda lime silicate safety glass that meets the requirements of EN 12150-1 shall be manufactured and approved to comply with EN 12150-2.

## 4. Heat Soaked Thermally Toughened Soda Lime Silicate Safety Glass

### 4.1 General

The description of a heat soaked thermally toughened soda lime silicate safety glass from EN 14179-1 can be presented as follows:

Heat soaked thermally toughened soda lime silicate safety glass has a similar break pattern to thermally toughened soda lime silicate safety glass according to EN 12150. It also has a known level of residual risk of spontaneous breakage arising from the possible presence of critical nickel sulfide (NiS) inclusions in the thermally toughened soda lime silicate glass.

### 4.2 Manufacturing process

Heat soaked thermally toughened soda lime silicate safety is manufactured initially as thermally toughened soda lime silicate safety glass that is then subjected to the heat soak process cycle.

The heat soak process cycle consists of heating the glass up to 280 °C. The glass is then held at a temperature between 290 °C ± 10 °C for a period of two hours. After the holding period the glass is cooled in a controlled manner.

NOTE: With the publication of EN 14179-1: 2016, the holding temperature will change to 260 ± 10 °C.

NOTE: If a critical nickel sulfide inclusion is present then the glass should break during the heat soak process.

### 4.3 Properties

The heat soaked thermally toughened soda lime silicate safety glass has the same properties as thermally toughened soda lime silicate safety glass. (See clauses 3.1 to 3.6)

### 4.4 Nickel sulfide inclusions

Heat soaked thermally toughened soda lime silicate safety glass is manufactured so as to limit the likelihood of critical nickel sulfide inclusions being present in the final product.

According to EN 14179-1:

> The risk of spontaneous breakage, on a statistical basis, due to the presence of critical nickel sulfide inclusions is 1 breakage per 400 tonnes of heat soaked thermally toughened soda lime silicate safety glass.

NOTE: This residual risk is on a statistical basis and does not necessarily refer to any specific batch.

(See also GGF Data Sheet 4.4.2: Thermally Treated Soda Lime Silicate Glass Products – Spontaneous Breakage)

### 4.5 Marking

The heat soaked thermally toughened soda lime silicate safety glass in accordance with EN 14179-1 shall be marked as follows:

- Manufacturers trade mark or name;
- The standard number, i.e. EN 14179,

And when used in critical locations, see BS 6262-4: 2005,

- EN 12600 classification

### 4.6 Compliance

Heat soaked thermally toughened soda lime silicate safety glass that meets the requirements of EN 14179-1 shall be manufactured and approved to comply with EN 14179-2.

## Bibliography


### British Standards

**BS 6262-4: 2005** Glazing for buildings - Part 4: Code of practice for safety related to human impact

**BS 6262-6: 2005** Glazing for buildings - Part 6: Code of practice for special applications

### European Standards

**EN 1863-1** Glass in building - Heat strengthened soda lime silicate glass - Part 1: Definition and description

**EN 1863-2** Glass in building - Heat strengthened soda lime silicate glass - Part 2: Evaluation of conformity/Product standard

**EN 12150-1** Glass in building - Thermally toughened soda lime silicate safety glass - Part 1: Definition and description

**EN 12150-2** Glass in building - Thermally toughened soda lime silicate safety glass - Part 2: Evaluation of conformity/ Product standard

**EN 12600** Glass in building - Pendulum test - Impact test method and classification for flat glass

**EN 14179-1** Glass in building - Heat soaked thermally toughened soda lime silicate safety glass - Part 1: Definition and description

**EN 14179-2** Glass in building - Heat soaked thermally toughened soda lime silicate safety glass - Part 2: Evaluation of conformity/Product standard

**EN 14449** Glass in building - Laminated glass and laminated safety glass

### GGF Data Sheets

**GGF Data Sheet 4.4** Quality of Thermally Toughened Soda Lime Silicate Safety Glass for Building

**GGF Data Sheet 4.4.2** Thermally Treated Soda Lime Silicate Glass Products - Spontaneous Breakage

# GGF Data Sheet: Thermally Treated Soda Lime Silicate Glass Products - Spontaneous Breakage

4.4.2 May 2016

**Contents**



## Introduction

Thermally treated glasses may fracture from a variety of causes. These may be as follows:

- Edge damage, caused during e.g. manufacture, transportation, installation, service conditions
- Sharp body impact, either accidental or malicious
- Poor glazing design, e.g. glass to metal contact
- Poor workmanship e.g. incorrect installation, inappropriate assembly of fittings, unskilled labour
- Inferior glazing materials, e.g. use of incorrect gaskets, bushes, etc.
- Excessive loads either mechanical or thermal
- Incorrect processing of glass
- Inclusions in the glass

Thermally treated glass thus becomes associated with unexplained, but noticeable, breakages and these have been labelled "spontaneous fractures", whereas breakages from similar causes in other types of glass are frequently referred to as "cracks".

In fact, thermally treated glass is less susceptible to breakages than any other form of glass, but the fracture propagates with a loud noise which may be accompanied by falling particles, and is therefore much more obvious.

In addition, the origin of the fracture, which is a source of information as to the cause, is often lost.

Of the various causes of "spontaneous fracture", only that associated with the presence of foreign particles in the glass is more likely to cause fracture in thermally treated glass than in other forms of glass, because they can disturb the very high built-in stresses in thermally treated glass.

Spontaneous breakage due to inclusions is possible in any of the three different types of thermally treated glass products available:

- Heat strengthened soda lime silicate glass – EN 1863
- Thermally toughened soda lime silicate safety glass – EN 12150
- Heat soaked thermally toughened soda lime silicate safety glass – EN 14179

**NOTE: The presence of an inclusion within annealed glass is not a problem. It is only of concern when in the tensile stress zone of a thermally treated product.**

## 1. Scope

This GGF Data Sheet covers the spontaneous breakage of thermally treated glasses, together with types of critical inclusions, the rate of occurrence, and associated risks.

Whilst breakage for other reasons can occur, these are not dealt with in this GGF Data Sheet.

Thermally toughened soda lime silicate safety glass is covered in GGF Data Sheet 4.4: Quality of Thermally Toughened Soda Lime Silicate Safety Glass for Building.

Other thermally treated soda lime silicate glasses are covered in GGF Data Sheet 4.4.1: Thermally Treated Soda Lime Silicate Glass Products - General.

## 2. Definitions and Descriptions

(See also GGF Data Sheet 4.4.1: Thermally Treated Soda Lime Silicate Glass Products - General)

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### 2.1 Heat strengthened soda lime silicate glass

Glass within which a permanent surface compressive stress, additionally to the basic mechanical strength, has been induced by a controlled heating and cooling process in order to give it resistance to mechanical and thermal stress and prescribed fracture characteristics.

### 2.2 Thermally toughened soda lime silicate safety glass

Glass within which a permanent surface compressive stress, additionally to the basic mechanical strength, has been induced by a controlled heating and cooling process in order to give it greatly increased resistance to mechanical and thermal stress and prescribed fragmentation characteristics

NOTE: The mechanical properties, i.e. thermal durability and mechanical strength, and safety properties, i.e. fragmentation characteristics, are generated by the stress distribution through the glass. Mechanical properties are related to the level of surface compression. Fragmentation is dependent on the inner tensile stress. These properties are not size dependent.

### 2.3 Heat soaked thermally toughened solda lime silicate safety glass

Glass within which a permanent surface compressive stress has been induced in order to give it greatly increased resistance to mechanical and thermal stress and prescribed fragmentation characteristics; and which has a reduced level of residual risk of spontaneous breakage due to the presence of critical nickel sulfide inclusions.

NOTE: The mechanical properties, i.e. thermal durability and mechanical strength, and safety properties, i.e. fragmentation characteristics, are generated by the stress distribution through the glass. Mechanical properties are related to the level of surface compression. Fragmentation is dependent on the inner tensile stress. These properties are not size dependent.

### 2.4 Spontaneous breakage (also referred to as spontaneous fracture)

An apparent unexplained fracture that can occur in heat treated glasses without an obvious external influence.

### 2.5 Inclusions

An inclusion that by virtue of its size and position in the thermally treated glass can cause failure.

NOTE: These can be of various materials that are either critical e.g. nickel sulfide, or non-critical e.g. refractory stone, un-melted frit.

### 2.6 Critical inclusions

An inclusion or small impurity in the glass that can undergo a phase change which may lead to fracture of thermally toughened soda lime silicate glass sometime after toughening.

NOTE: Failure is also possible in heat strengthened soda lime silicate glass.

### 2.7 Nickel Sulfide inclusions

The most common type of critical inclusion found within thermally treated soda lime silicate glass is nickel sulfide.

### 2.8 Level of associated risk

Risk of spontaneous breakage of thermally treated soda lime silicate glass on a statistical basis due to the presence of critical inclusions.

## 3. Heat Strengthened Soda Lime Silicate Safety Glass

### 3.1 The process

Heat strengthened glass is formed by heating annealed glass and then cooling it under controlled conditions. (More rapidly than during the annealing process, but not as rapidly as for toughened glass). Differential rates of cooling between the surface and the core of the glass causes differential contraction, the effect of which is to generate a compressive stress in the surface layer of the glass and a balancing tensile stress in the core.

Heat strengthened glass has a built-in stress as a result of this process, giving a surface compressive stress in the range of 25 N/mm² to 42 N/mm², i.e. 3,600 psi to 6,000 psi.

Heat strengthened glass offers some of the mechanical and thermal strength benefits of toughened glass but it still fails in a manner similar to that of annealed glass, but at higher loads.

### 3.2 Thermal characteristics

Heat strengthened glass will resist thermal stress and thermal shock at levels more than 2.5 times higher than annealed glass. The figure quoted in EN 1863-1 is 100K. It has a maximum operating temperature of 200 °C.

### 3.3 Rate of occurrence of fracture due to inclusions

Because the central tensile zone in heat strengthened glass has a reduced level of stress compared with that in thermally toughened safety glass, the size of the inclusion needed to propagate fracture is much larger

### 3.4 Residual risk

Spontaneous breakage is highly unlikely due to the low compressive stress level in this product and the size of critical inclusion necessary to initiate breakage. There are very few reported cases of spontaneous fractures of heat strengthened glass in Europe. The residual risk of fracture due to a critical inclusion is considered minimal.

## 4. Thermally Toughened Soda Lime Silicate Safety Glass

### 4.1 The process

Thermally toughened soda lime silicate safety glass is made from annealed glass which has been heated to a uniform temperature above 650 °C and cooled rapidly, usually by blowing cold air evenly at both surfaces. Toughened glass has a high built-in stress as a result of the rapid cooling, giving a surface compressive stress in the range of 80 N/mm² to 150 N/mm², i.e. 11,600 psi to 21,700 psi.

A thermally toughened glass suitable for safety glass applications, i.e. one that can be classified in accordance with EN 12600, is likely to have a surface compressive stress greater than 100 N/mm², i.e. 14,500 psi.

### 4.2 Thermal characteristics

Toughened glass will resist thermal stresses and thermal shock at levels equal to or greater than 5 times that of annealed glass. The figure quoted in EN 12150-1 is 200K. It has a maximum operating temperature of 250 °C.

### 4.3 Fracture characteristics

Due to the high levels of built-in stresses, once a fracture is initiated in toughened glass, it propagates rapidly due to the released energy. The effect is to disintegrate the glass into numerous small pieces, the edges of which are generally relatively harmless and are unlikely to cause cutting and piercing injuries like broken pieces of annealed glass.

A fractured vertical pane may remain in its frame unless dislodged by external actions such as wind, thermally induced bowing, human interference or freezing water.

Sloping panes and other types of glazing systems are highly likely to fall after fracture, even if framed.

### 4.4 Rate of occurrence of fracture due to inclusions

There are no definitive and proven concentration levels for critical inclusions in any manufacturers thermally toughened soda lime silicate safety glass.

NOTE: Glass manufacturers have taken action to reduce nickel contamination of the annealed glass since NiS was shown to be a cause of spontaneous fracture of toughened glass. Consequently the incidence of NiS in glass has now been reduced.

### 4.5 Residual risk

Spontaneous breakage of thermally toughened soda lime silicate safety glass due to critical inclusions remains statistically unlikely for the large quantities of glass supplied and installed in buildings.

NOTE: A residual risk of fracture due to critical inclusions in thermally toughened soda lime silicate safety glass still remains.

## 5. Nickel Sulfide Inclusions

### 5.1 Background

Nickel sulfide has two main states, one of which is stable at high temperatures and one which is stable at lower temperatures. When glass is thermally treated the nickel sulfide transforms to the high temperature state during the heating process, but the glass is cooled rapidly which does not allow the reverse transformation to the low temperature state. This reverse transformation occurs over a period of time, accompanied by an increase in volume.

Therefore if:

- the nickel sulfide inclusion is large enough, and
- within the tensile (central) portion of the thermally treated glass,

It can cause fracture at some time after manufacture.

NOTE: Nickel sulfide is referenced as the critical inclusion. Actually the chemical composition will not be true $Ni_{(1)}S_{(1)}$ but a range. Generally the inclusion will also have other elements, e.g. iron, selenium, etc, incorporated. These multi component inclusions act at different temperatures and/or times when undergoing the phase change.

All types of thermally treated glass, i.e. heat strengthened, thermally toughened, can be subject to spontaneous breakage as the result of the presence of critical nickel sulfide inclusions.

However, the risk of spontaneous breakage due to the presence of a critical nickel sulfide inclusion can be significantly reduced by using heat soaked thermally toughened soda lime silicate safety glass in accordance with EN 14179.

NOTE: In service conditions the conversion of critical inclusions is affected by glass temperature. The higher the temperature, the rate of conversion is greater therefore increasing the risk of fracture.

For further information, see Annex A.

## 6. Heat Soaked Thermally Toughened Soda Lime Silicate Safety Glass

### 6.1 The process

Heat soaked thermally toughened soda lime silicate safety glass is manufactured by taking thermally toughened panes and subjecting them to the heat soak process cycle.

The heat soak process cycle consists of a heating phase, a holding phase and a cooling phase.

This process encourages unstable **α** phase to convert to the **β** stable phase and force the glass to fracture within the heat soaking oven.

The heat soak process cycle in EN 14179-1 requires the glass to be heated to a temperature greater than 280 °C, held at a temperature of 290 °C ± 10 °C for a period of 2 hours before controlled cooling to an ambient temperature.

This process is used to reveal the presence of critical inclusions in glass panes. It is a destructive test that is designed to break glass that is at risk.

NOTE: With the publication of EN 14179-1: 2016, the holding temperature will change to 260 °C ± 10 °C

### 6.2 Thermal Characteristics

Heat soaked thermally toughened soda lime silicate safety glass will resist thermal stress and thermal shock at levels equal to or greater than 5 times that of annealed glass. The figure quoted in EN 14179-1 is 200K. It has a maximum operating temperature of 250 °C

### 6.3 Rate of occurrence of fracture due to inclusions

Heat soaked thermally toughened soda lime silicate safety glass in accordance with EN 14179-1 has a reduced rate of fracture due to the presence of critical inclusions.

### 6.4 Residual risk

Heat soaked thermally toughened soda lime silicate safety glass in accordance with EN 14179-1 will have a residual risk of occurrence of critical inclusions of 1 in 400 tonnes.

NOTE: This residual risk is on a statistical basis and does not necessarily refer to any specific batch.

Reliance on other published predictions can give a false impression of the probability of contaminations within float glass. The heat soak process cycle itself is not failsafe. Other types of non-critical inclusions that may not be removed during the heat soak process cycle, and smaller sized critical inclusions that do not necessarily fracture in the heat soak oven, may cause fracture in use.

NOTE: Expectations and claims that no fracture due to critical inclusions are allowed are erroneous. (See also 6.5)

It is not possible to provide a specific definitive quantifiable residual risk of fracture due to critical inclusions in any specific batch of heat soaked thermally toughened soda lime silicate safety glass.

Heat soaked thermally toughened soda lime silicate safety glass in accordance with EN 14179 is deemed to be the best product for reducing spontaneous fractures as a result of critical inclusions.

NOTE: Heat soaked thermally toughened soda lime silicate safety glass is recommended for all situations where:

- the stability of the structure,
- the maintenance of the barrier,
- the safety of users

may be at risk from breakage.

### 6.5 Batch occurrence of critical nickel sulfide inclusions

The statistical analysis which provides the level of risk of critical nickel sulfide inclusions remaining in heat soaked thermally toughened soda lime silicate glass is valid for large volumes of production, but does not necessarily relate to individual projects.

Contamination of the float glass occurs in batches leading to periods of glass containing no critical nickel sulfide inclusions followed by "spikes" when a number of inclusions are present in a particular batch of float glass. It is for this reason that there appear to be batches of glass supplied for specific projects that have been selected "by chance" from a contaminated batch of float glass and others that appear to be free from contamination.

Residual risk analysis is indicative only and over the life of a building. Nickel sulfide induced failures may occur despite heat soaked thermally toughened soda lime silicate safety glass in accordance with EN 14179-1 being installed.

## 7. Assessment of Fracture Pattern Characteristics of Thermally Treated Soda Lime Silicate Glass

The statistical information, risk data and conclusions contained within this document have been determined by and therefore refer to heat soaked thermally toughened soda lime silicate safety glass products that have been produced from soda lime silicate annealed float glass supplied by mainline manufacturers who continuously operate systems and safeguards that minimise the inclusion of Nickel Sulfide and similar contaminants in their product.

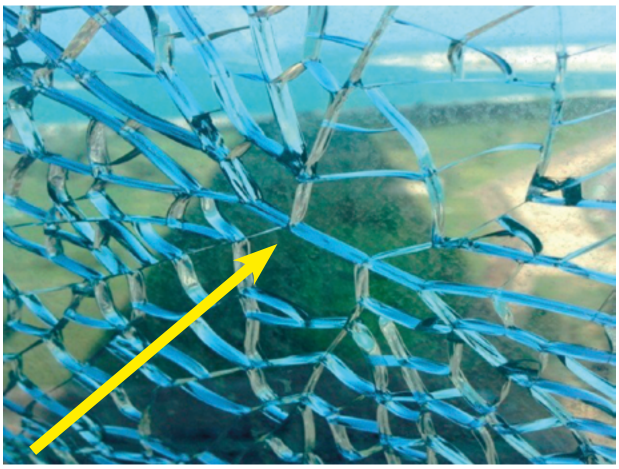

**Figure 1:** Butterfly pattern at origin

The characteristic fracture pattern associated with thermally toughened glass has at its origin a butterfly shape. See Figure 1.

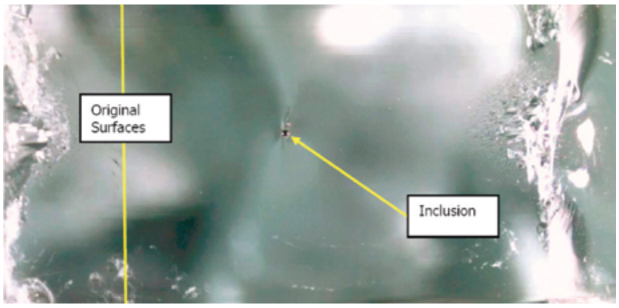


**Figure 2:** Fracture surface showing inclusion

If there is a visible dot on the primary fracture face, it is likely that the cause of fracture is an inclusion. See Figure 2.

The causes of fracture, which always produce such a fracture pattern are wind, snow, soft body impact, centre punch, surface chips and any type of particle inclusion.

To determine the cause of the fracture, it is necessary to send the inclusion particle for laboratory analysis.

## Annex A

In 1962, Ballantyne of the CSIRO (Building Research, Melbourne) published a report indicating that the cause of many of the spontaneous breakages was nickel sulfide (NiS). NiS is a complex material that undergoes a phase change (a change in crystalline structure) at 290 °C, which is accompanied by a volume change. The **α**NiS, which is stable above 290 °C, has a smaller volume than the **β**NiS, which is stable below 290 °C.

The glass manufacturing process melts the batch mix and then allows the glass to set on cooling. The glass moves into the annealing lehr, at around 600 °C, in which it is cooled to room temperature over a period of about 20 minutes. Any NiS in the glass is converted to the **α** phase at the high temperatures during melting, but the rapid cooling does not allow time for the conversion to the **β** phase. The NiS is thus "frozen" into the glass in an unstable form.

Over a period of time the **α** phase slowly converts back to the **β** phase, the conversion being accompanied by an increase in volume of 2%-4%. In annealed (ordinary, untreated) glass this is not a practical problem. However, if a particle (inclusion) of NiS is sufficiently large and is in the central (tensile stress) zone of toughened glass, then the expansion caused by the conversion can exert sufficient excess stress, in this already pre-stressed product, to cause a crack to propagate and result in disintegration of the pane.

The most common cause of spontaneous breakage is due to critical particles of nickel sulfide; however, silicon particles have also been identified as another cause.

### Bibliography

### European Standards

**EN 1863-1** Glass in building - Heat strengthened soda lime silicate glass - Part 1: Definition and description

**EN 1863-2** Glass in building - Heat strengthened soda lime silicate glass - Part 2: Evaluation of conformity/Product standard

**EN 12150-1** Glass in building - Thermally toughened soda lime silicate safety glass - Part 1: Definition and description

**EN 12150-2** Glass in building - Thermally toughened soda lime silicate safety glass - Part 2: Evaluation of conformity/Product standard

**EN 12600** Glass in building - Pendulum test - Impact test method and classification for flat glass

**EN 14179-1** Glass in building - Heat soaked thermally toughened soda lime silicate safety glass - Part 1: Definition and description

**EN 14179-2** Glass in building - Heat soaked thermally toughened soda lime silicate safety glass - Part 2: Evaluation of conformity/Product standard

### GGF Data Sheets

**GGF Data Sheet 4.4** Quality of Thermally Toughened Soda Lime Silicate Safety Glass for Building

**GGF Data Sheet 4.4.1** Thermally Treated Soda Lime Silicate Glass Products - General

# GGF Data Sheet: Thermally Treated Glass: Appearance - Interference Phenomenon

4.4.3 May 2016

**Contents**



## Introduction

The appearance of the surface of a thermally treated glass product is dependent on the following:

- Type and thickness of the glass pane,
- Thermal treatment manufacturing process
- Orientation, Environmental and local lighting conditions when installed.

## 1. Scope

This GGF Data Sheet details the appearance of thermally treated glasses with respect to specific optical phenomenon.

The phenomenon covered by this GGF Data Sheet is 'anisotropy'

## 2. Definitions

For the purpose of this GGF Data Sheet the following definitions apply.

### 2.1 Thermally treated glass product

See GGF Data Sheet 4.4.1: Thermally Treated Soda Lime Silicate Glass Products - General

These are:

- Thermally toughened soda lime silicate safety glass (see also GGF Data Sheet 4.4: Quality of Thermally Toughened Soda Lime Silicate Safety Glass in Building)
- Heat soaked thermally toughened soda lime silicate safety glass
- Heat strengthened soda lime silicate glass

### 2.2 Appearance

An effect that can be observed when the surface of thermally treated glass is viewed under specific lighting conditions.

### 2.3 Interface phenomenon

An optical effect that occurs with thermally treated glass under polarised light.

### 2.4 Anisotropy

The interference phenomenon that occurs with thermally treated glass.

NOTE: Also known as toughening marks, quench marks, strain pattern, iridesence or 'leopard spots'.

### 2.5 Bi-refringence

The optical property of a material having a refractive index that depends on the polarisation and propagation direction of light.

## 3. Glass Types

Thermally toughened, heat soaked thermally toughened or heat strengthened glasses.

These are annealed glasses that have been thermally treated to modify their strength and breakage characteristics.

These enhanced characteristics are the result of the thermal treatment process where a surface compressive layer and central tensile layer are produced.

NOTE: The magnitude of the stress levels is dependent upon glass thickness. The thicker the glass the higher the stress levels.

These glasses will comply with one of the following standards:

- EN 1863-1: Glass in building – Heat strengthened soda lime silicate glass products -- Part 1: Definition and description
- EN 12150-1: Glass in building – Thermally toughened soda lime silicate safety glass products -- Part 1: Definition and description
- EN 14179-1: Glass in building – Heat soaked thermally toughened soda lime silicate safety glass products - Part 1: Definition and description

See also GGF Data Sheet 4.4.1: Thermally treated soda lime silicate glass products – General.

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## 4. Anisotropy

### 4.1 General

Anisotropy arises from local variations in the toughening stress.

NOTE: The greater the magnitude of the stress levels the more obvious can be the effect.

It occurs because the cooling air is blown at the glass through an array of nozzles during the quench part of the process. Immediately under a nozzle the cooling effect and stress is greater than away from the nozzles. If the glass is static in the quench, then spots of greater stress are formed. If the glass or the quench head is moving then the spots are smeared.

NOTE: It is this spotted pattern, sometimes seen on the rear screens of cars, that gives rise to the term "leopard spots".

These local variations in toughening /thermal treatment stress are present in every pane of thermally treated glass.

Glass has a natural property which twists polarised light when the glass is stressed, so the slight variations in toughening stress are visible when the glass is viewed in polarised light. Since light can be polarised by a variety of effects – reflected light from other surfaces, blue sky (especially in the evening), and hazy sky or light cloud, for example – they will show up from time to time.

The pattern of the anisotropy is determined by the mechanics of the toughening/thermal treatment plant (usually not in the control of the operators) and can vary from distinct spots, to linearly smeared spots to smeared areas.

Anisotropy is a natural property of thermally toughened glass, heat soaked thermally toughened glass and heat strengthened glass and cannot be eliminated.

### 4.2 Extracts from Standards

Extract from the European Standard EN 12150: Glass in building – Thermally toughened soda lime silicate safety glass.

9.2 Anisotropy (Iridescence)

*The toughening process produces areas of different stress in the cross section of the glass. These areas of stress produce a bi-refringent effect in the glass, which is visible in polarised light.*

*When thermally toughened safety glass is viewed in polarised light, the areas of stress show up as coloured zones, sometimes known as 'leopard spots'.*

*Polarised light occurs in normal daylight. The amount of polarised light depends on the weather and the angle of the sun. The bi-refringent effect is more noticeable either at a glancing angle or through polarised spectacles.*

*Anisotropy is not a defect but a visible effect.*

Extract from the ASTM Standard C1048 - 12: Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass.

7.4 Strain Pattern

*A strain pattern, also known as iridescence, is inherent in all heat-strengthened and fully tempered glass. This strain pattern may become visible under certain lighting and other conditions. It is a characteristic of heat-treated glass and should not be mistaken as discoloration, non-uniform tint or color, or a defect in the glass. The strain pattern does not affect any physical properties or performance values of the glass.*

### 4.3 Light reflection/polarisation

The amount of light reflected from the glass surface depends on the angle of incidence and the polarisation of the light.

Any reflection effects associated with the polarisation of the light are more obvious when the glass is viewed at angles of incidence between 35 ° and 75 ° than for lower or higher angles of incidence.

When viewed from directly in front, reflection effects associated with the polarisation of the light are least obvious.

## 5. Viewing Conditions

Anisotropy can be differentiated from stains or marks on the glass, or colour variations of the glass, because the anisotropy will appear more or less severe depending on the angle of view and may not be apparent at all when viewed from some angles.

Anisotropy will also be absent if there is no polarised light (e.g. under heavy cloud or viewed under artificial lighting). Stains and colour variations in the glass will be present whatever the angle of view and whatever the lighting conditions.

Anisotropy is a variation in the amount of light reflected from the glass and is commonly more obvious when there is no backlighting, e.g. in spandrel areas and in buildings with no internal lights on.

## Bibliography

### European Standards

**EN 1863-1** Glass in building – Heat strengthened soda lime silicate glass products - Part 1: Definition and description

**EN 12150-1** Glass in building – Thermally toughened soda lime silicate safety glass products - Part 1: Definition and description

**EN 14179-1** Glass in building – Heat soaked thermally toughened soda lime silicate safety glass products - Part 1: Definition and description

### Evaluation of conformity/product standards

With the publication of the harmonised European standards, hENs, the glass components will become available as CE marked products. The CE marking will be a declaration that the glass product conforms to the appropriate hEN.

The hENs are as follows:

**EN 1863-2** Glass in building – Heat strengthened soda lime silicate glass products - Part 2: Evaluation of conformity/product standard

**EN 12150-2** Glass in building – Thermally toughened soda lime silicate safety glass products - Part 2: Evaluation of conformity/product standard

**EN 14179-2** Glass in building – Heat soaked thermally toughened soda lime silicate safety glass products – Part 2: Evaluation of conformity/product standard

### GGF Data Sheets

**GGF Data Sheet 4.4** Quality of Thermally Toughened Soda Lime Silicate Safety Glass for Building

**GGF Data Sheet 4.4.1** Thermally Treated Soda Lime Silicate Glass Products –General - Heat Treated Glasses

# Glazing with Plastics

4.5 AUGUST 2003

Introduction

The objective of this Data Sheet is to stimulate careful thought about the use of plastics glazing sheet materials and to present important design, fixing and handling information in simple terms. The Glass and Glazing Federation issues this data sheet to specifying authorities in all industries. It is intended for designers of new buildings, as well as for the maintenance engineer and the estate manager who face ever-increasing problems as a result of vandalism. Whilst offering a range of practical tips, it serves as a check and reminder that if in doubt consult your glass merchant or the plastics manufacturer.

Relevant recommendations made in BS 626 : 1982 should also be observed. This data sheet deals only with the vertical glazing of solid plastics sheeting. For hollow section plastics sheets, reference should be made to the manufacturer.

## 1 Design

### 1.1 Suitability of plastics

Techniques required to glaze successfully with plastics are different to those used with glass because of the different properties and service behaviour. The most commonly used transparent and translucent plastics for flat glazing applications are listed in Table 1.

Table 1

| Materials | Common Name |
|---|---|
| Polycarbonate | Polycarbonate |
| Polymethylmethacrylate | Acrylic |
| Polyvinyl chloride | Rigid PVC or PVCu |

All these materials have different properties and your glass merchant or the plastics manufacturers should be consulted on the suitability of the material for a specific application.

**Check List**

- Physical properties ☐
- Mechanical properties ☐
- Thermal properties ☐
- Effect of sunlight ☐
- Durability to sunlight ☐
- Fire properties ☐

Table 2

Recommended Minimum Thickness (mm) for Single Glazing Relating toWind Load

| | | Design Wind Loading N/m² | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Area m² | Aspect Ratio | 600 | 800 | 1000 | 1500 | 2000 | 2500 | 3000 |
| 0.25 | 1.0 :1 - 1.5 :1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| | 1.5 :1 - 2.5 :1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 0.5 | 2.5 :1 - 3.5 :1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| | 1.0 :1 - 1.5 :1 | 3 | 3 | 3 | 4 | 4 | 5 | 5 |
| 1.0 | 1.5 :1 - 2.5 :1 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |
| 1.5 | 2.5 :1 - 3.5 :1 | 3 | 3 | 3 | 3 | 3 | 3 | 4 |
| 2.0 | 1.0 :1 - 1.5 :1 | 4 | 5 | 5 | 6 | 6 | 6 | 8 |
| | 1.5 :1 - 2.5 :1 | 4 | 4 | 5 | 5 | 6 | 6 | 6 |
| | 2.5 :1 - 3.5 :1 | 3 | 3 | 4 | 4 | 5 | 5 | 6 |
| | 1.0 :1 - 1.5 :1 | 6 | 6 | 6 | 8 | 8 | 8 | 10 |
| | 1.5 :1 - 2.5 :1 | 5 | 6 | 6 | 6 | 8 | 8 | 8 |
| | 2.5 :1 - 3.5 :1 | 4 | 5 | 5 | 6 | 6 | 6 | 6 |
| | 1.0 :1 - 1.5 :1 | 6 | 6 | 8 | 8 | 10 | 10 | 10 |
| | 1.5 :1 - 2.5 :1 | 6 | 6 | 6 | 8 | 8 | 10 | 10 |
| | 2.5 :1 - 3.5 :1 | 5 | 5 | 6 | 6 | 8 | 8 | 8 |

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### 1.2 Thickness

Plastics are not as rigid as glass and Table 2 is a guide to the thickness required for plastic panels supported on all four edges, related to a given wind loading, the area and aspect ratio of the panels, assuming an edge cover of 15mm (see 1.3.2).

### 1.3 Dimensions

Due to the greater co-efficient of thermal explanation and contraction of plastics compared with glass, it is necessary to make sufficient provision for:

**Table 2 (page one)**

Recommended Minimum Thickness (mm) for Single Glazing Relating to Wind Load

The aspect ratio in this table is based on a ratio of length to width. Where the area of the panel exceeds 2.0m2 consult your glass merchant.

### 1.3.1 Clearance

Between the panel edges and the frame. Table 3 gives a guide to the recommended reduction in panel size compared with the tight rebate dimension.

Table 3

| Length of side | Reduction |
|---|---|
| mm | mm |
| up to 1,000 | 3 |
| 1,001 – 2,000 | 6 |
| 2,001 – 3,000 | 9 |

1.3.2 Rebates

To prevent the panels being withdrawn due to flexing under impact or stress, it is essential to provide adequate edge cover. Except where small panels are installed, it is recommended that the rebate be such as to allow an edge cover of at least 15 mm. (Rebate depth equals edge cover + expansion allowance). If inadequate rebates are present (as with re-glazing it is possible to use lesser rebates but with thicker sheets, see BS 6262. To maintain the flexibility of the plastic glazing material, the gaskets, tapes and glazing compounds used must also be flexible. For anti-vandal glazing, heavy industrial glazing, security glazing or situations where extreme movement of the panel may occur, it may be advisable to use a greater rebate depth, in accordance with the manufacturer's recommendations.

### 1.3.3 Infill Panels

The overall design must allow for expansion and contraction without restraint. The use of over tightened bolts, screws and hard setting glazing compounds must be avoided. Further details about glazing infill panels for balustrades see BS 6180. In certain circumstances some materials may have mechanical fixings but consult your glass merchant or the manufacturer of the plastics.

## 2. Fixing

### 2.1 Tools

Detailed information on cutting and finishing techniques can be obtained from your glass merchant or plastics supplier. The best results are usually achieved by using carbide tipped circular saws or fine tooth bandsaws.

### 2.2 Edges

Maximum breakage and impact resistance will be obtained by ensuring a smooth cut. If a small chip or crack is present at the edge, the panel may fracture under flexing or impact.

2.3 Fixing

Observe the design recommendations in Part 1, and check again for the correct

i) thickness (paragraph 1.2)
ii) clearance (paragraph 1.3.1)
iii) rebate depth (paragraph 1.3.2)
(iv) recommended glazing compounds (paragraph 2.7), tape or gaskets (all of which must be compatible with the plastics sheet).

### 2.4 Small Panels

3mm thick materials may be used where the longest edge of the panel does not exceed 500 mm. Where vandalism is a problem, material of thickness greater than 3 mm should be used.
Cut the panel 3mm shorter than the width and length of the sash. Ensure the edge cover of the panel is at least 12 mm.

Beads should be bedded and attached in the conventional way.

### 2.5 Setting Blocks

Setting blocks may be used especially where increased security is required, otherwise they are not essential. Normally the bottom edge of plastics sheet should rest directly onto the rebate. Where setting blocks are to be used, decide at the design stage and make allowances for them by reducing the height of the panel to compensate for the setting blocks and the thermal expansion.

### 2.6 Typical Detail

Fixing should be carried out using suitable glazing tapes or gaskets combined with the beading. During fixing peel back just sufficient masking from the plastics glazing sheet to the height of the edge cover. This reduces the risk of scratches and finger marks on the main body of the sheet. The remainder of the masking should be removed as soon as possible after completion of the process.

(diagram)

### 2.7 Glazing Compounds

**Table 4 Suitable Glazing Sealant**

For compatible glazing tapes and gaskets, consult the plastics supplier for details.

| Edge Length | Glazing Compound |
|---|---|
| Up to 500 mm | Butyl compounds |
| 501 to 200 mm | Silicone or two part polysulphide |
| over 2001 mm | Silicone |

## 3. Cleaning

Warm soapy water should be used for cleaning. Rinse thoroughly and wipe dry using a clean, soft cloth or damp chamois leather.

### 3.1 Fresh Paint, Grease, Glazing

### Compound

Some cleaning solvents attack plastics. Abrasive materials or blades should never be used. For a compatible removal method consult the plastics supplier for details.

### 3.2 Removal of scratches

Hairline scratches may be removed by gently polishing with an appropriate product recommended by the plastics supplier.

### 4. Handling and Storage

**4.1** Store single sheets vertically or at an angle or not more than 100 to the vertical. For bulk storage it is preferable to store horizontally on their original pallets.

### 4.2 Do not allow panels to:

**i)** ie. sag – give adequate support;
**ii)** be stored near any heating appliances;
**iii)** be stored out of doors.

### 4.3 Masked Products

Always protect against rain, sunlight or excessive dry heat.

Where the surface protected sheets are used, ensure that the sheets are fixed the correct way round, ie, with the weather-protected surface (as indicted on the protective masking) to the exterior of the building.

Place sheets on clean working surfaces. Do not remove masking from the panel until the glazing operation is completed. On outdoor glazing applications, ensure that the masking is removed after glazing work has been completed and within the time limit specified by the manufacturer:

**Important Notice**

Some sealants require a priming agent.

For polycarbonates use approved primers only.

Always consult the manufacturer of the sealant/compound or the plastics supplier.

Excess sealant should be carefully removed immediately after installation.

Avoid using sharp tools, which may scratch the plastics surface.

# Recommendations for fixing Mirrors
## - with suggested applications

4.8 FEBRUARY 2000

### 1 Scope

This Data Sheet details the characteristics of mirrors and gives guidance notes on their installation and use. Design considerations are also explained with the use of sketches to illustrate recommendations.

### 2 Design considerations

Properly used mirrors have the ability to add light and space to a room, and shown in section 8 are eight examples of ways of doing this. The basic principle is, of course, the same in each case: to use the reflection in the mirror to create the illusion of additional width, length or height; and, in the case of light, to use the reflection both to bring light deeper into a room, and to create the illusion of a greater natural light source.
One of the most important things to remember is that we are dealing in illusions. Therefore the panel of mirror glass should be 'invisible'. It is the reflection - additional wall, floor or ceiling space - we want to see, not the mirror itself. Points to remember in achieving this are:

**2.1** As far as possible the mirrors should be placed where the occupants of the room will not be seeing their own reflections constantly.

**2.2** All edges and fixing beads should be concealed wherever possible.

**2.3** Because it is the reflection which is important, the mirror should have something attractive to reflect, and this means that floor and ceiling treatments demand special attention.

**2.4** Awkward breaks between mirror panels and other wall treatments should be avoided so that joints between wall, floors and ceilings appear to be continuous.

**2.5** For light reflection mirrors should be placed as near as possible to the window in order to 'bounce' light back into the interior.

### 3 Fixing methods

When fixing mirrors, care must be taken to ensure that the backing and edges cannot be attacked by chemical action from substrates.
Ensure that the area to which the mirror will be fixed is cleaned, to be free of dirt or grease. When clean, the area should be sealed. In order to achieve the required seal, a suitable primer such as an undercoat and 2 coats of gloss should be used. Vinyl paints are not recommended for this purpose. It is important that any recently plastered surfaces are given sufficient time to dry out before any attempt is made to seal them.
Where practicable an air space of 3 to 5 mm should be provided between the mirror and the background to allow free circulation of air behind the mirror.
Having satisfied the foregoing initial preparation requirements mirrors can be fixed in a number of ways. These can be summarised as follows:

**3.1** Direct to a permanently dry background, as might be found in a living room, using screws with dome or rosette heads and spacer washers, or with clips.

**3.2** Where damp conditions prevail such as in bathrooms or kitchens it is recommended that the back and edges of the mirror are protected by applying metal foil to these areas of the mirror. If the backing is not supplied with the mirror the mirror supplier should be consulted to ensure that the adhesive of the metal backing is compatible with the paint backing of the mirror.

**3.3** With edge beads either against a flat surface or on battens spaced not more than 375 mm (15 in) apart, faced with a continuous cushion such as a non hardening glazing strip.

**3.4** Where the mirror has to be set flush in a tiled wall, e.g. as in a bathroom, and where a metal foil, or other suitable protective backing has been applied to the backing paint...an appropriate adhesive may be used. Alternatively self adhesive foam pads can be used as recommended by foam pad manufacturers. The number and size of pads to be used is critical and will depend on the weight of the mirror being fixed. Pad manufacturers specify the area of their pad required in relation to the weight of the mirror to be fixed.
Whilst it is noted that foam pads and adhesives are available for the fixing of mirrors, it is recommended that a preference be given to mechanical fixings. See sections 4 and 5.

**3.5** To backboards using clips, beads or a suitable adhesive, as recommended by the adhesive manufacturers. The complete assembly being then fixed to walls or furniture by independent means.
It is important that the adhesive does not create sealed areas on the back of the mirror. Generally it is advisable to apply in vertical strips.

### 4 Screw fixing of drilled mirrors

**4.1** The mirror should be fixed securely but free from stress to avoid distortion and risk of breakage. The mirror should not be fixed to a very uneven surface but where there is any unevenness, nylon washers should be used as packing.

**4.2** Make sure that the wall or door substance is strong enough to take the weight of the mirror and thick enough to take the full length of the screw provided.

GGF
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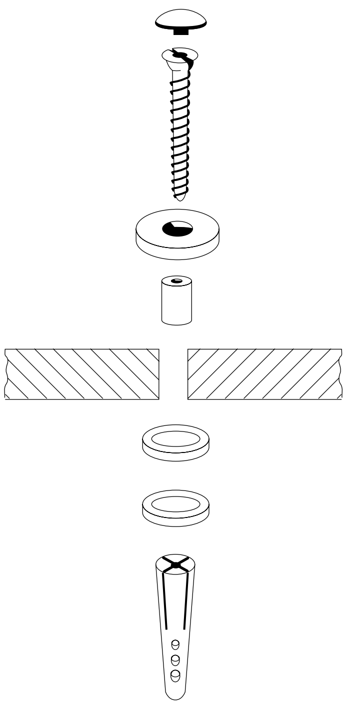
In some panelled wall situations it may be necessary to use butterfly plugs for the screws.

**4.3** Mirrors should be fixed as shown in the diagram. It is essential that there is no glass to metal contact, therefore ensure that a plastic collar is used between the screw and the mirror. Nylon or suitable rubber washers must be used to ensure a freely ventilated air space between the mirror and the wall.



**4.4** Do not overtighten the screws. This will cause distortion and may lead to breakage of the mirror.

## 5 Clip fixing of undrilled mirrors

Manufacturer's instructions must be followed according to the type of clip fixing set supplied. For a typical set of clips the following general recommendations apply. (For small mirrors 4 clips may be supplied.)

**5.1** Because clip fixing involves glass to metal contact, edge treatment of the glass is very important. The edges of the mirror must therefore be arrissed, ground or polished.

**5.2** The mirror should be fixed securely but free from stress to avoid distortion and risk of breakage.

**5.3** The mirror should not be fixed to a very uneven surface.

**5.4** Make sure that the wall or door substance is strong enough to take the weight of the mirror and thick enough to take the full length of the screws provided.

**5.5 Procedure of fixing**
There are two suggested methods for the initial setting out of the position of the holes:

Method 1

a) Measure from a level floor and mark up the position of the two bottom holes which will be 13 mm (0.5 in) above the required bottom line of the mirror, and then screw in the fixed clips.
b) Rest the mirror on the clips and lightly draw a small pencil line at the edge of the mirror, where the four sliding clips will be.
c) Remove the mirror. Mark out the positions of the holes for the four sliding clips as follows - top edge 19 mm (0.75 in) below the edge and preferably one quarter of the width of the mirror, but not less than 76 mm (3 in) in from the sides. Sides - 19 mm (0.75 in) in from the edge and half way up the mirror.

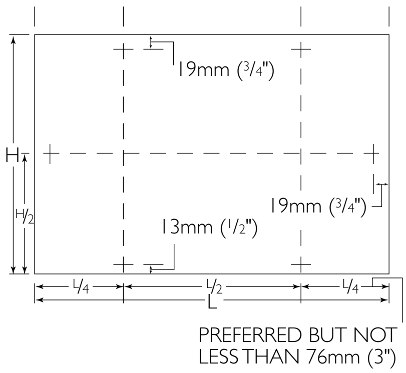
Method 2

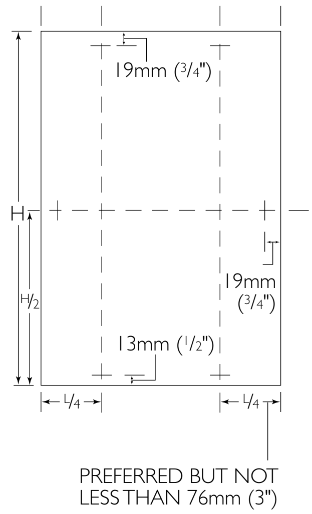
a) Hold the mirror in the required position and lightly pencil the outline of the mirror on the wall or door.
b) Mark up position of the holes:
(i) For the two fixed clips 13 mm (0.5 in) up from the bottom line of the mirror.
(ii) For the four sliding clips 19 mm (0.75 in) below the top edge and one quarter of the width of the mirror, but not less than 76 mm (3 in) in from the sides. Sides - 19 mm (0.75 in) in from the edge and half way up the mirror.

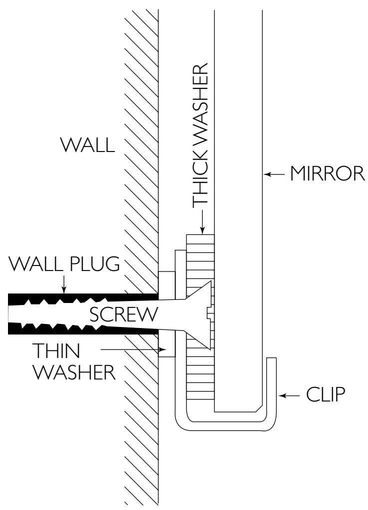
Then proceed as indicated below.
After the holes have been set out:

a) Fix the clips and screws so that the thin metal washer is against the wall, then the clip and the thick nylon washer, so that the screw head is totally countersunk in the larger washer. Only tighten the screws sufficiently to keep the clips firm. The sliding clips should be able to move without difficulty.
b) Place the mirror on the bottom fixed clips and push the sliding clips into position, so that they gently retain the mirror in position without any stress.
c) If one or more of the clips do not fit easily over the glass, this is probably due to unevenness of the wall. Pack out the clip with spare thin metal washers as necessary.

Note: Large mirrors fixed by screws or clips must be provided with additional support at the bottom edge by means of supplementary clips, anchors or fixing beads and adequate to carry the weight of the mirror.



## 6 Do's and Don'ts for installing mirrors

**Do not** allow the mirror faces, backs or edges to rub against sharp protrusions, corners, rough floor surfaces or glass chips during unpacking or cutting.

**Do** use great caution in unpacking mirrors, and always store in a vertical position, paper interleaved, and stand on soft wood or similar material.

**Do not** install mirrors with edges or backs contaminated by foreign materials or with perspiration from handling. Use gloves if necessary.

**Do** clean backs and edges before installation, preferably with a dry cloth.

**Do not** mount mirrors flush against the wall. This causes stress and abrasions on walls that are not plumb. In all cases, it can cause collection of pockets of cleaning solution or water that can attack the mirror backing. No cleaning fluids should ever get to the back of a mirror.

**Do** let the mirror "breathe" - by mounting it 3/5 mm from the wall.

**Do not** rest the supporting bottom edge directly on splash back panels or base boards. This is structurally unsound and also causes collection of moisture at the critical edge area.

**Do** raise the supporting bottom edge with suitable spacers if necessary. This is structurally sound and allows air circulation.

## 7 Do's and Don'ts for cleaning mirrors

**Do not** use harsh commercial cleaning solutions or any proprietary brands that contain ammonia or solvent based agents.

**Do** ensure that any cleaner is recommended by your trade supplier.

**Do not** use dirty or gritty rags, knives, scrapers, emery cloth, or any other abrasive materials for cleaning.

**Do** use a clean, soft rag when cleaning mirrors.

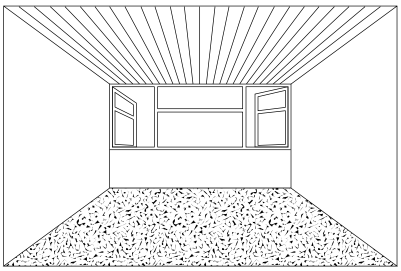
**Do not** abuse the mirror edges, since most failures are at the edges where moisture and solutions attack the metal films (silver and copper).

**Do** protect the edges from accidental cleaning solutions by applying the cleaner to the cloth rather than to the mirror. It is a good final cleaner practice to wipe the edges clean and dry off any surplus cleaning solution.

## 8 Examples of how mirrors are used

### 8.1 For width

One way of making a room look wider is to fit floor-to-ceiling mirror panels adjacent and at right angles to the window. Because the apparent increase in width comes from reflections, these should be emphasised by the use of ceiling lines, venetian blinds, and any wall pattern which will also help to disguise the edges of the mirrors. See fixing details, 9.1, 9.4, 9.5, 9.6, 9.7, 9.9, 9.10 and 9.12.



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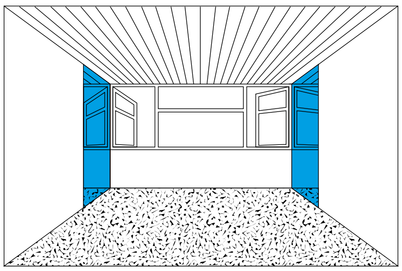

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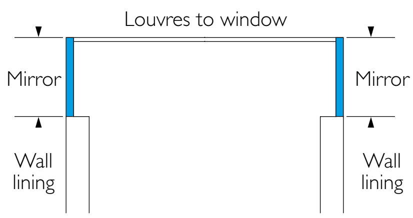
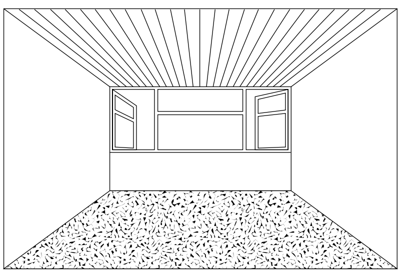



PLAN

### 8.2 For width

Rooms can also be made to appear wider by fitting long horizontal bands of mirrors along the top and bottom of the side walls and giving the centre section a decorative wall treatment. The mirror glass panels reflect the ceiling, floor and window wall treatments, making the actual floor area appear part of a very much larger room.

See fixing details 9.3, 9.7, 9.8, 9.9, 9.10, 9.11, 9.12, 9.13, 9.14 and 9.15.



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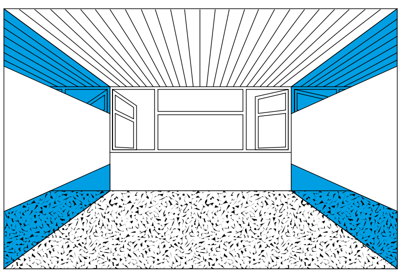

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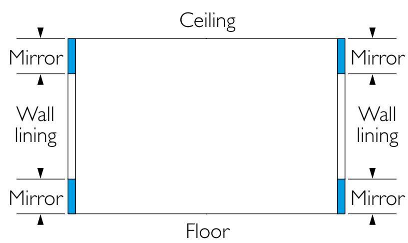
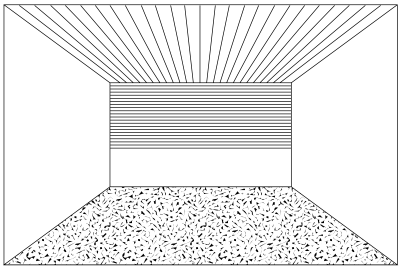



SECTION

### 8.3 For height

Ceilings can be 'lifted' by panelling part with mirror, within a deep frame. The impression of depth in a pierced ceiling can be strengthened by the use of a chandelier or distinctive light fittings, which provide something for reflection.

See fixing details 9.14, 9.16 and 9.17.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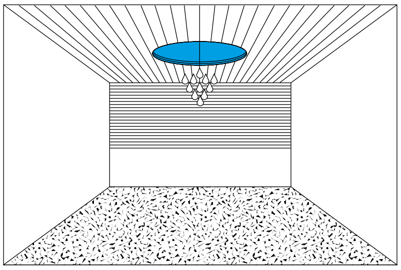
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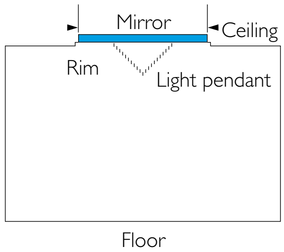
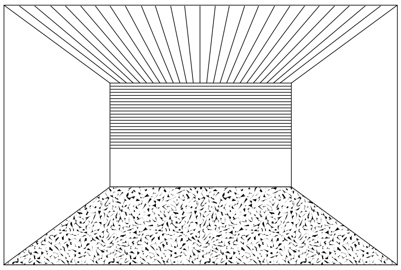


SECTION

### 8.4 For height

Here is a use of mirrors which gives the impression of greater height and taller windows. A mirror panel is fixed to the ceiling across the full width of the window opening or room width immediately adjacent to the window. This allows itself to be reflected increasing its apparent height. Care should be taken that the mirror is contained in a natural recess. See fixing details 9.3, 9.13, 9.14, 9.16 and 9.17.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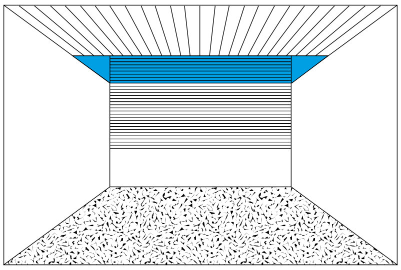
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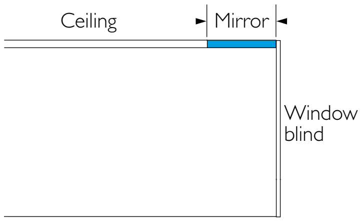
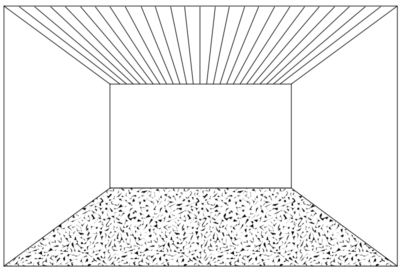


SECTION

### 8.5 For length

The impression of a much longer room can be obtained by fitting a floor-to-ceiling mirror panel in the centre of the end wall and flanking it with panels of decorative wall lining. A ribbed ceiling treatment will conceal the mirror-to-ceiling junction, and plants can be used to prevent people seeing only themselves.

See fixing details 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, 9.7, 9.9, 9.10 and 9.12.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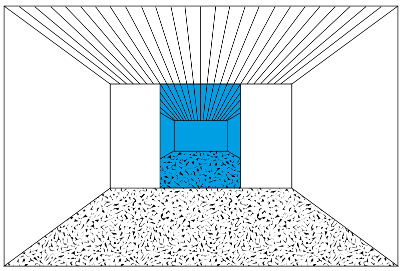
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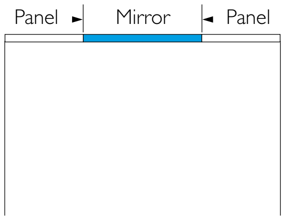
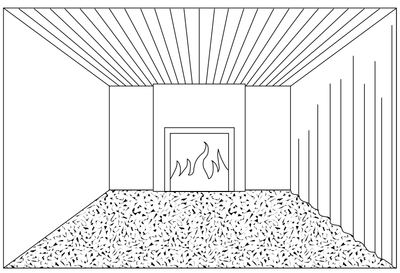


PLAN

### 8.6 For length

Another way to get extra length is to fit two mirror panels in recesses separated by a projecting wall panel or fireplace. The mirrors run from floor to ceiling. Curtains can help to conceal the mirror and wall junctions, and together with the ceiling treatment, provide the necessary patterned surfaces for reflection. See fixing details 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, 9.7, 9.9, 9.10 and 9.12.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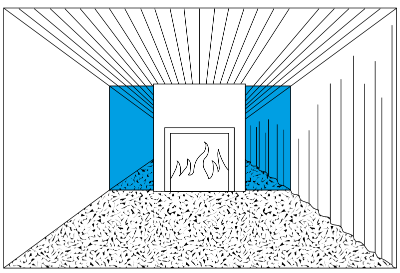
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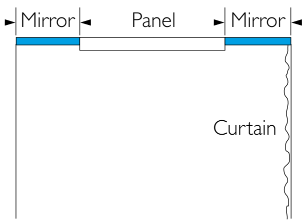
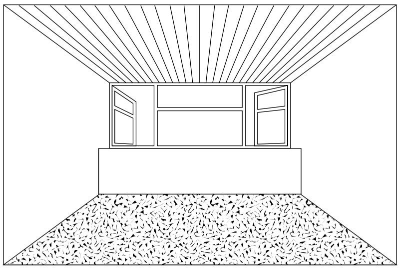


PLAN

### 8.7 For light

Increased daylight can be obtained by lining the inner reveals to the windows, allowing daylight to 'bounce' further into the interior of the room. Mirrors generally should be at right angles to the window and as close as possible. See fixing details 9.1, 9.3 and 9.6.



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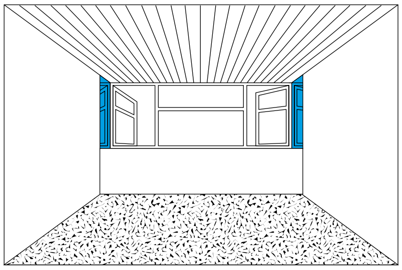

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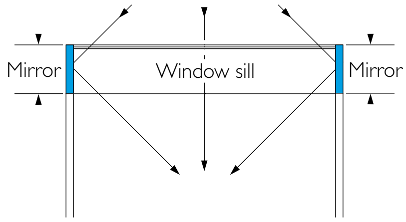
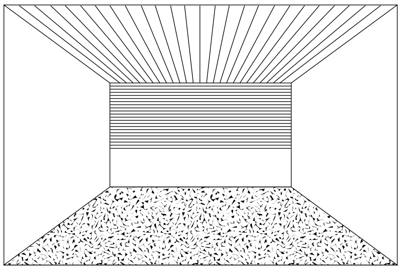



PLAN

### 8.8 For light

Floor-to-ceiling mirror panels spaced at intervals along the walls adjacent to the window wall help light to penetrate into the depth of a room. See fixing details 9.1, 9.3, 9.4, 9.5, 9.6, 9.7, 9.9, 9.10 and 9.12.



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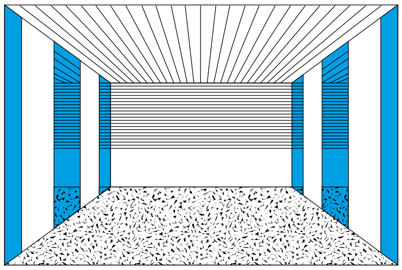

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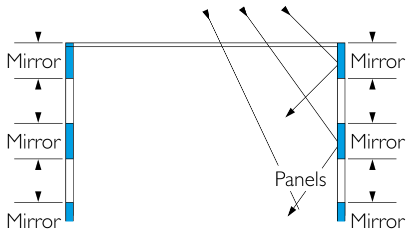
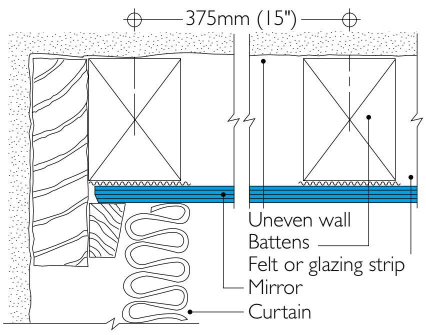



PLAN

## 9 Hints on fixing mirrors

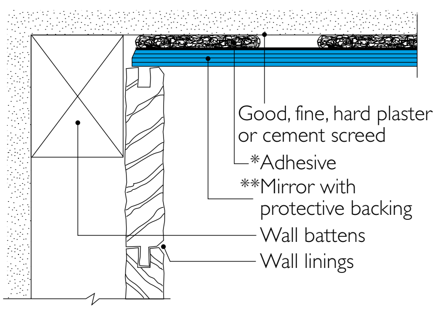
### 9.1 Wall mirror junction with curtains, etc.

Simple frame and bead edging concealed by curtain.



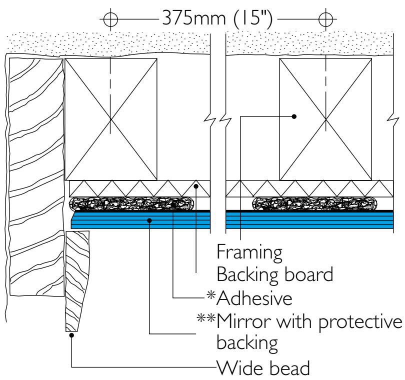

### 9.2 Junction between wall mirror and wall lining

Wall lining runs up to the face of the mirror and conceals the edge. Pattern of wall lining repeats.



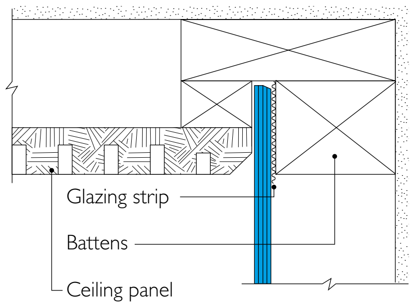

### 9.3 Inset mirror

Suitable alternative to 9.1 or as a partition. Wide bead edging when reflected gives greater apparent depth and can also be used at head and floor, or to give edge support to ceiling mirrors.



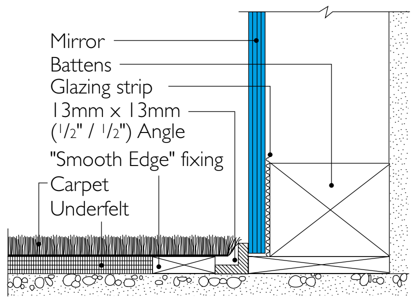

### 9.4 Junction of wall mirror with ceiling

Mirror is retained by a glazing bead. This in turn is concealed by the suspended or false ceiling panel which is allowed to run up to the face of the mirror glass.




### 9.5 Carpet and wall mirror junction

Mirror sits on a thin wooden floor plate and is retained by 13 mm x 13 mm (1/2 in x 1/2 in) metal angle. This is concealed by the carpet which extends right up to the mirror.



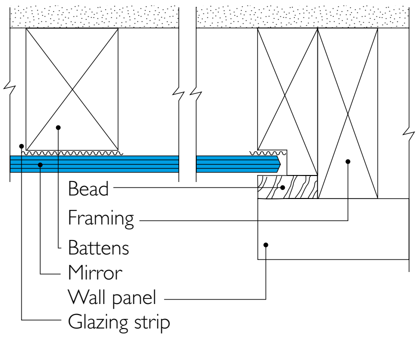

*Protective strips of felt or proprietary glazing tapes must be used to isolate the glass from other materials.*

** Adhesive as recommended by the adhesive manufacturer*

*** Mirror with suitable protective backing*

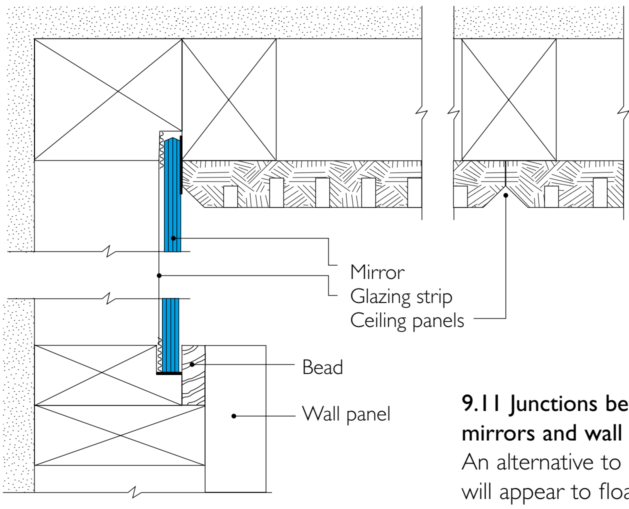
### 9.6 Junction of mirror with vertical wall panel

The mirror is contained in a rebated batten and held by a bead. The bead is mastered by a wall panel, giving apparently greater thickness to the wall, and allowing the wall panel to be secretly fixed to the framing.



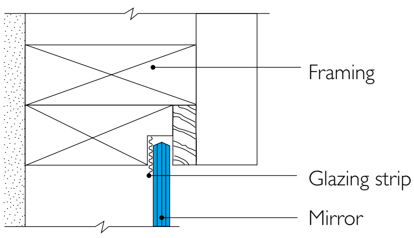

### 9.7 Ceiling to wall mirror junction

This is similar to 9.4. The mirror is pushed up into a slot and the "V" jointed ceiling panels camouflage the reflection.



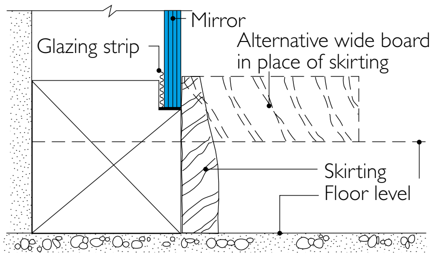

### 9.8 Junctions between horizontal wall mirrors and wall panelling

Rebated battens carry the mirror which is held by beads. The wall panels master the beads as in 9.6.



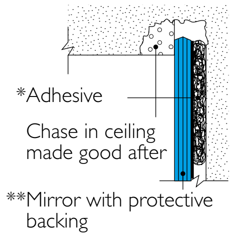

### 9.9 Junction between wall mirror and floor

Alternative to 9.5 and 9.12. This skirting fixing should be used in vulnerable situations, to protect the mirror from damage by cleaners, etc. A flat wide board (shown dotted) would give a better illusion.



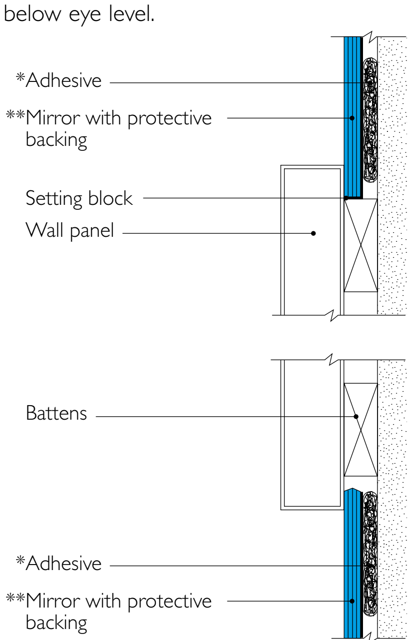

### 9.10 Ceiling to wall mirror junction

A chase is cut in the ceiling to receive the mirror and this is then made good.



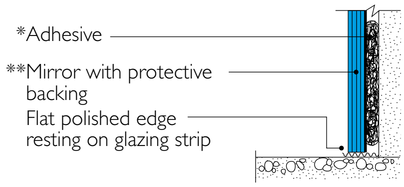

### 9.11 Junctions between horizontal wall mirrors and wall panelling

An alternative to 9.8. The wall panelling will appear to float without support if the top and bottom edges are above and below eye level.



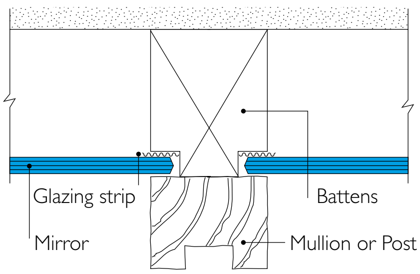

### 9.12 Wall mirror and floor junction

Alternative to 9.5 and 9.9. The bottom edge of the mirror must be scribed to the floor as closely as possible and flat polished because it will be seen. The mirror must rest on a resilient glazing strip.



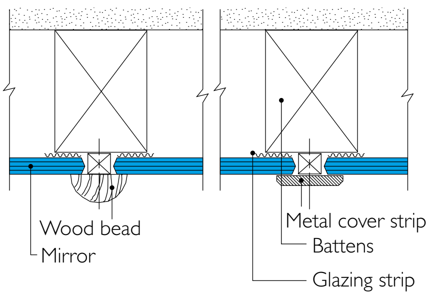

### 9.13 Vertical junction between wall mirror panels

Mirrors are set into a rebated batten and held in position with a face member which appears as a post or mullion by reflection.




### 9.14 Butting mirrors

A 6 mm (1/4 in) wood fillet is fixed to the battening and the mirrors are mastered by a suitable wood or metal cover bead screwed through the fillet to the batten, giving the effect of a light glazing bar.



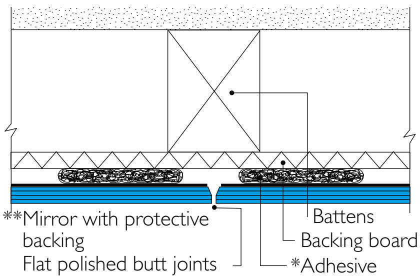

*Protective strips of felt or proprietary glazing tapes must be used to isolate the glass from other materials.*

** Adhesive as recommended by the adhesive manufacturer*

*** Mirror with suitable protective backing*

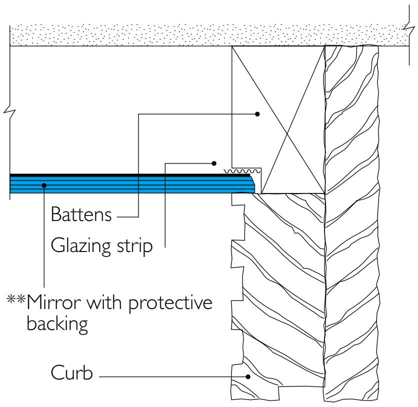
**9.15 Butting mirrors**

The edges of the mirrors are ground and polished accurately to butt. Care must be taken when fixing to ensure continuity of reflections across the joint.



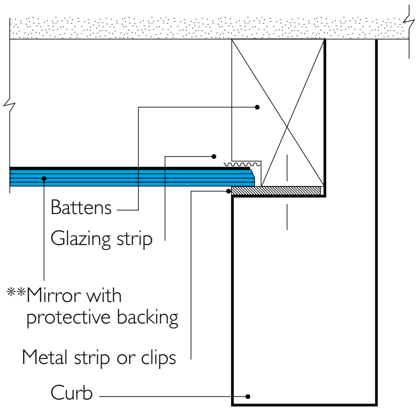

**9.16 Ceiling mirror panel and ceiling junction**

All ceiling mirrors should have suitable protective backing as a safety measure. The mirror is cushioned against the ceiling battens and supported at its edge by a wood curb which is grooved to conceal the junction with the mirror. On large areas screw fixing may be necessary in addition but this should be avoided if possible by the use of cover beads (9.14). In any event, care must be taken to provide insulation and ensure uniform support.




**9.17 Junction between ceiling mirror panel and ceiling**

The mirror is supported along its edge by continuous metal strip or clips adequately insulated. This enables alternative forms of curb to be used.




*Protective strips of felt or proprietary glazing tapes must be used to isolate the glass from other materials.*

* *Adhesive as recommended by the adhesive manufacturer*

** *Mirror with suitable protective backing*

# Mirrors – Visual quality standard for installed mirrors

4.8.1 FEBRUARY 2000

1 Introduction

This Data Sheet is designed to be used in conjunction with Data Sheet 4.8. (Recommendations for Fixing Mirrors), and will deal specifically with the Visual Quality Standard for Installed Mirrors.

2 Scope

This Data Sheet relates to the Visual Fault Characteristics which can be found in, and the relevant quality standards expected of, Finished Mirrors.

3 Mirror Standard

The standard will apply in full only to mirrors made of flat, annealed float glass, clear or coloured, supplied in 2 to 6mm thickness in all sizes, having the rear surface coated with a reflective silver deposit which is protected by a layer of metallic copper or another material, and one or more protective coatings, e.g. paint, lacquer, etc..., for use inside normally occupied domestic or commercial buildings.

NB: An uncut stock size Mirror cannot be expected to conform to the same standards as a finished mirror.

4 Method for observing mirrors

*General Aspect*
The Mirror is observed in a vertical position, with the naked eye and under normal diffused daylight conditions (maximum 600 Lux at the mirror) from a distance of 1 metre. The use of an additional spotlight source is not allowed.

5 Mirror Faults

The quality of a Mirror can be affected by faults altering the appearance of the image of reflected objects.

Alternation of images can result from ageing, optical faults in the glass and faults in the reflective coating.

5.1 Appearance Faults
The visual Quality can be altered by the presence of spot and/or linear and/or enlarged area of faults.

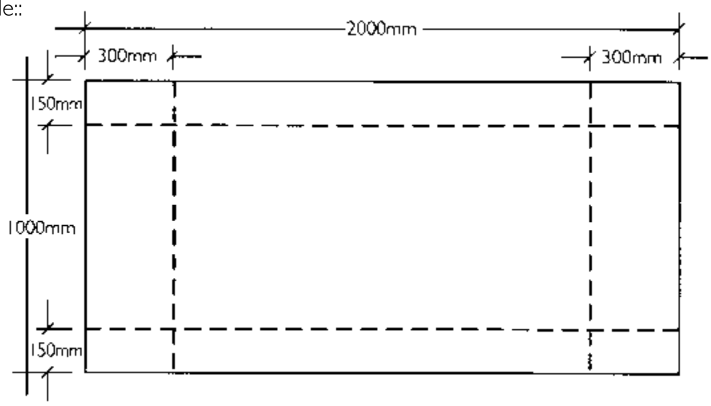
5.1.1 Surface and Body Faults
Solid or gaseous inclusions, deposits, scratches, etc, are admissible as defined in the following table.

5.1.2 Optical Faults
A mirror shall be examined in areas of 500 x 500mm at a time. The observer is located at a distance of 2 metres at right angle to the area being examined. Behind the observer must be a non uniform background. The reflected image must not be optically disturbed by another mirror or window, for instance. The mirror or window, for instance. The mirror meets the requirements if it does not exhibit optical variation outside the allowed tolerances.

| | Area | Spot Faults | | | Surface Faults | |
|---|---|---|---|---|---|---|
| | | ≥ 0.2mm ≤ 0.3mm | ≥ 0.3mm ≤ 0.4mm | Border Zone* ≥ 0.2mm ≤ 0.8mm | Hairline Scratches ≤ 50mm – | Scratches |
| Mirror Tiles etc. | ≤ 0.3m$^2$ | 2 | 1 | – | 2 | – |
| Cut Sizes Sizes | ≤ 1.0m$^2$ | 1 | 1 | – | 2 | – |
| | ≤ 1.5m$^2$ | 2 | 1 | – | 2 | – |
| | > 1.5m$^2$ | 3 | 2 | 1 | 3 | – |

• The width of the border zone is determined as 15% of the edge length, as illustrated below.

Example::

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Optical faults are directly associated with the distortion of the reflected image.

**5.1.2.1 Spots Faults**
Spot faults consist of nucleus (solid or gaseous inclusions), deposits, crush marks etc. In certain instances spot faults are accompanied by a distortion zone call 'Halo'.

**5.1.2.2. Linear Faults**
Linear faults can be in the form of scratches, extended spot faults etc.

**5.1.2.3. Enlarged Area Faults**
Enlarged area faults can be as the result of tin deposits, glass surface erosion etc.

**5.1.2.4. Edge Faults**
Edge faults are entrant/emergent faults in the form of chips, shells, corners on/off, vents etc.

**5.1.3 Reflected Silver Coating Faults**

**5.1.3.1. Scratches**
Surface defects of various width, length and depth.

**5.1.3.2. Stain**
An alteration to the reflective coating where the reflective surface exhibits zones with various degrees of discoloration.

**5.1.3.3. Colour Spots**
Any visible coloured spots.

**5.1.3.4. Edge Deterioration**
Discoloration of the reflective silver at the edge of the mirror.

This Data Sheet is not intended to deal with the relevant methods or test criteria, to which mirrors should conform.

# Compatibility of Glazing Sealants and Compounds with Insulating Glass Units

4.9 November 2014

**Contents**



## 1. Introduction

This document has been produced with the aim of increasing understanding of the impact of compatibility on the long term performance of insulating glass units (IGUs) and the effect on the economic life expectancy of the IGU. There are four areas of compatibility that need to be considered:

- Glazing components with the IGU
- Components of the IGU with each other
- Glazing components with each other
- Frame finishes and treatments with the components of the IGU and the glazing components

This datasheet is intended to provide information for:

*Architects*

*Specifiers*

*Main Contractors*

*Glaziers*

*IGU Manufactures*

*Window Manufacturers*

This guidance expands on recommendations given in other documents such as GGF Datasheet 4.2 Systems Design and Glazing Considerations for Insulating Glass Units and BS 8000-7 Workmanship on building sites – Code of practice for glazing.

## 2. Scope

This document gives guidance on the issue of glazing components and their compatibility with the IGU. This is the least understood aspect of glazing, results in many of reported system failures and is the most difficult to control once on site. The issue of compatibility of the components of the IGU with each other is better understood and, in general, lies within the control of the IGU manufacturer.

This document does not cover the issue of the glazing of low maintenance and other coated glass, where the coating may be on the outer surface of the IGU.

This document does not cover the issue of compatibility of frame finishes and treatments, for example timber preservatives or stains, with the components of the IGU and the glazing components.

## 3. Definition of Compatibility

Two materials are compatible if there is no change in the physical/chemical properties, including the adhesive properties, of either when they are in direct contact or close proximity. Conversely if there is an interaction which causes a change in the properties of one or both of the materials they are said to be incompatible. Incompatibility may result from a chemical reaction between the materials or physical changes due to migration of components from one material into the other. In the case of migration of volatile components from the materials in the form of vapour, there does not have to be direct contact for the effects of incompatibility to become apparent.

## 4. Components to be considered

A component in this case is defined as one or more parts of the glazed system that may be in direct contact with other parts of the system. For example, two or more of the following may be in contact with each other: glazing sealant or compound, setting blocks/distance pieces; gaskets; primary and secondary IGU sealants; the interlayer of laminated glass, either polyvinyl butyral (PVB) or cast in place (CIP) resin or ethylene vinyl acetate (EVA); the edge spacer tape of a CIP laminate.

Some units are provided with an edge tape as part of the design and this needs to be considered as far as compatibility is concerned. General purpose edge tape applied to the IGU should not normally be relied upon to form a barrier between the glazing sealant and the IGU edge seal as tapes are easily damaged. One exception to this is fire resistant IGU's where robust specialist tapes which are not easily damaged are used to form a barrier.

It should be noted that edge tapes can be damaged during transportation, handling and installation and this may result in migration of solvents/fluids through the damaged area. Even if undamaged, plastic coated cloth tapes are permeable to solvent vapours and may themselves be degraded by an incompatible glazing sealant. Aluminium foil tapes may constitute an impermeable barrier, but the adhesive may contribute to incompatibility issues leading to other effects.

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### 5. Possible Effects of Incompatibility

The properties of the IGU components can be changed by interaction with an incompatible glazing sealant. An effect on unit aesthetics may be observed in a relatively short period. Incompatibility may also affect the long term durability of the unit.

The extent of the effects of incompatibility depends on the type of components used in the manufacture of IGU's and the concentration and type of incompatible constituents of the glazing sealant.

A common situation where incompatibility becomes visually apparent is where a glazing sealant containing a volatile hydrocarbon solvent is used with a dual seal IGU constructed with a polyisobutylene (PIB) primary seal and a secondary seal. The solvent vapours are able to permeate through the outer, secondary seal and attack the primary seal. In less severe cases the secondary sealant is not visually affected but the PIB is softened and exudes past the spacer bar into the vision area of the unit. In more extreme cases the PIB is dissolved by the solvent which also extracts plasticiser from the secondary sealant.
The visual effect of this is greatest at the top edge of the unit, where dribbles of the black PIB mixed with a clear liquid run down the internal surfaces of the glass.

In the case of laminated glass with a PVB interlayer incompatibility can result in small bubbles or cloudiness. One common cause is the use of an acid cure silicone sealant.

In the case of a CIP interlayer, where an acrylic edge tape is used, plasticisers from the glazing sealant can migrate into the tape resulting in a swelling of the tape and delamination of the interlayer.

Note: IGU manufacturers should consider the aspect of compatibility between their secondary sealant and the acrylic edge tape.

### 6. Influence of the Glazing Material

There are a number of different generic types of glazing material in common use and within each of these types there can be many different formulations of product available from the various suppliers.

The most commonly used products are the one part neutral curing silicone sealants. These products cure by reaction with atmospheric moisture vapour and produce a non acidic (usually alcohol) by-product as a result of this reaction. Another type of silicone is the acetoxy cure sealant whose by-product is acetic acid vapour.

However, of itself, the type of cure mechanism is not the sole indication of compatibility or incompatibility.
Certain silicone sealant formulations contain organic solvents or low molecular weight plasticisers, usually added to cheapen the product and modify the viscosity. Depending on the chemical nature and quantity of solvent and/or plasticiser present there is a potential for incompatibility. Thus it is possible for a specific neutral cure silicone product to be incompatible with an IGU edge sealant, contrary to the common misconception that all neutral cure silicones are compatible. Conversely it is possible for an acetoxy cure silicone to be compatible with the IGU edge sealant, although it may not be suitable for use in all glazing situations due to the potential for the acetic acid to react with other glass or frame components.

Certain types of glazing sealants other than silicone may also contain organic solvents or low molecular weight plasticisers. Like silicones, depending on the chemical nature and quantity of solvent and/or plasticiser present, there is a potential for incompatibility.

### 7. Influence of the type of IGU sealant

Most IGU edge sealants may be adversely affected by contact with solvents or plasticisers from incompatible glazing materials. The failure mechanism may be different depending on whether the sealant is chemically cured or is a thermoplastic material. Failure may, for example be a result of hardening or softening of the sealant or a loss of adhesion of the sealant to the glass or spacer bar. However despite the differences between IGU edge sealant types, the focus of avoiding incompatibility should be the selection of suitable glazing sealants.

### 8. General Compatibility Considerations

When the selection of a glazing sealant is being considered, compatibility with the IGU should be taken into account alongside other technical and commercial considerations.

Glazing materials should be chosen that are compatible with the IGU components.

Advice on the compatibility of any components used in contact with the edge seals of the IGU should be sought from the supplier/manufacturer of the component and the supplier/manufacturer of the edge sealant(s). In some cases it may also be available from the IGU manufacturer.

If there is no information available, then the person responsible for the installation may need to consider alternative materials that can be confirmed as compatible or to consider commissioning compatibility tests.

The IGU manufacturer should indicate through their terms and conditions of sale (warranty) that incompatible components must not be used in the installation of the units and their use will render the guarantee as void.

The IGU manufacturer should consider attaching a warning label about incompatibility of glazing components with their IGU.

The person responsible for the installation should follow all instructions regarding the use and application of the sealant that they have selected.

There should be no variation from specified materials unless the process of confirming the compatibility of the substitute material is repeated.

### 9. Test Methods

In Europe there is no generally accepted standard or test method for assessing compatibility. This has resulted in different companies/organisations/bodies having different test methods and therefore different acceptance criteria.

Available test methods that could be used to assess some aspects of compatibility are:

ASTM C 1294-01 Standard Test Method for Compatibility of Insulating Glass Edge Sealants with Liquid-Applied Glazing Materials

ASTM C1087-00(2006)

Standard Test Method for Determining Compatibility of Liquid-Applied Sealants with Accessories Used in Structural Glazing Systems

Whatever test method is used it should be borne in mind that the composition of the material may be subject to change without notification and that the results of earlier tests may no longer be valid.

### 10. Summary

This datasheet offers a brief guidance to the relevant issues of compatibility. It is advisable that all parties to a contract identify and resolve the technical, commercial and legal concerns prior to embarking on any project.

Should testing be required, a sufficient period of time should be allowed - accelerated ageing will take several months.

It is important that all specifications, test procedures and agreements are confirmed in writing.

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# Products, Appearance and Visual Quality Specification for Insulating Glass Units

4.10 May 2014

**Contents**



## Introduction

The appearance/visual quality of an insulating glass unit (IGU) is dependent on the following:

- Optical quality of the component glass panes, i.e. distortion inherent during the manufacture of the glass pane;
- Visual quality of the component glass panes, i.e. number/size/type of defects;
- Inherent characteristics of an IGU, i.e. behaviour of a hermetically sealed body;
- Processing, handling, and glazing techniques.

## 1. Scope

This Data Sheet details all appropriate optical and visual quality factors of the glasses used to manufacture the IGU that influence the appearance of an installed IGU.

The major criteria is the view through the IGU from the inside of a building. This is covered in detail within this Data Sheet.

However, it is appreciated that the appearance from the outside of the building, i.e. in reflection, can also be important in certain applications and some non-specific comments are made on this subject.

NOTE: Due to the specialist nature of fire resistant glass, the optical and visual quality of fire resistant IGU's is not covered in detail within this Data Sheet.

## 2. Definitions

For the purpose of this Data Sheet the following definitions apply:

### 2.1 Appearance

The overall effect on the observer when looking at objects through the IGU.

### 2.2 Optical quality

The appearance of an object when observed through the glass.

### 2.3 Visual quality

The effect of faults, e.g. spot, linear extended, etc., on the vision through the glass.

### 2.4 Transparent glass

Glass that transmits light and permits clear vision through it.

### 2.5 Textured and translucent glass

Glass that transmits light with varying degrees of light scattering so that vision is not clear, providing some privacy; or glass that had been sand blasted or acid etched, or laminated glass with a white interlayer making the glass translucent.

### 2.6 Insulating glass unit (IGU)

An assembly consisting of at least two panes of glass, separated by one or more spacers, hermetically sealed along the periphery, mechanically stable and durable.

### 2.7 Condensation

The presence of moisture and/or other liquid on a glass surface either inside or outside the IGU.

- **Interstitial**
Condensation that occurs within the hermetically sealed cavity of the IGU.
- **Peripheral**
Condensation that occurs on the inside, i.e. room surface, of the IGU around the edge of the unit adjacent to the frame.
- **External**
Condensation that occurs on the external, i.e. outside surface, of the IGU

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## 3. Glass types

### 3.1 General

The IGU manufacturer uses glass panes within the IGU that comply with other standards as to their optical and visual quality. In general the IGU manufacturer cannot alter these quality characteristics. During the IGU manufacturing process, and in subsequent handling, there is a risk that further visual faults, e.g. scratches, scuffs, could be added to those already present in the components.

The standards relating to the appropriate glass products will detail their optical and visual quality appertaining to the individual pane.

### 3.2 Basic and special basic glasses

These are annealed glasses that comply with one of the following standards:

BS EN 572 - Parts 2 to 6 or Part 8
BS EN 1748 - 1
BS EN 1748 - 2
BS EN 14178 - 1
BS EN 15681 - 1

NOTE: Typically annealed soda-lime silicate glass, i.e. BS EN 572 is used. Specialist glasses are normally used for specific purposes.

### 3.3 Toughened, toughened and heat soaked, or strengthened glasses

These are annealed glasses that have been thermally or chemically treated to modify their strength and breakage characteristics. They will comply with one of the following standards:

BS EN 1863 - 1
BS EN 12150 - 1
BS EN 12337 - 1
BS EN 13024 - 1
BS EN 14179 - 1
BS EN 14321 - 1
BS EN 15682 - 1

### 3.4 Laminated glasses

These are annealed, toughened or heat strengthened glasses, in any combination, that have been combined with an interlayer(s) to produce a product with modified characteristics.
These modifications will affect one or more of the following:

- post-breakage behaviour
- spectrophotometric characteristics
- acoustic characteristics
- resistance to penetration

They will comply with the following standards:

BS EN ISO 12543 - Parts 1 - 6,
BS EN 14449

### 3.5 Coated glasses

A glass substrate of any of the above, that either incorporates a coating within the glass surface or has had a coating applied to the surface. The coatings are designed to modify the spectrophotometric characteristics of the glass. They will comply with the following standard:

BS EN 1096 - Parts 1 - 3

## 4. Optical Quality

### 4.1 General

The optical quality of a glass component is the result of the following:

- the method of manufacture of the glass component; together with
- the effect of any subsequent processing.

### 4.2 Basic and special basic glasses

The optical quality of transparent glass is entirely dependent on the manufacturing method.

Generally glass made by the float process has less distortion and manufacturing faults than drawn sheet glass. Depending on the specific product, e.g. drawn sheet glass, there may be a number of classes for optical quality.

Polished wired glass can be visually as good as float glass, but the presence of the wire mesh may affect the optical appearance and it has its own section within the standards.

Translucent glasses, i.e. cast, patterned and wired patterned are all textured glasses with varying degrees of light scattering disruption.

These glasses do not have a specific optical quality as they are designed to disrupt vision through the product.

### 4.3 Toughened or strengthened glasses

Thermal toughening and heat strengthening processes may adversely affect the optical quality of the float or drawn sheet glass that is processed.

The heating and cooling of the glass during the process can result in imperfections that will reduce the optical quality e.g.:-

- bow, overall and/or local,
- roller wave distortion
- edge lift/dip

NOTE 1: Details on allowable bow and how it is measured are given in the product standards. Specific details relating to roller wave, edge lift/dip including the method of measurement, are given in GGF Data Sheet 4.4.

NOTE 2: Any lack of flatness with thermally treated glasses can produce problems with reflected images. See Annex A for an example.

Chemical strengthening is less likely to affect the optical quality of the unprocessed glass.

#### 4.3.1 Specific effects of thermal treatment process

The process may give rise to:-

- A degree of haze, i.e. a cloudy look to the surface and/or
- Cause an effect that is known as anisotropy (iridescence).

Anisotropy is the result of stress patterns in the cross section of the glass becoming visible. These areas of stress produce a bi-refrigent effect in the glass, which is visible when viewed in polarised light. These areas show up as coloured zones, sometimes referred to as 'leopard spots'.

The haze and bi-refrigent effects are more noticeable at glancing angles. These are not considered as faults.

### 4.4 Laminated glasses

The optical quality of laminated glass is dependent on the following:

- type and number of glass panes
- type, thickness and number of interlayer(s)
- presence or not of plastics glazing sheet materials
- laminating process, e.g. folio, cast in place, etc.

Generally folio lamination processes, i.e. ones using an interlayer such as pvb, eva and pvc have only minor influences on the optical quality of the final product. The degree of influence will increase with more panes of glass and more/thicker interlayers as each ply has the potential for faults.

Details on allowable bow and how it is measured are given in the product standards. Specific details relating to roller wave, including method of measurement, is given in GGF Data Sheet 4.4.

Cast in place laminating is more likely to result in a product that does not have parallel faces, and hence distortions may occur. Problems may arise with slight discrepancies in uniformity of curing of the interlayer that may produce refractive index discrepancies.

NOTE: Further information on laminated glass is given within GGF Data Sheet 4.11

### 4.5 Coated glasses

The optical quality of coated glass is dependent on the following:

- type of glass substrate
- type, thickness and make-up of coating, e.g. single or multilayer,
- coating process, e.g. on-line, off-line, etc

Generally the addition of a coating to a glass substrate does not significantly alter the optical quality. Therefore the optical quality of a coated glass is that of the substrate. Coatings are added to influence thermal efficiency, solar control, reflective properties, or cleaning attributes, and may change the light transmittance or reflectance of the product.

However, as the majority of coatings work due to thin film interference effects there can be a perceived change if there is a lack of uniformity in the coating. Similarly these thin coatings can offer variations in colour that can appear as a lack of uniformity.

Some low-e coatings on glass may produce a haze, i.e. a cloudy look to the surface, when viewed in oblique lighting (see 7.3).

Note: Pigmented or decorative coatings are not included within this reference

## 5. Visual Quality

### 5.1 General

The visual quality of a glass component is the result of the following:

- method of manufacture of the glass component; together with
- the effect of any subsequent processing and handling.

NOTE: Specialist glass types, e.g. fire resistant, may not have the same optical/visual qualities as basic glass.

### 5.2 Basic and special basic glasses

The visual quality can be found for stock and final cut sizes in the product standards (see 4.2). The exception is basic soda lime silicate glass products which are given in BS EN 572 Part 8.

Cutting down of stock plates into final cut sizes, i.e. panes for further processing, is an opportunity to reduce the number and size of inherent spot and/or linear extended faults. However, care should be taken to ensure that the cutting process does not introduce other defects, e.g. scratches.

The visual quality of textured glasses also depends on the following:

- pattern type/depth
- directionality of the pattern
- wire mesh uniformity, squareness, alignment etc.

Quantification of these parameters can be found in the appropriate product standards.

Generally the visual quality is higher for a transparent glass than for a textured or translucent glass. With textured glasses the light scattering reduces the visible impact of the faults. Therefore the greater the degree of light scattering the less likely is it that any specific fault is visually disturbing.

### 5.3 Toughened or strengthened glasses

As these products are manufactured from final cut sizes then the processing should not alter the basic visual quality of the glass.

However, the cutting, edge working and toughening/strengthening could impart additional scratches/scuffs onto the glass surface.

These processing faults will affect the visual quality.

The thermal treatment process may result in small imprints in the surface ('roller pick-up'). This usually only applies to horizontally processed glass of 6mm or thicker

### 5.4 Laminated glasses

The visual quality of laminated glass depends on the following:

- component glass panes
- interlayer type, thickness
- laminating process
- cutting/sawing to final cut size

The manufacture of stock size laminated glass is influenced by the visual quality of the initial stock size glass panes used. These panes will have a visual quality in accordance with the product standards (see 3.2). The visual quality of the laminated glass may be worse than that of any component pane. Therefore the greater number of glass panes within a laminated glass the greater the likely number of defects (see BS EN ISO 12543 Par t 6).

With selective cutting of finished sizes from stock plate of laminate glass some defects can be avoided in the final product.

Further faults can be introduced during the laminating process due to faults in the interlayer, and entrapment of any contamination between the layers. Defects can appear as bubbles, opaque spots, foreign bodies, and creases in the interlayer.

Cutting, sawing and edge working can impart scratches etc. The thicker/heavier the laminated glass then the higher is the probability of increasing the visual defects during these processes. This applies to all glass types.

### 5.5 Coated glasses

The visual quality of coated glass depends on the following:

- component glass panes

- coating type, colour, spectrophotometric properties
- coating process
- cutting to final size

The presence of a coating on a glass substrate may increase the visibility of a spot fault or linear extended fault within the substrate.

Similarly faults within and/or on the coating, e.g. pinholes, scratches, scuffs, non-uniformities, etc., may decrease the visual quality. These effects are more pronounced with coatings that are highly coloured and/or highly reflective.

The likelihood of the visual quality being decreased is dependent on both the type of coating and the number of steps involved within the manufacturing process.

Generally on-line coating is inherently more resistant to scratching, etc. than are off-line coatings. Certain 'off-line coatings need special processing, i.e. edge deletion, prior to incorporation into an IGU. This abrasion process can also result in decreased visual quality.

With multiple pane units any distortion or reflection is multiplied as the number of panes increases. Multiple reflections are not a fault.

In the case of heat treated glasses with coatings in multiple paned units, the effect can be significant. Any minor distortion will be exaggerated but this should not be deemed a failure.

## 6. Inherent characteristics of IGUs

### 6.1 General

An insulating glass unit as defined is a glass product that contains hermetically sealed space(s).

There are many designs of IGU. The major variations are as follows:

- Glass components
    - Glass composition e.g. soda lime silicate borosilicate glass ceramic alkaline earth silicate alumino silicate
    - Annealed glass e.g. float drawn sheet patterned wired
    - Coated glass
    - Thermally treated glass
    - Heat strengthened soda lime silicate glass
    - Thermally toughened soda lime silicate safety glass
    - Thermally toughened borosilicate safety glass
    - Thermally toughened alkaline earth silicate safety glass
    - Heat soaked thermally toughened soda lime silicate safety glass
    - Heat soaked thermally toughened alkaline earth silicate safety glass
    - Laminated glass
- Spacers
    - Metallic hollow to hold the desiccant
    - Composite either hollow to hold desiccant or incorporating a desiccant matrix
    - Organic incorporating the desiccant
- Airspace
    - Air filled
    - Gas filled e.g. argon
    - Vacuum
- Sealant systems
    - Single seal e.g. hot melt
    - Dual seal e.g. PIB as primary seal with polysulphide polyurethane silicone or hot melt as a secondary seal

The primary function of an IGU is to improve the thermal efficiency of the window

NOTE 1: IGUs incorporating more than two panes of glass have characteristics that may have an impact upon the appearance See 6.5

NOTE 2: IGUs which are manufactured using special glass types e.g. fire resistant, may not give the same optical/visual quality as units manufactured from soda lime silicate glass.

#### 6.1.1 Characteristics of the hermetically sealed cavity

The properties of a hermetically sealed cavity will change dependent on the following:

- temperature and barometric pressure when the cavity was sealed
- actual air temperature and barometric pressure
- temperature of the air or gas within the cavity as a result of radiation etc.
- thickness of the glass

These changes will result in a volume change in the cavity. This will result in the unit taking up either a concave or convex shape. This shape will cause a number of phenomena to become apparent (see 7.2, 7.3, 7.4).

### 6.2 Condensation

An IGU is designed to reduce the heat loss through the glazing. This means that, compared to single glazing, the incidence of moisture condensing on the room side glass surface is reduced. However, condensation can still occur as follows:

**Interstitial:** - when either the unit seal has failed or the cavity is saturated with moisture or when an internal component, e.g. Georgian bars, etc., has deteriorated and given off organic solvents. Under any of these conditions the appearance of condensation on one or both cavity surfaces can occur subject to the glass surface temperature.

**Internal:** - when the relative humidity within the room is extremely high and the glass surface is cold, i.e. in a kitchen, bathroom, etc. with large amounts of steam/moisture present.

**Peripheral internal:** - this occurs with units having low U-values and is the result of localised heat flow through the spacer bar within the unit.

NOTE: Using a combination of a thermally efficient window profile and 'warm edge technology' within the IGU can help to reduce this.

**External:** - this occurs with units having low U-values that significantly reduces heat loss. Under localised climatic conditions this can lead to moisture condensing onto the outside surface of the unit. This is not a fault, but rather demonstrates that the product is thermally efficient.

Note: Further information on condensation can be found within the GGF leaflet - Condensation: Some Causes Some Advice.

### 6.3 Fogging

Interstitial fogging (sometimes seen as a rainbow effect) may occur if unwanted elements are present which become visible under certain conditions

### 6.4 Interference phenomena

These are visual phenomena, similar to oil on water, and are the result of light interference patterns due to the IGU glass panes deflecting in relation to each other.

#### 6.4.1 Brewster's fringes

These are a visual effect seen as a rainbow within the unit. They are not a deterioration of the unit or the glass, but an effect created when light passes through two panes of glass that are parallel and of the same thickness. The resulting light refraction becomes visible as a rainbow effect.

Brewster's Fringes can be confirmed by pressing one surface of the unit. The rainbow effect will move and colours change as the surface is depressed and released.

This phenomenon is not a defect of the product and is solely dependent on the laws of physics.

NOTE: The effect can be avoided by using different thicknesses of glass for each pane of the IGU.

#### 6.4.2 Newton's rings

This visual effect is created when the central area of the glass panes making up an IGU come into close proximity to each other or in fact touch. It will appear as a circular or semi-circular rainbow effect in central areas of the unit.
This could be the result of one or more of the following:

- Incorrect air space for the unit size
- Manufacturing faults
- Temperature related pressure changes
- Improper pressure equalisation

### 6.5 Multiple images

As a result of the number of reflective surfaces (four in an IGU with two glass panes manufactured from monolithic glass) there exists the likelihood of multiple images being formed. This is only of minor significance when the observer is looking directly through the IGU, i.e. at normal incidence. However this will increase considerably as the angle of incidence becomes more oblique.

The presence of other reflective surfaces, e.g. laminated glass, coatings, may enhance the phenomena. Also any deflection effect within the unit may have an influence.

As the number of panes increases, such as triple glazed IGU's, this can further enhance the presence of multiple images. These are unavoidable.

NOTE: To alleviate the risk of thermal stress to a triple glazed IGU, the centre pane would generally be heat treated. This may have an effect on the visual appearance of the unit

Annex B will give a diagrammatic representation of the phenomena resulting from the inherent properties of an insulating glass unit.

### 6.6 Reflected image

As a result of the hermetically sealed cavity of an IGU the glass will deflect with changes of temperature and pressure. The result of this is that the reflected images can appear separated. This will be further exacerbated by the presence of multiple images that are being displaced different amounts.

The likelihood of this occurrence is dependent on the extent of the deflection in the IGU as a result of the difference in atmospheric temperature and pressure between the manufacturing conditions and the service conditions.
The effect may be more noticeable when reflective coatings are incorporated within the IGU.

Annex B will give a diagrammatic representation of the phenomena resulting from the inherent properties of an insulating glass unit.

## 7. Appearance

### 7.1 General

Appearance relates to the limitations that are placed upon the insulating glass unit manufacturer. These limitations are as a result of the following:

- Incoming glass components,
- Specification of the unit,
- Inherent properties of the unit,
- Framing and glazing systems.

The perceived appearance of an installed IGU can be adversely affected by distortions induced by the framing system and the installation.

### 7.2 Normal incidence

The IGU should be viewed at normal incidence, i.e. at 90° to the glass surface.

For IGUs containing transparent glass components the appearance relates to the vision through.

For IGUs containing textured or translucent glass components the appearance relates to the visual quality of the textured or translucent glass component.

### 7.3 Oblique incidence

The effects such as multiple images, haze, etc. are inherent characteristics of an IGU when viewed at oblique angles of incidence.

### 7.4 Reflection

Not generally considered. See Annexes A and B for further information.

## 8. Method of assessment

### 8.1 General

The standards for the component glass panes detail the method of observation and the distance and criteria for acceptance.
However for an IGU no such recommendations are given in the applicable European standard, i.e. BS EN 1279-1.

As there is no standardised method of assessment this Data Sheet lays down an appropriate methodology.

NB: Damage caused by following trades after glazing will not be considered as a fault of the installer.

For example damage can be caused by impact, scratching, deposit of plaster, cement, etc. and weld spatter and spatter from cutting tools.

For this reason, viewing IGUs for scratches or other damage on the outer faces of the panes must be carried out before any following trade's works adjacent to the glazing, and as early as reasonably practicable following installation of the IGUs.

#### 8.1.1 Area of IGU to be examined

The glass area to be viewed is the entire vision area with the exception of a 50mm wide band around the whole perimeter of each of the glass panes.

This edge zone, in terms of size, is similar to that given for the determination of coated glass in final cut sizes (see BS EN 1096-1).

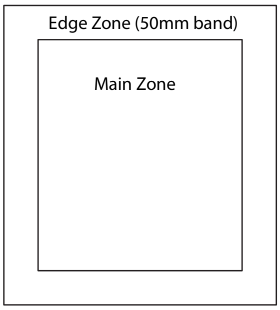


Figure 1

### 8.2 Inspection

The IGUs shall be viewed at near normal incidence, i.e. at right angles, to the glass surface from the room side, standing at a distance of not less than 2 metres away from the inner glass surface for annealed float glass and 3 metres away for all other glass types e.g. laminated or toughened glass.

The assessment of visual quality of the panes of glass should be carried out in natural daylight but not in direct sunlight and with no visible moisture on the surface of the inner or outer glass panes. The use of strong lamps and/or magnifying devices is not allowed.

It is not permissible to find defects at close range and then mark them so as to be visible from the given viewing distance.

Obtrusiveness of faults shall be judged by looking through the glass, not at it.

NOTE 1: This does not apply to textured or translucent glasses. See 7.2

NOTE 2: Triple glazed IGUs have special characteristics that may affect the visual quality. See 6.5.

### 9 Acceptance criteria

Acceptance criteria relate strictly to the inherent characteristics of an IGU or of the glasses used to make up an IGU, such as: -

- totally enclosed seeds,
- bubbles or blisters;
- hairlines or blobs;
- minute embedded particles;
- inherent faults and fine scratches on coated glasses.

IGUs with optical defects such as smears, finger prints or other dirt on the cavity faces of the glass or extraneous material inside the IGU cavity are unacceptable, and this applies also to any such defects within the 50mm edge zone if they are visibly disturbing.

Insulating glass units shall not be deemed unacceptable for any phenomena relating to the inherent characteristics of an IGU with the exception of 'Newton's Rings' (see 6.4.2.)

When viewed in accordance with Section 8.2 above the IGU will be deemed acceptable as long as, where appropriate the criteria below is followed:

- there are no defects noticed that are visually disturbing
- any defects that are noted comply with the visual quality, (see 7), for the glass component
- any visual disturbance, e.g. from roller wave, bow, etc., is within the tolerances given in the appropriate product standard
- coated glass quality, e.g. pinholes, colour variation, etc. comply with the appropriate product quality
- there is no distortion as a result of the framing system or the installation.

NOTE 1: Condensation on the internal or external surfaces of the IGU should be removed before carrying out the inspection.

NOTE 2: Interstitial condensation is not allowed.

### Bibliography

### European and/or national standards

**BS 952-1:** Glass for glazing – Part 1. Classification

**BS EN 572-1:** Glass in building – Basic soda lime silicate glass products - Part 1: Definition and general physical and mechanical proper ties

**BS EN 572-2:** Glass in building – Basic soda lime silicate glass products - Part 2: Float glass

**BS EN 572-3:** Glass in building – Basic soda lime silicate glass products - Part 3: Polished wired glass

**BS EN 572-4:** Glass in building – Basic soda lime silicate glass products - Part 4: Drawn sheet glass

**BS EN 572-5:** Glass in building – Basic soda lime silicate glass products - Part 5: Patterned glass

**BS EN 572-6:** Glass in building – Basic soda lime silicate glass products - Part 6: Patterned wired glass BS EN 572-8: Glass in building – Basic soda lime silicate glass products - Part 8: Supplied and final cut sizes

**BS EN 572-8:** Glass in Building – Basic soda lime silicate glass products – Part 8: Supplied and final cut sizes

**BS EN 1096-1:** Glass in building – Coated glass products - Part 1: Description and definitions

**BS EN 1096-2:** Glass in building – Coated glass products - Part 2: Test method for the durability of class A, B and S coatings

**BS EN 1096-3:** Glass in building – Coated glass products - Part 3: Test method for the durability of class C and D coatings

**BS EN 1279-1:** Glass in building – Insulating glass units - Part 1: Generalities, dimensional tolerances and rules for the system description

**BS EN 1748-1-1:** Glass in building – Special basic product – Borosilicate glasses - Part 1-1: Definition and general physical and mechanical properties

**BS EN 1748-2-1:** Glass in building Special basic product – Glass ceramics Part 2-1: - Definition and general physical and mechanical proper ties

**BS EN 1863-1:** Glass in building – Heat strengthened soda lime silicate glass products - Part 1: Description and definitions

**BS EN 12150-1:** Glass in building – Thermally toughened soda lime silicate safety glass products - Part 1: Description and definitions

**BS EN 12337-1:** Glass in building – Chemically strengthened soda lime silicate glass – Part 1: Description and definitions

**BS EN 13024-1:** Glass in building – Thermally toughened borosilicate safety glass – Part 1: Description and definitions

**BS EN 14178–1:** Glass in building – Alkaline earth silicate glass products – Part 1: Float glass

**BS EN 14179-1:** Glass in building – Heat soaked thermally toughened soda lime silicate safety glass products – Part 1: Description and definitions

**BS EN 14321-1:** Glass in building – Thermally toughened alkaline earth silicate safety glass products – Part 1: Description and definitions

**BS EN 15681-1:** Glass in building – Basic alumino silicate glass products – Part 1: Definition and description

**BS EN 15682-1:** Glass in building – Heat soaked thermally toughened alkaline earth silicate safety glass – Part 1: Definition and description

**BS EN ISO 12543-1:** Glass in building – Laminated glass and laminated safety glass - Part 1: Definitions and description of component parts

**BS EN ISO 12543-2:** Glass in building – Laminated glass and laminated safety glass - Part 2: Laminated safety glass

**BS EN ISO 12543-3:** Glass in building – Laminated glass and laminated safety glass - Part 3: Laminated glass

**BS EN ISO 12543-4:** Glass in building – Laminated glass and laminated safety glass - Part 4: Test methods for durability

**BS EN ISO 12543-5:** Glass in building – Laminated glass and laminated safety glass - Part 5: Dimensions and edge finishing

**BS EN ISO 12543-6:** Glass in building – Laminated glass and laminated safety glass – Part 6: Appearance

**Evaluation of conformity/product standards**

With the publication of the harmonised European Norms hENs, the glass components will become available as CE marked products. The CE marking will be a declaration that the glass product conforms to the appropriate hEN.

The hENs are as follows:

**BS EN 572-9:** Glass in building – Basic soda lime silicate glass products - Part 9: Evaluation of conformity/Product standard

**BS EN 1096-4:** Glass in building – Coated glass products - Part 4: Evaluation of conformity/Product standard

**BS EN 1279-5:** Glass in building – Insulating glass units - Part 5: Evaluation of conformity/Product standard

**BS EN 1748-1-2:** Glass in building – Special basic product – Borosilicate glasses - Part 1-2: Evaluation of conformity/Product standard

**BS EN 1748-2-2:** Glass in building Special basic product – Glass ceramics Part 2-2: - Evaluation of conformity/Product standard

**BS EN 1863-2:** Glass in building – Heat strengthened soda lime silicate glass products - Part 2: Evaluation of conformity/Product standard

**BS EN 12150-2:** Glass in building – Thermally toughened soda lime silicate safety glass products - Part 2: Evaluation of conformity/Product standard

**BS EN 12337-2:** Glass in building – Chemically strengthened soda lime silicate glass – Part 2: Evaluation of conformity/Product standard

**BS EN 13024-2:** Glass in building – Thermally toughened borosilicate safety glass – Part 2: Evaluation of conformity/Product standard

**BS EN 14178-2:** Glass in building – Alkaline earth silicate glass products – Part 2: Evaluation of conformity/Product standard

**BS EN 14179-2:** Glass in building – Heat soaked thermally toughened soda lime silicate safety glass products – Part 2: Evaluation of conformity/Product standard

**BS EN 14321-2:** Glass in building – Thermally toughened alkaline earth silicate safety glass products – Part 2: Evaluation of conformity/Product standard

**BS EN 14449:** Glass in building – Laminated glass and laminated safety glass - Evaluation of conformity/Product standard

**GGF Data Sheets**

Data Sheet 4.4. Quality Standard for Toughened Glass

Data Sheet 4.4.1 Heat Treated Glasses

Data Sheet 4.11 Laminated and Laminated Safety Glass

**GGF Leaflets**

Condensation: Some Causes Some Advice

**Annex A**

**Appearance in reflection**

With multiple pane units any distortion or reflection is multiplied as the number of panes increases. Multiple reflections are not a fault.

The following descriptions and diagrams refer to double glazed units. Triple glazing will further enhance the effects.

**1. Problem due to lack of flatness**

**1.1. General description**

A glass, especially one that is thermally treated, can rarely be glazed perfectly flat. This may be due to the framing system, glazing system, installation and the inherent flatness of the glass.

Imagine a rectilinear feature, e.g. a telegraph pole, some 10 metres from a glazed panel. The observer is viewing the feature by reflection from a similar distance.

If the plane of the glazing changes by one tenth of one degree, 0.1° between two points on its surface, then the viewer will see either two images apparently displaced by 70mm or one image distorted by this amount.

**1.2 Is one tenth of one degree, 0.1°, significant?**

YES. This amount of flatness change is equivalent to a deflection of 0.8mm over a one-metre length.

This should be compared with the allowable deflection limits for framing, i.e. L/125 for single glazing, L/175 for double glazing.

This would mean for an L of one metre deflections of either 8mm for single-glazing or 5.7mm for double-glazing.

Deflections of greater magnitude can occur due to wind-loading. For thermally treated glass, i.e. thermally toughened, heat strengthened, etc., the standards allow overall bows of 2mm/metre and local bows of 3mm/metre.

For insulating glass units the deflection due to barometric/temperature effects can be significantly greater than 0.8mm/m.

**1.3 Optical explanation**

Figure A1 shows the geometry involved.

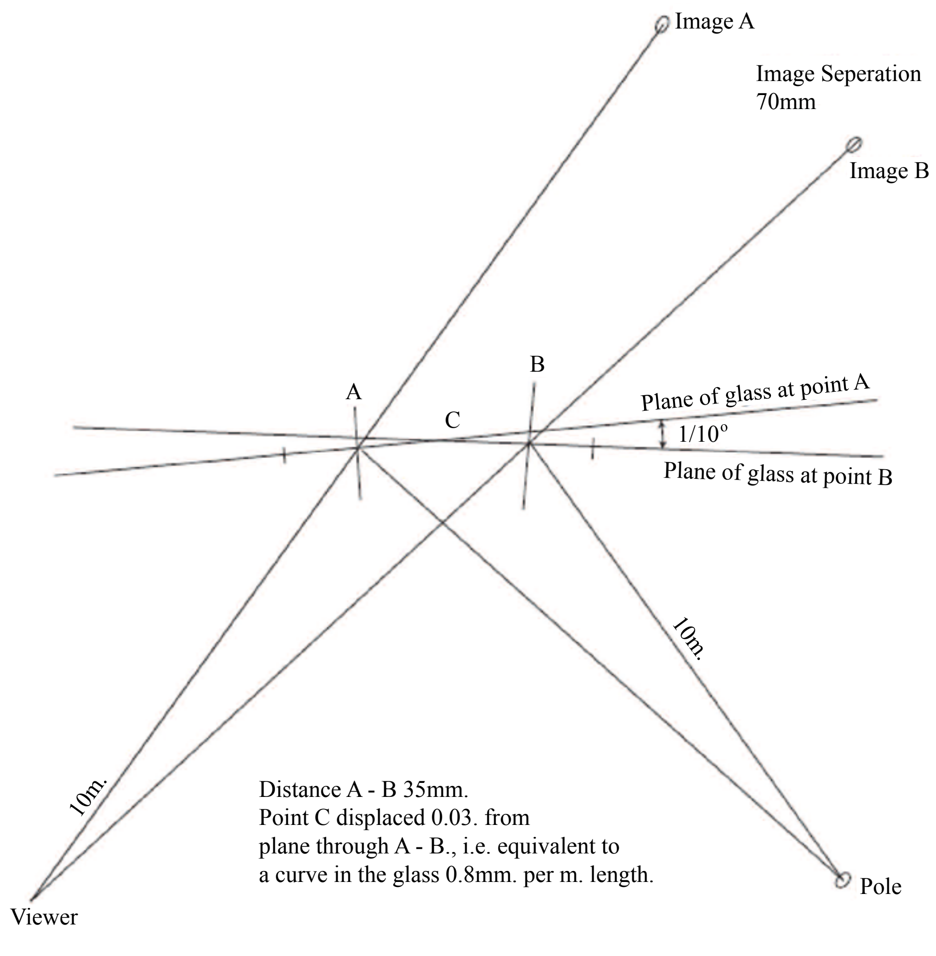


Figure A1 Explanation of lack of flatness

**Annex B**

**Diagrammatic explanation:**

With multiple pane units any distortion or reflection is multiplied as the number of panes increases.

Multiple reflections are not a fault.

The following descriptions and diagrams refer to double glazed units. Triple glazing will further enhance the effects.

### 1. Multiple images

#### 1.1. General

When light meets a smooth glass surface; some is transmitted through, some is reflected and some is absorbed.

It is a law of physics that the angle of incidence is equal to the angle of reflection. Therefore if the incident ray is at normal incidence, i.e. at right angles to the glass surface then it is reflected directly back, (see Figure (B1(A)). If the incident ray falls obliquely on the surface then the reflected ray bounces back at the same angle but on the other side of the perpendicular.
(See Figure (B1(B)).

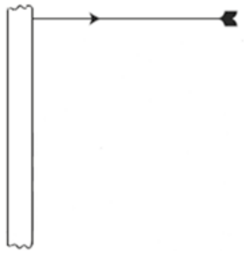

Figure B1(A)

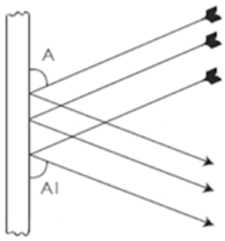


Figure B1(B)

#### 1.2 Refraction

Another law of physics is that when a ray enters a medium of differing density it is bent (refracted).

When a ray enters the glass from the air the angle of refraction is less than the angle of incidence. Therefore when reflected from the second surface it is displaced with respect to the incident ray.

When the ray leaves the glass into the air the angle of refraction is greater than the angle of incidence.

Therefore when leaving the first pane of glass the ray is parallel to the incident ray but displaced.

A similar situation occurs when the ray meets the second pane.

For each pane of glass there are two reflected images, a primary and a secondary image. The primary images result from surfaces 1 and 3 and the secondary images from surfaces 2 and 4.
(See Figure B2).

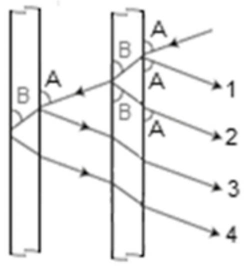


Figure B2

#### 1.3 Influencing factors

The following will increase the spacing between images:

- Increasing glass thickness,
- Increasing cavity width,
- Decreasing the angle of incidence.

The effects of coatings and body tints are dependent upon their spectrophotometric properties, i.e. transmittance, reflectance, absorbtance, and their position.

Generally body tinted glasses will enhance the primary image and reduce the secondary image produced by the pane. Coatings will enhance the image reflected from the coating.

### 2 Distorted images

#### 2.1 General

When light rays strike a curved glass surface, they reflect in different directions. However, they will still obey the law that the angle of incidence equals the angle of reflection. Therefore the image of an object will be distorted. The curvature of the glass surface causes it to act as a lens.

#### 2.2 Concave curvature

This is when the surface is bowed inwards.

A concave curvature will cause the light rays to be projected inwards towards a central point. This causes the reflected image to appear short and thin. (See Figure B3 (A)

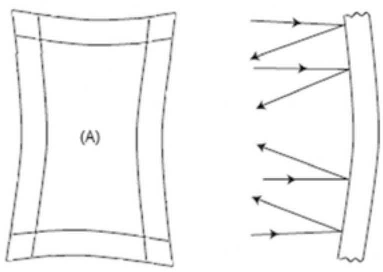


Figure B3 (A)

**2.3 Convex curvature**

This is when the surface is bowed outwards.

A convex curvature will cause the light rays to be projected outwards away from a central point. This causes the reflected image to be stretched out in all directions. (See Figure B3 (B))

The outcome of having different curvatures on the panes will result in some images being made smaller/thinner and others being stretched out.

NOTE: Figure B4 only examines the first reflection of the light ray.

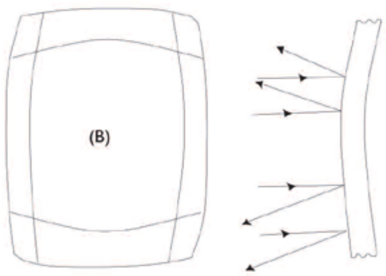


Figure B3 (B)

**2.4 Curvature in IGUs**

When an IGU is subjected to barometric and/or temperature and/or altitude effects the whole unit will change shape.

If the effects on the unit cause it to shrink inwards then this will result in pane #1 being concave and pane #2 being convex, (see Figure B4 – Type (A)). Similarly if the effects on the unit cause it to swell outwards then this will result in pane #1 being convex and pane #2 being concave, (see Figure B4 – Type (B)).

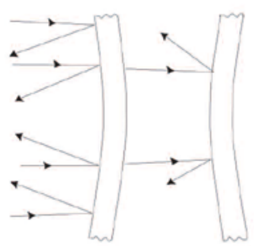

Figure B4 (A)
Surface 1 - Primary image - shrunk
Surface 3 - Primary image - spread out

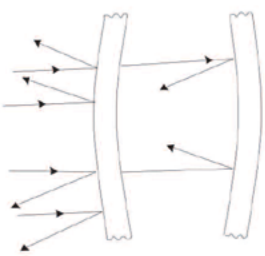

Figure B4 (B)
Surface 1 - Primary image - spread out
Surface 3 - Primary image - shrunk

The outcome of having different curvatures on the panes will result in some images being made smaller/thinner and others being stretched out.

NOTE: Figure B4 only examines the first reflection of the light ray.

**3 Composite factors**

The combination of multiple images, B1, and distorted images, B2, is extremely difficult to describe.

**What is certain is that nothing can be done to stop these effects occurring.**

**Always use a current GGF Member.**
To see the latest list of GGF Members
visit www.ggf.org.uk/directory



# GGF Data Sheet: Laminated Glass and Laminated Safety Glass

4.11 June 2016

**Contents**



## 1. Scope

**1.1** This GGF Data Sheet specifies the characteristics of flat laminated glass and flat laminated safety glass for use in buildings. It covers both stock and finished sizes as manufactured. This GGF Data Sheet does not apply to panes of area < 0.05 m².

**1.2** This GGF Data Sheet covers laminated glass and laminated safety glass manufactured using one and/or more of the following types of interlayers:

**1.2.1** Folio interlayers, e.g. polyvinyl butyral (pvb), polyethylene acetate (eva), polyurethane (pu), ionoplast.

**1.2.2** Cast in place resin interlayers, e.g. poly methly methacylate (pmma), polyurethane (pu), epoxy.

**1.2.3** Fire protection interlayers, intumescent interlayers.

**1.3** This GGF Data Sheet gives definitions, dimensional sizes and tolerances as well as methods of determining visual and optical quality.

**1.4** All flat laminated glass covered by this GGF Data Sheet will meet, where appropriate, the following standards:

- EN 14449 Glass in building – Laminated glass and laminated safety glass – Evaluation of conformity/Product standard
- EN ISO 12543 Glass in building – Laminated glass and laminated safety glass -

*Part 1: Definitions and descriptions of component parts*

*Part 2: Laminated safety glass*

*Part 3: Laminated glass*

*Part 4: Test methods for durability*

*Part 5: Dimensions and edge finishing*

*Part 6: Appearance*

**1.5** Curved laminated glass and curved laminated safety glass is excluded from this GGF Data Sheet.

NOTE: For information on curved laminated safety glass see GGF Data Sheet 4.12.4 Curved Glass Part 4: Curved Laminated Glasses.

## 2. Definitions

NOTE: The definitions used in this GGF Data Sheet have, where possible, been taken from the appropriate European standards, i.e. EN 14449, EN ISO 12543 Parts 1-6.

### 2.1 General

#### 2.1.1 Laminated glass

Assembly consisting of one sheet of glass with one or more sheets of glass and/or plastics glazing sheet material joined together with one or more interlayers.

#### 2.1.2 Interlayer

Layer or material acting as an adhesive and separator between plies of glass and/or plastics glazing sheet material.

NOTE: The interlayer can also give additional performance to the finished product, e.g. enhanced impact resistance, resistance to fire, solar control, acoustic insulation, etc.

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While every attempt is made to present up to date information, this Data Sheet, produced by the Glass and Glazing Federation, is issued for guidance but without responsibility for any advice given therein or omission therefrom or for the consequences of acting in reliance thereon and all liability on the part of the Glass and Glazing Federation however arising in connection therewith is expressly disclaimed.

### 2.1.3 Laminating processes

#### 2.1.3.1 Folio lamination process

Process where the interlayer is a solid film which is placed between the plies of glass or plastics glazing sheet material and is then subjected to pressure and/or heat to produce the final product.

#### 2.1.3.2 Cast-in-place lamination process

Process where the interlayer is obtained by pouring a liquid between the plies of glass or plastics glazing sheet material that is then chemically cured to produce the final product.

NOTE: Other lamination processes than those defined in clause 2.1.3.1 and clause 2.1.3.2 are available which do not necessarily fit into either of the two methods described above.

### 2.1.4 Stock sizes

Sizes that are intended to be re-cut or further processed for final use.

### 2.1.5 Finished sizes

Sizes which are either manufactured to size or cut from stock sizes, and may be further processed, e.g. edgeworked, drilled or face decorated etc.

***NB: In clause 2.1.6 to clause 2.1.10 the term 'laminated glass' can also mean 'laminated safety glass'.***

### 2.1.6 3-ply laminated glass

Laminated glass manufactured from a pane of glass together with either another pane of glass or plastics glazing sheet material and interlayer.

### 2.1.7 5-ply laminated glass

Laminated glass manufactured from either 3 panes of glass or 2 panes of glass and 1 pane of plastics glazing sheet material together with 2 interlayers.

### 2.1.8 Flat laminated glass

Laminated glass in which the constituent glass and/or plastics glazing sheet materials have not been deliberately formed or bent in the course of manufacture.

### 2.1.9 Symmetrical laminated glass

Laminated glass in which, from both outer surfaces, the sequence of glass panes, plastics glazing sheet material and interlayer(s) by type, thickness, finish and/or general characteristics is the same.

### 2.1.10 Asymmetrical laminated glass

Laminated glass in which, from both outer surfaces, the sequence of glass panes, plastics glazing sheet material and interlayer(s) by type, thickness, finish and/or general characteristics is different.

## 2.2 Products

***NB: With the exception of clause 2.2.1 the term 'laminated glass' can also refer to 'laminated safety glass'.***

### 2.2.1 Laminated safety glass

Laminated glass where in the case of breakage the interlayer serves to retain the glass fragments, limits the size of opening, offers residual resistance and reduces the risk of cutting or piercing injuries.

***NB: A laminated safety glass has no fire resistance properties unless it meets clause 2.2.2 or clause 2.2.3.***

### 2.2.2 Laminated glass with fire resistant properties

Laminated glass which does not achieve its fire resistance by means of interlayer(s) which react to high temperatures.

NOTE: The fire resistance is a result of fire resistant components incorporated into the fire resistant glass.

### 2.2.3 Fire resistant laminated glass

Laminated glass where at least one interlayer reacts to the high temperature to give the product its fire resistance.

NOTE: This product may also contain glass components that are themselves fire resistant.

### 2.2.4 Laminated security glass

Laminated glass designed to withstand a specified level of attack.

NOTE: For further information see GGF Data Sheet Series 8.1 Security Glazing.

The following types are available:

#### 2.2.4.1 Manual attack resistant laminated glass

Laminated glass designed to resist attack by means of an axe, crowbar, pickaxe, etc. and to delay access to a protected space for a short period of time.

NOTE: For further information see GGF Data Sheet 8.1.2 Security Glazing - Part 2: Manual Attack Resistant Glazing.

#### 2.2.4.2 Bullet resistant laminated glass

Laminated glass designed to provide protection against firearm attack.

NOTE: For further information see GGF Data Sheet 8.1.3 Security Glazing - Part 3: Bullet Resistant Glazing.

#### 2.2.4.3 Blast resistant laminated glass laminated glass

Designed to reduce the injurious effects of accidental or intentional blast forces.

NOTE: For further information see GGF Data Sheet 8.1.4 Security Glazing - Part 4: Explosion Resistant Glazing.

### 2.2.5 Solar control laminated glass laminated glass

Incorporating a body tinted and/or coated glass and/or a tinted interlayer.

### 2.2.6 Ultraviolet control laminated glass

Laminated glass incorporating a special interlayer which absorbs > 99 % of the ultraviolet radiation reaching the glass surface.

NOTE: Ultraviolet radiation measured over the range 280 nm to 380 nm.

### 2.2.7 Acoustic laminated glass

Laminated glass incorporating a special interlayer that gives enhanced sound reduction properties.

### 2.2.8 Laminated thermally treated glass

Laminated glass incorporating one or more of the following glass types:

- Heat strengthened glass (to EN 1863)
- Thermally toughened glass (to EN 12150)
- Heat strengthened thermally toughened glass (to EN 14179)

NOTE: For further information on these types of glass see GGF Data Sheet 4.4 Quality of Thermally Toughened Soda Lime Silicate Safety Glass for Building and GGF Data Sheet 4.4.1 Thermally Treated Soda Lime Silicate Glass Products - General.

### 2.2.9 Translucent laminated glass

Laminated glass manufactured incorporating a patterned glass, a surface treated glass and/or a light diffusing interlayer.

## 3. Glass Components

Laminated glass and laminated safety glass may be manufactured from any combination of the glass types given in Annex A.

## 4. Interlayers

The types of interlayer materials available and their processing conditions are given in Annex B.

## 5. Performance

### 5.1 Laminated glass

A laminated glass is one that conforms to the definition given in EN ISO 12543-3 and meets the appropriate durability tests as given in EN ISO 12543-4.

### 5.2 Laminated safety glass

A laminated safety glass is one that conforms to the definition given in EN ISO 12543-2, has a pendulum impact performance classification of minimum 3(B)3 in accordance with EN 12600 and meets the appropriate durability tests as given in EN ISO 12543-4.

### 5.3 Laminated glass with fire resistant properties

A laminated glass or laminated safety glass product, see clause 5.1 and clause 5.2, that incorporates as part of its makeup a 'fire resistance' glass pane.

NOTE: Fire resistance being determined and classified according to EN 13501-2.

### 5.4 Fire resistant laminated glass

A laminated glass or laminated safety glass product, see 5.1 and 5.2, that incorporates as part of its makeup intumescent interlayer(s), i.e. an interlayer that reacts to high temperatures.

The interlayer can be either an intumescent one, i.e. one that swells under heat, or a specialist cast in place resin layer that chars when subjected to fire.

NOTE: Fire resistance being determined and classified according to EN 13501-2.

***NB: The product types in clauses 5.5, 5.6 and 5.7 may also be classified as laminated glass or laminated safety glass, see clauses 5.1 and 5.2.***

### 5.5 Laminated security glass

A laminated glass or laminated safety glass product, see clause 5.1 and clause 5.2, that when tested can meet the requirements of one and/or more of the following.

### 5.5.1 Manual attack resistant laminated glass

The performance requirements are determined and specified in EN 356.

### 5.5.2 Bullet resistant laminated glass

The performance requirements are determined and specified in EN 1063.

### 5.5.3 Blast resistant laminated glass

The performance requirements are determined and specified in EN 13541.

### 5.6 Ultraviolet control laminated glass

The ultraviolet transmission is determined in accordance with EN 410.

### 5.7 Acoustic laminated glass

The sound reduction properties are determined in accordance with EN 12758.

## 6. Thickness and Thickness Tolerances

### 6.1 Nominal thickness

The nominal thickness of a flat laminated glass or laminated safety glass shall be the sum of the nominal thickness of the constituent panes of glass, and plastics glazing sheet material, and the interlayer(s).

### 6.2 Thickness tolerance (limit deviation on thickness)

The thickness tolerance of the laminated glass/laminated safety glass shall not exceed the sum of the tolerances of the constituent glass panes, as specified in the appropriate product standard (see Annex A), and that of the interlayer.

### 6.2.1 Interlayer thickness tolerances

The thickness tolerance of the interlayer is dependent on the interlayer type (see Annex B).

Details of the tolerances are given in 6.2.2, 6.2.3 and 6.2.4.

Laminated glass containing different interlayer types is covered in 6.2.5.

### 6.2.2 Folio interlayers

Thickness tolerances (limit deviations) to be taken into account

| Nominal Interlayer Thickness | Limit Deviation |
|---|---|
| $< 2$ mm | $\pm$ 0.1 mm |
| $\geq 2$ mm | $\pm$ 0.2 mm |

**Table 1a:** Limits on deviation of folio interlayer(s)

### 6.2.3 Cast in place interlayer

Thickness tolerances (limit deviations) to be taken into account for cast in place interlayers are given in Table 1b.

| Nominal Interlayer Thickness | Limit Deviation |
|---|---|
| < 1 mm | ± 0.4 mm |
| ≥ 1 mm, < 2 mm | ± 0.5 mm |
| ≥ 2 mm, < 3 mm | ± 0.6 mm |
| ≥ 3 mm | ± 0.7 mm |

**Table 1b:** Limits on deviation of cast in place interlayer(s)

### 6.2.4 Fire resistant interlayer(s)

Thickness tolerances (limit deviations) to be taken into account for fire resistant interlayers are given in Table 1c..

| Nominal Interlayer Thickness | Limit Deviation |
|---|---|
| < 1 mm | ± 0.4 mm |
| ≥ 1 mm, < 2 mm | ± 0.5 mm |
| ≥ 2 mm, < 5 mm | ± 0.6 mm |
| ≥ 5 mm | ± 1.0 mm |

**Table 1c:** Limits on deviation of fire resistant interlayer(s)

### 6.2.5 Combinations of interlayer types

The thickness tolerances (limit deviation) to be taken into account for combination interlayers is the square root of the sum of the squares of the individual interlayer limit deviations, rounded to the nearest 0.1mm .

### 6.3 Calculated nominal thickness and thickness tolerances

These are given in the following examples:

**EXAMPLE 1:**

A laminated safety glass made from 2 panes of float glass of 3 mm nominal thickness and a folio interlayer of 0.38 mm.

From EN 572-2, the thickness tolerance on 3 mm float glass is ± 0.2 mm.

The folio interlayer is less than 2 mm so the tolerance is ± 0.1 mm.

Therefore, the nominal thickness of the laminated glass is 6.4 mm and the tolerance is ± 0.5 mm.

**EXAMPLE 2:**

A 5-ply laminated security glass is made from 3 panes of nominal 3 mm float glass and 2 x 1.14 mm folio interlayers.

From EN 572-2, the thickness tolerance on 3 mm float glass is ± 0.2 mm.

The total thickness of folio interlayer is 2 x 1.14 mm, i.e. 2.28 mm.

As this is > 2 mm then the tolerance on the interlayer is ± 0.2 mm.

Therefore, the nominal thickness of the laminated glass is 11.3 mm and the thickness tolerance is
[ 3 x ± 0.2 ] + [ ± 0.2 ] = ± 0.8 mm.

**EXAMPLE 3:**

A fire resistant laminated safety glass made from four sheets of float glass of nominal thickness 3 mm, a folio interlayer of 0.5 mm thickness and two fire resistant interlayers of 1.5 mm thickness.

Nominal thickness:

4 x 3 mm + 0.5 mm + 2 x 1.5 mm = 15.5 mm

Limit deviation:

$4 \times (\pm 0.2 \text{ mm}) \pm \sqrt{(0.1^2 \text{ mm} + 0.5^2 \text{ mm} + 0.5^2 \text{ mm})}$
$= \pm 0.8 \text{ mm} \pm 0.714 \text{ mm}$
$= \pm 1.5 \text{ mm}$

Therefore, the nominal thickness of the fire resistant laminated safety glass is 15.5 mm and the thickness tolerance (limit deviation) is ± 1.5 mm.

### 6.4 Measurement of actual thickness

The thickness of the pane shall be calculated as the mean of measurements taken at the centres of the four sides. The measurement shall be taken to an accuracy of 0.01 mm and the mean is rounded to the nearest 0.1 mm. The individual measurements when rounded to the nearest 0.1 mm shall also be within the tolerances.

For translucent laminated glass manufactured from a patterned glass the measurements shall be made by means of an instrument of the plate gauge type with a diameter of 55 mm + 5 mm.

## 7. Sizes and Dimensional Tolerances Including Displacement

### 7.1 Width B and length H

When laminated glass sizes are quoted for rectangular panes the first dimension shall be the width B and the second dimension the length H as shown in Figure 1.

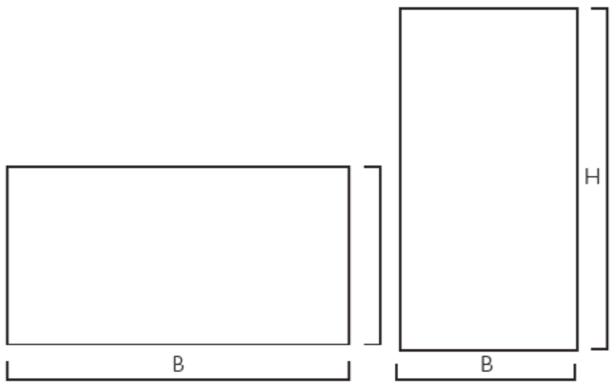


**Figure 1:** Examples of width, B, and length, H, relative to the pane shape

**NOTE: The maximum width and length of laminated glass are dependent on the constituent glass and interlayer(s) used in its composition and on the manufacturing plant of each individual manufacturer. Each manufacturer should indicate the maximum and minimum size they can produce.**

### 7.1.1 Methods of measuring dimensions and squareness

The pane of glass shall not be larger than the nominal dimensions, given in accordance with 7.1, either increased by the upper limit deviation t1 or smaller than the nominal dimensions reduced by the lower deviation limit t2 (see Figure 2).

The squareness of rectangular glass panes is expressed by the difference between its diagonals.

### 7.1.2 Limit deviations

Limit deviations on width B and length H shall be in accordance with Table 2 for finished sizes and stock sizes. Any displacement shall be included in these limit deviations.

NOTE: Displacement is covered in 7.1.3.

Dimensions in mm

| Nominal Dimension B or H | Nominal thickness ≤ 8 mm | Nominal thickness > 8 mm | |
|---|---|---|---|
| | | Each glass pane < 10 mm nominal thickness | At least one glass pane ≥ 10 mm nominal thickness |
| ≤ 2000 | + 3.0 - 2.0 | + 3.0 - 2.0 | + 5.0 - 3.5 |
| ≤ 3000 | + 4.5 - 2.5 | + 5.0 - 3.0 | + 3.0 - 2.0 |
| ≥ 3000 | + 5.0 - 3.0 | + 6.0 - 4.0 | + 7.0 - 5.0 |

**Table 2:** Limit deviations t on width B and length H

The limit deviations in Table 2 shall not be applied to fire resistant laminated glass and fire resistant laminated safety glass. In these cases, the manufacturer shall specify the limit deviations.

If one component of the laminated glass is a toughened or heat strengthened glass an additional tolerance of ± 3 mm shall be taken into account.

The difference between the two diagonal lengths of the pane of glass shall not be larger than the deviation limit, v, as specified in Table 3.

Dimensions in mm

| Nominal Dimension B or H | Nominal thickness ≤ 8 mm | Nominal thickness > 8 mm | |
|---|---|---|---|
| | | Each glass pane < 10 mm nominal thickness | At least one glass pane ≥ 10 mm nominal thickness |
| ≤ 2000 | 6 | 7 | 9 |
| ≤ 3000 | 8 | 9 | 11 |
| ≥ 3000 | 10 | 11 | 13 |

**Table 3:** Limit deviations, v, on the difference between diagonals

### 7.1.3 Displacement

Displacement d (see Figure 2) is the misalignment at any one edge of the constituent glass panes or plastic glazing sheet material making up the laminated glass.

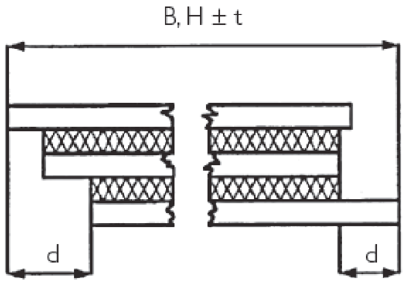


**Figure 2:** Displacement

The maximum displacement d shall be as given in Table 4. Width B and length H shall be considered separately.

| Nominal Dimension B or H | Maximum permissible Displacement d |
|---|---|
| B, H ≤ 1000 | 2.0 + 1[a)] |
| 1000 < B, H ≤ 2000 | 3.0 + 1[a)] |
| 2000 < B, H ≤ 4000 | 4.0 |
| B, H > 4000 | 6.0 |

**Table 4:** Maximum displacement

[a)] (additional tolerance for thermally toughened and heat strengthened glass)

## 8. Edgework

### 8.1 Laminated glasses incorporating thermally treated glass components

Thermally toughened safety glass and heat strengthened glass shall not be cut, sawn, drilled or edge worked before or after making into a laminate.

NOTE: Thermally treated glass components may be individually worked before toughening or heat strengthening in accordance with the applicable standard; e.g. EN 1863-1, EN 12150-1, EN 13024-1, and EN 14179-1, EN 14321-1, EN 15682-1.

**8.2 Cut edge**

Cut edges shall be either originally cut edges of the constituent glass panes not subsequently worked (see Figure 3), or the edges of the laminated glass which have been cut and not subsequently worked (see Figure 4).

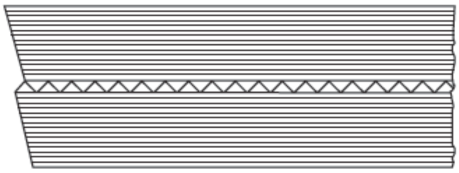

**Figure 3:** Cut edge built by cut edges of the constituent glass panes not subsequently worked

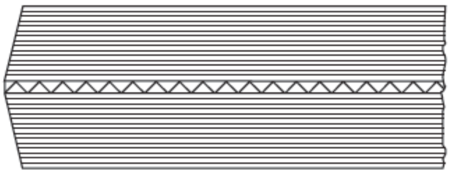

**Figure 4:** Cut edge of cut laminated glass, not subsequently worked

NOTE: The edges of fire resistant laminated glass and fire resistant laminated safety glass may be protected by an adhesive tape.

**8.3 Worked edge**

Details of the types of worked edges that are available are given in 8.3.1 to 8.3.7.

**8.3.1 Arrissed edge**

The originally cut edges of the outer glass panes of the laminated glass shall be ground off (see Figure 5).

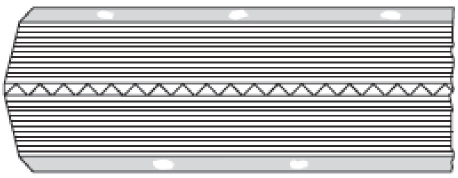

**Figure 5:** Arissed edge (with blank spots)

**8.3.2 Ground edge**

The glass shall be arrissed and flat ground (see Figure 6).

NOTE: Some bright areas may still exist on the edge face.

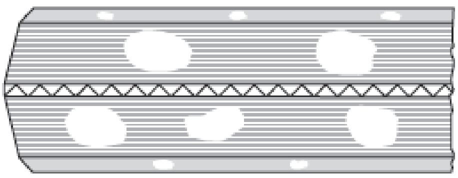

**Figure 6:** Ground edge (with bright areas)

**8.3.3 Smooth ground edge**

The edge face of the arrissed glass shall be ground and then smoothed with a finer grit than is used for ground edges, and all bright areas shall be removed (see Figure 7).

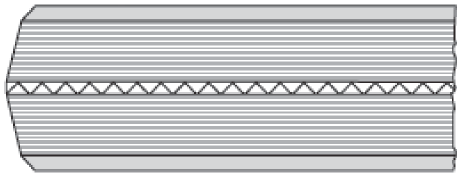

**Figure 7:** Smooth ground edge (no bright areas)

**8.3.4 Polished edge**

The previously smooth ground edge shall be polished in order to obtain a high lustre on the arrissed and smoothed edges surface (see Figure 8).

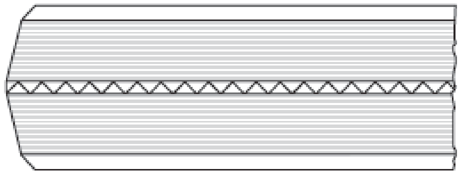

**Figure 8:** Polished edge (no bright areas)

**8.3.5 Bevelled edge**

A bevel edge shall be smooth ground or polished edge with an angle not exceeding 60 °. The limit deviation on bevel angle shall be ± 3 ° (see Figure 9).

NOTE: For greater angles and their limit deviations the manufacturer should be contacted.

The nominal dimension B or H shall be reduced by 2 mm to 3 mm to cater for an arrissed edge.

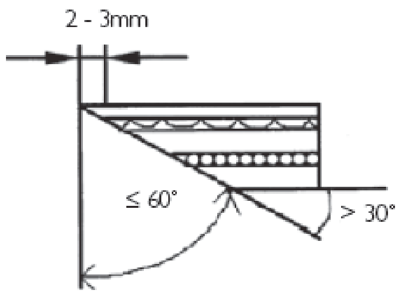


**Figure 9:** Bevel edge

**8.3.6 Sawn edge**

Sawn edge shall be obtained by cutting with a saw.

NOTE: The appearance is similar to ground edges but without bright spots and arrising.

**8.3.7 Water jet cut edge**

Water jet cut edge shall be obtained by cutting with a water jet.

NOTE: The appearance is similar to smooth ground edges but without bright spots and arrissing.

### 9. Flatness

The flatness of laminated glass is dependant on the flatness of the constituent parts and can be influenced by the manufacturing conditions.

For the flatness of final cut sizes of folio laminated glass ask the manufacturer.

### 10. Appearance

### 10.1 Optical

Flat laminated/laminated safety glass is manufactured by combining the glass panes with an interlayer. The optical quality is dependant upon the glass and interlayer type and the lamination process employed to manufacture the product.

#### 10.1.1 Folio interlayer/lamination

The final product has the optical quality of the component glass panes.

#### 10.1.2 Cast in place interlayer/lamination

The final product will not have the optical quality of the component glass panes. This is caused by the laminated/ laminated safety glass developing a concave or convex shape.

#### 10.1.3 Intumescent interlayer

The final product may have the same optical quality of the component glass panes.

### 10.2 Visual including edge bubbles

The visual quality/appearance of flat folio laminated glass is determined by means of a visual inspection test (see 10.2.4).

The presence of spot defects, linear defects and edge bubbles will be allowed depending on their size, frequency, position, size of the pane, make-up of the pane of laminated glass and whether or not they are obtrusive when the glass is inspected.

#### 10.2.1 Defects in vision area

#### 10.2.1.1 Spot defects

Spot defects which have been observed are noted and measured. They are assessed in relationship to their size, d, see Table 5.

| Size of Defect, d, mm | |
|---|---|
| d < 0.5 | ± 0.4 mm |
| 0.5 < d ≤ 1.0 | ± 0.5 mm |
| 1.0 < d ≤ 3.0 | ± 0.6 mm |
| d > 3.0 | ± 0.7 mm |

**Table 5:** Acceptance criteria for defects

| Laminated glass make-up | Distance between defects in mm |
|---|---|
| 3 ply | ≥ 200 |
| 5 ply | ≥ 180 |
| 7 ply | ≥ 150 |
| ≥ 9 ply | ≥ 100 |

**Table 6a:** Separation distances for accumulations not to occur

| Size of pane, A, m² | Number of permissible defects | | | |
|---|---|---|---|---|
| | 3 ply | 5 ply | 7 ply | ≥ 9 ply |
| A ≤ 1 | 1 | 2 | 3 | 4 |
| 1 < A ≤ 2 | 2 | 3 | 4 | 5 |
| 2 < A ≤ 8 | 1/m² | 1.5/m² | 2/m² | 2.5/m² |
| A > 8 | 1.2/m² | 1.8/m² | 2.4/m² | 3/m² |

**Table 6b:** Number of permissible defects

#### 10.2.1.2 Linear Defects

Linear defects that have been observed are assessed as given in Table 7.

| Size of pane, A, m² | Number of permissible linear defects of length, l, mm | |
|---|---|---|
| | l < 30 | l ≥ 30 |
| A < 5 | Allowed | Not allowed |
| 5 < A < 8 | Allowed | 1 |
| A > 8 | Allowed | 2 |

**Table 7:** Allowable linear defects

#### 10.2.2 Defects in edge area

#### 10.2.2.1 Framed edges

Defects that have been observed in the edge area are assessed as follows:

- Defects of diameter < 5 mm allowed
- Bubbles occupying < 5 % of edge area allowed

The edge area (see Figure 10) is defined with respect to the edge width as follows:

- Area of pane < 5 m² then edge width < 15 mm
- Area of pane > 5 m² then edge width < 20 mm

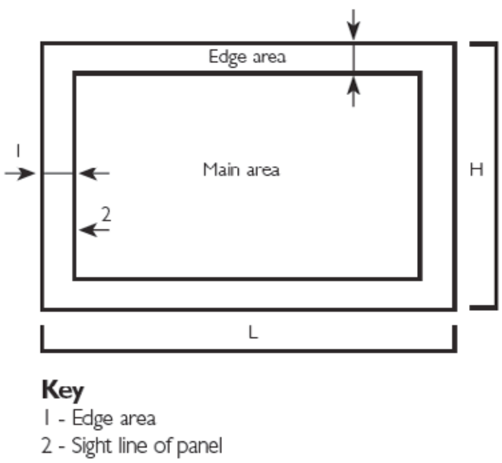


**Figure 10:** Edge area to be examined on finished sizes ready for glazing

#### 10.2.2.2 Defects in unframed edges

When used unframed the edge quality should be in compliance with clause 8.3.3, 8.3.4 or 8.3.5.

The following defects:

- Shells
- Bubbles
- Interlayer faults
- Interlayer retraction

are permissible if not obvious when subjected to the visual inspection (see 10.2.4).

For laminated glasses incorporating thermally treated glasses the following applies:

- Exposed edges
- Surface faults as a result of the thermal treatment process allowed if not visible when inspected as per 10.2.4
- Any bubbles around edges, cut outs, notches or drilled holes are allowed as long as they do not extend more than 15 mm from the 'edge'

#### 10.2.3 Interlayer defects

These are not allowed in the vision area if obvious.

#### 10.2.4 Inspection method

The laminated glass pane to be observed is placed vertically, in front of and parallel to a matt grey screen, lit by diffused daylight or equivalent.

The inspection shall not be undertaken in direct sunlight nor shall directional light sources, e.g. spotlights be used.

The observer stands 3 metres from the glass observing it perpendicularly (the matt screen being on the other side of the glass).

The observer marks all defects that are disturbing when viewed under this regime.

## 11. Marking

### 11.1 General

There are no requirements in EN 14449, i.e. the hEN, for the marking of laminated/laminated safety glass.

### 11.2 Safety glazing regulations

The laminated safety glass when installed MUST be clearly and indelibly marked with the marking visible after installation.

Details of critical locations, classification of product to be installed and marking are given in BS 6262-4.

Marking shall consist of the following:

- Manufacturer's name or trade mark;
- The standard number, i.e. EN 14449, and
- Classification according to EN 12600, i.e. 3(B)3, 2(B)2 or 1(B)1.

### 11.3 Fire regulations

The latest version of England & Wales Building Regulation Approved Document B recommends that all installed fire resistant glass be marked.

The marking must be clear and visible after installation to allow unambiguous identification.

## 12. Health and Safety

The cutting of laminated glass and laminated safety glass has to be undertaken safely.

The use of burning methylated spirits to warm the interlayer is considered unsafe and should be prohibited.

## ANNEX A

### Glass components

#### A.1 Basic soda lime silicate glasses

Soda lime silicate glasses products that are in accordance with EN 572 -9. They are as follows:

**A.1.1** Float glass EN 572-2

**A.1.2** Polished wired glass EN 572-3

**A.1.3** Drawn sheet glass EN 572-4

**A.1.4** Patterned glass EN 572-5

**A.1.5** Wired patterned glass EN 572-6

#### A.2 Special basic glasses

Special basic glass products that are in accordance with the following:

**A.2.1** Borosilicate glass EN 1748-1-2

**A.2.2** Glass ceramics EN 1748-2-2

**A.2.3** Alkaline earth silicate glass EN 14178-2

**A.2.4** Alumino silicate glass EN 15681-2

#### A.3 Thermally treated glasses

Thermally treated glass that is in accordance with the following:

**A.3.1** Heat strengthened soda lime silicate glass EN 1863-2

**A.3.2** Thermally toughened soda lime silicate safety glass EN 12150-2

**A.3.3** Heat soaked thermally toughened soda lime silicate safety glass EN 14179-2

**A.3.4** Thermally toughened borosilicate safety glass EN 13024-2

**A.3.5** Thermally toughened alkaline earth silicate safety glass EN 14321-2

**A.3.6** Heat soaked thermally toughened alkaline earth silicate safety glass EN 15682-2

#### A.4 Chemically strengthened glass

Chemically strengthened soda lime silicate glass that is in accordance with EN 12337-2

#### A.5 Acid etched, sandblasted glass

NOTE 1: Standards are being written for these products.

NOTE 2: The treated surface should not be in contact with the interlayer.

#### A.6 Coated glass

Coated glass products that are in accordance with EN 1096-4.

NOTE: Care should be taken if the coating is to be in contact with the interlayer. The coated glass manufacturer's advice should be sought.

## ANNEX B

### Interlayer types

#### B.1 Folio Interlayer(s)

**B.1.1** Polyvinyl butyral – pvb

**B.1.2** Polyethylene acetate – eva

**B.1.3** Polyurethane – pu

**B.1.4** Ionoplast

**B.1.5** Others

#### B.2 Cast in Place Interlayer(s)

**B.2.1** Polymethyl methacrylate – pmma

**B.2.2** Polyurethane – pu

**B.2.3** Epoxy

**B.2.4** Others

#### B.3 Intumescent Interlayer(s)

**B.3.1** Sodium Silicate

## Annex C

## Bibliography


### British Standards

**BS 6262-4:2005** Glazing for buildings - Part 4: Code of practice for safety related to human impact

### European Standards

**EN 356:2000** Glass in building.- Security glazing - Testing and classification of resistance against manual attack

**EN 410:1998** Glass in building - Determination of luminous and solar characteristics of glazing

**EN 572-2:2004** Glass in building - Basic soda lime silicate glass products - Part 2: Float glass

**EN 572-3** Glass in building - Basic soda lime silicate glass products - Part 3: Polished wired glass

**EN 572-4** Glass in building - Basic soda lime silicate glass products - Part 4: Drawn sheet glass

**EN 572-5** Glass in building - Basic soda lime silicate glass products - Part 5: Patterned glass

**EN 572-6** Glass in building - Basic soda lime silicate glass products - Part 6: Wired patterned glass

**EN 572-9** Glass in building - Basic soda lime silicate glass products - Part 9: Evaluation of conformity/Product standard

**EN 1063** Glass in building - Security glazing - Testing and classification of resistance against bullet attack

**EN 1096-4** Glass in building - Coated glass - Part 4: evaluation of conformity/product standard

**EN 1748-1-2** Glass in building - Special basic products - Borosilicate glasses - Part 1-2: Evaluation of conformity/Product standard

**EN 1748-2-2** Glass in building - Special basic products - Glass Ceramics - Part 2-2: Evaluation of conformity/Product standard

**EN 1863-2** Glass in buildings - Heat strengthened soda lime silicate glass - Part 2: Evaluation of conformity/Product standard

**EN 12150-2** Glass in building. - Thermally toughened soda lime silicate safety glass. Part 2: Evaluation of conformity/Product standard

**EN 12337-2** Glass in buildings - Chemically strengthened soda lime silicate glass - Part 2: Evaluation of conformity/Product standard

**EN 12600** Glass in building - Pendulum test - Impact test method and classification for flat glass

**EN 12758** Glass in building - Glazing and airborne sound insulation. Product descriptions and determination of properties

**EN 13024-2** Glass in buildings - Thermally toughened borosilicate safety glass - Part 2: Evaluation of conformity/ Product standard

**EN 13501-2** Fire classification of construction products and building elements - Part 2: Classification using data from fire resistance tests, excluding ventilation services

**EN 13541** Glass in building - Security glazing - Testing and classification of resistance against explosion pressure

**EN 14178-2** Glass in buildings - Basic alkaline earth silicate glass products - Part 2: Evaluation of conformity/Product standard

**EN 14179-2** Glass in buildings - Heat soaked thermally toughened soda lime silicate safety glass - Part 2: Evaluation of conformity/Product standard

**EN 14321-2** Glass in buildings - Thermally toughened alkaline earth silicate safety glass - Part 2: Evaluation of conformity/ Product standard

**EN 14449** Glass in buildings - Laminated glass and laminated safety glass - Evaluation of conformity/Product standard

**EN 15681-2** Glass in buildings - Basic alumino silicate glass products - Part 2: Evaluation of conformity/Product standard

**EN 15682-2** Glass in buildings - Heat soaked thermally toughened alkaline earth silicate safety glass - Part 2: Evaluation of conformity/Product standard

### International/European Standards

**EN ISO 12543-1** Glass in building - Laminated glass and laminated safety glass. - Part 1: Definitions and description of component parts

**EN ISO 12543-2** Glass in building - Laminated glass and laminated safety glass - Part 2: Laminated safety glass

**EN ISO 12543-3** Glass in building - Laminated glass and laminated safety glass - Part 3: Laminated glass

**EN ISO 12543-4** Glass in building. - Laminated glass and laminated safety glass - Part 4: Test methods for durability

**EN ISO 12543-5** Glass in building - Laminated glass and laminated safety glass - Part 5: Dimensions and edge finishing

**EN ISO 12543-6** Glass in building. - Laminated glass and laminated safety glass - Part 6: Appearance

### Building Regulations

England and Wales Building Regulations Approved Document B Fire Safety

### GGF Data Sheets

**GGF Data Sheet 4.4** Quality of Thermally Toughened Soda Lime Silicate Safety Glass for Building

**GGF Data Sheet 4.4.1** Thermally Treated Soda Lime Silicate Glass Products - General

**GGF Data Sheet 4.12.4** Curved Glass Part 4: Curved Laminated Glasses

**GGF Data Sheet 8.1.1** Security Glazing - Part 1: Definitions and Description

**GGF Data Sheet 8.1.2** Security Glazing - Part 2: Manual Attack Resistant Glazing

**GGF Data Sheet 8.1.3** Security Glazing - Part 3: Bullet Resistant Glazing

**GGF Data Sheet 8.1.4** Security Glazing - Part 4: Explosion Resistant Glazing

# GGF Data Sheet: Curved Glass Part 1: Generalities - Terminology, Properties and Basis of Measurement and Test

4.12.1 May 2016

**Contents**



## Foreword

GGF Data Sheet series 4.12 covers curved glass for building. It comprises the following parts:

Part 1: Generalities - Definitions, Terminology, Properties and Basis of Measurement and Test

Part 2: Curved Annealed Glass

Part 3: Curved Thermally Treated Glasses

Part 4: Curved Laminated Glasses

Part 5: Curved Insulating Glass Units

## 1. Scope

This part of GGF Data Sheet 4.12: Curved Glass defines curved glass and its types and gives:

- the terminology to be used to specify curved glass
- the procedures, measurement and test methods for the determination of dimensional parameters and visual and optical quality
- the range of available annealed glass types, thicknesses and thickness tolerances.

Data on maximum and minimum sizes and glass type/thickness availability is given in the product specific parts, i.e. GGF Data Sheets 4.12 Parts 2, 3, 4 and 5 (Annealed, Thermally Treated, Laminated and Insulating Glass Units respectively) as detailed in the Foreword.

Also included in these GGF Data Sheets are the allowable dimensional and quality limits.

## 2. Definitions

For the purpose of this GGF Data Sheet the following definitions apply.

### 2.1 Products

#### 2.1.1 Annealed glass

Glass that has been subjected to controlled cooling to reduce the presence of residual stresses in the glass thus allowing easy cutting. It is glass that includes float glass, patterned glass and wired glass.

#### 2.1.2 Coated glass

A glass which has an inorganic/organic coating applied either to a continuously moving ribbon of an annealed glass during its manufacture (on-line coating), or to individual pieces of annealed, laminated or thermally treated glass (off-line coating).

#### 2.1.3 Thermally treated glass (thermally toughened, heat strengthened, heat soaked thermally toughened)

This is made by subjecting annealed glass, with the exception of wired glass, to a temperature in excess of a specific temperature followed by a rapid controlled cooling, introducing a permanent stress distribution in the glass. This stress distribution gives the glass greatly increased resistance to mechanical and thermal stress.

#### 2.1.4 Laminated glass

Two or more panes with an interlayer between them. The interlayer(s) are permanently bonded to the glass panes.

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**2.1.5 Insulating Glass Units**

An assembly consisting of at least two panes of glass, separated by one or more spaces, hermetically sealed along the periphery, mechanically stable and durable.

**2.1.6 Curved glass**

A pane of annealed glass that is heated above a specific temperature and then given a deliberate shape either by sag bending or press bending.

**2.1.7 Curved annealed glass**

A curved glass that is allowed to cool down under controlled conditions after the bending process. As the glass has been reannealed during the process this type of curved glass can be cut.

**2.1.8 Curved thermally teated glass**

A curved glass that is subjected to rapid cooling after the bending process so as to produce a permanent in-built stress distribution.

**2.1.9 Curved laminated glass**

Two or more panes of curved annealed glass that are laminated together.

**2.1.10 Curved laminated thermally toughened glass**

Two or more panes of curved thermally treated glass that are laminated together.

**2.1.11 Curved coated glass**

A curved coated glass: either a coated glass whose coating is stable at the temperature of the bending process, or a curved glass that has been through an off-line coating process

NOTE: Care should be taken with the coated glass to ensure that the coating will not deteriorate during the process, i.e. whether the coating is on the concave or convex surface. Due to their design certain off-line coaters will only accept externally shallow curves.

**2.1.12 Curved insulating glass units**

An insulating glass unit manufactured from two or more panes of curved glass.

NOTE: The panes be of any type of curved glass, i.e. annealed, thermally treated, laminated, coated.

**2.2 Terminology (see Figure 1)**

**2.2.1 Angle**

The angular measurement of a segment of a curve.

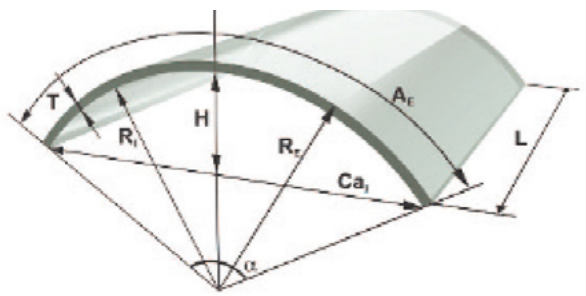


**Figure 1:** Angular measurement

**2.2.2 Arc**

The outside length of the curved portion of the bend.

NOTE: Generally described as either interior arc or exterior arc.

**2.2.3 Chord**

A straight-line segment that joins two points of an arc.

NOTE: Generally described as either interior chord or exterior chord.

**2.2.4 Concave**

The 'hollow' face of curved glass.

**2.2.5 Convex**

The 'bulge' face of curved glass.

**2.2.6 Cross-bed deviation (sag)**

Deviation from a straight edge along a line perpendicular to the curvature, measured on either the convex or concave side.

**2.2.7 Cold crack**

Cracks caused by a difference of temperature of the surface in the cooling process (e.g. around tong marks or ring marks) in a whisker-like or hair-line shape in case of curved toughened glass; and in a shell-shape appearance around crossing points of wires in the case of annealed curved wired glass.

**2.2.8 Curvature profile**

Geometrical shape of the curved part of the curved glass.

NOTE: This can be a variety of profiles, e.g. simple curve, double curve, or an S-bend. J-bend, V-bend, etc.

**2.2.9 Depth of bend**

The measurement from the width to the furthest point of the curve.

**2.2.10 Edge straightness (warp)**

The deviation from straightness of the straight edges of the glass, relative to a straight edge perpendicular to the edge.

NOTE: Includes minor changes to glass thickness due to stretching during forming/shaping.

**2.2.11 Flat**

The non-curved portion of a curved glass.

**2.2.12 Girth**

The distance around a concave or convex surface measured perpendicular to the rise including any flats.

**2.2.13 Gauge**

Measurement tool for checking the curvature profile of the finished product.

**2.2.14 Length**

Dimension of the straight edge of the curved glass.

**2.2.15 Pock marks**

Process surface blemishes that consist of small, shallow areas, circular in shape, on the surface of the glass.

### 2.2.16 Ring marks

Process surface blemishes that consist of shallow marks, typically running along the perimeter of the glass surface.

### 2.2.17 Rise

Segment between the middle of the arc of the circle and the middle of the chord that subtends the arc.

### 2.2.18 Shape accuracy

The accuracy of the contoured form including curvature, arc(s), and even flats.

### 2.2.19 Side straightness (flatness)

Deviation from straightness of the face of the glass along the length of the glass at the straight edges. Relative to a straight edge at 90 ° to the face.

### 2.2.20 Template

A device manufactured, at a scale of 1:1, to determine the shape of the product to be made.

### 2.2.21 Twist

Deviation of one or more of the corners of the glass from the same plane.

### 2.2.22 Width

The overall width of the product. This is not dependant on type of curve (see Figure 1).

## 3. Symbols

For the purpose of this GGF Data Sheet the symbols shown in Table 1 apply.

| | Definition | Comment |
|---|---|---|
| a° | Angle | Measured in degrees |
| A | Arc | Measured in mm |
| Ca | Chord | |
| E | Edge straightness (warp) | |
| H | Rise | |
| F | Cross bend deviation (sag) | |
| L | Length | |
| R | Radius | |
| S | Side straightness | |
| T | Thickness | |
| V | Twist | |
| I | Internal/inner | These subscripts can be used with CA (as per definition 2.2.3) and R |
| E | External/outer | |

**Table 1:** Symbols

## 4. Dimensional Characters

### 4.1 General

A curved glass is specified by the parameters given in Figure 1. All the parameters that have been given symbols in clause 3 can be checked as required; if applicable to the curve shape being manufactured. The checks that are required shall be defined for


Figure 2a Edge straightness (warp)


Figure 2b Edge straightness (warp)

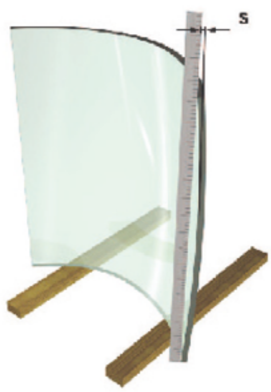


Figure 3a Side straightness

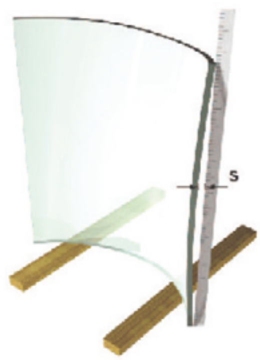


**Figure 3b** Side straightness

any particular curved glass. The tolerances are dependent on the method of manufacture and the final use of the product and should be agreed between the parties.

### 4.2 Measurement


Figure 4a Cross-bend deviation or sag


Figure 4b Cross-bend deviation or sag

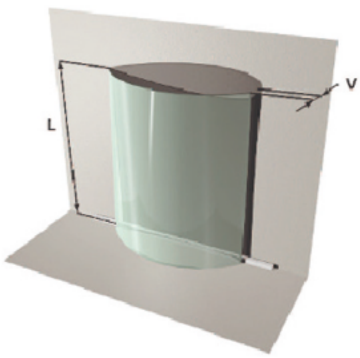


Figure 5 Twist

#### 4.2.1 General

Measurements of the shape and dimensional characteristics shall be undertaken in accordance with the specific methods given below.

#### 4.2.2 Shape, girth and height

The measurement of dimensions shall be either of the following methods, corresponding to the shape of the curved glass.

1. In the case of height dimension, measure the length of sides using a steel tape or straight edge of 1 mm scale intervals.
2. In the case of girth dimension and shape accuracy, measure on the convex surface with a steel tape measure of 1 mm scale interval.

#### 4.2.3 Edge straightness (warp)

Edge straightness (warp) is measured with the glass in a vertical position. A straight edge ruler is placed vertically along the length of the glass at a tangent to the glass edge. The gap (E) between the edge of the glass and the ruler is determined (see Figures 2a and 2b).

#### 4.2.4 Side straightness

Side straightness is measured with the glass in a vertical position. A straight edge steel ruler is placed vertically on the face of the glass, i.e. at 90 ° to the glass surface, at the edge of the glass pane. The gap (S) between the face of the glass and the ruler is determined (see Figures 3a and 3b).

#### 4.2.5 Cross-bend deviation (sag)

Cross- bend deviation is determined by placing a straight edge along the length of the glass, on the glass surface, perpendicular to the arc. Measure the gap (F) between the glass and the straight edge (see Figures 4a and 4b).

NOTE: The gap can be measured at any point on the arc.

#### 4.2.6 Twist (V)

Twist shall be measured on the 'vertical' of the curved glass standing on its curvature. The glass is positioned with the bottom corners in tight contact with the bead against the back surface. A top corner can be held against the surface, i.e. the one adjacent to the wall. The actual distance that the other corner is away from the surface is the twist value (see Figure 5).

### 4.3 Allowable deviations

These are given for the specific curved glass products in GGF Data Sheet Parts 2 to 5 respectively.

## 5. Available Glass Types, Thicknesses and Thickness Tolerances

Table 2 details the available annealed glass types, thicknesses and thickness tolerances for basic soda lime silicate glass products in accordance with the EN 572 series.

NOTE: Details for curved laminated glass is given in GGF Data Sheet 4.12.4 Curved Glass Part 4: Laminated Curved Glass.

## 6. Visual and Optical Quality

### 6.1 Optical quality

Any bending process will inevitably result in a product whose optical quality is lower than that of the glass from which it was produced.

Surface distortion occurs during the process and is seen particularly in reflection. This can appear exacerbated when the glass is body tinted, surface coated or enamelled (printed) and/ or incorporated into insulating glass units.

The likelihood of distortion is increased with curved laminated glass as there is more than one pane of glass involved. The laminating process itself may also introduce other distortions.

#### 6.1.1 Method of assessing optical quality

When assessing optical quality the pane should be observed under normal daylight conditions at a distance of 3 metres and the angle of observation should be normal (90 °) to the perpendicular part (or section) of the glass being assessed.

The focus of vision should be on an object not less than 1 metre behind the surface being assessed.

| Glass Type | Nominal thickness (mm) | Thickness tolerance (mm) |
|---|---|---|
| Float glass 1; Clear, tinted, white, coated[2] | 3 | ±0.2 |
| | 4 | ±0.2 |
| | 5 | ±0.2 |
| | 6 | ±0.2 |
| | 8 | ±0.3 |
| | 10 | ±0.3 |
| | 12 | ±0.3 |
| | 15 | ±0.5 |
| | 19 | ±1.0 |
| | 25 | ±1.0 |
| | | |
| Polished wired glass[3] | 6 | 6.0/7.4 |
| | | |
| Wired patterned glass[4] | 7 | ±0.6 |
| | 8 | ±0.8 |
| | | |
| Patterned glass[5] | 4 | ±0.5 |
| | 5 | ±0.5 |
| | 6 | ±0.5 |
| | 8 | ±0.8 |
| | 10 | ±1.0 |

Table 2

**Key**

1. In accordance with EN 572-2
2. In accordance with EN 1096-1
3. In accordance with EN 572-3
4. In accordance with EN 572-6
5. In accordance with EN 572-5

### 6.1.2 Acceptance Criteria

The degree of any distortion will depend on the process used to bend the glass and any subsequent processing e.g. laminating. The acceptability of optical distortion will depend on application for the product. The manufacturer/processor of the glass should be consulted to agree the acceptability of the product in relation to the achievable quality and application.

### 6.2 Visual quality

The visual quality is made up of body faults, i.e. those within the glass and surface faults, i.e. those on the surface of the glass. With laminated glass other faults that can affect the visual quality can result from the lamination process.

### 6.2.1 Body faults, e.g seeds, bubble, etc.

The number, size and distribution of seeds, bubbles, etc., are defined for different glass types used in the manufacture of curved glass and are detailed in GGF Data Sheets 4.12 Parts 2, 3, 4 and 5.

However, there will be no change in the body faults as a result of the high temperatures associated with the curving and/or thermal treatment processes.

### 6.2.2 Surface faults, e.g scars, scratches etc.

The number, size and distribution of scars, scratches, etc. are defined for the different glass types used to manufacture the curved glass and are detailed in GGF Data Sheets 4.12 Parts 2, 3, 4 and 5.

However, the presence and number of surface faults will be influenced by:

- any cutting, edgeworking, etc. undertaken prior to the glass bending process
- the glass bending process
- use of body tinted/coated glass, and
- screen printing/enamelling

### 6.2.3 Laminating faults, e.g. interlayer defects, entrapped air, etc.

Depending on the lamination process being used a number of faults can be introduced. These are covered in GGF Data Sheet 4.12 Curved Glass Part 4: Curved Laminated Glass.

### 6.2.4 Assessments of body faults

Assessment of body faults should be undertaken using the method/criteria given for the glass type (see GGF Data Sheets 4.12 Parts 2, 3, 4 and 5).

### 6.2.5 Assessment of surface faults

When assessing surface faults, the pane should be observed under normal daylight conditions at a distance of 3 metres and the angle of observation should be normal (90 °) to the particular part or section of the glass surface being assessed.

The pane should be vertical and may be glazed. A pane is deemed to be acceptable if surface faults, e.g. scars, scratches, etc., are not readily visible when viewed in transmission.

### 6.2.6 Assessment of lamination faults

When assessing lamination faults, the pane should be observed under normal daylight conditions at a distance of 3 metres and the angle of observation should be normal (90 °) to the particular part or section of glass surface being assessed.

The pane should be vertical and may be glazed.

Specific details for the assessment of laminated curved glass and applicable acceptance criteria are given in GGF Data Sheet 4.12 Curved Glass Part 4: Curved Laminated Glass.

## 7. Properties

### 7.1 Spectrophotometric

The light transmission and solar radiant heat properties of the glass are unaffected by the high temperature of the curving process.

NOTE: On-line coated curved toughened glass may show slight variations when compared to the annealed version. These can be noticeable on a building façade with a mix of both products, depending on the weather.

### 7.2 Acoustic

The curving process has no effect on the acoustic performance of the glass.

### 7.3 Mechanical strength

The strength of curved glass can be assumed to be the same as a flat pane of the same size, shape, glass type and thickness.

### 7.4 Resistance to accidental human impact

This will depend on the type of curved glass and is considered in GGF Data Sheets 4.12 Parts 2, 3, 4 and 5.

### Bibliography

**EN 572-1:** Glass in building – Basic soda lime silicate glass products – Part 1: Definition and general physical and mechanical properties

**EN 572-2:** Glass in building – Basic soda lime silicate glass products – Part 2: Float glass

**EN 572-3:** Glass in building – Basic soda lime silicate glass products – Part 3: Polished wired glass

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# GGF Data Sheet: Curved Glass Part 2: Curved Annealed Glass

4.12.2 May 2016

**Contents**



## Foreword

GGF Data Sheet series 4.12 covers curved glass for building. It comprises the following parts:

Part 1: Generalities – Definitions, Terminology, Properties and Basis of Measurement and Test

Part 2: Curved Annealed Glass

Part 3: Curved Thermally Treated Glasses

Part 4: Curved Laminated Glasses

Part 5: Curved Insulating Glass Units

## 1. Scope

This part of the GGF Curved Glass Data Sheet series deals with curved annealed glass, and details:

- glass types and thicknesses available
- maximum and minimum size availability
- acceptable tolerance for dimensional characteristics
- acceptance criteria for optical and visual quality

## 2. Definitions and Terminology

The definitions and terminology in GGF Data Sheet 4.12.1: Curved Glass Part 1: Generalities – Definitions, Terminology, Properties and Basis of Measurement and Test apply.

## 3. Availability

### 3.1 Glass types and thicknesses

The types and thicknesses of annealed glass, in accordance with EN 572-1, 2, 3, 4 and 6 and EN 1096-1, are given in Table 1.

Thickness tolerances are given in GGF Data Sheet 4.12.1: Table 2.

### 3.2 Maximum and minimum sizes

This will depend upon the type of bending equipment being used and the girth of the bend being produced. The following are generally accepted as the limits:

| Glass type | | Thickness (mm) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3 | 4 | 5 | 6 | 7 | 8 | 10 | 12 | 15 | 19 | 25 |
| Float | Clear | × | × | × | × | | × | × | × | × | × | × |
| | Tinted | | × | × | × | | × | × | × | | | |
| | White | × | × | × | × | | × | × | × | × | × | |
| | Surface coated | × | × | × | × | | × | × | × | | | |
| Patterned | Clear | | × | × | × | | × | × | × | | | |
| Wired | Polished | | | | × | | | | | | | |
| | Patterned | | | | | × | × | | | | | |

**Table 1:** Available thicknesses of annealed glass

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| Dimension, L or G, mm | Tolerance on length, L, and girth, G, for various nominal glass thickness, t (mm) | | | |
|---|---|---|---|---|
| | t ≤ 6 | 6 > t ≤ 10 | 12 & 15 | 19 & 25 |
| ≤ 1000 | ± 1 | ± 2 | ± 2 | ± 4 |
| > 1000 | ± 2 | ± 2 | ± 3 | ± 4 |

**Table 2:** Size tolerances for various nominal glass thickness

| Length of diagonal, mm | Allowable difference between diagonals, mm |
|---|---|
| ≤ 2000 | 4 |
| > 2000 | 5 |

**Table 3:** Squareness - Allowable differences in lengths of diagonals

Maximum dimensions

- Length of pane, L, up to 5500 mm
- Girth of pane, G, up to 2400 mm

Minimum dimensions

- No limitations

## 4. Dimensional Characteristics

### 4.1 Tolerances on length and girth

The tolerances on length, L, and girth, G, are dependent on nominal glass thickness rather than glass type. The generally accepted values are given in Table 2.

### 4.2 Squareness

The squaremess of a pane is determined by measuring and comparing diagonals. The allowable limits are given in Table 3.

### 4.3 Tolerances on shape

#### 4.3.1 Edge straightness (warp)

When determined in accordance with GGF Data Sheet 4.12.1; clause 4.2.3 the maximum tolerance on the gap (E) shall be ± 3 mm/m.

#### 4.3.2 Side straightness

When determined in accordance with GGF Data Sheet 4.12.1; clause 4.2.4 the maximum tolerance on the gap (S) shall be ± 3 mm/m.

#### 4.3.3 Cross bend deviation (sag)

When determined in accordance with GGF Data Sheet 4.12.1; clause 4.2.5 the maximum tolerance on the gap (F) shall be ± 3 mm/m.

#### 4.3.4 Twist (V)

When determined in accordance with GGF Data Sheet 4.12.1; clause 4.2.6 the maximum tolerance on the gap (V) shall be ± 3 mm/m.

## 5. Visual and Optical Quality

See GGF Data Sheet 4.12.1; clause 6.

## 6. Human Body Impact

### 6.1 General

The ability of glass to withstand accidental human body impact is determined using a pendulum impact test, i.e. EN 12600. Glass in building. Pendulum test. Impact test method and classification method for flat glass.

### 6.2 Annealed glass; excluding wired glass

Annealed glass in flat plates generally does not have a claimed impact performance classification. Therefore annealed curved glass will not be classsified for its impact performance.

### 6.3 Wired glass

Certain types of wired glass, i.e. safety wired, in flat plates can be classified in accordance with EN 12600. Therefore curved safety wired glass can be similarly classified; see BS 6262-4; clause 10.

## Bibliography


### European Standards

**EN 572-1** Glass in building – Basic soda lime silicate glass products – Part 1: Definition and general physical and mechanical properties

**EN 572-2** Glass in building – Basic soda lime silicate glass products – Part 2: Float glass

**EN 572-3** Glass in building – Basic soda lime silicate glass products – Part 3: Polished wired glass

**EN 572-5** Glass in building – Basic soda lime silicate glass products – Part 5: Patterned glass

**EN 572-6** Glass in building – Basic soda lime silicate glass products – Part 6: Wired patterned glass

**EN 1096-1** Glass in building – Coated glass – Part 1: Definitions and classification

**EN 12600** Glass in building – Pendulum test – Impact test method and classification for flat glass

### British Standards

**BS 6262-4** 2005 Glass for glazing – Part 4: Code of practice for safety related to human impact

### GGF Data Sheets

**GGF Data Sheet 4.12.1** Curved Glass Part 1: Generalities – Definitions, Terminology, Properties and Basis of Measurement and Test

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# GGF Data Sheet: Curved Glass Part 3: Curved Thermally Treated Glasses

4.12.3 May 2016

**Contents**



## Foreword

GGF Data Sheet series 4.12 covers curved glass for building. It comprises the following parts:

Part 1: Generalities – Definitions, Terminology, Properties and Basis of Measurement and Test

Part 2: Curved Annealed Glass

Part 3: Curved Thermally Treated Glasses

Part 4: Curved Laminated Glasses

Part 5: Curved Insulating Glass Units

## 1. Scope

This part of the GGF Curved Glass Data Sheet series deals with curved thermally treated glass and details:

- glass types and thicknesses available
- maximum and minimum size availability
- specific criteria relating to edgework, holes, etc.
- acceptable tolerance for dimensional characteristics
- acceptance criteria for optical and visual quality

## 2. Definitions and Terminology

The definitions and terminology in GGF Data Sheet 4.12.1 Curved Glass Part 1: Generalities – Definitions, Terminology, Properties and Basis of Measurement and Test apply together with the following:

### 2.1 Curved thermally toughened glass

A curved glass that as part of its manufacturing process undergoes a thermal toughening process so as to give the product defined mechanical and thermal strength and known fragmentation behaviour.

Refer to EN 12150-1: Glass in Building - Thermally toughened soda lime silicate safety glass - Part 1: Definition and description and GGF Data Sheet 4.4.1 Thermally Treated Soda Lime Silicate Glass Products.

### 2.2 Curved heat strengthened glass

A curved glass that as part of its manufacturing process undergoes a heat strengthening process so as to give the product defined mechanical and thermal strength and known fracture characteristics.

Refer to EN 1863-1: Glass in building – Heat strengthened soda lime silicate glass – Part 1: Definition and description and GGF Data Sheet 4.4.1 Thermally Treated Soda Lime Silicate Glass Products.

### 2.3 Curved heat soaked thermally toughened glass

A thermally toughened curved glass that as part of its manufacturing process undergoes a heat soaking process so as to give the product defined mechanical and thermal strength and known fragmentation characteristics but also has a known behaviour with respect to spontaneous breakage from critical nickel sulphide inclusions.

Refer to EN 14179-1: Glass in building – Heat soaked thermally toughened soda lime silicate safety glass – Part 1: Definition and description and GGF Data Sheet 4.4.2: Thermally Treated Soda Lime Silicate Glass Products: Spontaneous Breakage.

### 2.4 Vertically (tong) curved thermally treated glass

A curved glass that is manufactured by suspending from tongs during the curving and thermal treatment process.

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### 2.5 Horizontally (roller) curved thermally treated glass

A curved glass that is supported by rollers, i.e. nominally horizontal, during the heat process. The glass continues to be supported by the rollers during the bending and thermal treatment process.

NOTE: There are some furnaces where the glass is not supported by the rollers during the bending, where the glass is on a mould that is transported on a chain, or where the glass is supported on a ring mould.

### 2.6 Tong marks (hanging points in vertical forming)

Slight indentations slightly inboard of the top edge of vertically curved glass, resulting from the method of holding or supporting the glass with tongs.

### 2.7 Ring mould

A device that supports the glass at its periphery during the manufacturing process.

### 2.8 Roller wave distortion

Distortion produced in horizontal thermally treated glass as a result of the glass during the heating process being in contact with the rollers. This is a surface distortion produced by a reduction in surface flatness.

## 3. Availability

### 3.1 Glass types and thicknesses

The types and thicknesses of annealed glass, in accordance with EN 572-1, 2 and 5 and EN 1096-1, available that can be processed into curved thermally treated glass are given in Tables 1 and 2.

Thickness tolerances are given in GGF Data Sheet 4.12.1; clause 5; Table 2.

The following are generally accepted as the limits:

Maximum dimensions

- Length of pane, L, up to 4200 mm
- Girth of pane, G, up to 2440 mm

NOTE: There are furnaces on the market with larger specifications for L and G.

Minimum dimensions

- Length of pane, L, 325 mm
- Girth of pane, G, 220 mm

| Glass type | | Thickness, mm | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 3 | 4 | 5 | 6 | 8 | 10 | 12 | 15 | 19 |
| Float | Clear | × | × | × | × | × | × | × | × | × |
| | Tinted | | × | × | × | × | × | × | | |
| | White | × | × | × | × | × | × | × | × | × |
| | Surface coated | × | × | × | × | × | × | × | | |
| | Enamelled /Screen printed | × | × | × | × | × | × | × | × | × |
| Patterned | Clear | | × | × | × | × | × | | | |
| | Enamelled | | | × | × | × | × | | | |

**Table 1:** Available thicknesses of curved thermally toughened glass and curved heat soaked thermally toughened glass

| Glass type | | Thickness, mm | | | | |
|---|---|---|---|---|---|---|
| | | 3 | 4 | 6 | 8 | 10 |
| Float | Clear | × | × | × | × | × |
| | Tinted | | × | × | × | × |
| | White | × | × | × | × | × |
| | Surface coated | × | × | × | × | × |
| | Enamelled/ screen printed | × | × | × | × | × |

**Table 2:** Available thicknesses of curved heat strengthened glass

## 4. Edge Working

### 4.1 General

Any edge-working must be in accordance with the appropriate European standard, i.e. EN 1863-1 for heat strengthened, EN 12150-1 for thermally toughened, EN 14179-1 for heat soaked thermally toughened.

It is important that the edge remaining after mitre bevelling is not less than 2 mm or 1/3rd of the glass thickness, whichever is the larger.

Normally every glass, which is to be thermally treated, has to be edge-worked prior to thermal treatment. The simplest type of edge-working is the arrissed or linished edge (see Figure 1a). Other common types are shown in Figures 1b to 1d.

For specialist edge-work, such as water jet cutting, or 'as cut' edges, the manufacturers should be consulted.

### 4.2 Profiled edges

Various other edge profiles can be manufactured with different types of edge-work. The manufacturer should be consulted.

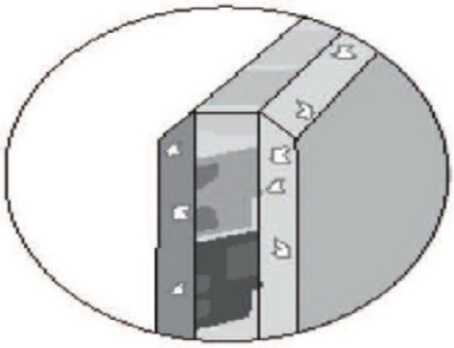

**Figure 1a:** Arrissed edge (with blank spots)

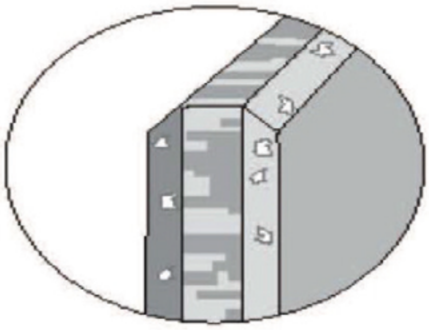

**Figure 1b:** Ground edge (with blank spots)

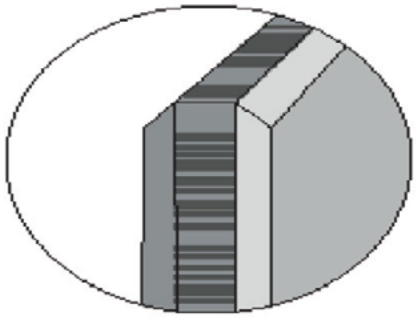

**Figure 1c:** Smooth ground edge (no blank spots)

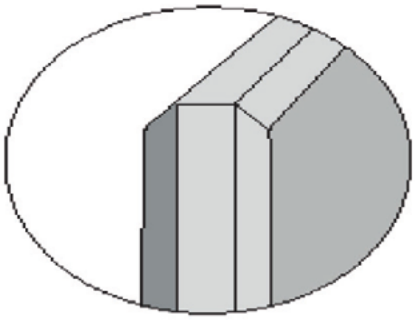

**Figure 1d:** Polished edge

## 5. Holes/Cut-outs

### 5.1 Warning

Thermally treated curved glass should not be cut, sawn, drilled or edge-worked after thermal treatment.

### 5.2 General

This section deals with the types, sizes and position of holes/cut-outs that can be incorporated within thermally treated curved glass of thickness of 4 mm and greater. Tolerances are given on hole/cut-out size and position. Comments are made on the quality of edge-work-associated holes/cut-outs.

Where there are more than four holes in a plate, the total area of all holes exceeds one sixth of the plate area or the glass is 3 mm, the manufacturer should be consulted.

### 5.3 Round holes

#### 5.3.1 General

This standard considers only round holes in glass that is not less than 4 mm nominal thickness. The manufacturer should be consulted about edge-working holes.

#### 5.3.2 Diameter of holes

The diameter of holes shall not, in general, be less than the nominal thickness of the glass. For smaller holes, the manufacturer should be consulted about edge-working holes.

#### 5.3.3 Limitations on position of holes

In general, the limitations on hole positions relative to the edges of the glass pane, the corners of the glass pane and to each other depends on:

- The nominal glass thickness (d)
- The dimensions of the pane (B, H)
- The diameter of the hole (ø)
- The shape of the pane
- The number of holes

The recommendations given below are those which are normally available and are limited to panes with a maximum of 4 holes.

1) The distance, a, of the edge of a hole to the glass edge should be not less than 2d.

2) The distance, b, between the edges of two holes should be not less than 2d.

3) The distance, c, of the edge of a hole to the corner of the glass should not be less than 6d.

NOTE: If one of the distances from the edge of the hole to the edge of the glass is less than 35 mm, it can be necessary to position the hole asymmetrically with respect to the corner. The manufacturers should be consulted.

| Nominal Hole Diameter ø, mm | Tolerances |
|---|---|
| ≥ 4, ≤ 20 | ± 1, 0 |
| > 20, ≤ 100 | ± 2, 0 |
| > 100 | Consult the manufacturer |

**Table 3:** Tolerances on hole diameters

### 5.3.4 Tolerances on hole diameters

The tolerances on hole diameters are given in Table 3. Dimensions in millimetres.

### 5.3.5 Tolerances on positions of holes

The tolerances on positions of holes are the same as the tolerances on the width, B, and the length, H (see Table 4). The positions of holes are measured in two directions at right angles (x- and y-axis) from a datum point (p) to the centre of the holes.

The datum point is generally chosen as a real or virtual corner of the pane (see Figure 2 for examples). The position of a hole (X,Y) is x t, y t, where x and y are the required dimensions and t is the tolerance from Table 2.

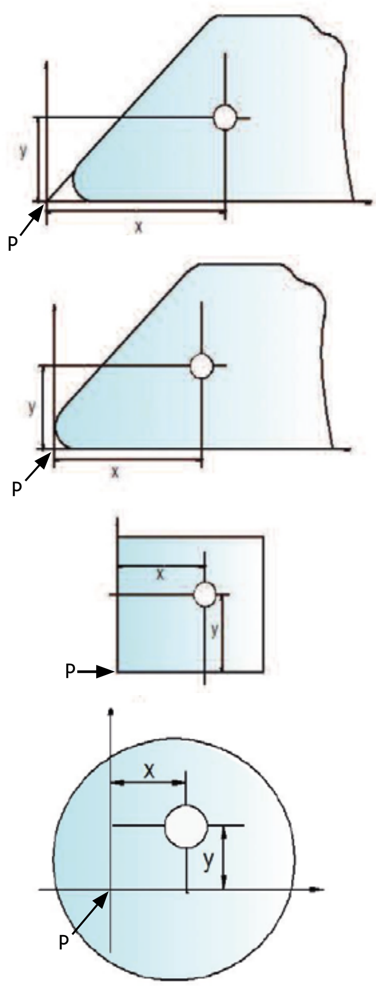


Figure 2

### 5.4 Notches and cut-outs

Many configurations of notches and cut-outs can be supplied. The manufacturers should be consulted about edge working of notches and cut-outs.

NOTE: Radius not less than 10 mm or glass thickness if greater.

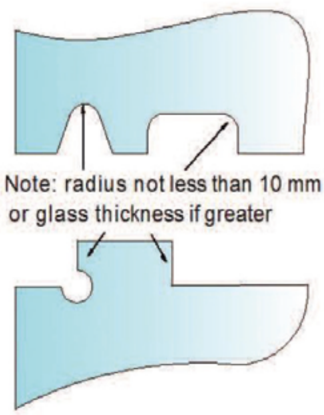


Figure 3

## 6. Dimensional Characteristics

### 6.1 General

The dimensional tolerances of curved thermally treated glass are dependent upon the actual dimensions of the curved glass, the type of curve and the equipment being used for the curving and thermal treatment process.

### 6.2 Thickness

Details of the available thicknesses of thermally toughened and heat soaked thermally toughened glass are given in Table 1 and heat strengthened glass in Table 2 respectively.

Information on thicknesses tolerances is given in GGF Data Sheet 4.12.1; Generalities - Definitions, Terminology, Properties and Basis of Measurement and Test apply –Table 2.

### 6.3 Tolerances on length and width

These are determined on the piece of glass before it has been subjected to the curving and thermal treatment processes.

Allowable tolerances are given in Table 4.

| Dimension of nominal width, B, or length, H | Tolerance | |
|---|---|---|
| | d ≤ 8 mm | d > 8 mm |
| ≥ 2000 | ± 2, 0 | ± 3, 0 |
| 2000 < B, H ≥ 3000 | ± 3, 0 | ± 4, 0 |
| > 3000 | ± 4, 0 | ± 5, 0 |

**Table 4:** Tolerances on width B and length H

### 6.4 Tolerances on shape

#### 6.4.1 Edge straightness (warp)

When determined in accordance with GGF Data Sheet 4.12.1; clause 4.2.3 the maximum tolerance on the gap (E) shall be ± 3 mm/m.

#### 6.4.2 Side straightness

When determined in accordance with GGF Data Sheet 4.12.1; clause 4.2.4 the maximum tolerance on the gap (S) shall be ± 3 mm/m.

#### 6.4.3 Cross bend deviation (sag)

When determined in accordance with GGF Data Sheet 4.12.1; clause 4.2.5 the maximum tolerance on the gap (F) shall be ± 3 mm/m.

#### 6.4.4 Twist (V)

When determined in accordance with GGF Data Sheet 4.12.1; clause 4.2.6 the maximum tolerance on the gap (V) shall be ± 3 mm/m.

## 7. Visual and Optical Quality

### 7.1 Optical quality

Any bending process will inevitably result in a product whose optical quality is lower than that of the glass from which it was produced.

Surface distortion occurs during the process and is seen particularly in reflection. This can appear exacerbated when the glass is body tinted, surface coated or enamelled (printed).

#### 7.1.1 Method of assessing optical quality

When assessing optical quality the pane should be observed under normal daylight conditions at a distance of 3 metres and the angle of observation should be normal (90 °) to the particular glass surface being assessed.

The focus of vision should be on an object not less than 1 metre behind the surface being assessed.

#### 7.1.2 Acceptance criteria

The pane will be deemed acceptable if there is no significant distortion of the image in transmission.

### 7.2 Visual quality

#### 7.2.1 Assessment of body faults

Assessment of body faults should be under taken using the method/criteria given, for the glass type. (EN 572-2 and EN 572-5)

#### 7.2.2 Assessment of surface faults

When assessing surface faults, the pane should be observed under normal daylight conditions at a distance of 3 metres and the angle of observation should be normal (90 °) to the particular glass surface being assessed. The pane should be vertical and may be glazed.

## 8. Human Body Impact

### 8.1 General

The ability of a thermally treated glass to withstand accidental human body impact is determined using a pendulum impact test, i.e. EN 12600. Glass in building – Pendulum test - Impact test method for flat glass and classification.

### 8.2 Curved thermally toughened and curved heat soaked thermally toughened glass

These glass types, if properly manufactured, will be capable of being classified by a pendulum impact test. However, these test methods are designed to be used with flat plate materials and not with curved plates. Therefore the performance will have to be determined by indirect methods.

NOTE: Further information can be found in BS ISO 11485-3: Glass in building – Curved glass – Part 3: Requirements for curved tempered and curved laminated safety glass.

### 8.3 Curved heat strengthened glass

Heat strengthened glass in flat plates does not obtain an impact performance classification. Therefore curved heat strengthened glass will not be classified for its impact performance.

## Bibliography

### European Standards

**EN 572-1** Glass in building – Basic soda lime silicate glass products – Part 1: Definition and physical and mechanical properties

**EN 572-2** Glass in building – Basic soda lime silicate glass products – Part 2: Float glass

**EN 572-5** Glass in building – Basic soda lime silicate glass products – Part 5: Patterned glass

**EN 1096-1** Glass in building – Coated glass – Part 1: Definitions and classification

**EN 1863-1** Heat strengthened soda lime silicate glass - Part 1: Definition and description

**EN 12150-1** Thermally toughened soda lime silicate safety glass - Part 1: Definition and description

**EN 12600** Glass in building – Pendulum test - Impact test method and classification for flat glass

**EN 14179-1** Heat soaked thermally toughened soda lime silicate safety glass - Part 1: Definition description for flat glass and classification

### British Standards

**BS ISO 11485-3** Glass in building – Curved glass – Part 3: Requirements for curved tempered and curved laminated safety glass

### GGF Data Sheets

**GGF Data Sheet 4.4.1** Thermally Treated Soda Lime Silicate Glass Products

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# GGF Data Sheet: Curved Glass Part 4: Curved Laminated Glasses

4.12.4 May 2016

**Contents**



## Foreword

GGF Data Sheet series 4.12 covers curved glass for building. It comprises the following parts:

Part 1: Generalities – Definitions, Terminology, Properties and Basis of Measurement and Test

Part 2: Curved Annealed Glass

Part 3: Curved Thermally Treated Glasses

Part 4: Curved Laminated Glasses

Part 5: Curved Insulating Glass Units

## 1. Scope

This part of the GGF Curved Glass Data Sheet deals with curved laminated glass and details:

- glass types and thicknesses available;
- maximum and minimum size availability
- acceptable tolerance for dimensional characteristics
- acceptance criteria for optical and visual quality

## 2. Definitions

The definitions in the GGF Data Sheet 4.12.1 Curved Glass Part 1: Generalities - Definitions, Terminology, Properties and Basis of Measurement and Test, and GGF Data Sheet 4.12.3 Curved Glass Part 3: Curved Thermally Treated Glasses apply, together with the following.

### 2.1 Curved laminated glass

A curved glass that is manufactured from two or more pieces of curved glass bonded together with one or more interlayer(s).

### 2.2 Curved laminated annealed glass

A curved glass manufactured from curved annealed glass (refer to ISO 11485-2: Glass in building - Curved Glass Part 2: Quality requirements and GGF Data Sheet 4.12.2 Curved Glass Part 2: Curved Annealed Glass).

### 2.3 Curved laminated thermally treated glass

A curved glass manufactured from curved thermally treated glass (refer to ISO 11485-3: Glass in building. - Curved glass part 3: Requirements for curved tempered and curved laminated safety glass and GGF Data Sheet 4.12.3 Curved Glass Part 3: Curved Thermally Treated Glasses).

### 2.4 Symmetrical curved laminated glass

A curved laminated glass where the glass types and thicknesses are the same.

### 2.5 Asymmetrical curved laminated glass

A curved laminated glass where the glass types thickness are not identical.

### 2.6 Interlayer

Layer or material acting as an adhesive and separator between plies of glass.

NOTE: It can also give additional performance to the finished product, e.g impact resistance, resistance to fire, solar control, acoustic insulation, etc. (See EN ISO 12543-1: Glass in building - Laminated glass and laminated safety glass - Part 1: Definition and description of component parts.)

## 3. Availability: Glass Types, Thicknesses and Thickness Tolerances

### 3.1 General

The possibility exists depending upon manufacturer, to produce numerous combinations of curved laminated glasses.

Information regarding the availability of the curved glass

Glass and Glazing Federation
**Glass and Glazing Federation**
**54 Ayres Street, London. SE1 1EU**
**Tel: 020 7939 9100 Fax: 0870 042 4266**
www.ggf.org.uk

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components can be found in the following,

- GGF Data Sheet 4.12.2 Curved Glass Part 2: Curved Annealed Glass, Section 4
- GGF Data Sheet 4.12.3 Curved Glass Part 3: Curved Thermally Treated Glasses, Section 4

### 3.2 Maximum and minimum sizes

This will depend upon the glass components and the laminating process capability.

The maximum manufactured size will be available from the curved laminated glass manufacturer.

## 4. Availability: Interlayer Types, Thicknesses and Thickness Tolerances

### 4.1 General

The two main lamination processes use either folio interlayers or cast in place resin interlayer (CIP).

NOTE: For further information see EN ISO 12543-1: Glass in building – Laminated glass and laminated safety glass – Part 1: Definition and description of component parts and GGF Data Sheet 4.11: Laminated Glass and Laminated Safety Glass.

### 4.2 Thickness and thickness tolerances

The type, thickness and number of interlayers will determine the overall thickness of the finished laminated glass.

NOTE: Information on interlayer thickness tolerances can be found in EN ISO 12543-5: Glass in building – Laminated glass and laminated safety glass – Part 5: Dimensions and edge finishing.

## 5. Dimensional Characteristics

### 5.1 General

The dimensional tolerances of curved laminated glass are dependent upon the actual dimensions of the component curved glass, the type of curve and the laminating process.

### 5.2 Tolerances on length and width

These are determined for the component pieces of curved glass before it has been subjected to the laminating process.

The process may result in misalignment of the individual glass plies. This is referred to as displacement. (see EN ISO 12543-5: Glass in building – Laminated glass and laminated safety glass – Part 5: Dimensions and edge finishing and GGF Data Sheet 4.11: Laminated Glass and Laminated Safety Glass).

### 5.3 Tolerances on shape

Information can be found in the appropriate GGF Data Sheets:

- GGF Data Sheet 4.12.2 Curved Glass Part 2: Curved Annealed Glass, Section 5.3
- GGF Data Sheet 4.12.3 Curved Glass Part 3: Curved Thermally Treated Glasses, Section 7.4

## 6. Visual and Optical Quality

### 6.1 General

Information on visual and optical quality of the component curved glasses can be found in the applicable GGF Data Sheets:

- GGF Data Sheet 4.12.2 Curved Glass Part 2: Curved Annealed Glass, Section 6
- GGF Data Sheet 4.12.3 Curved Glass Part 3: Curved Thermally Treated Glasses, Section 8

NOTE: Laminated glasses are covered by EN ISO 12543-6: Glass in building – Laminated glass and laminated safety glass – Part 6: Appearance. and GGF Data Sheet 4.11 Laminated Glass and Laminated Safety Glass, Section 10.

### 6.2 Visual/optical quality

Any laminating process will inevitably result in a product whose visual/optical quality is lower than that of the component glasses from which it was produced.

NOTE: It is unrealistic to generalise on visual/optical quality of curved laminated glass due to the numerous components and processes involved in the manufacture.

#### 6.2.1 Method of assessment

The pane shall be observed under normal daylight conditions at a distance of 3 metres and the angle of observation should be normal (90 °) to the particular glass surface being assessed.

The focus of vision shall be on an object not less than 1 metre behind the surface being assessed.

#### 6.2.2 Acceptance criteria

As a result of the number of variables the acceptance criteria must be agreed by the purchaser and manufacturer prior to manufacture.

## 7. Human Body Impact

The ability of a curved laminated glass to withstand accidental human body impact is determined using a pendulum impact test, i.e. EN 12600: Glass in building. Pendulum test. Impact test method and classification for flat glass.

NOTE: Further information can be found in BS ISO 11485-3: Glass in building – Curved glass – Part 3: Requirements for curved tempered and curved laminated safety glass.

## Bibliography


### European Standards

**EN 12600** Glass in building. Pendulum test. Impact test method and classification for flat glass

### European/International Standards

**EN ISO 12543-1** Glass in building. Laminated glass and laminated safety glass – Part 1: Definitions and description of component parts

**EN ISO 12543-5** Glass in building. Laminated glass and laminated safety glass – Part 5: Dimensions and edge finishing

**EN ISO 12543-6** Glass in building. Laminated glass and laminated safety glass – Part 6: Appearance International Standards

### International Standards

**ISO 11485-1** Glass in building. Curved glass. Terminology and definitions

**ISO 11485-2** Glass in building. Curved glass. Quality requirements

### British/International Standards

**BS ISO 11485-3** Glass in building. Curved glass. Requirements for curved tempered and curved laminated safety glass

### GGF Data Sheets

**GGF Data Sheet 4.11** Laminated Glass and Laminated Safety Glass

**GGF Data Sheet 4.12.1** Curved glass Part 1: Generalities – Definitions, Terminology, Properties, and Basis of Measurement and Test,

**GGF Data Sheet 4.12.2** Curved Glass Part 2: Curved Annealed Glass,

**GGF Data Sheet 4.12.3** Curved glass Part 3: Curved Thermally Treated Glasses,

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# GGF Data Sheet: Curved Glass Part 5: Curved Insulating Glass Units

4.12.5 May 2016

**Contents**



## Foreword

GGF Data Sheet series 4.12 covers curved glass for building. It comprises the following parts:

Part 1: Generalities – Definitions, Terminology, Properties and Basis of Measurement and Test

Part 2: Curved Annealed Glass

Part 3: Curved Thermally Treated Glasses

Part 4: Curved Laminated Glasses

Part 5: Curved Insulating Glass Units

## 1. Scope

This part of the GGF Curved Glass Data Sheet deals with curved insulating glass units (IGUs) and details:

- glass types and thicknesses available;
- maximum and minimum size availability
- acceptable tolerance for dimensional characteristics
- acceptance criteria for optical and visual quality

## 2. Definitions

The definitions in the GGF Data Sheet 4.12.1 Curved Glass Part 1: Generalities - Definitions, Terminology, Properties and Basis of Measurement and Test, and GGF Data Sheet 4.12.3 Curved Glass Part 4: Curved Thermally Laminated Glasses together with the following apply.

### 2.1 Curved insulating glass unit

An assembly consisting of at least two panes of curved glass, separated by one or more spacers, hermetically sealed along the periphery, mechanically stable and durable.

### 2.2 Curved annealed insulating glass unit

An IGU manufactured from curved annealed glass (refer to GGF Data Sheet 4.12.2 Curved Glass Part 2: Curved Annealed Glass).

### 2.3 Curved thermally treated insulating glass unit

An IGU manufactured from curved thermally treated glass (refer to GGF Data Sheet 4.12.3 Curved Glass Part 3: Curved Thermally Treated Glasses).

### 2.4 Curved laminated insulating glass unit

An IGU manufactured from curved laminated glass (refer to GGF Data Sheet 4.12.4 Curved Glass Part 4: Curved Laminated Glasses).

### 2.5 Symmetrical curved insulating glass unit

An IGU manufactured from curved glasses of the same type and thickness.

### 2.6 Asymmetrical curved insulting glass unit

An IGU manufactured from curved glasses of a different type and/or thickness.

### 2.7 Insulating glass unit components

For the purpose of this GGF Data Sheet, components are the other elements required to manufacture a curved IGU, e.g spacer(s), sealants, desiccant, gas etc.

## 3. Availability: Glass Types, Thicknesses and Thickness Tolerances

### 3.1 General

The possibility exists to produce curved IGUs incorporating a variety of glass and components.

Information regarding the availability of the curved glasses to be utilised can be found in the following:

- GGF Data Sheet 4.12.2 Curved Glass Part 2: Curved Annealed Glass, Section 4

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- GGF Data Sheet 4.12.3 Curved Glass Part 3: Curved Thermally Treated Glasses, Section 4
- GGF Data Sheet 4.12.4 Curved Glass Part 4: Curved Laminated Glasses, Section 4

### 3.2 Maximum and minimum sizes

This will depend upon the glass, components and the IGU manufacturing process.

The maximum manufactured size will be available from the curved IGU manufacturer.

### 3.3 Thickness and thickness tolerances

The type, thickness and number of glasses and components will determine the overall thickness of the finished curved IGU.

## 4. Dimensional Characteristics

### 4.1 General

The dimensional tolerances of curved IGUs are dependent upon the actual dimensions of the curved glasses and components used to manufacture the IGU.

### 4.2 Tolerances on shape

Information can be found in the appropriate GGF Data Sheets:

- GGF Data Sheet 4.12.2 Curved Glass Part 2: Curved Annealed Glass, Section 5.3
- GGF Data Sheet 4.12.3 Curved Glass Part 3: Curved Thermally Treated Glasses, Section 7.4
- GGF Data Sheet 4.12.4 Curved Glass Part 4: Curved Laminated Glasses, Section 5.3

## 5. Visual and Optical Quality

### 5.1 General

Information on visual and optical quality of the curved glasses used to manufacture the IGU can be found in the applicable GGF Data Sheets:

- GGF Data Sheet 4.12.2 Curved Glass Part 2: Curved Annealed Glass, Section 6
- GGF Data Sheet 4.12.3 Curved Glass Part 3: Curved Thermally Treated Glasses, Section 8
- GGF Data Sheet 4.12.4 Curved Glass Part 4: Curved Laminated Glasses, Section 6

### 5.2 Visual/optical quality

The manufacture of curved IGUs will inevitably result in a product whose visual/optical quality is lower than that of the glasses from which it was produced.

NOTE: It is unrealistic to generalize on visual/optical quality of curved IGUs due to the numerous glasses, components and processes involved in the manufacture.

### 5.2.1 Method of assessment

The pane shall be observed under normal daylight conditions at a distance of 3 metres and the angle of observation should be normal (90 °) to the particular glass surface being assessed.

The focus of vision shall be on an object not less than 1 metre behind the surface being assessed.

### 5.2.2 Acceptance criteria

As a result of the number of variables the acceptance criteria must be agreed by the purchaser and manufacturer prior to manufacture.

## 6. Human Body Impact

It is not possible to determine the ability of a curved IGU to withstand accidental human body impact using a pendulum impact test i.e. EN 12600: Glass in building. Pendulum test. Impact test method and classification for flat glass.

The performance, under accidental human body impact, of a curved IGU can only be determined by the performance of the individual glass leaves.

Information can be found in the appropriate GGF Data Sheets:

- GGF Data Sheet 4.12.2 Curved Glass Part 2: Curved annealed glass, Section 7
- GGF Data Sheet 4.12.3 Curved Glass Part 3: Curved thermally treated glasses, Section 9
- GGF Data Sheet 4.12.4 Curved Glass Part 4: Curved laminated glasses, Section 7

NOTE: Further information can be found in BS ISO 11485-3: Glass in building – Curved glass – Part 3: Requirements for curved tempered and curved laminated safety glass

## Bibliography


### European Standards

**EN 12600** Glass in building. Pendulum test. Impact test method and classification method for flat glass

### British International standards

**BS ISO 11485-3** Glass in building. Curved glass. Requirements for curved tempered and curved laminated safety glass

### GGF Data Sheets

**GGF Data Sheet 4.11** Laminated Glass and Laminated Safety Glass

**GGF Data Sheet 4.12.1** Curved glass Part 1: Generalities – Definitions, Terminology, Properties, and Basis of Measurement and Test

**GGF Data Sheet 4.12.2** Curved Glass Part 2: Curved Annealed Glass

**GGF Data Sheet 4.12.3** Curved Glass Part 3: Curved Thermally Treated Glasses

**GGF Data Sheet 4.12.4** Curved Glass Part 4: Curved Laminated Glasses

# GGF Emergency Glazing Group - Making safe procedures

5.1.1 August 2012

## Scope

This Data Sheet is not intended to be an exhaustive list of making safe methods, but is to be considered as 'best practice' guidance relating to making safe assemblies and is to be considered as the methods which have been sanctioned by the Federation's Emergency Glazing Group. The methods given are suitable for most vertical applications, and subsequent Data Sheets will give more comprehensive information of materials and fixing methods to be used on non-vertical applications.

## Definitions

### Making safe

Making safe with a structure consisting of either flat pieces of sawn timber or glass or rigid material (excluding chipboard, hardboard or materials which degrade due to dampness of water), specifically constructed to make safe with minimal damage to the building fabric and adequate for 24 hours to a glass area which is either damaged or broken.

### Primary Frame

The fixed frame which substantially contains the broken glazed element.

### Sub Frame

A frame usually of wood fixed on one side of the primary frame to assist in making the premises safe for 24 hours.

### Care of property

On completion, the site should be left in a clean and tidy condition with all broken glass to be removed from site unless specifically requested otherwise by the client. The Code of Good Practice of the Glass and Glazing Federation should be strictly observed particularly in respect of the protection of the property in which the installation is taking place.

## Classifications

There are a number of methods of making safe and the Glass and Glazing Federation list the acceptable major making safe methods which operatives and Members of the GGF Emergency Glazing Group will endeavour to use when called upon to do so.

All methods recommended herein will make the glass breakage and premises safe within the criteria laid down by the Group.

The order given below is unimportant.

1. Wooden boards fixed to temporary wooden sub-frames by means of screws/nails/clamps. Sub-frame to be wedged or fixed with minimum damage to existing building fabric. The minimum thickness of the wooden boards to be 8mm plywood or equivalent (excluding materials denoted above) and the minimum size of the sub-frame is to be 50mm x 50mm sawn softwood. In the case of annealed glass the whole of the glass panel must be boarded and not only the glass area damaged.

2. Wooden boards fixed to the laminated glass only by means of a fast setting adhesive. The boards can be fixed either to the inside or outside of the glass and must be a tight fit to the primary framing.

3. Laminated safety glass patches fixed to the existing damaged laminated glazed surface by means of fast setting adhesive thus allowing light into the premises with the exposed edges finished in accordance with BS 952: Part 2. It is important that the edge remaining after the treatment is not more than 2mm.

4. For application of self adhesive heavy duty safety film to the damaged surface area of the glass within the primary frame. Note: only acceptable for laminated glass.

5. Where practicable to cut out the damaged glass and reglaze with the right glass in the right place (Health, Safety and Welfare) Regulations 1992, Regulation 14, Document N of the Building Regulations and BS 6262 Part 4.

6. Wooden boards fixed within the rebate of the existing primary frame after the damaged glass has been safely removed. Any beads to be replaced temporarily but securely. Boards to be stiffened where required.

7. Wooden boards fixed in a sandwich construction – one board inside and one board outside securely bolted together with any nuts on the inside face.

8. Where a frameless toughened glass door has been destroyed, the opening is initially boarded up. A temporary wooden door in a subframe can then be fixed in a followup visit, should access be required.

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## Installation

When considering which method to be installed it will be paramount in the mind of the operator that no additional damage to the existing primary frame should be inflicted unless under exceptional circumstances where this should be kept to a minimum.

## Performances

We have already established that there are many methods of making safe and it cannot be over emphasised that the primary purpose of the method to be used is to make the premises safe with minimal damage to the building fabric and adequate for 24 hours.

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# GGF Data Sheet: Glass Repair
# Removal of surface damage from glass.

5.15.1 July 2015

**Contents**



## Introduction

The surface of glass can become damaged in a variety of ways. This Data Sheet is designed to advise and demonstrate that glass surfaces can be repaired as an effective alternative to replacement.

The main impact of this surface damage is on the appearance/ visual quality of the glass.

Appearance/visual quality is dependent on the following:

- Optical quality of the glass, i.e. inherent distortion ;
- Visual quality of the glass, i.e. number/size/type of defects
- Processing, handling, and glazing techniques.
- Polishing techniques and effectiveness

## 1. Scope

This Data Sheet details appropriate optical and quality factors of glass that influences its appearance following glass surface repair.

The major criterion is the view through the glass from the inside of a building.

NOTE: In the case of insulating glass units, this is covered in detail within GGF Data Sheet 4.10.

It is appreciated that the appearance from the outside of the building, can also be important in certain applications.

When surface damage is present, the visual properties of the glass will in most cases be affected.

This Data Sheet will detail what should be expected in terms of visual appearance, quality and performance characteristics, provided that the surface treatment has been completed in a competent manner.

NOTE: Although this Data Sheet refers to Soda Lime silicate glass, it may be possible to carry removal of surface damage from other types of glass. In this case, advice from the contractor and/or glass manufacturer should be sought.

NB: This Data Sheet, when referring to coated glasses, does not include liquid applied surface treatments.

## 2. Definitions

For the purpose of this Data Sheet the following definitions apply:

### 2.1 Appearance

The overall effect on the observer when looking at objects through the glass.

### 2.2 Optical quality

The distortion in the appearance of an object when observed through the glass.

### 2.3 Visual quality

The effect of faults, e.g. spots, scratches, abrasions etc., on the vision through the glass.

### 2.4 Surface damage

Any blemish on the glass surface which affects the visual and optical quality.

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**2.5 Scratches**

A mark or abrasion on a surface

**2.6 Graffiti**

Writing or drawings that have been scribbled, scratched or sprayed onto a glass surface

**2.7 Air Pollution**

Organic or inorganic materials or a combination of the two which may have an effect on the glass surface.

**2.8 Contamination**

Substances which make something dirty or polluted.

## 3. Normative references

EN 572-1: Glass in building – Basic soda lime silicate glass products - Part 1: Definition and general physical and mechanical properties

EN 572-2: Glass in building – Basic soda lime silicate glass products - Part 2: Float glass

EN 572-3: Glass in building – Basic soda lime silicate glass products - Part 3: Polished wired glass

EN 572-4: Glass in building – Basic soda lime silicate glass products - Part 4: Drawn sheet glass

EN 572-5: Glass in building – Basic soda lime silicate glass products - Part 5: Patterned glass

EN 572-6: Glass in building – Basic soda lime silicate glass products - Part 6: Patterned wired glass

EN 572-7: Glass in building – Basic soda lime silicate glass products - Part 7 Wired and unwired channel shaped glass

EN 572-8: Glass in building – Basic soda lime silicate glass products - Part 8: Supplied and final cut sizes

EN 1096-1: Glass in building – Coated glass – Part 1; Definitions and classification

EN 1863-1: Glass in building – Heat strengthened soda lime silicate glass – Part 1: Definition and description

BS EN 1279-1: Glass in building – Insulating Glass Units

EN 1863-1: Glass in building – Heat strengthened soda lime

EN 15683-1: Glass in building – Thermally toughened soda lime silicate channel shaped safety glass – Part 1: Definition and description

BS EN 12150-1: Glass in building – Thermally toughened soda lime silicate safety glass products - Part 1: Definition and description

BS EN ISO 12543-1: Glass in building – Laminated glass and laminated safety glass - Part 1: Definitions and description of component parts

BS EN ISO 12543-2: Glass in building – Laminated glass and laminated safety glass - Part 2: Laminated safety glass

BS EN ISO 12543-3: Glass in building – Laminated glass and laminated safety glass - Part 3: Laminated glass

BS EN ISO 12543-4: Glass in building – Laminated glass and laminated safety glass - Part 4: Test methods for durability

BS EN ISO 12543-5: Glass in building – Laminated glass and laminated safety glass - Part 5: Dimensions and edge finishing

BS EN ISO 12543-6: Glass in building – Laminated glass and laminated safety glass – Part 6: Appearance

## 4. Glass types

**4.1 General**

The glass manufacturer produces glass which complies with other standards as to their optical and visual quality.

During the manufacturing process, and in subsequent handling, there is a risk that further visual faults, e.g. scratches, scuffs, could be added to those already present.

The standards relating to the appropriate glass products will detail their optical and visual quality.

**4.2 Annealed glass**

Soda lime silicate glass in accordance with the EN 572 series i.e:

EN 572-2: Float glass

EN 572-3: Polished wired glass

EN 572-4: Drawn sheet glass

EN 572-5; Patterned glass

EN 572-6: Patterned wired glass

EN 572-7: Wired and unwired channel shaped glass

EN 572-8: Supplied and final cut sizes

**4.3 Thermally toughened, heat soaked thermally toughened heat strengthened or chemically strengthened glasses**

These are annealed soda lime silicate glasses that have been thermally or chemically treated to modify their strength and breakage characteristics. These products are in accordance with:

EN 1863 Heat strengthened soda lime silicate glass

EN 12150: Thermally toughened soda lime silicate safety glass products

EN 12337: Chemically strengthened soda lime silicate glass

EN 14179: Heat soaked thermally toughened soda lime silicate safety glass

EN 15683: Thermally toughened soda lime silicate channel shaped safety glass

**4.4 Laminated glasses**

These are annealed, toughened or heat strengthened glasses, in any combination, that have been combined with one or more interlayer(s) to produce a product with modified characteristics.

Laminated glass and/or laminated safety glass should conform to EN 14449. Specific information with respect to appearance can be found in EN ISO 12543-6.

**4.5 Coated glasses**

A glass substrate of any of the above, that either incorporates a coating within the glass surface or has had an inorganic coating applied to the surface.

Coated glasses shall conform to EN 1096

NOTE: Scratches cannot be successfully removed from any coated glass that has damage on the coated surface.

## 5. Optical Quality

### 5.1 General

The optical quality of glass is defined by the following:

- the method of manufacture of the glass; together with
- the effect of any subsequent processing.

NOTE: Optical quality through the glass will vary depending on the severity and extent of the scratch damage. A longer scratch may give a distorted view along its length which can appear increasingly worse at the ends.

## 6. Visual Quality

### 6.1 General

The visual quality of glass is defined by the following:

- the method of manufacture of the glass; together with
- the effect of any subsequent processing and handling.

### 6.2 Annealed glasses

The visual quality of basic soda lime silicate glass can be found in the appropriate product standards

### 6.3 Toughened or strengthened glasses

Cutting, edge working and toughening/strengthening could impart additional scratches/scuffs onto the glass surface.

These processing faults will affect the visual quality. The visual quality of toughened and strengthened soda lime silicate glass can be found in the appropriate product standards

### 6.4. Laminated glasses

Visual quality of the laminated glass may be worse than that of any component pane. Therefore the greater number of glass panes within a laminated glass the greater the likely number of defects (see BS EN ISO 12543 Part 6).

Further faults can be introduced during the laminating process due to faults in the interlayer, and entrapment of any contamination between the layers.

NOTE: These faults cannot be rectified.

Cutting, sawing and edge working can impart scratches etc.

### 6.5 Coated glasses

The visual quality is a composite of the visual quality of the glass substrate and the coating/coating process.

EN 1096-1 covers this topic.

NOTE: Scratches cannot be successfully removed from any glass that has damage on the coated surface.

Cutting, sawing and edge working can impart scratches etc.

## 7. Edge damage

It should be recognised that the ideal situation is a clean, as-cut edge on the glass. However, there is always the possibility of glass edges being produced to a lesser standard.

The glass industry has available documents that define the acceptable edge. They also define unacceptable edges e.g. shelled, vented etc.

The glass edge may be subjected to damage during handling, transportation or installation.

However the condition of the glass edge cannot be determined at the time of repair.

## 8. Surface Damage

### 8.1 Types of surface damage

Typical examples of surface damage that can be successfully removed by polishing:

- Graffiti
- Scratches
- Pollution deposits
- Chemical deposits
- Acid attack
- Grinder and weld spatter

NOTE 1: Graffiti may be etched into the surface or applied using paint or indelible ink which if removed incorrectly could damage the glass surface.

NOTE 2: Scratches can be caused by hard or sharp objects either accidentally or maliciously applied and may be a point of failure if left untreated and additional loads are imposed.

Successful polishing of surface damage on glass will be dependent on the severity and extent of the damage.

Light scratches, pollution and chemical deposits should be visually acceptable and free of distortion after polishing.

The deeper the damage e.g. graffiti, heavy scratch damage, grinder and weld spatter the risk of distortion after polishing is increased.

Glass that is extensively damaged can be successfully polished but in many cases the cost to treat could be similar to or more than the replacement cost. In this instance, a responsible contractor would advise you of the polishing costs before any work commences.

## 9. Surface polishing

### 9.1 Principles of polishing

By utilising specialised polishing equipment and skilled operatives polishing processes have been developed over many years to produce systems that can remove damage to glass and return the surface back to an acceptable standard.

The polishing process utilises an abrasive substance where two mediums are rubbed together by hand or machine to remove a layer of the glass surface (grinding). This process is then repeated with a softer material (lapping) to produce a polished surface.

The process of polishing involves the removal of a minimal amount of the glass surface in order to rectify the defect, without impairing the visual quality.

Polishing results can vary considerably with the type of technology used and more importantly the skill levels of the operator.

Equipment, whether it's DIY or commercial quality can cause serious damage to the surface of glass if used by an unskilled operator.

It is therefore recommended that all glass polishing be conducted by a GGF Glass Repair Group member

#### 9.2 Polishing Thermally Treated Glass

Providing polishing on thermally treated glass is carried out in a competent manner, the removal of surface damage should not have a detrimental effect on the failure characteristics of thermally treated glass.

NOTE 1: GGF (Glass Repair Group Members) have successfully demonstrated under controlled laboratory conditions that their polishing technology and processes do not have a detrimental effect on the failure characteristics of thermally toughened safety glass.

NOTE 2: In some cases the severity of the surface damage may make repair impractical; this would normally be advised during the initial survey.

In exceptional circumstances an unacceptable level of distortion may only become evident during or after treatment. In these instances, replacement would be advised

### 10. Appearance

Following the polishing process, the appearance criteria should be as described within;

- BS EN 572-Parts 2 to 7(for single glazing)
- BS EN 12150-1 thermally toughened soda lime silicate glass
- BS EN 14449 for laminated glass
- EN 1096-1 for coated glass
- GGF Data Sheet 4.10 for Insulating Glass Units (IGU)

### 11. Method of Assessment

#### 11.1 General

Damage may be caused by following trades after glazing, and this is not to be considered as a fault of the installer.

For this reason, viewing for scratches or other damage on the surface must be carried out as early as reasonably practicable following installation.

It is at this stage that the decision could be made whether to repair or replace any damaged glass.

#### 11.1.1 Area of Glass to be examined

The glass area to be viewed is the entire vision area with the exception of a 50mm wide band around the whole perimeter of the glass.

#### 11.1.2 Inspection

The glass shall be viewed at near normal incidence, i.e. at right angles, to the glass surface from the room side, standing at a distance of not less than 2 metres away from the glass surface for annealed float glass and 3 metres away for all other glass types e.g. laminated or toughened glass.

The assessment of visual quality of glass should be carried out in natural daylight but not in direct sunlight and with no visible moisture on the surface.

The use of strong lamps and/or magnifying devices is not allowed.

It is not permissible to find defects at close range and then mark them so as to be visible from the given viewing distance.

Obtrusiveness of faults shall be judged by looking through the glass, not at it.

### 12. Acceptance Criteria

Following the polishing process, there should be no additional visual disturbance to that of the original product.

NOTE: Due to the inherent properties of thermally treated glasses, some optical distortion created by the thermal treatment process should not be confused with that which may be caused by poor quality polishing

### 13. Bibliography

#### 13.1 GGF Data Sheets

Data Sheet 4.10. Products, Appearance and Visual quality for Insulating Glass Units

#### 13.2 GGF Leaflets

Glass Repair: Professional Advice on Repairing Damage on Glass Surfaces

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# Appearance and Visual Quality Specification for Fire-Resistant Glass and Insulating Glass Units (IGUs) Incorporating Fire-Resistant Glass

5.16.1 March 2016

## Contents



## Introduction

The Glass and Glazing Federation (GGF) publish a comprehensive guide the 'Best Practice Guide for the Specification and Use of Fire-Resistant Glazing' available as a download from www.ggf.org.uk. This publication covers all aspect of fire-resistant glazing and should be read in conjunction with this datasheet.

NOTE; This Best Practice Guide is referenced within Approved Document B, Building Regulations England and Wales

The appearance/visual quality of fire-resistant glass is dependent on the following:

- Optical quality of the glass pane, i.e. distortion inherent during the manufacture of the glass pane;
- Visual quality of the glass panes, i.e. number/size/type of defects;
- When incorporated in an IGU, the inherent characteristics of the component glass panes and the behaviour of a hermetically sealed body;
- Processing, handling, and glazing techniques.

NOTE: The primary purpose of fire-resistant glass is life safety and protection of property and therefore, in certain instances, visual quality may be compromised.

## 1. Scope

This Data Sheet details all appropriate optical and visual quality factors of fire-resistant glass, used either as single panes or incorporated into an IGU.

The major criteria is the view through the Fire-resistant glass. This is covered in detail within this Data Sheet.

## 2. Definitions

For the purpose of this Data Sheet the following definitions apply:

### 2.1. Appearance

The overall effect on the observer when looking at objects through the fire-resistant glass.

### 2.2. Optical quality

The appearance of an object when observed through the glass.

### 2.3. Visual quality

The effect of faults, e.g. spot, linear extended, etc., on the vision through the glass.

### 2.4. Transparent glass

Glass that transmits light and permits clear vision through it.

### 2.5. Textured and translucent glass

Glass that transmits light with varying degrees of light scattering so that vision is not clear, providing some privacy; or glass that has been sand blasted or acid etched, or laminated glass with a white or coloured interlayer making the glass translucent or opaque.

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**2.6 Fire-rated IGU**

An assembly consisting of at least two panes of glass, at least one of which is fire-resistant, separated by one or more spacers, hermetically sealed along the periphery, mechanically stable and durable.

**2.7. Condensation**

The presence of moisture and/or other liquid on a glass surface either inside or outside of the pane or the IGU.

- Interstitial

  Condensation that occurs within the hermetically sealed cavity of the IGU.

- Peripheral

  Condensation that occurs on the inside, i.e. room surface, of the Glass or IGU around the edge adjacent to the frame.

- Surface condensation

  Condensation that occurs on the surface of the glass.

## 3. Glass Types, Characteristics, Optical and Visual Qualities

### 3.1 General

Fire-resistant glass is manufactured in a number of ways depending on the fire-resistant performance required.

**3.1.1 Integrity only glass**

Glass that is required to provide a barrier to fire and the products of combustion only, are called integrity only glasses and are tested to enable classification based on the number of minutes the glass, when glazed in a specifically designed frame manufactured from specific materials, will prevent the passage of fire and the products of combustion. Integrity only glass does not provide any degree of protection from heat transfer, either as radiant or conducted heat. Integrity only glazing is recognised in the national Building Regulations or Building Standards. Integrity only fire-resistant glasses will be classified by the letter E followed by the number of minutes the glass will provide protection, e.g. E30, E60 etc. These glasses may be specially manufactured glass, processed glass or laminated fire-resistant glass.

**3.1.2 Integrity and radiant heat glass**

Some glasses that offer fire-resistant properties also reduce the level of radiant heat transfer through the glass but cannot be classified as an insulating glass as they do not offer insulation against conducted heat. Integrity fire-resistant glasses with a level of radiant heat insulation are classified by the letters EW followed by the number of minutes the glass will provide protection, e.g. EW30, EW60 etc.

NOTE: This classification of glass is not recognised in the UK's Building Regulations or Building Standards and are considered to be integrity only glasses in the UK.

**3.1.3 Integrity and insulation glass**

Glass that is required to provide insulation against radiant and conducted heat as well as integrity are classified as Integrity and insulation fire-resistant glass. This classification of glass is recognised in the UK Building Regulations and Building Standards and are required in certain locations where it is necessary to provide protection to people and objects from the effects of radiant and conducted heat. Integrity and Insulation fire-resistant glasses will be classified by the letters EI followed by the number of minutes the glass will provide protection, e.g. EI30, EI60 etc. These glasses will be manufactured as laminated products only.

### 3.2. Other properties

**3.2.1 Safety in relation to human impact**

A majority of fire-resistant glasses will also be classified for safety in relation to human impact following testing to BS EN 12600, Glass in Building. Pendulum Test. Impact Test Method and Classification for Flat Glass.

**3.2.2 Containment**

Where a change in floor levels either side of a glass partition is greater than 380mm in buildings other than dwellings and greater than 600mm in dwellings, the glazing is required to provide containment. For thermally toughened soda lime silicate glass refer to BS 6180 for minimum performance and thickness requirements. For fire-resistant laminated glass refer to manufacturers data. Further information on containment may be found in GGF Datasheet 7.2, Guidelines for the Use of Glass in Protective Barriers.

**3.2.3 Sound attenuation**

Fire-resistant glasses can be configured to provide various levels of sound attenuation, refer to manufacturers data.

**3.2.4 Thermal efficiency**

Fire-resistant glasses may also be used in conjunction with coated glasses in IGUs to provide a higher level of energy efficiency. This may be particularly important in domestic entrance doors in flats and some curtain walling systems.

**3.2.5 Solar control**

Fire-resistant glass may need to provide a degree of solar control. This may be achieved by incorporating a solar control glass in a laminated fire-resistant glass or by incorporating a solar control glass pane within an IGU.

### 3.3 Fire-resistant glass Optical Quality

**3.3.1 Optical quality**

The optical quality of fire-resistant glass is dependent on the optical quality of the basic glass(es) and components such as interlayers, resins etc. used in its manufacture. The optical quality of the fire-resistant glass is dependent on:

- The manufacture of the base glass component and:
- The effect of subsequent processing such as thermal toughening, laminating etc.

The optical quality of transparent fire-resistant glass is dependent on the method of manufacture, Polished wired glass can be visually as good as float glass but the presence of the wire mesh will affect the optical appearance and it has its own optical quality detailed within the European Standard BS EN 572-3:2012 – Glass in Building. Basic Soda Lime Silicate Glass Products. Polished Wired Glass.

Translucent fire-resistant glass, i.e. cast, patterned and patterned wired, are all textured glasses with varying degrees of light scattering disruption. These glasses do not have a specific optical quality as they are designed to disrupt vision through them.

**3.3.2 Thermally toughened and heat soaked thermally toughened glass**

The process of thermally thoughening glass may adversely affect the optical quality of the original float or drawn sheet glass used to produce the fire-resistant glass.

The heating and subsequent cooling of the glass during the thermal toughening process may result in the following imperfections that will reduce the optical quality of the fire-resistant glass:

- Bow, overall and/or local
- Roller wave distortion
- Edge lift/dip

For details of allowable bow, roller wave and edge lift/dip and how they are measured, refer to GGF Datasheet 4.4 – GGF datasheet for the quality of thermally toughened soda lime silicate safety glass for building.

**3.3.3 Fire-resistant laminated glasses**

The optical properties of fire-resistant laminated glass are dependent on the number of laminates of both glass and interlayers, used to manufacture the fire-resistant laminated glass. Unlike standard laminated glass, fire-resistant laminated glass may use a number of different types of interlayer including PVB, resins, gels etc. and these interlayers may have a detrimental effect on the optical qualities of the laminate. The primary functions of fire-resistant laminated glass is to provide protection from fire and to allow light through and therefore any reduction in optical quality must be accepted as a consequential effect.

**3.3.4 Coated fire-resistant glasses**

Fire-resistant glasses may be required to provide other functions such as reducing heat loss from a building, solar control, reduced maintenance etc., this being provided by various coatings being applied to one or more surfaces of the glass or its constituent parts. Any coatings applied to the glass will have an effect on the optical quality of the glass and this must be considered when assessing.

**3.4 Fire-resistant glass visual quality**

As with optical quality, the visual quality of fire-resistant glass is dependent on the optical quality of the glass components and the effect(s) of the processing into fire-resistant glass.

**3.4.1 Thermally toughened and heat-soaked thermally toughened fire-resistant glasses**

The visual quality of thermally toughened and heat-soaked thermally toughened glass may be assessed using similar criteria to standard thermally toughened glass, refer to GGF datasheet 4.4 – GGF datasheet for the quality of thermally toughened soda lime silicate safety glass for building

**3.4.2 Other monolithic fire-resistant glasses**

For visual quality standards for other monolithic glasses refer to the relevant European Standard as follows:

BS EN 1748-2-1:2014 – Glass in building. Special Basic products. Glass Ceramics. Definitions and General Physical and Mechanical Properties.

BS EN 13024-1:2011 Glass in Building. Thermally Toughened Borosilicate Safety Glass. Definition and Description

BS EN 14321-1:2005 Glass in Building. Thermally Toughened Alkaline Earth Silicate Safety Glass. Definition and Description.

**3.4.3 Laminated fire-resistant glasses**

Appearance of laminated fire-resistant glasses is based on the criteria detailed in BS EN ISO 12543-6:2011 – Glass in Building-Laminated Glass and Laminated Safety Glass Part 6 Appearance.

Further reference to fire-resistant laminated glasses may be found in BS EN 14449:2005 – Glass in Building. Laminated Glass and Laminated Safety Glass. Evaluation of Conformity/Product Standard.

Additional guidance may also be found in GGF datasheet 4.11 – Laminated glass and laminated safety glass.

Due to the type and thickness of interlayers used to produce the fire-resistant properties of laminated fire-resistant glasses, the effects on visual quality may be greater than those described in the Standards and Datasheets referenced above.

**3.4.4 Coated fire-resistant glasses**

Fire-resistant glasses may be required to provide other functions such as reducing heat loss from a building, solar control, reduced maintenance etc., this being provided by various coatings being applied to one or more surfaces of the glass or its constituent parts. Any coatings applied to the glass may have an effect on the visual quality of the glass and this must also be considered when assessing the coated fire-resistant glass against the basic glass product standards.

These additional requirements are given in BS EN 1096-1:2012 - Glass in Buildings – Coated Glass – Definitions and Classification.

**3.4.5 IGU incorporating fire-resistant glass**

Reference should be made to GGF datasheet 4.10 – Products, appearance and visual quality specification for Insulating Glass Units as well as the optical and visual qualities of fire-resistant glasses as described above.

**3.5 Appearance of fire-resistant glass and IGUs incorporating fire-resistant glass**

**3.5.1 General**

Appearance relates to the limitations that are placed upon the fire-resistant glass manufacturer and the insulating glass unit manufacturer. These limitations are as a result of the following:

- Incoming glass components,
- Processing the glass is subject to.
- Type and specification of interlayers.
- Specification of the fire-resistant glass,
- Specification of the insulating glass unit
- Inherent proper ties of the insulating glass unit,

- Framing and glazing systems.

The perceived appearance of installed single fire-resistant glass or IGUs incorporating fire-resistant glass can be adversely affected by distortions induced by the framing system and the installation.

**3.5.2 Normal incidence**

The fire-resistant glass or IGU should be viewed at normal incidence, i.e. at 90º to the glass surface.

For transparent fire-resistant glass or IGUs containing transparent glass components the appearance relates to the vision through.

For translucent or textured fire-resistant glazing or IGUs containing textured or translucent glass components the appearance relates to the visual quality of the textured or translucent glass component.

**3.5.3 Oblique incidence**

Effects such as multiple images, distortion, haze, etc. may be observed in fire-resistant glass or IGU's containing fire-resistant glass when viewed at oblique angles of incidence.

**3.5.4 Reflection**

Not generally considered. See Annexes A and B for further information.

**4. Method of assessment**

**4.1 General**

The standards for fire-resistant glass panes and the component glass panes of an IGU detail the method of observation and the distance and criteria for acceptance.

However for a fire-resistant IGU no such recommendations are given in the applicable European Standard, i.e. BS EN 1279-1. As there is no standardised method of assessment this datasheet lays down an appropriate methodology.

NOTE: Damage caused by faulty installation of the fire-resistant glass or following trades after glazing will not be considered as a glass fault.

For example damage can be caused by impact, scratching, deposit of plaster, cement, etc., weld spatter and spatter from cutting tools.

For this reason, viewing fire-resistant glass for scratches or other damage on the faces of the panes must be carried out before any following trades' works adjacent to the glazing, and as early as reasonably practicable following installation of the fire-resistant glass.

**4.2 Area of fire-resistant glass to be examined**

**4.2.1 Single pane glass (monolithic or laminated)**

The glass area to be viewed is the total visible area of glass.

**4.2.2 IGUs containing fire-resistant glass**

The glass area to be viewed is the entire vision area with the exception of a 50mm wide band around the whole perimeter of each of the glass panes.

This edge zone, in terms of size, is similar to that given for the determination of coated glass in final cut sizes.

(See BS EN 1096-1).

See Figure 1.

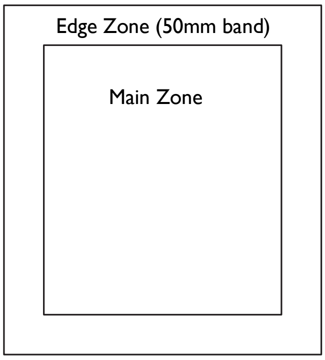


**Figure 1**

**4.3 Inspection**

The glazing shall be viewed at near normal incidence, i.e. at right angles, to the glass surface from the room side, standing at a distance of not less than 3 metres away for all glass types.

The assessment of visual quality of the panes of glass should be carried out in natural daylight but not in direct sunlight and with no visible moisture on the surface of the glass. The use of strong lamps and/or magnifying devices is not allowed.

It is not permissible to find defects at close range and then mark them so as to be visible from the given viewing distance.

Obtrusiveness of faults shall be judged by looking through the glass, not at it.

NOTE 1: This does not apply to textured or translucent glasses.

NOTE 2: Triple glazed IGUs have special characteristics that may affect the visual quality. See GGF Datasheet 4.10.

**4.4 Acceptance criteria**

Acceptance criteria relate strictly to the inherent characteristics of the fire-resistant glasses.

- totally enclosed seeds,
- bubbles or blisters;
- hairlines or blobs;
- minute embedded particles;
- inherent faults and fine scratches on coated glasses.

Fire rated IGUs with optical defects such as smears, finger prints or other dirt on the cavity faces of the glass or extraneous material inside the cavity are unacceptable, and this applies also to any such defects within the 50mm edge zone if they are visibly disturbing..

Fire-resistant insulating glass units shall not be deemed unacceptable for any phenomena relating to the inherent characteristics of an IGU with the exception of 'Newton's Rings' (see GGF Datasheet 4.10)

When viewed in accordance with Section 3.4 above, the fire-resistant glass will be deemed acceptable as long as, where appropriate, the criteria below is followed:

- there are no defects noticed that are visually disturbing other than those referred to in section 3
- any defects that are noted comply with the visual quality, (see section 3), for the glass type
- any visual disturbance, e.g. from roller wave, bow, etc., is within the tolerances given in the appropriate product standard
- coated glass quality, e.g. pinholes, colour variation, etc. comply with the appropriate product standard
- there is no distortion as a result of the framing system or the installation.

NOTE: Due to the complex production process of fire-resistant glasses it should be borne in mind that when inspecting the glass, that the primary functions of fire-resistant glass is to provide life-safety and property protection and therefore in certain instances visual quality may be compromised.

### Bibliography Check

#### European and/or national standards

BS 952-1: Glass for Glazing – Part 1. Classification

BS EN 572-1: Glass in Building – Basic Soda Lime Silicate Glass Products - Part 1: Definition and General Physical and Mechanical Proper Ties

BS EN 572-2: Glass in Building – Basic Soda Lime Silicate Glass Products - Part 2: Float Glass

BS EN 572-3: Glass In Building – Basic Soda Lime Silicate Glass Products - Part 3: Polished Wired Glass

BS EN 572-4: Glass in Building – Basic Soda Lime Silicate Glass Products - Part 4: Drawn Sheet Glass

BS EN 572-5: Glass in Building – Basic Soda Lime Silicate Glass Products - Part 5: Patterned Glass

BS EN 572-6: Glass in Building – Basic Soda Lime Silicate Glass Products - Part 6: Patterned Wired Glass Bs En 572-8: Glass in Building – Basic Soda Lime Silicate Glass Products - Part 8: Supplied and Final Cut Sizes

BS EN 572-8: Glass in Building - Basic Soda Lime Silicate Glass Products – Part 8: Supplied and Final Cut Sizes

BS EN 1096-1: Glass in Building – Coated Glass Products - Part 1: Description and Definitions

BS EN 1096-2 Glass in Building – Coated Glass Products -

Part 2:Test Method for the Durability of Class A, B and S Coatings

BS EN 1096-3: Glass in Building – Coated Glass Products - Part 3:Test Method for the Durability of Class C and D Coatings

BS EN 1279-1: Glass in Building – Insulating Glass Units -

Part1: Generalities, Dimensional Tolerances and Rules for the System Description

BS EN 1748-1-1: Glass in Building – Special Basic Product – Borosilicate Glasses - Part 1-1: Definition and General Physical and Mechanical Properties

BS EN 1748-2-1: Glass in Building Special Basic Product – Glass Ceramics Part 2-1: - Definition and General Physical and Mechanical Proper Ties

BS EN 1863-1: Glass in Building – Heat Strengthened Soda Lime Silicate Glass Products - Part 1: Description and Definitions

BS EN 12150-1: Glass in Building – Thermally Toughened Soda Lime Silicate Safety Glass Products - Part 1: Description and Definitions

BS EN 12337-1: Glass in Building – Chemically Strengthened Soda Lime Silicate Glass – Part 1: Description and Definitions

BS EN 13024-1: Glass in Building – Thermally Toughened Borosilicate Safety Glass – Part 1: Description and Definitions

BS EN 14178–1: Glass in Building – Alkaline Earth Silicate Glass Products – Part 1: Float Glass

BS EN 14179-1: Glass in Building – Heat Soaked Thermally Toughened Soda Lime Silicate Safety Glass Products – Part 1: Description and Definitions

BS EN 14321-1: Glass in Building – Thermally Toughened Alkaline Earth Silicate Safety Glass Products – Part 1: Description And Definitions

BS EN I5681-1: Glass in Building – Basic Alumino Silicate Glass Products – Part 1: Definition and Description

BS EN I5682-1: Glass in Building – Heat Soaked Thermally Toughened Alkaline Earth Silicate Safety Glass – Part 1: Definition and Description

BS EN Iso 12543-1: Glass in Building – Laminated Glass and Laminated Safety Glass - Part 1: Definitions and Description of Component Parts

BS EN Iso 12543-2: Glass in Building – Laminated Glass and Laminated Safety Glass - Part 2: Laminated Safety Glass

BS EN Iso 12543-3: Glass in Building – Laminated Glass and Laminated Safety Glass - Part 3: Laminated Glass

BS EN Iso 12543-4: Glass in Building – Laminated Glass and Laminated Safety Glass - Part 4: Test Methods for Durability

BS EN Iso 12543-5: Glass in Building – Laminated Glass and Laminated Safety Glass - Part 5: Dimensions and Edge Finishing

BS EN Iso 12543-6: Glass in Building – Laminated Glass and Laminated Safety Glass – Part 6: Appearance

#### Evaluation Of Conformity/Product Standards

With the publication of the harmonised European standards, hENs, the glass components will become available as CE marked products. the CE marking will be a declaration that the glass product conforms to the appropriate hEN.

The hENs are as follows:

BS EN 572-9: Glass in Building – Basic Soda Lime Silicate Glass Products - Part 9: Evaluation of Conformity/Product Standard

BS EN 1096-4: Glass in Building – Coated Glass Products - Part 4: Evaluation of Conformity/Product Standard

BS EN 1279-5: Glass in Building – Insulating Glass Units - Part 5: Evaluation of Conformity/Product Standard

BS EN 1748-1-2: Glass in Building – Special Basic Product – Borosilicate Glasses - Part 1-2: Evaluation of Conformity/Product Standard

BS EN 1748-2-2: Glass in Building Special Basic Product – Glass Ceramics Part 2-2: - Evaluation of Conformity/Product Standard

BS EN 1863-2: Glass in Building – Heat Strengthened Soda Lime Silicate Glass Products - Part 2: Evaluation of Conformity/Product Standard

BS EN 12150-2: Glass in Building – Thermally Toughened Soda Lime Silicate Safety Glass Products - Part 2: Evaluation of Conformity/Product Standard

BS EN 12337-2: Glass in Building – Chemically Strengthened Soda Lime Silicate Glass – Part 2: Evaluation of Conformity/Product Standard

BS EN 13024-2: Glass in Building – Thermally Toughened Borosilicate Safety Glass – Part 2: Evaluation of Conformity/Product Standard

BS EN 14178–2: Glass in Building – Alkaline Earth Silicate Glass Products – Part 2: Evaluation of Conformity/Product Standard

BS EN 14179-2: Glass in Building – Heat Soaked Thermally Toughened Soda Lime Silicate Safety Glass Products – Part 2: Evaluation of Conformity/Product Standard

BS EN 14321-2: Glass in Building – Thermally Toughened Alkaline Earth Silicate Safety Glass Products – Part 2: Evaluation of Conformity/Product Standard

BS EN 14449: Glass in Building – Laminated Glass and Laminated Safety Glass - Evaluation of Conformity/Product Standard

**GGF Data Sheets**

Data Sheet 4.4. Quality Standard for Toughened Glass

Data Sheet 4.10 Products, Appearance, and Visual Quality for Insulating Glass Units

Data Sheet 4.4.1 Heat Treated Glasses

Data Sheet 4.11 Laminated and Laminated Safety Glass

**GGF Publications**

A guide to best practice in the specification and use of the resistant glazed systems.
Standard fot: The Specification, supply and installation of the - resistant barriers contacting glass.

**Annex A**

Appearance in reflection

With multiple pane units any distortion or reflection is multiplied as the number of panes increases.

Multiple reflections are not a fault.

The following descriptions and diagrams refer to double glazed units. Triple glazing will further enhance the effects.

**1. Problem due to lack of flatness**

**1.1. General description**

A glass, especially one that is thermally treated, can rarely be glazed perfectly flat. This may be due to the framing system, glazing system, installation and the inherent flatness of the glass.

Imagine a rectilinear feature, e.g. a telegraph pole, some 10 metres from a glazed panel. The observer is viewing the feature by reflection from a similar distance.

If the plane of the glazing changes by one tenth of one degree,

0.1° between two points on its surface, then the viewer will see either two images apparently displaced by 70mm or one image distorted by this amount.

**1.2. Is one tenth of one degree, 0.1°, significant?**

Yes. this amount of flatness change is equivalent to a deflection of 0.8mm over a one-metre length.

This should be compared with the allowable deflection limits for framing, i.e. L/125 for single glazing, L/175 for double glazing.

This would mean for an L of one metre deflections of either 8mm for single-glazing or 5.7mm for double-glazing.

Deflections of greater magnitude can occur due to wind-loading. For thermally treated glass, i.e. thermally toughened, heat strengthened, etc., the standards allow overall bows of 2mm/metre and local bows of 3mm/metre.

For insulating glass units the deflection due to barometric/temperature effects can be significantly greater than 0.8mm/m.

**1.3. Optical explanation**

**Figure A1** shows the geometry involved.

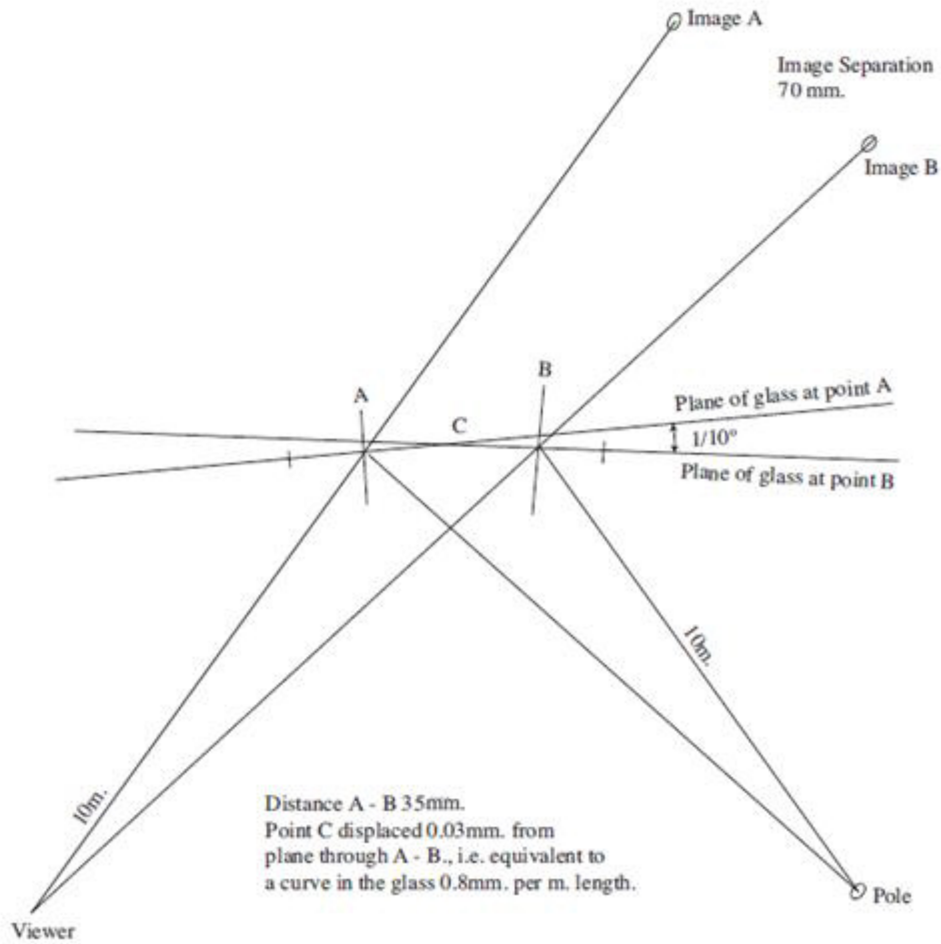


**Figure A1** Explanation of lack of flatness

**Annex B**

Diagrammatic explanation:

With multiple pane units any distortion or reflection is multiplied as the number of panes increases. Multiple reflections are not a fault. The following descriptions and diagrams refer to double glazed units. Triple glazing will further enhance the effects.

**1. Multiple images**

**1.1. General**

When light meets a smooth glass surface; some is transmitted through, some is reflected and some is absorbed.

It is a law of physics that the angle of incidence is equal to the angle of reflection. Therefore if the incident ray is at normal incidence, i.e. at right angles to the glass surface then it is reflected directly back, (see Figure B1 (A). If the incident ray falls obliquely on the surface then the reflected ray bounces back at the same angle but on the other side of the perpendicular.

(See Figure B1 (B)).

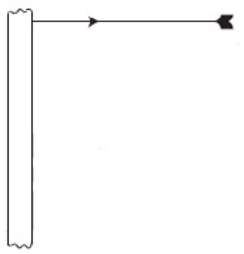

Figure B1(A)

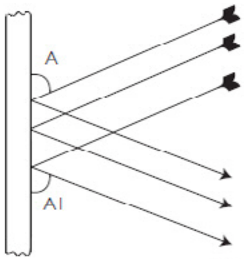


Figure B1(B)

**1.2. Refraction**

Another law of physics is that when a ray enters a medium of differing density it is bent (refracted).

When a ray enters the glass from the air the angle of refraction is less than the angle of incidence. Therefore when reflected from the second surface it is displaced with respect to the incident ray.

When the ray leaves the glass into the air the angle of refraction is greater than the angle of incidence.

Therefore when leaving the first pane of glass the ray is parallel to the incident ray but displaced.

A similar situation occurs when the ray meets the second pane.

For each pane of glass there are two reflected images, a primary and a secondary image. The primary images result from surfaces 1 and 3 and the secondary images from surfaces 2 and 4.

(See Figure B2).

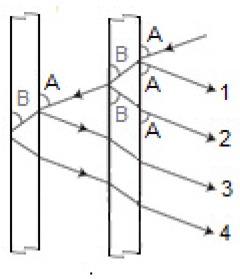


Figure B2

**1.3. Influencing factors**

The following will increase the spacing between images:

- Increasing glass thickness,
- Increasing cavity width,
- Decreasing the angle of incidence.

The effects of coatings and body tints are dependent upon their spectrophotometric properties, i.e. transmittance, reflectance, absorptance, and their position.

Generally body tinted glasses will enhance the primary image and reduce the secondary image produced by the pane. Coatings will enhance the image reflected from the coating.

**2. Distorted images**

**2.1. General**

When light rays strike a curved glass surface, they reflect in different directions. However, they will still obey the law that the angle of incidence equals the angle of reflection. Therefore the image of an object will be distorted. The curvature of the glass surface causes it to act as a lens.

**2.2. Concave curvature**

This is when the surface is bowed inwards.

A concave curvature will cause the light rays to be projected inwards towards a central point. This causes the reflected image to appear short and thin.

(See Figure B3 (A))

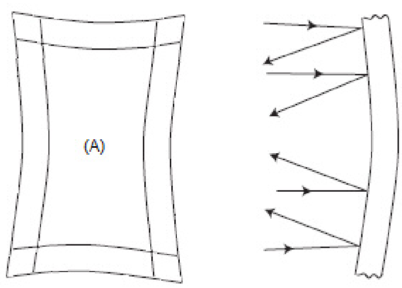


Figure B3(A)

### 2.3. Convex curvature

This is when the surface is bowed outwards.

A convex curvature will cause the light rays to be projected outwards away from a central point. This causes the reflected image to be stretched out in all directions. (See Figure B3 (B))

(See Figure B1 (B)).

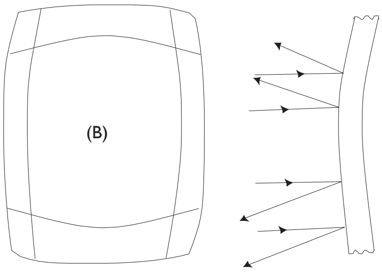


Figure B3 (B)

### 2.4. Curvature in IGUs

When an IGU is subjected to barometric and/or temperature and/or altitude effects the whole unit will change shape.

If the effects on the unit cause it to shrink inwards then this will result in pane #1 being concave and pane #2 being convex, (see Figure B4 – Type (A)). Similarly if the effects on the unit cause it to swell outwards then this will result in pane #1 being convex and pane #2 being concave, (see Figure B4 – Type (B)).

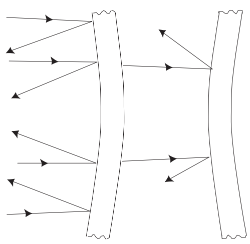

Figure B4 (A)
Surface 1 - Primary image - shrunk
Surface 3 - Primary image - spread-out

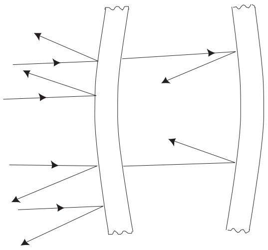

Figure B4 (B)
Surface 1 - Primary image - spread-out
Surface 3 - Primary image - shrunk

The outcome of having different curvatures on the panes will result in some images being made smaller/thinner and others being stretched out.

NOTE: Figure B4 only examines the first reflection of the light ray.

### 3. Composite factors

The combination of multiple images, B1, and distorted images, B2, is extremely difficult to describe.

What is certain is that nothing can be done to stop these effects occurring.

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# GGF Data Sheet: Visual Quality for Adhesive Backed Polymeric Filmed Glass

5.18.1 May 2016

**Contents**



## Introduction

This standard has been developed by the GGF Window Film Group, in association with all major film manufacturers, to define the visual quality standard for adhesive backed polymeric filmed glass.

## 1. Scope

This standard details the acceptable visual quality for adhesive backed polymeric film ("film") applied to architectural glass. Adhesive backed polymeric filmed glass is not expected to have identical visual quality as the glass on which it is installed. The following criteria apply to the installed film only and not to any defect inherent in the glass.

## 2. Definitions and Description

See GGF Data Sheet 5.18.3 Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions and Components.

## 3. Cure Time

Installed film has a discrete time for full adhesion to be effected since installation utilises a detergent solution in water to float the film onto the glass; the excess water is squeegeed out but inevitably residual water will remain between the film and glass. The time to achieve full adhesion is often referred to as "the adhesive cure time". Adhesion will be increasing from a lower value during this time. Visual and adhesive cure time is related to thickness and type of film used. Typical visual cure times may be extended or shortened according to local environmental conditions.

## 4. Inspection for Visual Quality

Inspection for optical quality can be made before full visual cure is attained. Table 1 provides a guide for typical visual cure times for adhesive backed polymeric film not containing layers of metal, alloys, oxides and similar coatings. It should be noted that effects during cure, such as water bubbles, water distortion, and water haze are not to be regarded as defects.

## 5. Inspection Conditions

### 5.1 Internally applied film

The glass with applied film shall be viewed by looking through the film at right angles to the glass from the room side, at a distance of not less than 2 metres. Viewing shall be carried out in natural daylight, not in direct sunlight, and shall assess the normal vision area with the exception of a 50 mm wide band around the perimeter of the unit.

### 5.2 Externally applied film

The glass with applied film shall be viewed by looking through the film at right angles to the glass from either side as appropriate at a distance of not less than 2 metres. Viewing shall be carried out in natural daylight, not in direct sunlight, and shall assess the normal vision area with the exception of a 50 mm wide band around the perimeter of the unit.

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## 6. Acceptance Criteria

### 6.1 Internally applied film

The installation shall be deemed acceptable if any of the following are not visually disturbing (effects during visual cure should be disregarded):

| | |
|---|---|
| Dirt Particles | Water Haze |
| Hair and Fibres | Scores and Scratches |
| Adhesive Gels | Film Distortion |
| Fingerprints | Insects |
| Creases | Air Bubbles |
| Edge Lift | Nicks and Tears |

Initial inspection may be undertaken within 1 day of installation. Visual quality shall be judged by looking through the film installation under the conditions described in Section 5.

### 6.2 Externally applied film

The installation shall be deemed acceptable if any of the following are not visually disturbing (effects during visual cure should be disregarded):

| | |
|---|---|
| Dirt Particles | Water Haze |
| Hair and Fibres | Scores and Scratches |
| Adhesive Gels | Film Distortion |
| Fingerprints | Insects |
| Creases | Air Bubbles |
| Edge Lift | Nicks and Tears |

Initial inspection may be undertaken within 1 day of installation. Visual quality shall be judged by looking through the film installation under the conditions described in Section 5.

Due to the conditions existing in external installations the visual quality of applied film may not be as good as for internally applied film. However, the installation quality should not reduce the performance and / or the expected life of the applied film.

## 7. Inspection of Perimeter Zone

### 7.1 Internally applied film

The 50 mm wide band around the perimeter shall be assessed by a similar procedure to that in 4 and 5, but a small number of particles are considered acceptable where poor frame condition mitigates against the high quality standards normally achieved.

### 7.2 Externally applied film

The 50 mm wide band around the perimeter shall be assessed by a similar procedure to that in 4 and 5, but allowing for a small increase in defects since external environmental conditions usually mitigate against the high quality standards normally achieved.

## 8. Edge Gaps

Edge gaps will normally be 1- 4 mm without allowing the film to contact the frame / glazing margin, gaskets, or similar, but may need to be greater where frame / glazing conditions do not allow close fitting of the applied film. This edge gap allows for the water used in the installation to be squeegeed out and ensures that film edges are not raised up by contact with the frame margin. Contact with the frame margin could lead to peeling of the film, and is an installation fault. For thicker films of > 200 μ the edge gaps will normally be < 4 mm, depending upon frame / glazing conditions.

An edge gap of < 2 mm is recommended for darker (tinted, metallised, tinted/metallised, and sputtered) films to minimise the light line around the edge of the installed film.

## 9. Splicing of Film

Splicing of film is necessary when larger panels of glass are treated, where both length and width of the glazing panel exceed the maximum width of film. The splice line itself should not be viewed as a defect. This line should be straight and should be parallel to one edge of the frame margin. The two pieces of film may be butt jointed, and should be close but not touching; the maximum gap at any point in the splice line should be 1 mm. Film of less than 50 μ may be overlapped, spliced or butt jointed.

**NOTE: In some cases a butt joint (e.g. safety / security film) is necessary on glazing panels that are subject to bow. In these cases the gap along the splice may have to be greater than 1 mm.**

## 10. Visible Light Reflections

It should be noted that visible light reflections can be changed by installation of window film. This is especially the case for films with deposited layers containing metal, metal alloys, or similar. This is not a defect, but is a natural consequence of the high performance coatings used within the film.

## 11. Marking of Safety Film

Safety films used to comply with BS 6262-4, "Safety Related to Human Impact", shall be correctly marked to show compliance with the relevant British Standard (BS EN 12600). The marking shall be as follows:

(a) an identifiable name, or trademark, or other mark capable of identification

(b) the type of material, i.e. "F" for film applied glass

(c) the number of the British Standard, BS EN 12600

(d) the classification according to BS EN 12600

This mark shall be permanent, and applied during installation in a position so that it will remain completely visible and readable after installation. Examples of permanent marking include non-reusable labels (e.g. perforated or brittle labels that peel from the substrate in small pieces) and UV stabilised ink printing.

**NOTE: Typical cure times are for the installed product to reach acceptable visual quality and are not to be confused with time to performance. Cure times will be extended for certain environmental conditions, e.g. low temperature and / or high humidity and / or external blinds drawn down to shade the film from direct sunlight.**

| Film thickness/μ | Typical cure times/days |
|---|---|
| Up to 100 | 30 |
| 100 to 200 | 60 |
| 200 to 300 | 100 |
| 300 to 425 | 140 |

**Table 1:** Typical cure times for film (Section 3)

**12. References**

Current GGF Data Sheets for Adhesive Backed Polymeric Film are:

**GGF Data Sheet 5.18.1** Visual Quality for Adhesive Backed Polymeric Filmed Glass

**GGF Data Sheet 5.18.2** Installation Quality Standard for Applying Adhesive Backed Polymeric Film To Glass

**GGF Data Sheet 5.18.3** Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions And Components

**GGF Data Sheet 5.18.4** Recommendations For Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment Of Glass in the Event of Failure: Types of Systems and Precautions in use

**GGF Data Sheet 5.18.5** Recommendations For Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Test Method

**GGF Data Sheet 5.18.6** Recommendations For Blast Mitigation: Adhesive Backed Polymeric Film Applied to Glass

**GGF Data Sheet 5.18.7** Standard For On-Site Peel Adhesion Testing of Aged Adhesive Backed Polymeric Film Applied to Vertical Flat Glass

**GGF Data Sheet 5.18.8** Adhesive Backed Polymeric Film-Guidelines for Installation onto Existing Glazing

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# GGF Data Sheet: Installation Quality Standard for Applying Adhesive Backed Polymeric Film to Glass

5.18.2 May 2016

**Contents**



## Introduction

This standard has been developed by the GGF Window Film Group, in association with all major film manufacturers, to provide a methodology for the assessment and application of adhesive backed polymeric film to glass. It is an evolving specification reflecting current design, material requirements and legislation and will be subject to review as necessary.

## 1. Scope

This standard details the typical equipment, test methods, application and acceptance criteria applicable to the process of applying adhesive backed polymeric film ("film") to glass. Information is given on preparation of a method statement covering site risk assessment. The certified applicator shall install the window film in accordance with this GGF standard, and the manufacturer's recommendations, in order to meet the criteria of this Data Sheet and GGF Data Sheet 5.18.1 Visual Quality for Adhesive Backed Polymeric Filmed Glass.

It is recommended that applicators read through this GGF Data Sheet prior to commencing film installation.

Applicators should ensure suitable training is obtained prior to film installation including appropriate health and safety and working from heights training.

## 2. Definitions and Description

See GGF Data Sheet 5.18.3 Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions and Components.

## 3. Appropriate Equipment / Materials

Appropriate installation materials include the following:

- Pressure spray bottle
- Clean water
- Cleaning / application solution
- Cutting machine
- Access equipment
- Trimming knife
- Glass scraper
- Window cleaning squeegee
- Application squeegees
- Straight edge margin cutting tool
- Calibrated tape measure
- Adhesive tape
- Soft paper towels or water absorbing material (non lint)
- Rubbish bags
- Protective sheets
- External edge sealan
- Sharp disposal container

NOTE: In general, it is recommended to use high quality distilled or Reverse Osmosis (RO) water for application of adhesive backed polymeric film to glass, but in many cases local tap water has been found to be acceptable quality. However, applicators should be aware that water containing minerals such as calcium carbonate (found in hard water) can react with many soaps, including those found in shampoos and washing up liquids.

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This reaction can form a solid residue that contaminates the cleaning / installation solution and reduces the ability to position the film ("slip"); the contamination may also reduce the adhesive bond strength between the film and the glass surface, including for safety / security films.

Other residues in tap water, such as chemicals containing chlorine and / or sulphur, may react with metal layers within the film to cause demetallisation. Local tap water may also be too acidic due to pollution (e.g. from "acid rain"). If RO water is used, the RO filters must be changed according to quality of the source water.

**4. Pre-checks**

**4.1** Ensure all relevant equipment is present clean and in good working order.

**4.2** Check that frame type and condition, glass size and site access all agree with the written work instructions.

**4.3** Prepare a written statement covering the work site Risk Assessment. Details of the Risk Assessment can be found in the GGF Installation Training Manual.

**5. Location Preparation**

**5.1** The applicator shall ensure that there is sufficient room to operate all equipment safely, with minimum disruption to the client. When a cutting machine is required, it shall be erected in an area where few people pass. Protect all appropriate areas with an absorbent material if required.

NOTE 1: Depending on the Risk Assessment, working areas may need to be cordoned off and suitable warning signs displayed.

NOTE 2: As the procedures require the use of water, care should be taken to minimise slipping, electrical and other risks.

**5.2** The glazing area should be clean and dust free.

NOTE: If the glazing area is unacceptably dirty or dusty, then pre-cleaning before commencement of film installation is necessary.

**5.3** Spray the window thoroughly with cleaning / application solution.

**5.4** Thoroughly clean the surface of the glass using appropriate equipment, removing all foreign bodies, taking care to avoid damage to the glass, frame and glazing system.

**5.5** Rinse glass and frame from top to bottom with the cleaning/ application solution. Some types of cleaning solution require rinsing with clean water, in which case the manufacturer's recommendations should be followed.

**5.6** Using a window cleaning squeegee remove all residual cleaning / application solution from the glass, working from the top to the bottom.

**5.7** Using a lint free absorbent material, wipe around the frame of the window to remove excess cleaning / application solution.

**5.8** Inspect glass, frame and glazing to ensure readiness for film application and re-clean if necessary.

**5.9** Spray the prepared glass surface with a fine mist of application solution.

**6. Film Preparation**

**6.1 Inspection**

**6.1.1** Check film specification and note the manufacturer's film type and batch/reference number, and record it.

**6.1.2** Remove film from packing and inspect for visual defects and damage.

**6.1.3** Any non-conforming film should be labelled "Reject", segregated from other film, and notified to internal quality assurance.

**6.2 Material cutting**

**6.2.1** Where required, mount the film on a cutting machine and secure in position.

**6.2.2** Cut the film to the appropriate size.

**6.2.3** Where necessary, roll each piece of film with the release liner outermost, and secure with masking tape with the film reference and size marked on it.

**6.2.4** When the film for a group of premeasured panes has been cut and rolled, transfer the film from the cutting area to the installation location, storing it according to the manufacturer's recommendations.

**7. Installation**

**7.1** Spray the pre-cleaned pane with the cleaning / application solution.

**7.2** Remove the liner from the pre-cut film, spraying the adhesive face of the film thoroughly with the cleaning / application solution. If the film has an over-coat barrier, rinse off thoroughly with the cleaning / application solution.

NOTE: Depending upon adhesive type, e.g. dry water activated adhesives, spraying of the adhesive surface during removal of the liner may not be necessary.

**7.3** Offer the adhesive side of the film to the prepared surface of the glass and place it in position.

**7.4** Spray the surface of the film using the application solution to enable the squeegee to move freely across the surface without disturbing its position and to minimise surface abrasion.

**7.5** Use the appropriate squeegee to remove the excess application solution from between the film and the glass (see Figure 1), taking care to overlap the squeegee strokes.

**7.6** Where appropriate, place the straight edge margin cutting tool against the window frame. Using a trimming knife with a sharp blade, trim the excess film ensuring all margins (edge gaps) are in accordance with GGF Data Sheet 5.18.1 Visual Quality for Adhesive Backed Polymeric Filmed Glass.

**7.7** Repeat the previous squeegee procedure with increasing pressure as necessary. Ensure good contact between the edge of the film and the glass.

**7.8** Dry thoroughly the perimeter of the glass and film, using a lint free absorbent material.

**7.9** It may be necessary to re-squeegee a perimeter band of about 100 mm to ensure the edge of the film is in close contact with the glass surface.

## 8. Splicing of Applied Film

The majority of manufacturers supply film in varying widths, generally up to 1524 mm (60 ") with some films available in 1829 mm (6 ") width. Inevitably some window panes will exceed maximum film width; under these circumstances, it becomes necessary to perform a splice using two or more sections of the film. Under normal circumstances, a splice is vertical and positioned for low visual disturbance. Under some circumstances, horizontal splices or vertical splices in the middle of the pane can be used.

### 8.1 Methods of splicing

Depending upon the film type, the methods given in 8.2, 8.3 and 8.4 may be used. Overlap joints (Section 8.4) are not to be used for safety / security films.

### 8.2 Butt splice

Apply one piece of film (in accordance with Section 6) to one side of the glass up to the trimming stage. Apply the second piece of film to the glass positioning the film so that the two edges butt together. Both pieces of film shall be applied so that the shading is matched; usually this means that the same machine edge of the film is used.

NOTE 1: If the window bows, the machine edge of the film is not straight, or the glazing uses curved glass, a cut splice will be required.

NOTE 2: In some specialised cases an additional piece of safety film may be required to overlap both pieces of film at the butt joint to reinforce the join.

### 8.3 Cut splice

Overlap the film by approximately 25 mm. Use a sharp stainless steel blade to cut through both pieces of film. Squeegee the film parallel to the splice, and finish the window in the normal way.

Note: Take care to avoid damage to the glass surface during this process. Do not use carbon steel blades since these have a significant risk of scratching the glass.

### 8.4 Overlapped splice

This method shall not be used when applying safety / security films. Initially overlap the film by approximately 25 mm, positioning the film so that there is a final overlap ≤ 6 mm.

## 9. Visual Quality Inspection

A visual inspection of the installation shall be carried out by the applicator in accordance with the GGF Data Sheet 5.18.1 Visual Quality for Adhesive Backed Polymeric Filmed Glass. Any nonconformities identified, either during installation or on final quality inspection, shall be corrected.

## 10. Marking of Safety Film

Safety films used to comply with BS 6262-4 Safety related to human impact, shall be correctly marked to show compliance with the relevant British Standard (BS EN 12600). The marking shall be as follows:

(a) an identifiable name, or trademark, or other mark capable of identification through a suitable source*

(b) the type of material, i.e. "F" for film applied glass

(c) the number of the British Standard, i.e. BS EN 12600

(d) the classification according to BS EN 12600

This mark shall be permanent, and applied during installation in a position so that it will remain completely visible and readable after installation.

## 11. Housekeeping

The applicator shall clear all the waste film and excess water from the installation and cutting areas, and reinstate the area as close as possible to the condition in which it was found originally.

## 12. External films

Where external films have been specified and where circumstances dictate, e.g. climatic conditions and glazing angle, the installer shall check the manufacturer's installation recommendations in relation to the use of external sealants.

## 13. References

Current GGF Data Sheets for adhesive backed polymeric film are:

**GGF Data Sheet 5.18.1** Visual Quality for Adhesive Backed Polymeric Filmed Glass

**GGF Data Sheet 5.18.2** Installation Quality Standard for Applying Adhesive Backed Polymeric Film to Glass

**GGF Data Sheet 5.18.3** Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions and Components

**GGF Data Sheet 5.18.4** Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Types of Systems and Precautions in Use

**GGF Data Sheet 5.18.5** Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Test Method

**GGF Data Sheet 5.18.6** Recommendations for Blast Mitigation: Adhesive Backed Polymeric Film Applied to Glass

**GGF Data Sheet 5.18.7** Standard for On-Site Peel Adhesion Testing of Aged Adhesive Backed Polymeric Film Applied to Vertical Flat Glass

**GGF Data Sheet 5.18.8** Adhesive Backed Polymeric Film - Guidelines for Installation on Existing Glazing

# GGF Data Sheet: Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions and Components

5.18.3 May 2016

**Contents**



**Introduction**

This standard has been developed by the GGF Window Film Group, in association with all major film manufacturers, to define common terms used in GGF Data Sheets for adhesive backed polymeric film.

**1. Scope**

This standard provides definitions and descriptions of common terms used in GGF Data Sheets relating to adhesivebacked polymeric film ("film"). These definitions and descriptions apply to all GGF adhesive backed polymeric film Data Sheets. Specific terms will be found with the appropriate GGF Data Sheet.

**2. Definitions and Description**

**2.1 Adhesive backed polymeric film**

One or more layers of polymeric film laminated together, with an adhesive on one external face. It may also incorporate one or more of the following: Colouring, UV absorbers, UV inhibitors, metal layer(s), metal alloy layer(s), metal oxide layer(s), scratch or abrasion resistant surface, release liner.

**2.2 Safety film**

Adhesive backed polymeric film designed so that when applied to a glass pane the final product can be classified in accordance with BS EN 12600 Glass in building – Pendulum test – Impact method test and classification for flat glass. Safety film is also known as 'Anti-Shatter film' or ASF since it is intended to retain broken glass fragments and hence reduce shattering of glass over a wide area.

**2.3 Security film**

Adhesive backed polymeric film designed so that when applied to a glass pane the final product can be classified in accordance with an appropriate standard for security glazing, such as BS EN 356 Glass in building. Security glazing. Testing and classification of resistance against manual attack and BS EN 13541 Glass in Building. Security Glazing. Testing and Classification of Resistance Against Explosion Pressure. Security film is also known as 'Anti-Shatter film' or ASF since it is intended to retain broken glass fragments and hence reduce shattering of glass over a wide area.

**2.4 Thickness**

The total thickness of the safety film is the sum of the thicknesses of its polyester film layers, excluding the thicknesses of adhesive and other coatings.

**2.5 Cure time**

The time required for the adhesive backed polymeric film to achieve its expected adhesion level and for visual effects due to water haze/water bubbles/etc. to disappear.

NOTE: Cure time should not be confused with performance time. Safety film will, with correct installation procedures, achieve good performance before complete cure.

**2.6 Containment system**

A system designed to attach safety film to the glazing system in order to reduce the risk of the glass + safety film exiting the frame, thereby enhancing the protective effect of the safety film. The safety film + containment system may be used for blast mitigation and for containment of glass in the overhead position in the event of glass failure. Containment systems should not be confused with the containment characteristics for personal safety given in BS EN 12600.

**2.7 Risk assessment**

An assessment made by a trained and experienced professional in order to identify the potential risks, e.g. to glass due to thermal stress, to people from unsafe glazing, to people from lack of containment with overhead glazing, to people from glazing broken in an explosion.

NOTE: The GGF has a list of approved manufacturers and installers who offer professional risk assessments.

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**2.8 Non-vertical overhead glazing**

Glazing which is above head height where there is general access to the areas beneath and which is truly vertical or has a slope of > 15 ° from the vertical.

**2.9 Vertical glazing**

Glazing which is truly vertical or has a slope of ≤ 15° from the vertical.

**2.10 Vertical glazing**

Machine edges are the two edges running along the length of a roll of film as supplied by the manufacturer.

## 3. Components – Substrates

Adhesive backed polymeric film can be applied to any glass substrate as described below:

**3.1** Basic soda lime silicate glass products in accordance with BS EN 572-1

**3.1.1** Float glass in accordance with BS EN 572-2

**3.1.2** Polished wired glass in accordance with BS EN 572-3

**3.1.3** Drawn sheet glass in accordance with BS EN 572-4

**3.1.4** Patterned glass in accordance with BS EN 572-5

**3.1.5** Wired patterned glass in accordance with BS EN 572-6

**3.1.6** Wired or unwired channel shaped glass in accordance with BS EN 572-7

**3.1.7** Supplied and final cut sizes in accordance with BS EN 572-8

**3.2** Special basic products

**3.2.1** Borosilicate glasses in accordance with BS EN 1748-1-1

**3.2.2** Glass ceramics in accordance with BS EN 1748-2-1

**3.3** Basic alkaline earth silicate glass – Float glass in accordance with BS EN 14178-1

**3.4** Mirrors – manufactured from silvered float glass in accordance with BS EN 1036-1

**3.5** Thermally toughened soda lime silicate safety glass in accordance with BS EN 12150-1

**3.6** Heat soaked thermally toughened soda lime silicate safety glass in accordance with BS EN 14179-1

**3.7** Thermally toughened borosilicate safety glass in accordance with BS EN 13024-1

**3.8** Thermally toughened alkaline earth silicate safety glass in accordance with BS EN 14321-1

**3.9** Heat strengthened soda lime silicate glass in accordance with BS EN 1863-1

**3.10** Chemically strengthened soda lime silicate glass in accordance with BS EN 12337-1

**3.11** Laminated glass and laminated safety glass in accordance with BS EN ISO 12543-1

**3.12** Coated glass in accordance with BS EN 1096-1

## 4. Components – Adhesive Backed Polymeric Film

**4.1** Components typically used in the manufacture of adhesive polymeric film are:

- Biaxially oriented polyethylene terephthalate (polyester) film as the base film
- Laminating adhesive
- Mounting adhesive
- Hard surface coating, e.g. Scratch Resistant (SR) or Abrasion Resistant (AR)
- UV absorbers / inhibitors
- Pigments and dyes
- Metal coatings
- Release liner

**4.2 Polyester base film**

Biaxially oriented polyethylene terephthalate film is used in the manufacture of adhesive backed polymeric films due to its excellent tensile properties, glass-like visible light transmission, low haze, and good dimensional stability. The exact type of polyester base film used depends upon the end use requirements of the adhesive backed polymeric film.

The properties of the polyester base film, especially for safety and security films, must be carefully balanced in order to obtain the required end-use performance for the final product.

Further information on the manufacture and properties of polyester film can be obtained from polyester film manufacturers such as Hoechst, Mitsubishi and DuPont Teijin Films.

**4.3 Laminating adhesive**

Appropriate laminating adhesives are selected for their durability, performance and optical qualities, and are used to adhere layers of polyester film together. Not all adhesive backed polymeric films have laminated structures, but most do.

Different layers of polyester films are used to either enhance the main property of the final product or, more usually, so that the final product has a combination of properties. A variety of different adhesive types are used including acrylic pressure sensitive and polyester adhesives.

For all types of adhesive backed polymeric films, the laminating adhesive must have high optical transmission, low optical haze, good adhesion to the two polyester film surfaces (included coated surfaces), and long durability. For adhesive backed polymeric films other than safety and security films, the laminating adhesive merely needs to hold the polyester film layers together over the life of the product, so is usually a fairly thin coating of a few microns thickness.

For safety and security films the laminating adhesive is usually much thicker and of higher adhesive strength; the increased adhesive thickness and strength improves the safety / security performance of the final product.

4.4 **Mounting adhesive**

An adhesive is added to one surface of the single or multi-ply structure to allow the film to be installed to a glass surface.

As with laminating adhesives, the mounting adhesive must have high optical transmission, low optical haze, good adhesion to the polyester film surface, good adhesion to glass, and long durability. UV absorbers and / or UV inhibitors are often added to add extra durability.

Adhesive backed polymeric films use either acrylic pressure sensitive mounting adhesives or so-called 'dry water activated' mounting adhesives. The 'dry' adhesives may have improved clarity, effectively zero distortion, and enhanced durability.

Acrylic pressure sensitive adhesives are sticky to the touch and generally adhere to any surface on contact. 'Dry water activated' adhesives are not sticky to the touch but are chemically activated upon contact with moisture. Normally, a soapy water solution is used to install the adhesive backed polymeric film onto the required glass surface; the soapy water allows the film to be positioned on the glass, prevents unwanted adhesion of pressure sensitive adhesives, and activates 'dry' adhesives.

Some manufacturers add a 'detackifying' coating onto pressure sensitive mounting adhesive; this coating acts as a lubricant during installation, allowing low soap or soap free installation if desired. This system should not be confused with 'dry water activated' adhesives.

### 4.5 Hard surface coating

A coating is added to the surface of the laminated film opposite to the mounting adhesive coated side. This coating provides scratch or abrasion resistance to the adhesive backed polymeric film, giving many years of useful life with minimal surface damage when used and maintained correctly.

### 4.6 UV absorbers / inhibitors

UV absorbers / inhibitors are used within an adhesive backed polymeric film to enhance its durability and UV filtering properties. The UV absorbers / inhibitors are added to the mounting adhesive and / or the laminated structure. When used within the laminated structure, the UV absorbers / inhibitors are either added as a coating or are deep dyed into one or more layers of polyester film.

### 4.7 Pigments / dyes

Pigments and dyes are used to impart colour and tint to the adhesive backedpolymeric film. Some films use colour / tint in the mounting adhesive, the laminating adhesive, the hard surface coating, or as a coating; more often the colour / tint is deep dyed into one or more layers of polyester film.

### 4.8 Metal coatings

One or more layers of polyester film are metallised or sputtered with metals or metal alloys; occasionally metal oxides and / or other metal containing materials may be used. These coatings are designed to add solar control, low 'E' or other properties to the adhesive backed polymeric film.

NOTE: For discussions of metallising and sputtering processes, refer to the various on-line encyclopeadias available.

### 4.9 Release liner

A polymeric film used to cover the mounting adhesive and prevent contamination before installation of the adhesive backed polymeric film to a glass surface. Some adhesive backed polymeric films use a detackifying coating rather than a release liner.

## 5. Standards and References

### 5.1 Standards for adhesive backed polymeric film

Standards for adhesive backed polymeric film have beeen prepared by CEN TC129 /WG 18. The current working titles are:

**EN 15752-1** Glass in Building. Adhesive Backed Polymeric Film. Definitions and Descriptions

**EN 15755-1** Glass in Building. Adhesive Backed Polymeric Filmed Glass. Definitions and Descriptions

NOTE: Other standards for adhesive backed polymeric film will also be developed e.g. Evaluation of Conformity.

### 5.2 Other standards

Standards relevant to adhesive backed polymeric film (apart from those in Section 3) include:

**British/European Standards**

**EN 356** Glass in building. Security glazing. Testing and classification of resistance against manual attack

**EN 410** Glass in building. Determination of luminous and solar characteristics of glazing

**EN 673** Glass in building. Determination of Thermal Transmittance (U value). Calculation method

**EN 1063** Glass in Building. Security Glazing. Testing and Classification of Resistance Against Bullet Attack

**EN 12600** Glass in building. Pendulum test.
Impact test method and classification for flat glass

**EN 12898** Glass in Building. Determination of the Emissivity

**EN 50147-1** Anechoic Chambers. Shield Attenuation Measurement

**EN 50147-2** Anechoic Chambers. Alternative Site Suitability with Respect to Site Attenuation

**British/European/International Standards**

**BS EN ISO 527-3** Plastics. Determination of tensile properties. Test conditions for films and sheets

**BS EN ISO 4892-1** Plastics. Methods of exposure to laboratory light sources. General guidance

**BS EN ISO 4892-2** Plastics. Methods of exposure to laboratory light sources. Xenon-arc sources

**International Standards**

**ISO 16933** Glass in building. Explosion resistant security glazing. Test and classification for arena air-blast loading

**ISO 16934** Glass in building. Explosion resistant security glazing. Test and classification by shock-tube loading

### 5.3 GGF Data Sheets

Current GGF Data Sheets for adhesive backed polymeric film are:

**GGF Data Sheet 5.18.1** Visual Quality for Adhesive Backed Polymeric Filmed Glass

**GGF Data Sheet 5.18.2** Installation Quality Standard for Applying Adhesive Backed Polymeric Film to Glass

**GGF Data Sheet 5.18.3** Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions and Components

**GGF Data Sheet 5.18.4** Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Types of Systems and Precautions in Use

**GGF Data Sheet 5.18.5** Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Test Method

**GGF Data Sheet 5.18.6** Recommendations for Blast Mitigation: Adhesive Backed Polymeric Film Applied to Glass

**GGF Data Sheet 5.18.7** Standard for On-Site Peel Adhesion Testing of Aged Adhesive Backed Polymeric Film Applied to Vertical Flat Glass

**GGF Data Sheet 5.18.8** Adhesive Backed Polymeric Film-Guidelines for Installation on Existing Glazing

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# GGF Data Sheet: Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Types of Systems and Precautions in Use

5.18.4 May 2016

**Contents**



**Introduction**

This document clarifies the recommendations concerning the use of adhesive backed polymeric film applied to glass in the overhead position for the containment of glass in the event of failure. It is the first of two documents, the second of which describes a test method.

**1. Scope**

This document describes and recommends the general types of containment systems used with adhesive backed polymeric film applied to glass in the overhead position for containment of glass in the event of glass failure. It is concerned with self weight, snow loading and snow loading plus intermittent wind loading. This document does not cover the risk of injury from objects falling through the glass, nor can it cover every possible containment system.

NOTE: **Each installation of adhesive backed polymeric film for containment purposes has to be individually assessed.**

**2. Definitions and Description**

**2.1** See GGF Data Sheet 5.18.3 Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions and Components.

**2.2 Containment system**

A system designed to attach an installed adhesive backed polymeric film to the glazing bar, glazing system or frame, and thereby provide containment of glass in the overhead position in the event of glass failure. This should not be confused with the containment characteristics for personal safety given in BS EN 12600.

**3. Breakage Characteristics of Glass**

The breakage characteristics and associated properties of commonly used glass types are described below.

**3.1** Laminated glass to BS EN ISO 12543-2 or BS EN ISO 12543-3

When laminated glass is broken the pieces of glass are held together by the interlayer(s) and are likely to remain in position and continue to provide short term weather resistance.

NOTE: **Laminated glass includes laminated annealed, laminated thermally toughened, laminated heat soaked thermally toughened and laminated heat strengthened glasses.**

**3.2** Thermally toughened glass in accordance with BS EN 12150-1, BS EN 14179-1, BS EN 13024-1, or BS EN 14321-1.

Thermally toughened glass is stronger than ordinary annealed glass of equal thickness and is therefore comparatively difficult to break. In addition, thermally toughened glass will withstand the maximum thermal stress associated with solar radiation.

NOTE: **Thermally toughened glass will not break due to thermal stress in all architectural situations except when a fire occurs in the building. When broken, thermally toughened glass shatters into small relatively harmless pieces, which are likely to fall.**

Thicker toughened glass, when broken, will exhibit a greater tendency for the small pieces to stay together and fall in a cluster. Thermally toughened glass may contain Nickel Sulphide (NiS) inclusions which could cause spontaneous breakage although the risk of this happening is very low.

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### 3.3 Heat soaked thermally toughened glass to BS EN 14179-1

Heat soaked thermally toughened glass has the same properties and breakage characteristics as thermally toughened glass. However, the incidence of breakage due to Nickel Sulphide inclusions is negligible.

### 3.4 Heat strengthened glass to BS EN 1863-1

Heat strengthened glass will withstand the thermal stress associated with solar radiation but it breaks in a manner similar to annealed glass (Section 4.6).

The built-in stresses in heat strengthened glass, which are lower than those in thermally toughened glass, make it much less susceptible to spontaneous fracture due to Nickel Sulphide inclusions.

### 3.5 Wired glass to BS EN 572-3 or BS EN 572-5

When wired glass is broken, the wire will hold most pieces of the glass together thereby preventing them from falling. safety film is between the batten bar and the frame, and is secured to the frame with self-tapping screws set a suitable intervals

### 3.6 Annealed glass excluding wired glass (e.g. to BS EN 572 parts 1-8 and BS EN 1748-1-1)

When annealed glass is broken, it tends to break into dangerous pieces which are likely to fall.

## 4. Design Considerations

**4.1** Glass breakages may occur for many reasons including the following:

- Excessive loads (e.g. self-load, snow, wind loads)
- Inadequate framing or other glazing defects
- Incorrect glazing procedures
- Impact from falling, wind-borne or thrown objects
- The higher thermal stresses encountered in non-vertical overhead glazing
- Malicious attack
- Damaged or defective glass
- Breakage due to Nickel Sulphide inclusions in thermally toughened glass
- Explosive pressures

**4.2** The breakage of glass in non-vertical overhead glazing is a very rare occurrence. The risk of injury from falling broken glass may be reduced by the use of adhesive backed polymeric film and a suitable containment system.

**4.3** Thermally toughened glass in the overhead position may, when broken, create risks by falling down in fragments and / or as clusters of fragments. If adhesive backed polymeric film is installed to such glazing an appropriate risk assessment must be completed in order to determine whether a containment system is necessary.

**4.4** In no circumstances should adhesive backed polymeric film be installed by itself to overhead thermally toughened or heat soaked thermally toughened glass without an appropriate risk assessment and, where necessary, the use of an appropriate containment system. Installation of adhesive backed polymeric film to such glazing can significantly increase the risk if the glass fails and the sheet of film and glass falls as one piece.

## 5. Containment Systems

### 5.1 General

- Suitable containment systems include:
- Silicone structural adhesive
- Mechanically fixed batten bar
- Adhesively fixed batten bar
- Polyester and acrylic foam tapes
- Structural washers

**NOTE: The minimum recommended bite depth for new blast resistant glazing with any one dimension > 1 m is 30 mm, although this value may be adjusted in future with further testing and technological development. Containment systems such as the structural silicone and batten bar methods can effectively increase the bite depth of the glazing within the frame.**

Figures 1 to 7 give examples of possible glazing systems with installations of containment systems. In all situations, both the safety film and the containment system must be installed according to the manufacturers' recommendations.

It is strongly recommended that the installer only use containment systems that have been tested in accordance with the GGF Data Sheet 5.18.5 Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Test Method. The testing must be carried out by an independent test laboratory such as the GGF test facility.

### 5.2 Silicone structural adhesive

A silicone structural adhesive is used to bridge between the safety film and the frame. This has the following minimum characteristics:

- The gap between the edge of the safety film and the frame margin shall be 1.0 + 0.0 / - 0.5 mm.
- The silicone shall be a neutral cure structural silicone with good adhesion to plastic and glass surfaces (silicone adhesives often contain adhesion promoters for this purpose), with good weatherability and UV resistance.
- The structural silicone shall be added such that the final cross section is triangular.
- There shall be at least 10 mm width of contact between the structural silicone and the safety film.
- There shall be at least 10 mm width of contact between the structural silicone and the frame.
- It is often necessary to clean the frame prior to application of the structural silicone. Wipe away any dust or debris using a soft dry cloth and cleaning with IPA (isopropyl alcohol) is usually suitable for this purpose, but cleaning with soapy water may also be necessary.
- Installation of the structural silicone shall otherwise be according to the manufacturer's recommendations, including the time and conditions required for the silicone to attain full performance; the adhesive backed polymeric film manufacturer may have additional requirements.
- It may be necessary to cut away the gasket flush with the frame in order to ensure that a width of structural silicone of 10 mm contacts the frame and/or safety film.

Figures 1 and 2 give an example of a possible silicone structural adhesive containment system.

NOTE: Dow Corning 995 and Tremco ProGlaze SSG structural silicone sealants may be suitable for this type of containment system. Other similar silicones are also suitable but it is expected that the manufacturer or installer of the safety film / containment system will ensure that adequate testing has been completed to demonstrate that the particular silicone selected performs as required.

### 5.3 Mechanically fixed batten bar

There are various possible types of a batten bar with mechanical securing of film which typically have the following minimum characteristics:

- The safety film is installed to the glass surface but with additional film so that the film is extended past the vision area of the glazing and between the batten bar and the frame; some systems further extend the film so that it wraps inside the batten bar.
- A batten bar is installed such that the safety film is between the batten bar and the frame, and is secured to the frame with self-tapping screws set a suitable intervals.
- The distance between the batten bar and the safety film / glass surface may be critically important and must be in accordance with the manufacturer's recommendations.
- The batten bar should not extend past the frame.

To improve the performance of a mechanically fixed batten bar, dependent upon the design, the following additional criteria may apply:

- A structural silicone or similar high bond high performance adhesive may be included between the batten bar and the surface of the safety film to enhance the retention of the film between the batten bar and the frame. Alternatively, double sided high bond strength foam tape may be used between the batten bar and the safety film rather than structural silicone.
- An additional gasket may be present on the batten bar so that the safety film is firmly pressed firmly towards the glass. This is aimed at avoiding shearing of the film at the point where it curves away from the glass and under the batten bar, as well as increasing bite depth.
- Both the options above may be present in a mechanically fixed batten bar.
- It may be necessary to cut away the gasket flush with the frame in order to ensure that the batten bar contacts the frame sufficiently and / or the distance between the batten bar and the safety film on the glazing is correct.
- Doors are similar treated.

Figures 3, 4 and 5c give examples of possible installations of mechanically fixed batten bar containment systems.

### 5.4 Adhesively fixed batten bar

This system is similar to the mechanically fixed batten bar, but self tapping screws are not used; they have the following minimum characteristics:

- The gap between the edge of the safety film and the frame margin shall be 1.0 + 0.0 / - 0.5 mm.
- A batten bar of suitable cross section profile is fitted so that one flat surface contacts the safety film and one flat surface contacts the frame; often the batten bar has a simple L shaped profile.

**Figure 1:** Example of installing film on framed glazing

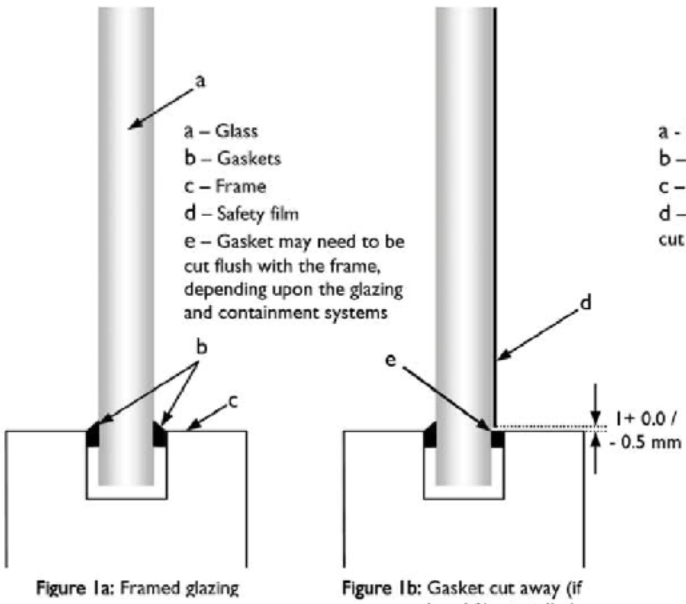
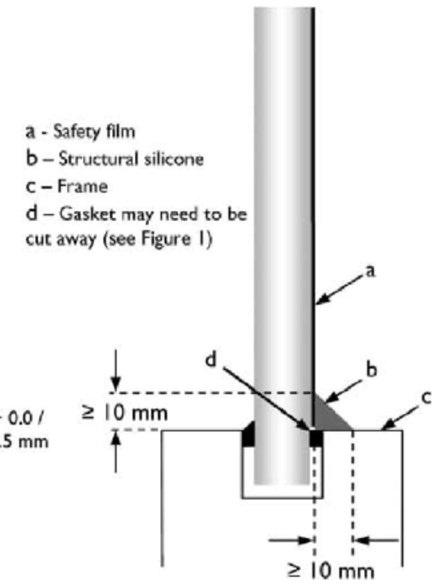



**Figure 1a:** Framed glazing

**Figure 1b:** Gasket cut away (if necessary) and film installed

**Figure 2:** Example of a structural silicone containment system on framed glazing



- Double sided high bond strength foam adhesive tape is used to adhere the batten bar to the safety film and the batten bar to the frame.
- The batten bar should not extend past the frame and should have a minimum width of 12 mm contact with both the frame and safety film.
- The system is designed so that the batten bar minimises shearing of the safety film along an edge of the batten bar.
- It may be necessary to cut away the gasket flush with the frame in order to ensure that the batten bar contacts the frame and / or safety film sufficiently for good adhesion.
- Both the safety film and the batten bar are otherwise installed according to manufacturer's recommendations.
- Doors may be similar treated.

Figures 3, 5a and 5b give examples of possible installations of adhesively fixed batten bar containment systems.

**NOTE: At the current state of technology, carefully designed mechanically fixed batten bar systems have higher performance than adhesively fixed batten bar systems.**

However, some adhesively fixed batten bars design ensures greater absorption of sudden stresses so that less stress is transferred to the frame; this characteristic may enhance performance of adhesively fixed batten bars in, for example, an explosion.

### 5.5 Polyester and acrylic foam tapes

These systems are similar to adhesively fixed batten bar systems except that a polyester or acrylic tape is used in place of a batten bar. Self tapping screws cannot be used.

- The gap between the edge of the safety film and the frame margin shall be 1.0 + 0.0 / - 0.5 mm.
- The tape is fitted so that part contacts the safety film and part contacts the frame.
- Double sided high bond strength foam adhesive tape is used to adhere the tape to the safety film and the tape to the frame.
- The tape should not extend past the frame and should have a minimum width of 12 mm contact with both the frame and safety film.
- The system is designed so that the tape minimises shearing of the safety film.
- It may be necessary to cut away the gasket flush with the frame in order to ensure that the tape can contact the frame and / or safety film sufficiently for good adhesion.
- Both the safety film and the tape are otherwise installed according to manufacturer's recommendations.
- Doors may be similar treated.

Figure 6 gives an example of a polyester or acrylic tape containment system.

**NOTE: At the current state of technology, both mechanically and adhesively fixed batten bar systems have higher performance than polyester and acrylic tape systems.**

### 5.6 Structural washers

Structural washers are used with bolted structural glazing systems. Guidance on these systems should be obtained from the system manufacturer because certain types of systems do not have re-usable fittings or components.

It is also important to ensure that the sequence of unfastening and re-tightening the fittings are done correctly. Structural washers vary in form but typically have the following characteristics:

- 316 Stainless steel is used for the structural washers.
- Double sided high bond strength foam tape is used between the washer and film; this adheres the washer both to the fittings supplied by the structural glazing manufacturer and to the safety / security film.
- A plastic spacer may be used between the washer and the metal retaining plate; this avoids binding of the metal washer to the metal plate and allows easier tightening of the complete assembly.
- The fittings are removed and safety / security film is installed close to the holes already cut through the glazing; it is usually best to treat one fitting at a time rather than remove all the fittings at the same time.

Figure 7 gives an example of a structural washer containment system.

## 6. References

**6.1** UK Home Office publication "Bombs – Protecting People and Property", 4th edition, Appendix 2.

Current GGF Data Sheets for adhesive backed polymeric film are:

**GGF Data Sheet 5.18.1** Visual Quality for Adhesive Backed Polymeric Filmed Glass

**GGF Data Sheet 5.18.2** Installation Quality Standard for Applying Adhesive Backed Polymeric Film to Glass

**GGF Data Sheet 5.18.3** Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions and Components

**GGF Data Sheet 5.18.4** Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Types of Systems and Precautions in Use

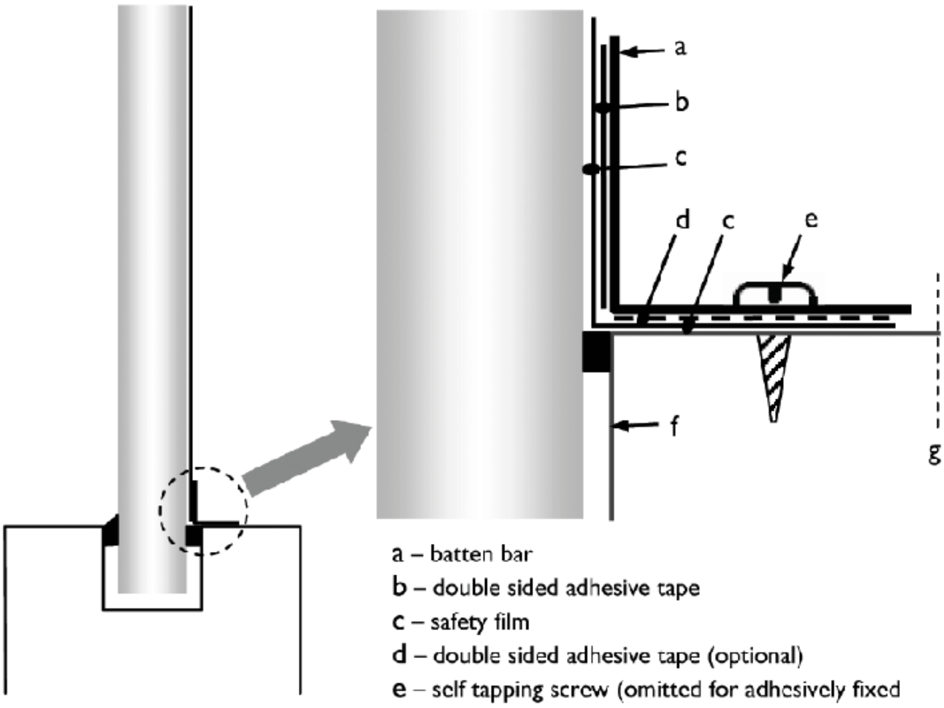
**GGF Data Sheet 5.18.5** Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Test Method

**GGF Data Sheet 5.18.6** Recommendations for Blast Mitigation: Adhesive Backed Polymeric Film Applied to Glass

**GGF Data Sheet 5.18.7** Standard for On-Site Peel Adhesion Testing of Aged Adhesive Backed Polymeric Film Applied to Vertical Flat Glass

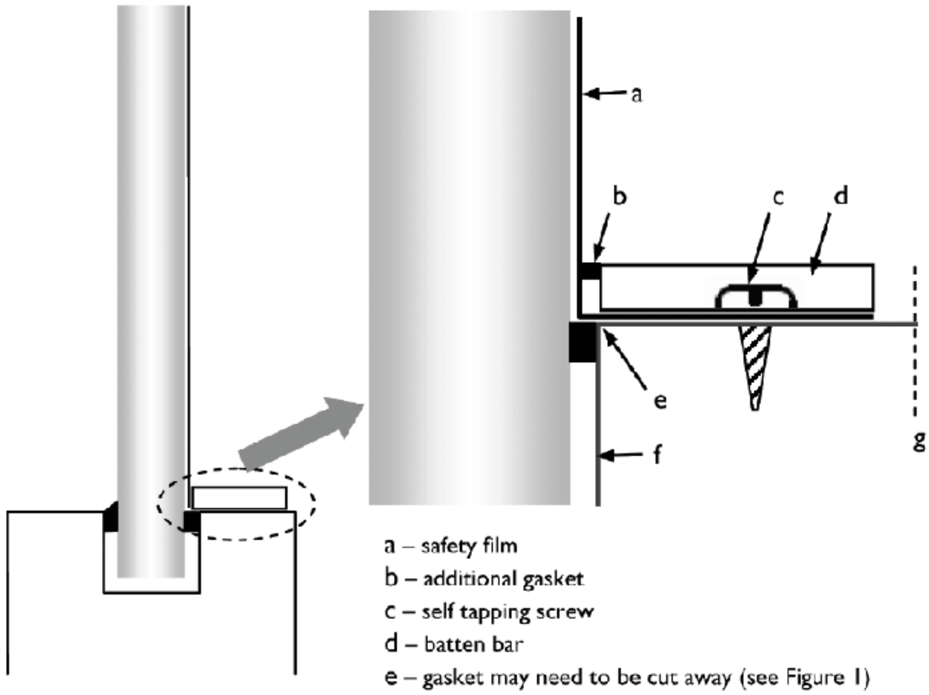
**GGF Data Sheet 5.18.8** Adhesive backed Polymeric Film-Guidelines for Installation on Existing Glazing

**Figure 3:** Example of a mechanically or adhesively fixed batten bar containment system




a – batten bar
b – double sided adhesive tape
c – safety film
d – double sided adhesive tape (optional)
e – self tapping screw (omitted for adhesively fixed batten bars)
f – frame
g – limit of frame ≥ limit of batten bar

**Figure 4:** Example of a mechanically fixed batten bar containment system on framed glazing (see Figure 5c for close-up schematic)




a – safety film
b – additional gasket
c – self tapping screw
d – batten bar
e – gasket may need to be cut away (see Figure 1)
f – frame
g – limit of frame ≥ limit of batten bar

**Figure 5:** Schematic diagrams of mechanically and adhesively fixed batten bar containment systems

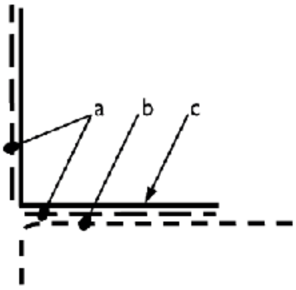



**Figure 5a**: Steel plate batten bar – various profiles are possible (see also Figure 3)

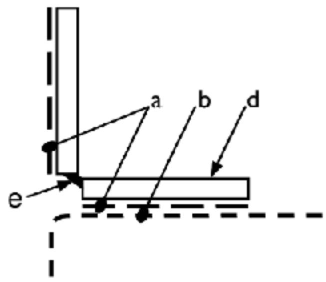



**Figure 5b**: Plastic batten bar (see also Figure 3)

- a double sided self-adhesive tape
- b frame
- c L shaped metal batten bar
- d plastic batten bar with plastic join
- e plastic join ('hinge')
- f additional rubber gasket
- g shaped metal batten bar
- h specially formed curve on batten bar to avoid cutting into film
- i self tapping screw
- J decorative metal clip to cover batten bar
- x plastic version is hinged between points x

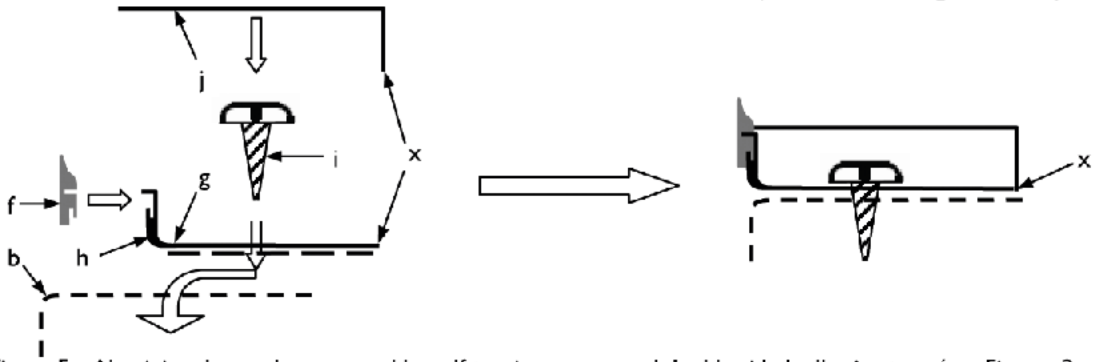
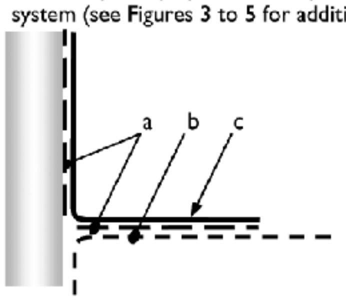



**Figure 5c:** Aluminium batten bar, secured by self tapping screws and double sided adhesive tape (see Figures 3 and 4); a plastic version is identical except there is a hinge joining the two sections at points x

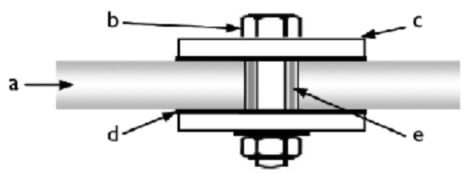
**Figure 6:** Example of polyester or acrylic tape containment system (see Figures 3 to 5 for additional details)




- a double sided self-adhesive tape
- b frame
- c polyester or acrylic tape

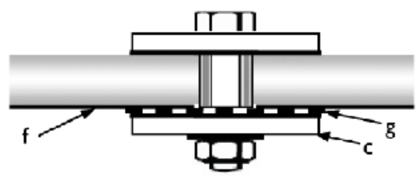
**Figure 7:** Example of installing film on bolted glazing

**Figure 7a** No safety film installed




a – Glass
b – Bolt
c – Metal plate
d – Fibre gasket (incompressible)
e – Nylon bush
f – Safety film
g – Structural washer

**Figure 7b** Safety film installed




Note: Some structural washer systems use a thin plastic spacer between the structural washer and the metal retaining plate

5.18.5 May 2016

# GGF Data Sheet: Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Test Method

### Contents



### Introduction

This standard has been developed by the GGF Window Film Group, in association with all major film manufacturers, to clarify the recommendations concerning the use of adhesive backed polymeric film applied to glass in the overhead position for the containment of glass in the event of failure.

It is the second of two documents, the first of which describes the different types of adhesive backed polymeric films and containment systems (see GGF Data Sheet 5.18.4 Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure:Types of Systems and Precautions in Use) and gives guidance on their selection.

### 1. Scope

This standard describes a test method for adhesive backed polymeric film ("film") and containment systems used on non-vertical overhead glazing. The aim is to evaluate the reduction of risk in the event of glass failure. It is based upon a load uniformly applied to a horizontal test piece. Testing must be carried out by an independent test laboratory such as the GGF test facility.

### 2. Definitions and Description

**2.1** See GGF Data Sheet 5.18.3 Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions and Components.

**2.2** Detachment

Separation of the containment system from the frame or from the test sample.

**2.3** Minor detachment

A length of separation < 1/3 of the edge length.

**2.4** Major detachment

A length of separation < 1/3 of the edge length.

### 3. Test Conditions

**3.1** The following minimum conditions must be met:

- The film has been installed according to the manufacturer's recommendations
- Water condensation is not present on the film surface during cure or during the test
- Test room temperature is 20 ± 5 °C

### 4. Test Equipment

**4.1** General equipment:

- Thermally toughened sodium silicate safety glass, in accordance with BS EN 12150, 10 ± 0.3 mm x 2500 ± 5 mm x 1500 ± 5 mm (nominal mass: ~94 kg)
- Standard mild steel frame with a rubber gasket for retaining the toughened glass with 19 ± 2 mm edge cover, representing a normal dry glazing system (Figure 1), or
- Steel supporting frame of sufficient robustness to securely hold the glazing / frame (Section 4.2) in a horizontal position at 800 ± 100 mm above the ground
- White witness sheet of < 3000 mm x 2000 mm dimensions (card or thick paper are suitable)
- Sand for adding load to glazing (400 kg in 10 kg sacks is suitable)

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- Centre punch
- 1200 mm spirit level
- Tape measure
- Mechanical lifting apparatus
- Calibrated micrometer
- Digital camera

NOTE: Due to the weight of the toughened glass, the frame and support frame, they must be transported and positioned by mechanical means.

### 4.2 Glazing

The glass may be held in place in a variety of ways; for the purposes of this test method, two systems are defined:

**4.2.1** A mild steel frame with rubber gasket and sufficient dimensions, including return, for the installation of the toughened glass pane and a containment system. The frame may provide either two or four edged support for the toughened glass.

**4.2.2** A system of securing the mild steel frame (Section 4.2.1) to the steel supporting frame (Section 4.1) is also required, e.g. scissor clamps or bolts.

## 5. Principles of Test

**5.1** The test allows a safety film and containment system applied to glass to be tested. There are four levels of test (see Table 1).

| Film thickness, t | Typical cure times/days |
|---|---|
| t ≤ 100 μ | ≥ 30 days |
| 100 < t ≤ 200 | ≥ 60 days |
| 200 < t ≤ 300 | ≥ 90 days |
| t > 300 | 100+ days† |

**Table 1:** Typical cure times

† The manufacturer will provide the minimum time period required.

**5.2** A serviceable imposed uniform load of 100 kg is used as an equivalent to snow loading for the UK. An imposed uniform load of 400 kg is used as an equivalent to snow loading plus intermittent wind loading for the UK. This simulates a 'worst case' situation where the glass fails, a snow loading is present, and an intermittent wind loading occurs.

**5.3** The self weight, snow loading, and snow loading plus intermittent wind loading tests are carried out consecutively on the same test piece.

## 6. Test Setup

The test piece is made from the toughened glass pane, the safety film, and the containment system.

### 6.1 Safety film

Install the safety film to the toughened glass according to the manufacturer's recommendations and leave to cure in well ventilated conditions and for the appropriate times (Section 3). Ensure the film will not be held within the rebate of the steel frame if this frame is to be used; the film edge shall be installed to within 1 mm +0.0 / -0.5 mm inside the sight line of the frame. If bolts are to be used the safety film shall be installed to within 1 mm +0.0 / -0.5 mm of all glass edges including the bolt holes.

### 6.2 Securing the glass

Install the toughened glass + safety film into the steel frame or attach the bolts (Section 4) to the corner holes in the toughened glass + safety film, with edge cover of 19 ± 2 mm.

NOTE: If the film is installed after glazing, ensure that the appropriate tolerances and cure time are met (Section 5.1).

### 6.3 Containment system

**6.3.1** Install the containment system according to the manufacturer's recommendations. For some containment systems, particularly the structural silicone and batten bar systems, the gaskets may need to be positioned so that the containment system can be installed correctly.

**6.3.2** For adhesively fixed batten bar containment systems, ensure the batten bar has a suitable cross section profile and is installed so that one flat surface contacts the safety film and one flat surface contacts the frame; the batten bar is normally a simple L shaped profile but other profiles can be used.

**6.3.3** For adhesively fixed batten bar containment systems, the batten bar should have sufficient contact with both the frame and safety film in order to meet current test standards.

**6.3.4** For all batten bar containment systems, the batten bar should not extend past the frame.

**6.3.5** For structural silicone glazing, the width of contact between the silicone and the safety film and between the silicone and the support frame shall be < 10 mm; the cross section shall be triangular.

**6.3.6** For 4 edged supported glazing, the containment system must be applied to at least two parallel edges; normally the containment system is applied to all four edges.

**6.3.7** For 2 edged support glazing, the containment system must be applied to two parallel edges.

**6.3.8** Leave the completed test piece for the time recommended by the manufacturer of the containment system. Condition the test piece at 20 ± 5 °C for at least 24 hours immediately prior to test.

NOTE: For example, structural silicone systems normally take longer than batten bar systems due to their different curing characteristics.

**6.4** Place the witness sheet underneath the support frame on the floor level with the centre of the witness sheet approximately where the centre of the installed test piece will be, and secure to the floor.

### 6.5 Positioning the test piece

**6.5.1** Ensure that when installed upon the supporting frame, the test piece will be 5 ° from horizontal in both longitudinal and transverse directions and at 800 ± 100 mm from floor level Ensure that no obstructions are present beneath or immediately around the support system.

**6.5.2** Lift the test piece into position by mechanical means and attach it securely to the steel support frame ensuring the safety film side is facing downwards.

NOTE: Do not allow any part of your body to pass underneath the test piece during or after installation to avoid injury in case the test piece is accidentally dropped. Likewise, ensure that other people present are not exposed to this risk.

**6.5.3** When using the steel frame, place the spirit level midway along a long dimension on the frame holding the toughened glass, and check that this is horizontal to < 5 ° adjusting if necessary; repeat for the other long dimension then the two short dimensions. Make a final check on all four sides to ensure that no movement away from horizontal has occurred during the levelling process.

**6.6** Sweep the witness sheet clean of any debris prior to the test using a long handled broom.

NOTE: The witness sheet may be re-used for subsequent tests if it has no or only minor damage.

**6.7** Check that the temperature in the test room is 20 ± 5 °C.

## 7. Classification

### 7.1 Fragmentation

If the test piece does not exhibit the fragmentation pattern in accordance with BS EN 12150-1, no classification is possible.

### 7.2 Self weight

If, after testing according to Sections 8.2 to 8.4.5, the test piece meets the criteria in 9.2 and 9.3 it is classified as Class A.

### 7.3 Snow load

If, after testing according to Sections 8.2, 8.3 and 8.5, the test piece meets the criteria in 9.2 and 9.3 it is classified as Class B.

### 7.4 Snow load plus intermittent

Wind Load If, after testing according to Sections 8.2, 8.3, 8.5 and 8.6, the test piece meets the criteria in 9.2 and 9.3 it is classified as Class C.

### 7.5 Weather tightness

If the test piece is a framed system, and if the test piece meets the criteria in Section 9.2 but with no detachments, it is further classified as Class WT.

NOTE: WT can be applied to any of the three classes, e.g. A/WT.

- Classification Class A, B or C and, if applicable, Class WT (Section 10)
- Deviations from the test method and an explanation of why they were done

## 8. Test Method

**8.1** In order to ensure the test report is comprehensive, i.e. fully describes the test piece, take sufficient digital photographs immediately prior to commencement of the test to clearly show the safety film, the type of containment system used, and the method(s) of installation of both the safety film and the containment system within the test piece. Take additional digital photographs during each stage of the test and at test completion to clearly show the reaction of the structure to the loading and any debris that has fallen onto the witness sheet.

**8.2** Break the toughened glass using a centre punch on the un-filmed glass surface of the panel immediately adjacent to the centre of one of the long edges.

**8.3** Leave the test piece for ten minutes after breakage and check the fragmentation. If the fragmentation does not show the required pattern as in BS EN 12150 Part 1, the test shall be terminated and a new test piece used.

| Loading | Class |
|---|---|
| Self weight | A |
| Self weight plus snow load | B |
| Self weight plus now load plus intermittent window load | C |

**Table 2:** Loading type and classification

**8.4** Self weight – 72 hour test

NOTE: If the manufacturer wishes to claim a Class B, then the requirements of Class A can be ignored (proceed to Section 8.5).

**8.4.1** When using the steel frame, note any glass fragments that have separated from the test piece and passed through the safety film and/or containment system and have fallen onto the witness sheet.

**8.4.2** Note any minor and major detachments of the safety film from the containment system and any minor and major detachments of the containment system from the frame.

**8.4.3** If glass fragments have passed through the safety film and/or the containment system and fallen onto the witness sheet (Section 8.4.1), or more than two minor detachments and / or any major detachments are present (Section 8.4.2), stop the test and record a failure for the imposed load.

**8.4.4** Maintain the test piece in position for 72 hours and repeat evaluation every 24 hours, sweeping the witness sheet clean (Section 6.6) after each evaluation (Sections 8.4.1 to 8.4.3).

**8.4.5** If the test piece passes the test (Section 9), then proceed to 8.5.

**8.5** Snow load – 72 hour test.

**8.5.1** If the self load test is omitted, follow the procedure in 8.1 to 8.3.

**8.5.2** Uniformly position 10 x 10 kg sand bags (= 100 kg) over the broken pane to give a total loading of ~194 kg, and leave for 10 minutes. Sand bags are to be placed gently withou any impulse loading within a maximum period of 5 minutes.

**8.5.3** Repeat 8.4.1 to 8.4.5.

**8.5.4** If the test piece passes the 72 hour snow loading test, testing may be extended for snow load plus intermittent wind load (Section 8.6).

Note: Do not allow any part of your body to pass underneath the test piece during the test to avoid injury in case the test piece fails. Likewise, ensure that other people present are not exposed to this risk.

**8.6** Snow load plus intermittent wind load test – 30 second test

**8.6.1** Uniformly position 30 x 10 kg sand bags (= 300 kg) over the broken pane plus the 100 kg of sand bags from the snow load test to give a total loading of ~494 kg, and leave for 30 seconds. Sand bags are to be placed gently without any impulse loading within a maximum period of 5 minutes.

**8.6.2** Repeat 8.4.1 to 8.4.4.

**8.7** Film characterisation: Obtain a small piece of the safety film and measure its thickness in microns using a calibrated micrometer. Ensure that no contaminants are present to affect correct thickness measurement.

### 9. Test evaluation

**9.1** The test piece shall exhibit the fracture pattern expected of a thermally toughened soda lime silica safety glass complying with BS EN 12150-1.

**9.2** For any type of containment system, no glass fragments passing through the safety film and/or containment system are permitted.

**9.3** No more than 2 minor detachments are permitted in the test piece. No major detachments are permitted.

**9.4** After evaluation, the test piece shall be classified according to Section 7.

### 10. Test Report

The test report shall include the following:

- Date and time of commencement of the test
- Details of the test laboratory (name, address, etc.)
- Person(s) performing the test
- Temperature of the test area
- Description of the test piece (Section 5) including a full description of the containment system type, safety film type and, if available, product code, manufacturer and installer
- Film thickness in microns
- Digital photographs of the test piece clearly showing the safety film, the type of containment system, and the reaction of the structure to the loading (Section 8.1)
- Confirmation that the test piece has been conditioned for at least 24 hours at 20 ± 5 °C prior to test and that the test piece was < 5 ° from horizontal
- Installation dates of the film and containment system
- Observations made during the tests (Section 8)
- If the test was terminated part way through, the date and time of test termination and the reason(s) for termination

### 11. Certificate of Conformity

A certificate of conformity shall be issued by the GGF on proof of production of a suitable test report.

### 12. References

Current GGF Data Sheets for adhesive backed polymeric film are:

**GGF Data Sheet 5.18.1** Visual Quality for Adhesive Backed Polymeric Filmed Glass

**GGF Data Sheet 5.18.2** Installation Quality Standard for Applying Adhesive Backed Polymeric Film to Glass

**GGF Data Sheet 5.18.3** Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions and Components

**GGF Data Sheet 5.18.4** Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Types of Systems and Precautions in Use

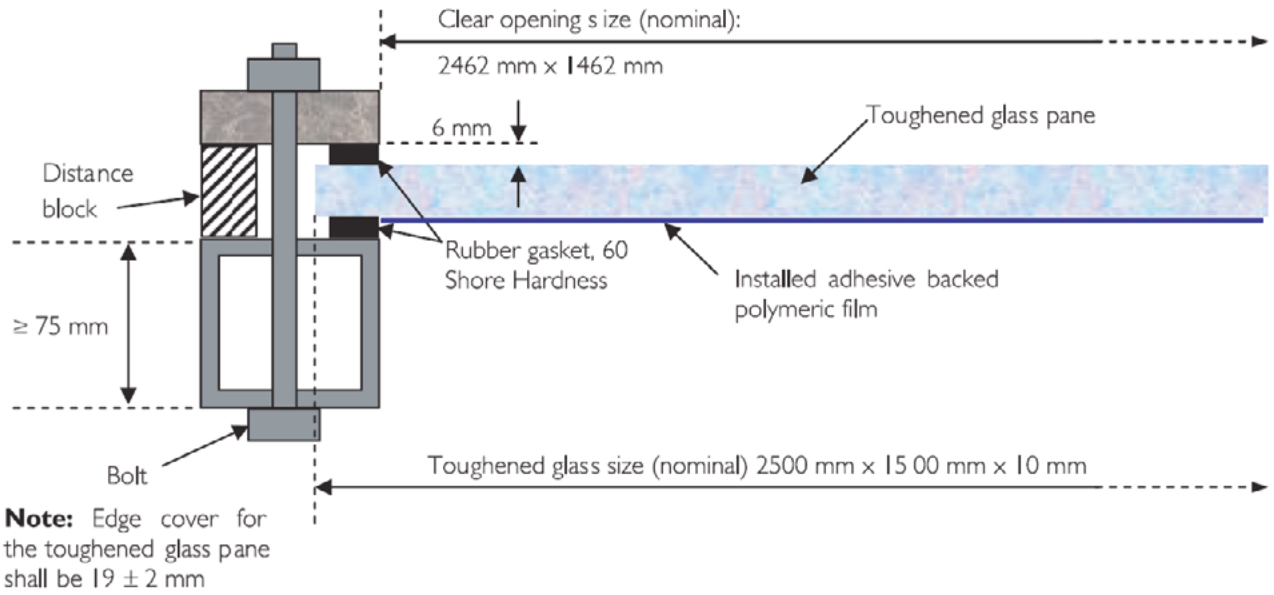
**GGF Data Sheet 5.18.5** Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Test Method

**GGF Data Sheet 5.18.6** GGF Recommendations for Blast Mitigation: Adhesive Backed Polymeric Film Applied to Glass

**GGF Data Sheet 5.18.7** Standard for On-Site Peel Adhesion Testing of Aged Adhesive Backed Polymeric Film Applied to Vertical Flat Glass

**GGF Data Sheet 5.18.8** Adhesive backed Polymeric Film- Guidelines for Installation on Existing Glazing

**Figure 1:**
Example of suitable glazing frame for containment testing



# GGF Data Sheet: Recommendations for Blast Mitigation: Adhesive Backed Polymeric Film Applied to Glass

5.18.6 May 2016

**Contents**



**Introduction**

This standard has been developed by the GGF Window Film Group, in association with all major film manufacturers, to clarify recommendations concerning the use of safety film applied to glass for blast mitigation purposes.

**1. Scope**

This standard gives recommendations for the use of adhesive backed polymeric safety film ("safety film") applied to glass for reducing the risk of injury from glass shattered in an explosion. It does not give guidance concerning peel testing of aged safety film (see GGF Data Sheet 5.18.7 Standard for On-Site Peel Adhesion Testing of Aged Adhesive Backed Polymeric Film Applied to Vertical Flat Glass).

**2. Definitions and Description**

**2.1** See GGF Data Sheet 5.18.3 Recommendations for Adhesive backed polymeric Film Applied to Glass: Definitions, Descriptions and Components.

**2.2** Blast mitigation reduction of injuries, property damage and business disruption resulting from glass breakage under explosive pressure.

**3. Hazard Rating / Threat Levels**

**3.1** Systems of Hazard Rating of the risks from shattered glass in an explosion have been developed by the UK Government and other organisations based upon decades of explosion testing, and are being incorporated into international standards such as ISO/DIS 16933.

**3.2** Figure 1 shows the Hazard Rating system from draft standard ISO 16933. ISO 16933 uses a range test with 3 m deep test cubicles. Areas defined within the cubicle classify different hazard levels.

**3.3 Explosion properties**

It can be difficult if not impossible to define exactly the specific properties and effects an explosion may have on particular buildings and structures around them. However, extensive research has developed substantial practical and theoretical understanding of explosions, allowing protective measures to be taken in order to reduce the effects of explosions to be made with confidence.

**3.4 Threat levels**

Two levels of the potential threat of an explosion have been established: Low Threat and High Threat.

Low Threat is for buildings where there is a significant risk of a nearby explosion of approximately a satchel bomb size.

High Threat is for buildings where there is a significant risk of a nearby explosion of approximately a van sized bomb.

Although these definitions are given in terms of improvised explosive devices, corresponding definitions can be extrapolated for explosion threats from other sources, e.g. oil refinery plant.

**3.5** Recommendations for the use of safety film at these threat levels are given in Section 5.

**4. Risk Reduction with Safety Film**

**4.1** Safety films on annealed glass are intended to reduce High Hazard to Low Hazard or Very Low Hazard. Safety film on annealed glass with specifically designed containment systems can further improve the performance to Minimal Hazard or No Hazard.

(Figure 1 and Section 6)

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### 4.2 Risk Assessment

**4.2.1** A professional Risk Assessment is required to establish the risks for man explosion for a particular building. This will be dependent upon criteria including the glazing and glass types, size and thickness, the assessed threat, the building location, the building environment, and the usage of the building. The Risk Assessment will also identify the measures required for reducing the risks for man explosion. Installation of safety film is only a part of the overall strategy for protecting people and property in an explosion.

**4.2.2** For specification of safety film, building owners and managers very often select the appropriate safety films based upon a High Threat (see Section 3.4), principally because many at risk buildings are in major cities and are close to potential 'targets'. In addition, the cost penalty for the increased protection of higher performing is relatively small.

### 5. Recommended Safety Films for Blast Mitigation

**5.1** The recommendations given below are the minimum levels of protection to be employed against both threat levels (Section 3.4). They are based upon the current Home Office Scientific Development Branch (HOSDB) recommendations and publications and the current understanding of the effects of an explosion on glass.

**5.2** Safety films for blast mitigation are recommended based upon their performance. This generally means that as film thickness increases, so does film performance, although the expectation is that technology improvements may result in higher performing products without always an increase in thickness.

**5.3** These recommendations are not intended to substitute for a professional Risk Assessment but can be used to quickly decide the minimum specification of safety film required for the threat level (Section 3.4).

### 5.4 Recommendations for buildings at Low Threat

The recommendations for use of safety film for a Low Threat from an explosion are given in Table 1.

| Floor level | Typical cure times/days |
|---|---|
| All floors | Safety film ≥ 100 microns and meeting BSEN 12600 Class 2B2 |

**Table 1:** Low Threat: Safety film recommendations for all pane sizes and thicknesses

### 5.5 Recommendations for buildings at High Threat

**5.5.1** The recommendations for use of safety film for a High Threat for man explosion and where pane size ≤ 3 m² and pane thickness ≤ 6 mm are given in Table 2.

| Floor level | Recommendation |
|---|---|
| Ground – 11th | Safety film ≥ 150 microns and meeting BS EN 12600 Class 1B1 |
| 12th and over | Safety film ≥ 100 microns and meeting BS EN 12600 Class 2B2 |

**Table 2:** High Threat: Safety film recommendations for panes ≤ 3 m² & ≤ 6 mm

**5.5.2** The recommendations for use of safety film for a High Threat for man explosion and where pane size > 3 m² and/or pane thickness > 6 mm are given in Table 3.

| Floor level | Recommendation |
|---|---|
| Ground – 1st | Safety film ≥ 275 microns and meeting BS EN 12600 Class 1B1 |
| 2nd – 11th | Safety film ≥ 150 microns and meeting BS EN 12600 Class1B1 |
| 12th and over | Safety film ≥ 100 microns and meeting BS EN 12600 Class 2B2 |

**Table 3:** High Threat: Safety film recommendations: panes > 3 m² and/or > 6 mm

### 5.6 Recommendations for internal glass partitions

The recommendations for use of safety film for internal glass partitions are given in Table 4. For internal insulating glass units, it may be necessary to treat both sides with safety film.

| Floor level | Recommendation |
|---|---|
| All floors | Safety film ≥ 100 microns and meeting BSEN 12600 Class 2B2 |

**Table 4:** Internal glass partitions: Safety film recommendations for all pane sizes and thicknesses

### 5.7 Recommendations for secondary glazing

The recommendations for use of safety films where the window consists of two separate frames and where both frames can be accessed independently (e.g. as in secondary glazing) are given in Table 5.

| Glazing | Recommendation |
|---|---|
| Primary | As in Sections 5.4 to 5.5 |
| Secondary | Safety film 100 microns and meeting BSEN 12600 Class 2B2 |

**Table 5:** Secondary and similar glazing: Safety film recommendations for all pane sizes and thicknesses

**5.8** It is possible to obtain a different classification for a safety film on one thickness of float glass than for the same film on a different thickness of float glass. Therefore, classification to BS EN 12600 for safety film means that:

- The specific safety film has been independently tested as a safety film + float glass composite and meets the stated BS EN 12600 classification.
- Glass thickness is the same as that to be treated.
- The exception to the above is that occasionally glass > 6 mm may require protection, but independent testing to BS EN 12600 may not have been carried out for the specified film on the thicker glass. In these cases, it is normal to accept that testing on thinner glasses is sufficient evidence to demonstrate adequate performance. A film of at least 150 microns thickness is recommended. However, the client must decide whether further testing is needed to demonstrate BS EN 12600 performance for the particular film + glass thickness composite.

**5.9** These recommendations are generally for monolithic glass. Laminated glass may be treated with safety film for blast mitigation and to reduce spalling.

**5.10** It is important to check whether there are any other requirements when installing safety film, e.g.marking of safety glazing required in BS 6262-4.

### 6. Containment Systems

A containment system is designed to attach the safety film to the glazing bar, glazing system or frame.The use of a containment system with safety film can further reduce the risks from glass shattered in an explosion.

See GGF Data Sheets 5.18.4 Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure:Types of Systems and Precautions in Use, and 5.18.5 Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure:Test Method.

### 7. Additional Notes

**7.1** Independent testing has shown the efficacy of safety films for protection in an explosion. As with all safety products, correct installation is essential. It is therefore very important to use a professional installation company with an appropriately trained and experienced work force.

**7.2** The cure time should not be confused with time to achieve a level of performance. For example, with good installation, performance against impact to BS EN 12600 maybe achieved within one or two days of installation for many safety films.

**7.3** Peel adhesion testing is recommended for both newly installed and cured safety film and for aged safety film.

See GGF Data Sheet 5.18.7 Standard for On-Site Peel Adhesion Testing of Adhesive Backed Polymeric Film Applied to Vertical Flat Glass.

### 8. References

### 8.1 Standards

**European Standard**

**EN 12600** Glass in building – Pendulum test – Impact classification for flat glass

**International Standard**

**ISO 16933** Glass in building - Explosion-resistant security glazing - Test and classification by arena air-blast loading

### 8.2 GGF Data Sheets

Current GGF Data Sheets for adhesive backed polymeric film are:

**GGF Data Sheet 5.18.1** Visual Quality for Adhesive Backed Polymeric Filmed Glass

**GGF Data Sheet 5.18.2** Installation Quality Standard for Applying Adhesive Backed Polymeric Film to Glass

**GGF Data Sheet 5.18.3** Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions and Components

**GGF Data Sheet 5.18.4** Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure:Types of Systems and Precautions in Use

**GGF Data Sheet 5.18.5** Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure:Test Method

**GGF Data Sheet 5.18.6** Recommendations for Blast Mitigation: Adhesive Backed Polymeric Film Applied to Glass

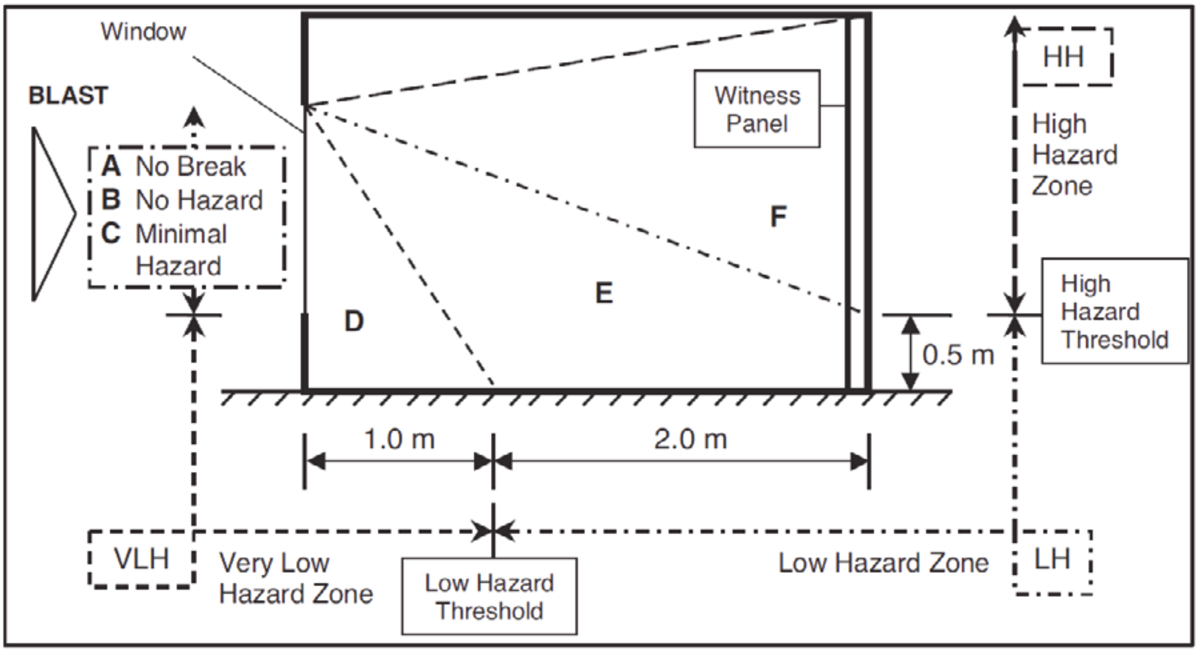
**GGF Data Sheet 5.18.7** Standard for On-Site Peel Adhesion Testing of Aged Adhesive Backed Polymeric Film Applied to Vertical Flat Glass

**GGF Data Sheet 5.18.8** Adhesive backed Polymeric Film-Guidelines for Installation on Existing Glazing

### 9. Acknowledgement

The Home Office Scientific Development Branch (HOSDB) has provided valuable assistance and advice in preparation of these recommendations.

**Figure 1:**
Hazard Ratings in relation to a typical test cubicle; refer to the (draft) standard ISO/DIS 16933 for a fuller description.



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# GGF Data Sheet: Standard for On-Site Peel Adhesion Testing of Aged Adhesive Backed Polymeric Film Applied to Vertical Flat Glass

5.18.7 May 2016

**Contents**



## Introduction

This standard has been developed by the GGF Window Film Group, in association with all major film manufacturers, to provide a common basis for on-site peel testing of adhesive backed polymeric safety film.

## 1. Scope

This standard specifies a test method for on-site 180 ° peel adhesion of aged adhesive backed polymeric safety film ("safety film") of thicknesses < 230 microns applied to flat, vertical architectural glass.

The on-site 180 ° peel test is to be used to determine the ongoing behaviour of the adhesive system on applied adhesively backed polymeric safety film that has been subject to natural ageing.

This test method is not applicable to films > 230 microns since the peel angle can be substantially less than 180 ° and peel test results (static and dynamic) can be extremely variable.

**NOTE: Peel testing of newly applied adhesive backed polymeric film is not appropriate as there is no direct relationship between performance according to BS EN 12600 and the results of peel testing.**

## 2. Definitions and Description

**2.1** See GGF Data Sheet 5.18.3 Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions and Components.

### 2.2 Aged adhesive backed polymeric film

Film is classed as aged only when the manufacturer's warranty has expired.

### 2.3 Embrittlement

Embrittlement is easy and repeated breakage of an adhesive backed polymeric film during preparation of a test strip or during peel testing; it is usually shown by aged safety film.

### 2.4 Adhesive odour

An aged safety film may have significant odour due to degradation of its components by sunlight; it is particularly strong as an aged film is peeled from the glass.

### 2.5 Discolouration

Significant yellowing of an aged safety film compared to new film.

**NOTE: Discolouration should not be confused with differences in film properties caused by slight lightening of a combined solar control-safety film during ageing, small batch-to-batch variations during manufacture (e.g. visible light transmission), and similar phenomena.**

### 2.6 Adhesive distortion

Obtrusive distortion of objects viewed through an aged safety film.

### 2.7 Adhesive failure:

Peeling/Bubbling Separation of an aged safety film from the glass at its corners / edges (peeling) or elsewhere (bubbles) is evidence of adhesive degradation.

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### 2.8 Buildings at Low Threat / High Threat

For these definitions, please refer to GGF Data Sheet 5.18.6 Recommendations for Blast Mitigation: Adhesive Backed Polymeric Film Applied to Glass.

### 3. Test Conditions

**3.1** Peel testing is done under the environmental conditions existing at the time of the test.

**3.2** The test shall only be performed when the following conditions are satisfied:

- The glass pane is vertical
- The glass pane is < 425 mm high and ≥ 150 mm wide
- The drop from the bottom of the test strip to the floor is equal to or greater than the sum of the length of the test strip plus 250 mm
- The film thickness is < 230 microns
- The peel test angle is < 160 °; ledges or other obstructions must not reduce the peel test angle to < 160 °
- Water condensation is not present on the film surface (Section 5.2, note)

NOTE 1: **If all panes are < 150 mm wide, the method described here may be adapted by using a spring balance to estimate peel test data. The exact method should be agreed with the client in advance of peel testing.**

NOTE 2: **In addition, it is preferable that panels selected for testing are sufficiently wide to allow two peel tests to be performed per panel.**

**3.3** One peel test shall be performed per elevation of installed safety film or per 500 m² of installed safety film, whichever is greater.

**3.4** If failures are found, the number of peel tests is increased in order to determine whether only part or all of the installed film requires replacing. Up to one peel test per 50 m² of installed film may be required.

### 4. Test Equipment

**4.1** The on-site peel test equipment shall include the following items:

- A clip of 20 ± 5 g, used to affix the test weights to the test strip
- Two steel weights of 250 ± 10 g
- A steel weight of 700 ± 10 g
- A steel weight of 800 ± 10 g
- Stopwatch measuring to tenths of a second or better
- Straight edged ruler
- Sharp thin bladed knife, e.g. a craft knife with snap-off blades; the blades must not scratch the glass (stainless steel blades are recommended)
- Calibrated micrometer
- Spring balance measuring 0 - 4000 g with an accuracy of ± 100 g, e.g. a fisherman's spring balance

**4.2** The weights shall be suitably certified and of a shape and size to ensure that the peel angle is < 160 °, and that glazing panels of < 150 mm width can be tested.

NOTE: **The steel weights usually have hooks to hang them onto the clip; the weight of these hooks should be included as part of the steel weight. Alfred Woods & Co. of Mitcham, Surrey has a suitable test kit available. This should not be taken as an endorsement by the GGF of this product.**

### 5. Preparation of Test Strips

**5.1** Ensure the test conditions in Section 3 are met. Note both glass and room temperatures and the environmental conditions; especially check that the film is fully cured, the peel angle is always < 160 ° during the test, and the distance from the bottom of the test strip to the floor allows the weights to hang freely.

**5.2** Check that the installed safety film is undamaged and is free from defects that will affect adhesion e.g. water condensation and particulates.

NOTE: **Substantial water condensation can cause the adhesive to be constantly wet, resulting in reduction or complete loss of adhesive strength. Peel testing is therefore only valid where condensation is generally not present; condensation over occasional short periods of time of < 1 hour is acceptable provided that the film is fully cured, ventilation and temperature allow the condensation to dry quickly, and peel testing is not done on panels where condensation is currently present.**

**5.3** Do not pre-treat the installed film prior to testing, e.g. do not squeegee the film before testing to increase adhesion. Exceptionally, where the surface of the film is very dirty, the film may be cleaned but at least 24 hours is required for the film to dry prior to the peel test.

**5.4** Ensuring all film layers are completely cut through to the glass surface, cut a 25 ± 1 mm wide vertical test strip into the safety film, preferably < 200 mm away from the vertical edges of the test panel.

If a 200 mm distance is not viable, cut the strip close to the vertical centre line of the glazing; allow sufficient distance from the vertical edges of the panel for the test weights to hang freely (usually < 70 mm). If the test weights do not hang freely, a different test panel must be used.

NOTE: **If the thickness of the film is already known, the thickness of the test strip may be measured at this point rather than at section 7.11 to verify that all layers in the safety film have been completely cut through.**

**5.5** The strip shall be at least 400 mm long and preferably 600 mm long. Cut a line at ~ 45 ° to the horizontal across the top of the strip.

**5.6** Mark a horizontal line next to and at the bottom of the test strip ($m_3$ in Figure 1).

Place similar marks next to the test strip at 100 mm, 200 mm and 300 mm up from this initial mark (marks $m_0$, $m_1$ and $m_2$ in Figure 1) giving a total length for the dynamic peel test of 300 mm in 100 mm increments.

**5.7** Carefully commence manual peeling of the top part of the test strip from the glass. A sharp stainless steel blade may be required to start the peel but care should be taken to avoid damaging the glass. Peel about 100 mm of the test strip from the glass, ensuring the line of adhesive peeling is < 25 mm from $m_0$

(Figure 1); if the strip is limited in length, less than 100 mm may be used to attach the clip but the line of adhesive peeling must be < 25 mm away from mark $m_0$.

**5.8** Wrap the peeled film around the clip, ensuring that it is firmly attached. Occasionally a staple may be needed for this purpose.

### 6. Static Peel Test

**6.1** Ensuring the line of adhesive peel is above mark $m_0$ (Figure 1), attach the weight specified in Table 1 to the clip, positioning the weight and clip such that no peel force is applied to the strip.

| State | Recommended weights |
|---|---|
| Aged safety film – low threat | 250 g |
| Aged safety film – high threat | 500 g |

**Table 1:** Recommended weights for static peel testing of safety film

**6.2** Make any minor adjustments so that the line of adhesive peeling from the glass is horizontal (Figure 1).

**6.3** To apply the static peel force to the test strip, position the weight so that it will have no movement at the moment of release (slight tension on the test strip is usually needed), keep it perfectly still and in position for 5 seconds, and then gently release the weight.

**NOTE: It is advised that you are ready to catch the weight in case fast peeling of the test strip occurs – it is best to position your hands immediately beneath the weights.**

**6.4** Closely observe the test strip for any movement or 'creep', then remove the test weight and record the results.

### 7. Dynamic Peel Test

**7.1** Ensuring the line of adhesive peel is above mark $m_0$, attach the lowest weight specified in Table 2 to the clip, positioning the weight and clip such that no peel force is applied to the test strip.

| State | Recommended weights |
|---|---|
| Aged safety film – low threat | 250 g<br>700 g |
| Aged safety film – high threat | 700 g<br>950 g<br>1300 g |

**Table 2:** Recommended weights for dynamic peel testing

**7.2** Check that the weight used gives at least slow 'creep' of the film. If the specified weight does not cause peeling of the film, incrementally increase the weight using Table 2 to obtain at least a slow 'creep'.

**7.3** If the maximum weight from Table 2 does not cause peeling of the film, incrementally increase the weight using Table 3 to obtain at least a slow 'creep'. If no peeling occurs at the maximum weight given, use the spring balance test method (Section 7.9).

| State | Incremental weights (use in the order shown) |
|---|---|
| Aged safety film – low threat | 950 g, 1050 g, 1300 g, 1500 g, 1750 g & 2000 g |
| Aged safety film – high threat | 1500 g, 1750 g & 2000 g |

**Table 3:** Sequence for increasing weights for dynamic peel testing after maximum recommended weight has been reached

**7.4** Make any minor adjustments so that the line of adhesive peeling from the glass is horizontal (Figure 1).

### 7.5 Zero the stopwatch.

**NOTE: Optionally, the weight may be attached at this point in the procedure to test the first 100 mm increment; however, ensure the line of peeling remains horizontal and aligned with the appropriate mark, and that no peel force is applied to the test strip before the test begins.**

**7.6** Keeping the line of adhesive peeling horizontal, manually peel the test strip down the glass pane until the line of adhesive peel is exactly aligned with the top mark ($m_0$ in Figure 1). Once this operation is completed, ensure that no peel force is placed on the test strip so that the line of adhesive peeling remains aligned with the mark.

**7.7** To apply the dynamic peel force to the test strip, position the weight so that it will have no movement at the moment of release, i.e. so that movement of the weight occurs only by the effect of gravity (slight tension on the test strip is usually needed). Keep the weight perfectly still and in position for 5 seconds, and then gently release the weight, starting the stopwatch at the same time.

**NOTE 1: It is advised that you are ready to catch the weight in case fast peeling of the test strip occurs – it is best to position your hands immediately beneath the weights.**

**NOTE 2: The strip may stop peeling if it has not been cut through, if peeling stops, immediately remove the weights and stop the stopwatch. Note the time taken and re-cut the strip on both sides. Replace the weights on the clip, recommence the peel and restart the stopwatch. If there is any uncertainty about the validity of the test, especially if the time for a 100 mm increment is close to 20 seconds or if the time for 300 mm is close to 60 seconds, repeat the test with a new test strip.**

**NOTE 3: The peel test is invalid if the weight is already moving when it applies force to the test strip because peel strength varies with the speed of testing.**

It is essential to ensure that no impetus is imparted to the weight as it is released.

### 7.8 Timing

Timing of the 100 mm segments and the total 300 mm distance for the dynamic peel test can only be done where at least slow 'creep' is present; the procedure above should be used to determine which weight gives the required movement.

**7.8.1** Note the time taken for the weight to peel the film over the first 100 mm increment (between marks $m_0$ and $m_1$ in Figure 1).

**7.8.2** If the time taken for the test strip to peel 100 mm is < 30 seconds for the first 100 mm increment, allow the strip to continue peeling for the other 100 mm increments between marks $m_1$ and $m_2$ and then between marks $m_2$ and $m_3$ (Figure 1), noting the time taken for each increment and the total time taken for the complete 300 mm length.

**7.8.3** If the peel rate is slow (> 30 seconds for the first 100 mm increment):

**7.8.3.1** Stop the dynamic peel after 30 seconds and gently lift the weight so that no peel force is applied to the test strip; note the length of the test strip that has peeled within the first 100 mm increment (between marks $m_0$ and $m_1$ Figure 1).

**7.8.3.2** If the peel rate is > 30 seconds for the first 100 mm increment, stop the stop watch and repeat Section 7.2 to 7.8.3.1 between marks $m_1$ and $m_2$ and then between marks $m_2$ and $m_3$ (Figure 1).

**7.8.4** If the specified weight does not cause peeling of the film, incrementally increase the weight using Table 3 to obtain at least a slow 'creep'. If no peeling occurs at the maximum weight, use the spring balance test method (Section 7.9).

**NOTE: If the peel rate changes from one 100 mm increment to another it may be necessary to adopt a mixture of the methods above.**

**7.9** If no peeling occurs with the weights, remove the weights leaving the spring clip in place. Attach one end of the spring balance to the clip ensuring the scale is visible. Align the direction of pull parallel to and close to the test strip so that the peel angle is ≤ 160 °. Pull the spring balance, slowly increasing the applied force, monitoring the reading on the scale.

Record the force required to produce peeling of the test strip such that the time for each 100 mm increment is ≥ 20 seconds; if the reading is > 4000 g without peeling record "> 4000 g".

**7.10** Remove the weights (or spring balance) and clip; record the results.

**7.11** Measure and record the safety film thickness using a calibrated micrometer. Ensure that no contaminants are present to affect correct thickness measurement.

**NOTE: As an approximation, it is possible to measure the total film thickness including adhesive and other coatings. The thickness of these coatings is not normally sufficient to make the total film thickness appear to be that of thicker safety films (e.g. a 100 micron safety film with coatings will not generally be close to the thickness of a 150 micron film)**

**7.12** If the total time is < 75 seconds, cut a similar test strip (as in Section 5) 50 to 200 mm from one vertical edge of the panel, allowing sufficient distance for the test weights to hang freely (usually < 70 mm). Test this second strip as described in

**7.1 to 7.10** If no panels are available of sufficient width then two adjacent panels may be tested instead of two tests on one panel.

**NOTE: It is possible to test safety film applied to sloping glazing and / or small pane sizes using a suitable spring balance and the principles described in this document, as long as the peel angle is > 160 °. The exact test procedure and pass/fail criteria should be agreed with the client prior to the test; this test procedure should include consideration of both the static peel test and dynamic peel test requirements.**

## 8. Additional Test Observations

**8.1** Note any adhesive peeling or bubbling, or film embrittlement.

**8.2** View the aged safety film in natural daylight (not direct sunlight) from a distance > 2 m and at an angle of < 30 ° from the perpendicular to the test pane.

To better see any distortion, look at objects through the film, not at the film itself. Note any particularly obtrusive distortion.

**8.3** Note any discolouration or adhesive odour.

**NOTE: Safety film has a small amount of natural adhesive distortion; this is not a defect but is a natural consequence of the high amounts of adhesive used to make these high performance products.**

## 9. Test Evaluation

**9.1** Static Peel Test (Section 6) – No significant movement is preferred but very slow 'creep' is allowed.

**9.2** Dynamic Peel Test, total time (Section 7): The time taken for the total 300 mm length shall be < 60 seconds. If the peel rate was slow and distances moved have been recorded, the total time for 300 mm will be < 90 seconds.

**9.3** Dynamic Peel Test, incremental times: The time taken for each of the 100 mm lengths shall be > 20 seconds; since initial peel rates can be slightly faster than normal, the time allowed for the first 100 mm increment is < 17.5 seconds as long as the total time (Section 9.2) is > 60 seconds. If the peel rate was slow and distances moved have been recorded, the time for every 100 mm increment will be < 30 seconds.

**9.4** Dynamic Peel Test – the film must peel when < 4000 g weight is used (Sections 7.9 - 7.10).

**9.5** Table 4 gives a summary of the above requirements.

| Peel test type | Requirement |
|---|---|
| Static | No movement preferred; very slow 'creep' is allowed |
| Dynamic, $m_0 - m_3$ | > 60 seconds |
| Dynamic, $m_0 - m_1$ | > 17.5 seconds |
| Dynamic, $m_1 - m_2$ & $m_2 - m_3$ | > 20 seconds |
| Dynamic | Must move with < 4000 g |

**Table 4:** Summary of the peel test requirements (see Figure 1 for marks)

**9.6** There shall be no embrittlement that makes the peel impossible to perform e.g. from repeated breaking of the test strip (Section 8.1).

**9.7** There shall be no adhesive bubbling or peeling (Section 8.1) and no obtrusive adhesive distortion (Section 8.2) present in any part of the test pane.

**9.8** Using the dynamic peel test data of aged film, the expected remaining lifetime can be taken from Table 5.

| Test Weight | Expected remaining lifetime for building at | |
|---|---|---|
| | Low Threat | High Threat |
| 500 g | 4 years | — |
| 700 g | 6 years | 2 years |
| 950 g | — | 4 years |
| ≥ 1300 g | — | 6 years |

**Table 5:** Expected lifetime of aged safety film

NOTE: Expected lifetime is indicative of the useful lifetime remaining in the safety film; it is subject to environmental conditions in future years and cannot be guaranteed.

**9.9** Discolouration and adhesive odourare allowed but these indicate film degradation and therefore a shorter expected remaining lifetime than those given in Table 5.

### 10. Test Report

**10.1** The test report shall include the following:

- Date and time of test

- Details of the testing organisation (name, address, etc.)

- Person performing the peel tests

- Film thickness in microns

- Film type and, if available, product code, manufacturer and installer

- Environmental conditions at the time of test e.g. sunny, cloudy, approximate glass temperature, room temperature

- Deviations from the test method, if any, and an explanation of why they were done

**10.2** The test report shall also include the following minimum details for each peel test performed:

- Precise location of the peel test (e.g. pane / window / elevation / floor)

- Static peel test results with the weights used (Section 6)

- Dynamic peel test results with the weights used, times taken / distances moved for each 100 mm increment, and, if applicable, total time for the 300 mm length (Section 7)

- The additional test observations for aged safety film (Section 8)

- Pass / Fail for static and dynamic peel testing, and for aged safety film (Sections 6 and 9)

- Recommendations for future peel testing

- The expected remaining lifetime for aged safety film from Table 5 (see also Section 9.9)

An example of a blank peel test record is shown in the Annex.

NOTE 1: Adhesive odour and film discolouration are indicative of film degradation but are not pass/fail criteria by themselves. Removal of aged safety film where significant adhesive odour is present should be done in well ventilated conditions; breathing apparatus and/or out of hours working may also be necessary.

NOTE 2: Film thickness is not a pass / fail criterion by itself. However, aged safety film may no longer meet the minimum specified performance and / or thickness requirements with respect to the threat to the building, e.g. for explosion protection.

### 11. Further peel testing

**11.1** Peel testing is a destructive test, so the tested panels will require replacement of the complete piece of film. Ensure that future peel tests do not test the panels previously tested.

**11.2** It is recommended to peel test between one to two years before the remaining lifetime of the film indicated from the dynamic peel testing (Section 7).

### 12. References

Current GGF Data Sheets for adhesive backed polymeric film are:

**GGF Data Sheet 5.18.1** Visual Quality for Adhesive Backed Polymeric Filmed Glass

**GGF Data Sheet 5.18.2** Installation Quality Standard for Applying Adhesive Backed Polymeric Film to Glass

**GGF Data Sheet 5.18.3** Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions and Components

**GGF Data Sheet 5.18.4** Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Types of Systems and Precautions in Use

**GGF Data Sheet 5.18.5** Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Test Method

**GGF Data Sheet 5.18.6** Recommendations for Blast Mitigation: Adhesive Backed Polymeric Film Applied to Glass

**GGF Data Sheet 5.18.7** Standard for On-Site Peel Adhesion Testing of Aged Adhesive Backed Polymeric Film Applied to Vertical Flat Glass

**GGF Data Sheet 5.18.8** Adhesive Backed Polymeric Film-Guidelines for Installation on Existing Glazing

### 13. Acknowledgement

The Home Office Scientific Development Branch (HOSDB) has provided valuable assistance and advice in preparation of this Data Sheet.

**Figure 1:**
On-site peel testing of adhesive backed polymeric safety film on glass

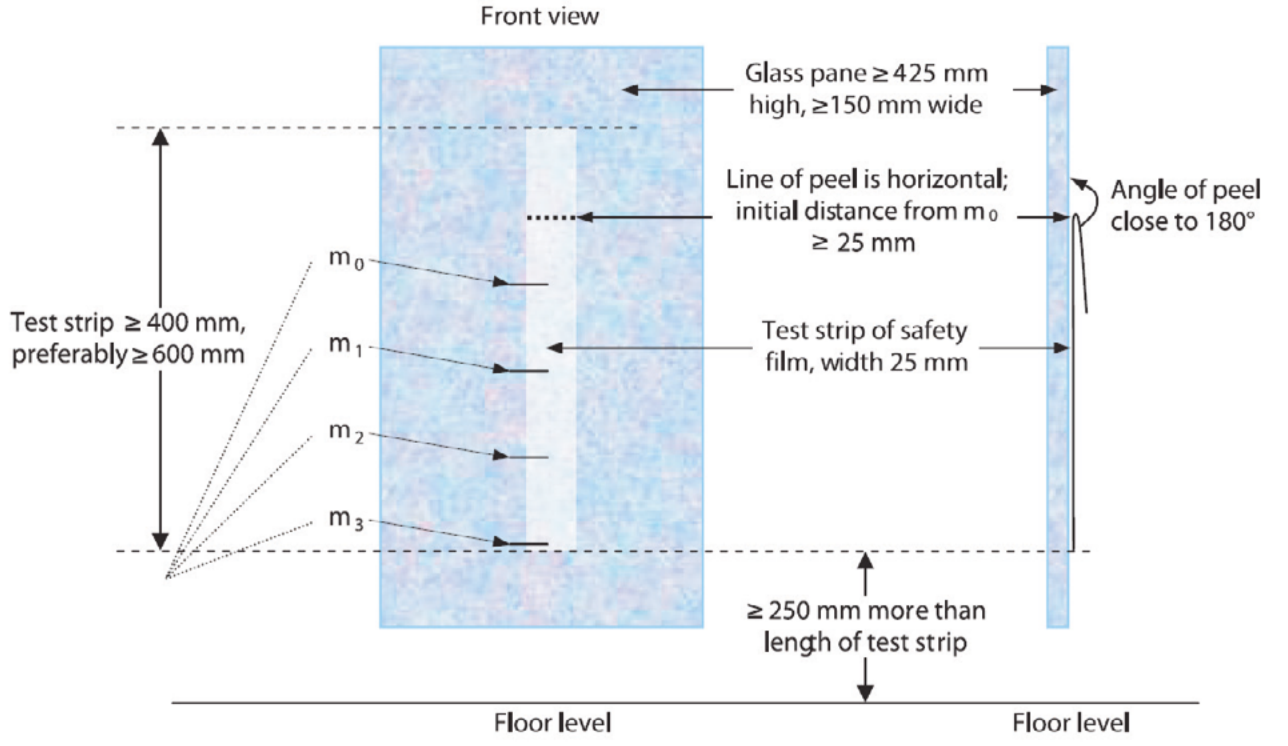


Figure 1: On-site peel testing of adhesive backed polymeric safety film on glass

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# GGF Data Sheet: Adhesive Backed Polymeric Film Guidelines for Installation onto Existing Glazing

5.18.8 May 2016

**Contents**



## Introduction

The application of adhesive backed polymeric film to already installed glass has been taking place in the U.K. for over 40 years. The early adhesive backed polymeric films were being used for 'solar control' and as such they were highly metallised/dyed and a few problems of thermal breakage were experienced.

However, since that time the types of adhesive backed polymeric films available and the number of applications has grown enormously. In the U.K. the market expanded to include 'human impact safety', i.e. converting annealed glass into a 'safety glass'.

Unfortunately the early experience has not been forgotten. This has led to a position whereby if an adhesive backed polymeric film is applied to a glass product, then it is not unknown for the supplier of the glass product to state that the "warranty is now void". This is an untenable position as the majority of adhesive backed polymeric films will have no detrimental affect what so ever on the existing glass product.

## 1. Scope

This GGF Data Sheet explains the influences of adhesive backed polymeric film on installed glass products. It details the checks that need to be undertaken to ensure that the application has no detrimental effect, i.e. increase risk of thermal breakage on the glass product.

Thermal stress is explained and a design methodology outlined.

A list of glass product types together with their possible vulnerability to adverse performance resulting from the application of adhesive backed polymeric film is given.

## 2. Definitions

The definitions contained within GGF Data Sheet 5.18.3 together with the following apply:

### 2.1 External film

A type of adhesive backed polymeric film that is designed to be applied to the external surface of the installed glazing.

### 2.2 Internal film

A type of adhesive backed polymeric film that is designed to be applied to the internal surface of the installed glazing.

### 2.3 Safe temperature difference

Maximum temperature difference that a glass can resist without the likelihood of thermal breakage.

NOTE: This is dependent on glass type and the quality of the glass edge.

### 2.4 Thermal breakage

Breakage of a glass pane caused by excessive thermal stress.

NOTE: Thermal breakage always originates at a glass edge.

### 2.5 Thermal stress

Stress produced in the edge of a glass pane as the result of centre of pane to edge of pane temperature difference.

## 3. Check List

### 3.1 General

The factors that influence the acceptable performance of an adhesive backed polymeric film when installed on a glazed glass pane depend upon both the film and the glass together with the details of the glazing.

For the purpose of this checklist the term 'acceptable performance' relates to the integrity of the glass pane, i.e. remaining unbroken and on-going durability of the glass product.

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### 3.2 Details of film

The influence of the adhesive backed polymeric film on 'acceptable performance' is dependent upon the following factors:

- Position of installed film, e.g. internally or externally;
- Spectrophotometric properties of the film, i.e. solar heat reflectance, transmittance, absorbance and emissivity.;

### 3.3 Details of installed glass

The influence of the glass on 'acceptable performance' is dependent upon the following factors:

- Glass type, e.g. float, sheet, patterned, wired, etc.
- Type of glazing
- Single Glazed
- Double Glazed
- Triple Glazed
- Processing the glass has received, e.g. heat strengthening, thermal toughening, laminating, insulating glass unit manufacture;
- Glass thickness and pane size have an influence on final combination choices.
- Type and quality of the glass edge;

With respect to the influence on thermal stress, the ideal situation is a clean, as-cut edge on the glass. However, there is always the possibility of glass edges being produced to a lesser standard.

The glass industry has available documents that define the acceptable edge. They also define unacceptable edges e.g. shelled, vented etc.

The safe temperature difference, see 4, always relates to a glass edge that is acceptable.

### 3.4 Details of glazing system

### 3.4.1 General

The following is a non-exhaustive list of the factors that need to be taken into account when the risk of thermal breakage is being considered.

### 3.4.2 Framing and glazing method

The frame material, construction and the glazing method must be taken into account when considering film to glass compatibility.

Examples of framing and glazing materials include;

- Metal
- PVC-u
- Timber
- Frameless
- Concrete
- Rubber gasket
- Silicone

### 3.4.3 Heating and cooling sources

It is important to identify the presence of both heating and cooling sources that can create a sudden temperature differential across the glazing.

### 3.4.4 Internal shading

Consideration must be given to any internal structure or other system that may create an increased build-up of heat. The most common examples of internal shading are:

- Window blinds
- Curtains
- Shutters
- Grilles
- Painted signs, labels and decals

It is imperative to identify both the colour of any internal shading and its proximity to the glass. Additionally the presence of a structural pocket (such as a void created by a suspended ceiling close to the window) must also be considered.

### 3.4.5 External shading

Consideration must be given to any external structure, system or object that may create a shadow line across the glazing creating a temperature differential across the glass. The most common examples of shading are:

- Building overhang
- Adjacent building structures
- Brise soleil
- External shutters
- External blinds
- Pillars and columns
- Painted signs, labels and decals
- External grilles
- Landscape

### 3.4.6 Location

It is important to identify the building orientation including the elevation and altitude together with winter and summer design temperatures.

## 4. Thermal Stress Determination

It is expected that any adhesive backed polymeric film installer will be able to offer to undertake an appropriate design calculation.

THE RESULT OF THE DESIGN CALCULATION SHALL BE CHECKED AND APPROVED BY THE ADHESIVE BACKED POLYMERIC FILM MANUFACTURER.

The calculation method consists, in principle, of the following:

- Determination of the basic temperature difference for the glass/film combination based on location, environmental factors, etc.
- Increase temperature difference taking account of blinds, back-ups, etc.

- Modify by frame factor and external shading.
- Compare the total temperature difference with the safe temperature difference.
- If total temperature difference is less than or equal to the safe temperature difference then there is no risk of thermal breakage.

As stated in 3.3 and providing the above points have been followed, then the risk of thermal breakage is dependent upon type and quality of the glass edge.

It should be recognized that this does not exclude the possibility of thermally propagated fractures.

The glass edge may be subjected to damage during manufacture, transportation or installation. However, the condition of the glass edge cannot be determined at the time of film application.

### 5. Recommendations

The following is a list of applications where the addition of an adhesive backed polymeric film will not cause a breakage risk:

- Clear safety film on ANY glass type.
- ANY film type on a 'thermally treated glass', i.e. heat strengthened glass, thermally toughened safety glass, heat soaked thermally toughened safety glass (see GGF Data Sheet 4.4.1).
- ANY film type on a laminated glass/laminated safety glass manufactured from 'thermally treated glass (see GGF Data Sheet 4.11).
- ANY glass/film combination glazed 'frameless', i.e. bolt fixed thermally treated glass, or structural sealant glazing.

NOTE: Both frameless glazing methods ensure that the edges of the glass are not covered up and therefore there is no possibility of a centre/edge temperature differential.

### 6. Other Considerations

Whilst this GGF Data Sheet deals with the risk of breakage due to thermal stress there are a number of other points that need consideration:

- The application of an adhesive backed polymeric film to an insulating glass unit, assuming that the film is not within the glazing system, should not affect the IGU lifetime.
- Care should be taken when applying any adhesive backed polymeric film to a laminated glass/laminated safety glass as there is a possibility that the mechanical loading associated with the application may cause breakages from poorly cut glass edges.
- Care should be taken when applying adhesive backed polymeric film to laminated glass incorporating an intumescent interlayer as the increase in temperature of the interlayer may produce changes, i.e. opaque spots, changes in colour/clarity/haze.

### 7. Bibliography

**GGF Data Sheets**

**GGF Data Sheet 4.4.1** Thermally Treated Soda Lime Silicate Glass Products

**GGF Data Sheet 4.11** Laminated Glass and Laminated Safety Glass

Current GGF Data Sheets for adhesive backed polymeric film are:

**GGF Data Sheet 5.18.1** Visual Quality for Adhesive Backed Polymeric Filmed Glass

**GGF Data Sheet 5.18.2** Installation Quality Standard for Applying Adhesive Backed Polymeric Film to Glass

**GGF Data Sheet 5.18.3** Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions and Components

**GGF Data Sheet 5.18.4** Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Types of Systems and Precautions in Use

**GGF Data Sheet 5.18.5** Recommendations for Adhesive Backed Polymeric Film Applied to Glass in the Overhead Position for Containment of Glass in the Event of Failure: Test Method

**GGF Data Sheet 5.18.6** Recommendations for Blast Mitigation: Adhesive Backed Polymeric Film Applied to Glass

**GGF Data Sheet 5.18.7** Standard for On-Site Peel Adhesion Testing of Aged Adhesive Backed Polymeric Film Applied to Vertical Flat Glass

**GGF Data Sheet 5.18.8** Adhesive Backed Polymeric Film-Guidelines for Installation on Existing Glazing

# Surface Modification of Glass for Ease of Maintenance on Externally Installed Glass

5.19 April 2008

**Contents**

**Foreword**



**Foreword**

This data sheet has been developed by a working party consisting of both the GGF and major manufacturers within the glazing and sealant industries. The aim being to provide a common basis for the applications and considerations of applied coatings and treatments on glass.

**1. Scope**

This data sheet covers coatings/treatments that can be applied to a glass surface, either during or post manufacture, to assist in the maintenance of the glass surface. The coatings/treatments covered are those that are durable, i.e. have a reasonable life expectancy, when used on the external surface of glazing in for example: windows, doors and conservatory roofs.

There are processes of materials being considered:

**1.1** Photo-catalytic coatings; also known as self-cleaning coatings

Note: Throughout the data sheet this process will be referred to as Self Cleaning Glass.

**1.2** Polymeric resins; also known as "non-stick" / easy clean treatments

Note: Throughout the data sheet this process will be referred to as Polymeric Resin Treated Glass.

Treatments for internal glazing are covered in Data Sheet 5.19.1.

**2. Descriptions**

**2.1 Titanium Dioxide**

A non-reactive chemical that is used in a micro fine coating applied during the manufacturing process.

**2.2 Photo catalytic process**

Through the influence of ultra-violet rays from daylight, the coating is energised and reacts with organic dirt, breaking it down.

Note: The coating remains unaffected by the reaction. It is a catalyst and is not consumed in the process.

**2.3 Polymeric Resin**

A chemically bonded cross-linked polymer that can be added to the surface of the glass at any time.

Note: This is a chemical process that is not affected by the surrounding environment i.e. airborne contaminants.

**3. Definitions**

For the purposes of this data sheet the following definitions apply.

**3.1 Organic**

Carbon based materials: i.e. bird droppings, road film and tree sap.

**3.2 Inorganic**

Non carbon based material: i.e. cement dust and brick dust.

**3.3 Cross-linked**

A description of the bond between the polymer molecules that results in added strength and durability of the polymeric resin.

**3.4 "Non-stick"**

The ability of a surface to minimise the accumulation of dirt on the surface, thus making it easier to clean and keep clean.

**3.5 Low maintenance**

Decrease the requirement for regular washing and improve the ease of cleaning.

**3.6 Stain resistant**

Helps maintain the visual appearance due to impact from a variety of contaminants including both organic and inorganic.

**3.7 Hydrophilic**

The ability of a glass surface to sheet water. (The water runs off the entire area of the glass in one motion)

**3.8 Hydrophobic**

The ability of a glass surface to repel water. (The water creates beads which run off individually)

Note: In both cases this process will be hindered by any contaminants that may be on the surface of the glass.

**4. Considerations**

**4.1** Self Cleaning Glass

**4.1.1** The photo-catalytic process is unable to break down or remove inorganic deposits.

**4.1.2** Can be handled and processed like ordinary glass.

Note: Manufactures guidance should be sort for both the installation and handling of post treated glass.

**4.1.3** Can help reduce the need to access areas that are difficult to reach. The reduced need for cleaning saves on water and the use of detergents for cleaning.

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**4.1.4** Self cleaning glass is suitable for glazing angles of 10 degrees from horizontal and greater to ensure sufficient flow of water across the surface. Angles of 30 degrees and steeper are ideal.

**4.1.5** Areas protected from rainfall or subject to prolonged periods of drought may require an application of water to remove loosened deposits.

**4.1.6** Areas protected from sunlight by severe shading may not receive sufficient UV light to activate the catalyst.

**4.1.7** The catalytic process can take approximately 5 days to activate after installation.

**4.1.8** Care should be taken during the re-patination of lead that is on or within the vicinity if the external coated surface.

**4.1.9** Helps maintain clean appearance of the glass.

**4.1.10** Self cleaning glass is compatible with a wide range of glazing products and the manufacturers publish details of tested gaskets and wet sealants.

Note: Generally self cleaning glass is not compatible with silicone based products which can contaminate the surface. Silicone oils can leach out from seals and mask the self cleaning effect whilst they are present.

**4.1.11** Self cleaning glass may be cleaned with warm soapy water if required. In hard water areas rapid drying of the surface may lead to residues on the glass. Demineralised water can be used to remove residues or some liquid proprietary cleaners. This should be done prior to the contaminated water drying. Contact the manufacturers for details.

**4.1.12** The sheeting affect (hydrophilic action) of rain water means that vision through the glass is quickly restored after rain fall and the glass dries more rapidly due to the water forming less droplets and rivulets on the glass.

**4.1.13** The hydrophilic action reduces the effect of external condensation and therefore helps maintain visual quality.

**4.1.14** Detection of coatings: The manufacturers can supply coating detectors for their product. An alternative method is to spray a fine mist of water on the surface and see that it shows the characteristic sheeting effect.

Note: A pattern of water droplets round the edge of the glass that is different from the centre indicates possible silicone contamination.

**4.1.15** Self cleaning glass can be recycled in the same manner as ordinary untreated glass without environmental impact.

### 4.2 Polymeric Resin Treated Glass

**4.2.1** Helps to maintain ongoing performance against industry standards, such as light transmission (t-value), by protecting the original visibility, clarity and cleanliness of glass through resistance against chemical attack and the two general categories of physical abrasion.

**4.2.1.1** Man-made, e.g. incorrect handling during transportation.

**4.2.1.2** Natural, e.g. wind erosion, windblown particles of dust, grit and sand.

**4.2.2** Resists adhesion of both organic and inorganic contaminants – before, during and after construction of the building to which it is being fitted.

**4.2.3** Protects glass surface against corrosion caused mainly by moisture and alkalinity.

**4.2.4** Resists staining and discolouration of the glass surface as a result of building run-off, lime scale, metal oxides and other contaminants.

**4.2.5** Performance is continuous and does not depend on external factors such as sunlight or rainfall.

## 5. Applications

### 5.1 Self Cleaning Glass

**5.1.1** Suitable for most types of exterior glazing: including windows, doors, curtain walling, atria and sloped glazing, e.g. conservatory roofs.

**5.1.2** Self cleaning glass can be toughened or laminated. If handled with care it can be processed face down to allow other products to be applied to the reverse.

**5.1.3** Available in some solar control options.

**5.1.4** Can be single glazed or combined with other panes in an insulating glass unit for thermal or acoustic control.

### 5.2 Polymeric Resin Treated Glass

**5.2.1** Suitable or all types of exterior glass including windows, doors, curtain walling and sloped glazing.

**5.2.2** Can be applied at the factory of any glass processor or fabricator.

**5.2.3** Can be applied on-site at any time – before, during or after construction. This should be carried out by an authorized and approved applicator.

**5.2.4** Starts to work after a short cure period, generally less then an hour.

**5.2.5** Can be re-applied in-situ whenever required.

**5.2.6** The expected service life for external, vertical glazing is up to 10 years.

Note: Frequency of reapplication depends on conditions of exposure and use.

**5.2.7** Has good durability and can be handled like ordinary glass.

Note: Manufactures guidance should be sort for both the installation and handling of post treated glass.

**5.2.8** Allowances should be made, when lifting with glass suckers, as excess cured residue may affect suction.

**5.2.9** Compatible with silicone-based and other wet sealants as well as dry gaskets.

**5.2.10** Part of a complete system of glass renovation.

**5.2.10.1** The removal of contaminants: Organic and inorganic.

**5.2.10.2** Protection: Application of the polymeric resin.

**5.2.10.3** Maintenance: Less than half that of normal untreated glass under the relevant conditions of exposure.

## 6. Bibliography

BS EN 12150-1: Glass in Building -Thermally Toughened Soda Lime Silicate Safety Glass - Part 1: Definition and Description.

BS EN 12150-2: Glass in Building -Thermally Toughened Soda Lime Silicate Safety Glass - Part 2: Evaluation of Conformity

BS EN 12600: Glass in Building - Pendulum Test - Impact Test Method for Flat Glass and Performance Requirements.

BS 952 Part 2: Terminology for Work on Glass.

BS EN 572-1: Glass in Building - Basic Soda Lime Silicate Glass products - Part 1 Definitions and General Physical and Mechanical Properties.

BS 6262 Part 4: Safety Related to Human Impact.

BS 8000 Part 7: Code of Practice for Glazing.

# Surface Modification of Glass for Ease of Maintenance on Internally Installed Glass

5.19.1 April 2008

**Contents**

**Foreword**



## Foreword

This data sheet has been developed by a working party consisting of both the GGF and major manufacturers within the glazing and sealant industries. The aim being to provide a common basis for the applications and considerations of applied coatings and treatments on glass.

## 1. Scope

This data sheet covers treatments that can be applied to a glass surface, post manufacture, to assist in the maintenance of the glass surface. The treatments covered are those that are durable, i.e. have a reasonable life expectancy, when used on the surface of glass in internal applications in buildings.

There is one process being considered

**1.1 Polymeric Resin Treated Glass;** also known as "non-stick" / easy clean treatments.

## 2. Description

Glass surface that has been treated with a cross-linked polymeric resin. The treatment provides surface protection that is "non-stick", low-maintenance and stain resistant and has a hydrophobic reaction to water.

## 3. Definitions

For the purposes of this data sheet the following definitions apply.

### 3.1 Cross-linked

A description of the bond between the polymer molecules that results in added strength and durability of the polymeric resin.

### 3.2 "Non stick"

The ability of a surface to minimise the accumulation of dirt on the surface, thus making it easier to clean and keep clean.

### 3.3 Low maintenance

Decrease the requirement for regular washing and improve the ease of cleaning

### 3.4 Stain resistant

The ability to maintain the visual appearance due to impact from a variety of contaminants including both organic and inorganic.

### 3.5 Hydrophobic

The ability of a glass surface to repel water. (The water creates beads which run off individually)

Note: This process will be hindered by any contaminants that may be on the surface of the glass.

## 4. Considerations

**4.1** Helps to maintain ongoing performance against industry standards, such as light transmittance (t-value), by protecting the original visibility, clarity and cleanliness of glass through resistance against chemical attack and physical abrasion: e.g. incorrect handling during transportation

**4.2** Resists adhesion of both organic and inorganic contaminants before, during and after construction of the building into which the glass is being installed.

**4.3** Protects the glass surface against corrosion caused mainly by moisture and alkalinity.

**4.4** Resists staining and discolouration of the glass surface as a result of building run-off, lime scale, metal oxides and other contaminants.

**4.5** Compatible with silicone-based and other wet sealants as well as dry gaskets.

**4.6** Part of a complete system of glass renovation.

**4.6.1** The removal of contaminants: Organic and inorganic.

**4.6.2** Protection: Application of the polymeric resin

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**4.6.3** Maintenance: Less than half as normal untreated glass under the relevant conditions of exposure.

**5. Applications**

**5.1** Any internally glazed area.

**6. Bibliography**

BS EN 12150-1: Glass in Building - Thermally Toughened Soda Lime Silicate Safety Glass - Part 1: Definition and Description.

BS EN 12150-2: Glass in Building - Thermally Toughened Soda Lime Silicate Safety Glass - Part 2: Evaluation of Conformity

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BS 952 Part 2: Terminology for Work on Glass.

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BS 6262 Part 4: Safety Related to Human Impact.

BS 8000 Part 7: Code of Practice for Glazing.

# Surface Modification of Glass for Ease of Maintenance - Liquid Applied Glass Surface Treatments

5.19.2 September 2015

**Contents**



## Introduction

There is a whole range of products that have been designed to make glass easier to clean and reduce the need for maintenance.

This Data Sheet relates to one specific group - 'Liquid Applied Glass Surface Treatments' (for the purposes of this document known as GST).

GST relate to a number of technologies and therefore, GST have a wide range of applications as follows:

- External;
- Internal,
- Under all types of environments, and
- Under many different types and degrees of exposure.

These technologies have certain features in common, i.e. they are hydrophobic (water-repellent).

Some GST provide protection by resisting attack by moisture, alkalinity and dirt. The degree of protection varies from durable or long-lasting to non-durable.

These products are inherently different in many ways. The differences become apparent with time and also with exposure to climatic conditions, which are complex and variable. It is therefore, important to make comparisons in order to confirm that a particular product or brand is fit for its intended use.

## 1. Scope

This Data Sheet sets standards for Liquid Applied Glass Surface Treatments (GST), with the objectives of:

- Clarifying definitions, descriptions and terminologies;
- Detailing the specific conditions for each market sector or application for which it is designed,
- Detailing the testing requirements for each specific application of GST
- Ensuring that the performance and durability of a GST is relevant to its intended use.

This Data Sheet does not cover photo-catalytic coatings, details of which can be found in the following GGF Data Sheet:

Data Sheet 5.19 Surface Modification of Glass for Ease of Maintenance on Externally Installed Glass.

## 2. Definitions

For the purposes of this Data Sheet, the following definitions apply

### 2.1. Liquid Applied Glass Surface Treatment (GST)

A liquid applied to a glass surface that, when dried or cured, forms a surface layer that either:

a) Cross-links with itself and chemically bonds to the surface forming a multi-molecular structure;

b) Bonds with the surface forming a mono-molecular structure; or

c) Deposits itself as a coating

### 2.2. Chemical cross-linking

A chemical bond between polymer chains and glass forming a multi-molecular structure.

### 2.3. Coating

A distinct layer that when deposited can have variations in thickness.

NOTE: These variations may result in internal stresses and microscopic cracks in the coating. Moisture can penetrate between the surface layer and substrate through capillary action, causing

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discolouration of the coating and potentially its failure.

### 2.4. Treatment

The application of an agent to preserve or give particular properties to the glass surface.

### 2.5. Hydrophobic

The ability of a surface treatment to repel water by causing the formation of beads of water which subsequently run off the surface.

NOTE 1: This is demonstrated with a contact angle of 90$^{o}$ or more when measured with water according to ASTM C813-90

NOTE 2: The hydrophobic effect as demonstrated by the contact angle shall not be used to determine if a GST is fit for a specific purpose or as an indication of its performance or durability.

### 2.6. Fit for Purpose

A GST can be described as 'fit for purpose' provided that it:

a) Meets the relevant laboratory testing requirements for products new to the market as outlined under section 6, or

b) Has a documented track record/case history sufficient to be considered as fit for its intended purpose within a specific market sector and geographical area.

### 2.7. Contact Angle

The angle at which a liquid/vapour interface meets a solid surface.

### 2.8. Durable

The ability of a treatment to last a defined period of time relevant to specific conditions of exposure and use without deterioration in performance.

### 2.9. Non-Stick

The ability of a surface to minimise the accumulation of dirt - both organic and inorganic - thus making it easier to clean and keep clean, by making the surface chemically inert to most substances.

### 2.10. Organic Deposit

Carbon based materials including, but not limited to, bird droppings, road film and tree sap.

### 2.11. Inorganic Deposit

Non carbon based materials including, but not limited to, cement and brick dust, building run off, and lime scale.

### 2.12. Non-durable Water-repellent Coating

A GST that has not yet been proven to meet the requirements of 2.8

NOTE: Until a GST is proven to be durable according to 2.8 or is chemically identical to a proven product, it is considered as non-durable with the only function of being water-repellent.

### 2.13. Nanotechnology

Technology at the Nano scale, i.e. dimensions of the order of 100 nm or less.

NOTE: This is a physical measurement and does not indicate either performance or durability.

### 2.14. Low Maintenance

Decreases the requirement for routine washing and improves the ease of cleaning.

### 2.15. Stain Resistant

Ability to maintain the visual appearance of glass when exposed to a variety of contaminants both organic and inorganic.

### 2.16. Chemical Effectiveness

A measurement of chemical activity, of a product at its time of manufacture that has shown to have close correlation with actual field performance and durability of the finished product.

### 2.17. Shelf Life

Length of time that a product, in its original and unopened container, maintains its chemical effectiveness.

NOTE: To achieve optimum performance and durability for each type of technology, it is important that chemical effectiveness measured at the time of production (see definitions) be adequately maintained until the time of application.

## 3. Descriptions

For the purposes of this Data Sheet, the following descriptions apply:

### 3.1. Glass Surface treatments

#### 3.1.1. Polymeric resin

A polymer that chemically cross-links with itself and bonds to the substrate during the curing process to produce a multi-molecular layer that is "non-stick", i.e. chemically inert to most substances after curing.

#### 3.1.2. Reactive Silicone Fluid

A short chain silicone polymer that, after curing, is mono-molecular in thickness and produces a hydrophobic surface.

### 3.2. Glass Surface Coatings

#### 3.2.1. Sol-Gel Silane, Type A Coating

A bi-layered structure that is silane based and shall be applied by a controlled method to produce a hydrophobic surface that consists of organic and inorganic segments

#### 3.2.2. Bi-functional Silane, Type B Coating

A mono layered structure that produces a hydrophobic surface

### 3.2.3. UV-cured Silane, Type C Coating

Technology similar to bi-functional silanes i.e. Type B coating, that requires high energy ultraviolet (UV) light to activate the curing process.

## 4. Applications

A GST, when correctly applied, offers a range of benefits for all types of glass used in buildings and transportation.

Applications include, but are not limited to, external and internal glass such as:

- Domestic windows and doors - new construction, replacement
- Commercial glazing - windows, doors, curtain walling, spandrel panels, roof lights
- Decorative glass - stained, leaded, sandblasted/ abrasively etched
- Shower doors and enclosure
- Glass blocks
- Mirrors and glass furniture
- Solar panels – thermal and photovoltaic (PV)
- Transportation - Glass in marine vessels and public service vehicles
- Display cabinets
- Splash backs

## 5. Effectiveness

To achieve optimum performance and durability for each type of technology, it is important that the product is used within its effective shelf life.

NOTE: For silane based products the shelf life is typically between twelve to eighteen months.

## 6. Testing

Laboratory tests can be used to determine if a GST is fit to place on the market. The way of proving performance and durability is under actual conditions of exposure and use over an extended period of time.

Test organisations have reported that laboratory tests or combination of tests alone cannot predict the performance or durability of a GST under actual field conditions.

Prior to a GST being introduced to the market it should meet the Type Testing (TT) as listed in Table 1.

NOTE: It is advised that as early as possible in the development process, field trials should be carried out under actual conditions of exposure and use in the specific markets sector(s) and application(s) involved.

**Table 1.** Initial Type Testing of a Product

| Property | Standard or Test Requirement | Outcome |
|---|---|---|
| UV Weathering | EN 1096 – 3<br>BS 3900-F16 | Requirements as per the Standard |
| Light transmission | EN 410:2011 | No differences observed in light transmission. |
| Condensation Resistance | EN 1096-2<br>as Type A | Requirements as per the Standard. After test Contact angle measured by ASTM C813-90 to be ≥90° measured in 5 places across the tested surface |
| Alkali Attack | EN 3473-1:1991 | Samples to be treated as per supplier's instructions, and then classified 'as a material'. Treated samples 'as a material' to show a minimum of 2% reduction in weight loss when compared to untreated samples |
| Failure Mode Engineering Analysis (FMEA) | Accepted Code of Practice (ACoPs) | No high level risks or consequences observed |

NOTE: The purchaser may request additional tests to be carried out.

**Table 2.** Additional Test Requirements - Specific to Market Sector(s)

| Property | Standard or Test Requirement | Outcome |
|---|---|---|
| **Shower Glass** | | |
| Resistance to humidity | EN 1096 – 2<br>as Type A | Requirements as per the Standard. After test Contact angle measured by ASTM C813-90 to be ≥90$^{O}$ measured in 5 places across the tested surface |
| **Glass in Marine Vessels and Public Service Vehicles** | | |
| Neutral salt spray | EN 1096 – 2<br>as Type A | Requirements as per the Standard. After test Contact angle measured by ASTM C813-90 to be ≥90$^{O}$ measured in 5 places across the tested surface |
| Resistance to Humidity | EN 1096 – 2<br>as Type A | Requirements as per the Standard. After test Contact angle measured by ASTM C813-90 to be ≥90$^{O}$ measured in 5 places across the tested surface |
| Resistance to pressure washing | ASTM D7089-06 using samples of 30cm square and cleaned for five minutes | The contact angle as measured by ASTM C813-90 must be ≥90$^{O}$ measured in five places across the tested surface. |
| **Protection During Installation or Construction** | | |
| Resistance to mortar Staining | Resist Mortar Mix as specified in section 2.2.3.2 of BS 3712-2 | After 42 days, no glass staining or damage to be observed |
| **Direct Food Contact** | | |
| Fit for direct food contact | European Directive 2002/72/EC<br>FDA Regulations (Chapter 21 Section 175.300) | To meet European and United States Food & Drug Administration (FDA) testing requirements for direct food contact |
| **Antimicrobial – Resistance to Adhesion and Growth** | | |
| Antimicrobial or resistance to adherence of Bacteria | Measure adhesion of staphylococcus aureus NCTC 4163 | Minimum of 80% reduction in the number of bacteria adhered to a treated surface after washing when compared to an untreated surface |
| **Glass Floors and Stair Treads** | | |
| Will not adversely affect the slip risk values | Tested to HSE slip risk value, PTV values and UKSRG. | No increase in the level of Slip Risk Rating |
| **Use with Vacuum Lifters** | | |
| Use with Vacuum Lifter | Tested to 200% of the Safe Working Load without slippage | There should be no sliding of the pads when applied to the coated surface.<br>NOTE: When pads are released sliding should be avoided. |

## 7. Considerations

### 7.1. Shelf Life

The polymeric resin (section 3.1.1) and reactive silicone fluid (section 3.1.2) have prolonged shelf lives. Products with a finite shelf life (silanes) need to be stored and handled so that best practice in stock rotation throughout the supply chain is achieved.

The manufacturers or distributors of glass surface treatments should always advise their end users of the effective shelf life of these products and display any use-by date in a prominent place on the labelling; this should conform to local or international regulations.

### 7.2. Health and Safety

When considering the use of liquid applied glass surface treatments it is critical to be conversant with the Health and Safety requirements associated with the use of the chemicals and processes involved and the legal requirement to protect personnel who may be affected by your actions.

**Step 1. Safety Data Sheet**

When sourcing the chemical products to be utilised in the process, ensure that Safety Data Sheets have been obtained from the supplier. This will provide specific information on the chemical(s) supplied and highlight areas for further consideration such as:

- Identification of the substance/mixture and of the company/undertaking
- Hazards identification,
- Composition/information on ingredients
- First-aid measures,
- Fire-fighting measures,
- Accidental release measures,
- Handling and storage,
- Exposure controls/personal protection,
- Physical and chemical properties,
- Stability and reactivity,
- Toxicological information,
- Ecological information,
- Disposal considerations.
- Transport information,
- Regulatory information,
- Other information,

It is essential to obtain and evaluate this information when undertaking the risk assessment process required for the use of liquid applied glass surface treatments.

**Step 2. The Process**

Having identified the chemicals to be used and utilised the information provided by the Safety Data Sheet, the process and how the products will be used should be considered.

**Safe working procedures must take into account every step of the process from receipt of stock to the disposal of used containers. Safe working procedures must also consider the application process and the possibility of any air borne contamination associated with the application technique.**

**Step 3. COSHH (Control Of Substances Hazardous to Health 2002)**

Principles of good practice

The COSHH Regulations define good control practice in schedule 2a as follows:

**1.** Design and operate processes and activities to minimise emission, release and spread of substances hazardous to health.

**2.** Take into account all relevant routes of exposure – inhalation, skin absorption and ingestion – when developing control measures.

**3.** Control exposure by measures that are proportionate to the health risk.

**4.** Choose the most effective and reliable control options which minimise the escape and spread of substances hazardous to health.

**5.** Where adequate control of exposure cannot be achieved by other means, provide, in combination with other control measures, suitable personal protective equipment.

**6.** Check and review regularly all elements of control measures for their continuing effectiveness.

**7.** Inform and train all employees on the hazards and risks from the substances they work with and the use of control measures developed to minimise the risks.

**8.** Ensure that the introduction of control measures does not increase the overall risk to health and safety.

**Further Information and resources:**

Glass and Glazing Federation
healthandsafety@ggf.org.uk

Control Of Substances Hazardous to Health 2002 (COSHH)
www.hse.gov.uk/coshh

Safety Data Sheets
www.hse.gov.uk/coshh/basics/datasheets.htm

Flammable Liquids
www.hse.gov.uk/fireandexplosion.htm

Disposal of hazardous waste
www.gov.uk/dispose-hazardous-waste/overview

Local Exhaust Ventilation
www.hse.gov.uk/lev.htm

# Security of Window and Door Products

6.3 FEBRUARY 2000

## 1 Foreword

**1.1** In the ten year period from 1975 to 1985, the number of reported cases of Breaking and Entering into domestic households doubled in number.

**1.2** It must be accepted that given sufficient uninterrupted time and suitable tools, a skilled burglar will succeed in breaking into any house. Thus, it is impossible for any window or door to provide complete protection against forced entry. One aim of current window and door products is to deter the burglar. Police experience has indicated that the opportunistic burglar will only attempt to break in through a window or door for a very short period of time before moving on to another window, or the next house.

**1.3** The following recommendations are aimed at manufacturers of Windows and Doors made from all materials whether of PVC-U, aluminium, timber, steel or others, and to point out good practices in design and manufacturing techniques that have been found to help deter forced entry. Not all of the following apply to all types of products nor to all materials from which they can be made.

## 2 General

**2.1** All hardware components should be tested for physical strength by simulated attacks on the products. Manufacturers of windows and doors should ensure that the components they use are fixed according to the hardware and/or system suppliers recommendations.

**2.2** The manufacturers should ensure that the styles or rails (mullions or transoms) cannot be deflected into the glazing cavity and thus permit the locking gear to disengage. The use of glazing packers adjacent to the locking points can assist in achieving this aim.

**2.3** The use of mushroom headed roller bolts and similar security developments at vulnerable positions, improves security.

**2.4** Locking devices that rely solely on the overlap between a tongue or bolt and striking plate should be tested to ensure that the cover is in accordance with the hardware manufacturers recommendations.

**2.5** It is recommended that, where possible, all manufacturers should assess their products by simulated attack.

**2.6** No screws or similar fixings, affecting security, should be accessible for removal from outside.

**2.7** Hardware may require routine maintenance and guidance should be provided on this and on its normal operation.

## 3 Glazing

**3.1** For sealed double glazing units the use of laminated glass of suitable thickness in at least one leaf of the unit will substantially improve domestic security.

Laminated glass of suitable thickness can equally be used for single glazing in accordance with the suppliers.

**3.2** Toughened glass is up to five times stronger than ordinary glass but when broken it provides no residual barrier to forced entry.

**3.3** Wired glass can also offer some deterrent to the intruder because of the difficulty in making a hole large enough through which to put an arm. This impediment to entry is increased if the window is securely locked as the intruder must then be able to enter the hole rather than merely put his hand through to release a catch.

**3.4** Polycarbonate offers the most resistance of the plastics glazing sheet materials. It is unbreakable and so will resist manual attack when correctly glazed in normal single glazing. It can be damaged by fire and by sharp objects, therefore care must be taken in fixing and cleaning.

**3.5** When using plastics glazing sheet materials it is essential that the recommended correct glazing and fixing techniques are used to ensure maximum benefit from the protection that these materials can provide.

**3.6** Attention must be paid to the method of secure glazing, whatever method of glazing is used.

**3.7** If glazing beads are external, then it may be possible to remove these by the use of a knife, screwdriver or similar hand tool. This applies to glazing beads on steel, wood, aluminium and uPVC windows or doors. If tests show that these beads are removable with such tools, then the manufacturer should use additional methods such as double sided tape or glazing clips to secure the glass in position.

**3.8** If glazing beads are internal, then care

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must be taken to ensure that they cannot be knocked out of position by kicking or hammering that infill panels or glazing.

#### 4 Window and Door Locks

**4.1** Manufacturers should ensure that the customers have signed for the exact number of keys issued with each door lock.

**4.2** If key locking handles are fitted to windows, then customers should be encouraged to make a habit of removing the keys from the locks when the window is fastened. Similarly door keys should not be left in place, as there is a risk that children could turn a key by putting a hand through a letterplate opening.

**4.3** In general, care should be taken with espagnolette fittings that rely on packing the glass opposite the fixing points. These packings should be firmly fixed in position.

**4.4** If mushroom headed roller bolts or similar, are used for security then the combination of bolts and their keeps should be selected in accordance with the suppliers recommendations. Anti-lift blocks may be required to prevent vertical or horizontal disengagement.

**4.5** Window fittings with 'night vent' positions should be capable of being locked or secured in those positions.

**4.6** External door handles should not compromise the security of the lock if removed from outside.

**4.7** Double doors should have a secure shootbolt system top and bottom.

**4.8** Double doors should have a secure shootbolt system top and bottom.

#### 5 Hinges

**5.1** Any hinges that are accessible from the outside when the window or door is closed, should have pins that are secure, and that cannot be driven out, thus allowing the window sash or door leaf to be removed.

#### Installation

**6.1** Installation can play an important part if the overall security of all door and window products. Installers must be made aware of the need to install and adjust all hardware correctly. A check should be made before leaving any site to ensure the correct function of all components and products.

**6.2** It may be necessary to fit wedge blocks to door leaves and frames to prevent hinges being overstrained to gain entry, and to minimise the risk of pull-out or shearing of screws.

# Fire, Safety the Security
# Choosing the Right Replacement Windows

6.5 NOVEMBER 1992

Contents



## 1 Introduction

**1.1** The purpose of this guidance note is to draw attention to the various requirements that need to be addressed by designers, suppliers and installers when considering the installation or replacement of windows in a property. Because so many people require so many different things from their property and their lifestyle, it is often difficult to balance the criteria that a window may need to meet to satisfy all those demands.

**1.2** There can be conflicting priorities, as this data sheet will show. The points set out here and in the 6.5 data sheet series will help designers and customers to take account of the various issues when making their decisions.

**1.3** In attempting to do so, three areas need to be given high priority with regard to design. They are:

Fire Safety
Security
Safety

**1.4** For some installations, it will no be possible to meet all these design features and keep within the customer's cost ceilings; in which case decisions need to made with regard to priorities. The notes below set out a guide to the principal standards, codes of practice and Buildings Regulations in these areas and show when these may at times be mutually exclusive – thus where decisions on priority need to be made. The latter part goes on to review a range of differing types of windows and how they relate to the desirable characteristics.

## 2 Standards, Codes of Practice and Building Regulations - An Introduction

The situation regarding mandatory Regulations and Codes of Practice is still not clarified. For example, the Building Regulations 1991 England and Wales do not call up a window as a means of escape at either ground or 1st floor level. However, on floors above these levels it is necessary to incorporate a window that will allow exit on a ladder.

Approved Document B of the Building Regulations does acknowledge that "Measures intended to prevent unauthorised access can also hinder entry of the Fire Service to rescue people trapped by fire", and that there may be a conflict when trying to control entry in the interest of security and exit in the interest of fire safety.

## 3 The Relationship of Current Building Regulations to Replacement Windows

### 3.1 England and Wales

**3.1.1** 1991 Building Regulations for England and Wales do not apply to replacement windows in an existing building unless the replacement window constitutes a "material alteration". Regulation 3(2) defines a material alteration as being anything which would result in a building becoming less compliant with any relevant requirement.

**3.1.2** In short this means that if the window being replaced complies with either the requirements of the current regulations or with the regulations in existence when it was installed, the replacement window must not make the building less compliant. The application of Approved Document B1 (Means of Escape from Fire) of the 1991 Building Regulations of England and Wales to replacement windows depends on whether the installation of a replacement window constitutes a material alteration as defined above. If it does constitute a material alteration then B1 does apply.

**3.1.3** In domestic dwellings B1 applies when any of the following occur:

- The floor height above ground level exceeds 4.5 metres or where there are three storeys or more.
- The room in which the windows are installed has no direct access onto a hallway or stairs leading to an entrance.
- There has been a material change of use, such as a conversion to a dwelling or a flat.

**3.1.4** Approved Document B1 (Means of Escape from Fire), Section 1 (dwelling houses) Paragraph1states that in the case of 1 or 2 storey houses, each habitable room must either open directly onto a hallway or stair leading to the entrance, or it must have a window or door through which escape could be made. More complex requirements apply for higher dwellings.

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**3.1.5** Even where it may not be a requirement to follow the current Building Regulations, those recommendations merit careful consideration and frequently it is good practice to adopt them. Some of these are mentioned further below.

### 3.2 Scottish Building Regulations

**3.2.1** As a general principal, the Scottish Building Regulations seem to apply to all building work, including the installation of replacement windows.

**3.2.2** With specific reference to fire, every storey of a dwelling above 4.5m (up to 11m in the case of flats and maisonettes) must have an emergency window. Also, every inner room in a dwelling (i.e. a room without direct access to a circulation area) must have an emergency window. These windows must have opening parts at least 850mm high and 500mm wide, with the bottom of the opening light not more than 1.1m above the floor. (There are several other requirements if the window is in a roof)

**3.2.3** There is a further provision in Regulation E2.21 which states that if any part of an access balcony provides escape in one direction only, then any window which opens onto that part of the balcony must be at least 1.1m above the floor level of the balcony. (The thinking behind this Regulation is that it allows people using the balcony as a means of escape to crawl under the window, should there be a fire in that room which had reached the point where smoke and flames were coming from the window).

## 4 Fire Safety

In the case of a fire, if a normal exit from the property is either restricted or blocked then it may be necessary to use a window as a means of escape. For further guidance on the role of domestic windows in fire safety, see GGF data sheet 6.5.1.

## 5 Security

Where security is of major concern, it may be necessary to ensure that the windows cannot open from outside and also to reduce the possibility of the glass being broken.

## 6. Safety

**6.1** When safety is a priority it may be a requirement that the window is difficult to open, thereby reducing the risk of children opening it and falling from higher windows.

**6.2** These basic considerations of fire safety on the one hand and security on the other can conflict. In trying to achieve the latter, a window should allow ventilation to take place whilst proving difficult to open (thus reducing both the possibility of entry by a burglar and of a child falling out). In the case of fire safety, however, it is important to ensure that a window is easy to open by people of all ages, and offers an opening large enough to allow escape.

## 7 Ventilation

All habitable rooms in England and Wales must allow for ventilation of an area equivalent to 1/20th of the total floor area and must also have a trickle ventilator opening of 4000 square mm. In Scotland the requirement for ventilation is an area equivalent to 1/30th of the total floor area. In kitchens and bathrooms, there must also be a mechanical ventilator capable of shifting 30 litres of air per hour.

## 8 Cleaning from the Inside

British Standard Code of Practice 153 Part (1969), called for a requirement to allow windows to be cleaned safely from inside. This has now been re-issued as BS 8213 Part 1, and now includes a cause relating to replacement windows which allows the householder to elect to use a window cleaner, thereby freeing himself from having to meet this safe-cleaning requirement. At the time of going to press, this clause has not yet been called up under the Scottish Building Regulations, which in Scotland are relevant also to the home improvement work.

## 9 Gas Appliances

**9.1** In some homes gas appliances have been installed without any provision for the supply of air necessary for the burning of gas, other than that which leaks in around ill fitted windows and doors.

**9.2** When this is the only air supply available, the householder should then make provision for an adequate, permanent air supply by means of an air brick or similar source. A gas installer / gas board official can advise on the supply which would be considered "adequate". By their nature, replacement windows will be well fitting and should therefore not to be regarded as contributing to this air supply.

## 10 British Standard - BS 5588 Fire Prevention in the Design and Construction of Buildings

The Code of Practice of BS 5588 Part 1, does not call up a window as a means of escape at ground and first floor level, but specifies that at levels above this windows should allow for an unobstructed opening of 850mm high by 500mm wide. The Building Regulations 1991 also state this, although the heights recommended for maximum and minimum installation do not in fact differ to those found in the Code of Practice.

## 11 British Standard – BS 8220: Part 1 – Security of Buildings/Dwellings

This British Standard gives very effective guidance on fitting lockable security fastening. It states "Opening windows that are considered to be a security risk should be fitted with lockable security fastenings".

## 12 The Guide to Security of Doors and Windows

A security document produced by the GGF, in conjunction with the Kent Police, the British Insurance Association and others, states that "Ground floor and other vulnerable windows should ideally be fitted with a security locking device".

With regard to doors, many mortice locks and some rim locks fall within the scope of BS 3621, which sets the criteria for resistance of manipulation, forceful attack and wear. The locks should have at least 1000 key differs. As BS 8220 Part 1 points out other locks exist which are not marketed as complying with BS 3621 but which have features that practical experience has shown to be especially relevant for securing certain categories of external doors.

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## 13 Mechanical Means of Assistance

In most family homes it is not feasible to install complex sprinkler systems to reduce the risk of fire. However it will allow greater time for escape if smoke alarms are fitted to a property. Also, where burglaries are considered to be of prime concern, installation of a burglar alarm will be an added deterrent.

## 14 Meeting Priority Requirements

The following sections are intended to assist the customer in choosing the design of windows that meet as many of these requirements as possible, or at least those considered to be most important.

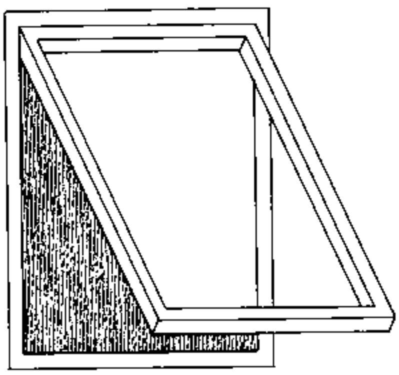
### 14.1 Characteristics of Window Styles

When deciding upon replacement windows, it is important to consider both style and size in relation to the architectural style of the property and how the window will be used.

### 14.2 Top Hung Windows

This style of opener has been used in small size windows for much of this century and has therefore historically been mainly supplied in timber and steel. It was designed originally to allow for ventilation over and above any other criteria.

However, with the development of alternative and stronger hinges, it has been possible to produce larger top hung windows that allow exit from a property,

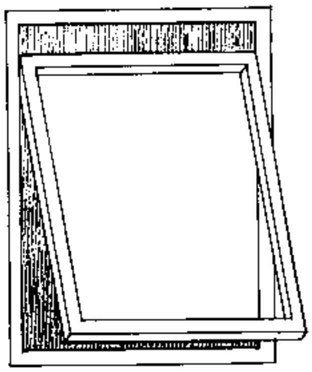


Fixed Hinge Top Hung Window

At the same time, these developments mean that the windows may also be produced in Aluminium and PVC-U.

However with units of this size it may be necessary, in areas where security is of priority concern, for locks to be fitted to handles and possibly to hinges.

Where child safety is of concern, it may be necessary to fit a restrictor to the leading edge of the sash. However, by using a specific type of hinge, the sash may be pivoted closer to the top of the frame than normal, thereby allowing easier exit in case of fire.

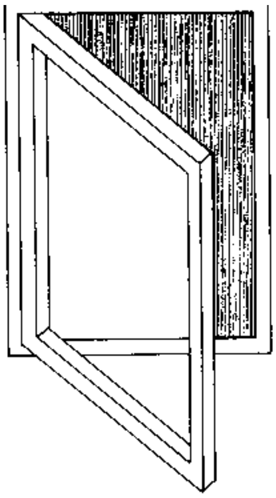


Top Hung Window

### 14.3 Side Hung Window

Like to top hung sash, this type of unit has become more popular during the last twenty five years. This style of sash is often used in conjunction with a small top hung sash (fanlight) in flat windows, whether these form part of individual windows or part of the bay window.

As with the top hung window, it will often be necessary to fit locking mechanisms when security is of concern

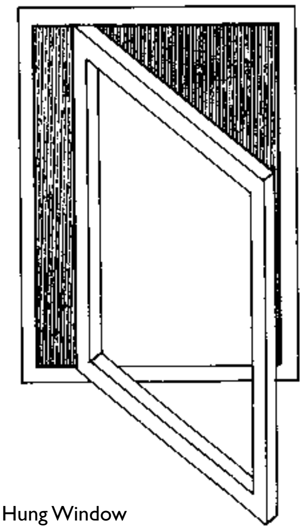


Fixed Hinge Side Hung Window

to the occupant, unless a burglar alarm is seen as an adequate alternative.

The use of geometric friction stays on these styles of window unit enables the sash to be cleaned from the inside of the property. However this feature also results in the opening created by a 600mm wide side opener being reduced to approximately 300mm width, as the sash moves across the opening when being used.

When considering exit in case of fire it is possible to fit friction stays to the window that, on releasing a restrictor, will allow the sash to open to 90 degrees and give a full size opening to the unit.



Side Hung Window

On child safety, although it can be harder for a child to open a side hung window because of the position of the handle, it may still be deemed appropriate to fit a restriction to the sash.

### 14.4 Pivot Windows

The pivot window is a more recent design innovation and comes in two main forms. One is where the pivot, having completed the opening cycle through a 90 degrees, ends in a position parallel to the ceiling and the floor with 50% of the sash remaining inside the building. The other is where the release of a catch will enable the sash to turn through a further 90 degrees; the sash will then turn into the room allowing for the exterior of the glass to be cleaned.

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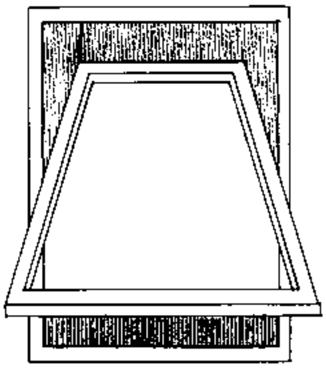


Pivot Window

Although the features mentioned above are extremely useful when cleaning, particularly in applications above 4.5 metres where restrictions have not been fitted to the window, this design may be considered very dangerous to children, who may be able to open the sash because of the position of the handle. For this reason, these units should be fitted with a restrictor which can be disengaged by an adult for cleaning. Also, sashes that only open to 90 degrees can be dangerous when being cleaned from inside the building.

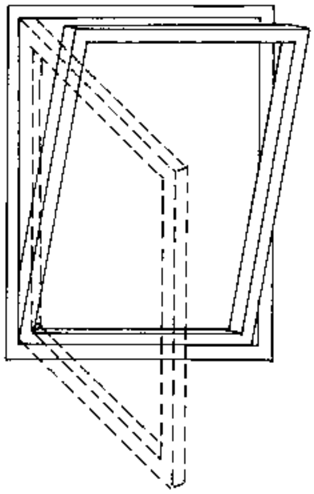
Such windows allow egress reasonably easily when trying to evacuate a building in an emergency, but for security purposes it is often felt necessary to fit window locks.

### 14.5 Tilt and Turn

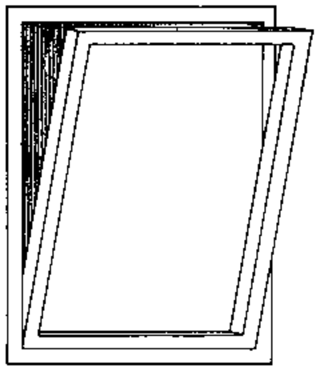
This style of window, originally of continental design, became more familiar to this country in the mind 1980s. The design allows for the sash to be fitted inwards to allow for ventilation.

By the use of mechanisms fitted to the handle, it is then possible to close the window, turn the handle and open a side hung sash directly into the room.

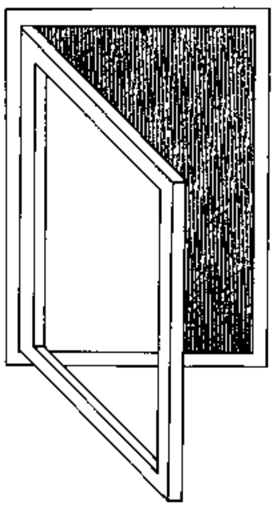
This feature ensures that the unit can be cleaned from the inside of the property without having to stand on ladders or lean out on the window. It is usual for the opening sash to be designed so that it opens to the full height of the window aperture and not in small units such as in top and side light window configurations.



Tilt and Turn Window



Window in Tilt Position



Window in Turn Position

Because the sash opens fully, the hinge mechanisms allow the window to turn through 90 degrees; this style of window can provide an ideal escape in the case of fire.

For additional security purposes locks can be fitted to the handles and at the sash fits into the window from the inside it is harder for a burglar to gain a purchase to force a window open.

The position of the handle is usually half way up the leading edge of the sash, and the tilting position which allows ventilation through the upper part of the sash means that there is a reduced likelihood of child accidents occurring. Some householders may nonetheless feel it necessary to fit restrictions to the unit.

## 15 Conclusion

This guidance note shows that it is possible to design windows that meet all the requirements, but such comprehensive performance inevitably has a cost attached. It is for the designer, the specifier and the householder to decide what their priorities are and for the salesman to be in a position to offer products that meet the various requirements – be they FIRE, SAFETY or SECURITY. Not all windows can meet all these requirements, therefore a decision by the customer or his professional representative will have to be taken with regard to the priority for his particular installation.

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# Hardware Specification Document. Guidelines for the selection, installation, maintenance of hardware for the window and door industry.

6.7 SEPTEMBER 2004

Foreword

This guidance document has been prepared by the Technical Committee of the Hardware Manufacturers Group.

It provides information to assist the specifier and end user in the selection, installation and maintenance of hardware. It aims to ensure that hardware chosen is the most appropriate to meet the product's application. With correct installation and maintenance the ultimate service and durability of the product should meet the expectations of the user.

## 1. Scope

This document covers the three main framing materials – PVC-U, Aluminium and Timber.

## 2. General

It is necessary to comply with the relevant British Standards for each of the framing materials that are being considered, BS 7412 for PVC-U windows, BS 4873 for aluminium windows, BS 644 for timber windows and PAS 23 for doors (all materials).

All products must comply with the relevant Building Regulations.

## 3. Selection

It is important to ensure that the hardware selected is suitable for the profile / system into which it is to be fitted. It is therefore, necessary to take into account features such as Eurogrooves, cavity size, and the position of the reinforcement / screw ports and vent frame step.

Hinged products are designed to carry specific weights or sizes; therefore it is essential not to exceed the carrying capacities specified by the product supplier.

Handle products are designed to aid the closing and sealing of the vent / leaf. They must not be stressed by overtight compression.

Locking products are designed to seal as well as provide increased security. Manufacturer's recommendations with regard to the number of locking points should be followed.

Hardware shall allow windows and doors to meet specific British and European standards.

Consideration should be given to application requirements such as child safety and fire escape. Products should be selected which offer these facilities while complying with relevant standards.

Care should also be taken to ensure that electrolytic reaction (bi-metallic) from incompatible metals is avoided.

Fasteners / fixings are an important part of the specification because incorrect fixings can reduce the overall performance of all hardware. The overall strength is dependent upon the weakest link, especially when considering high security applications.

It is important to select fixings with heads that do not obstruct the movement of other components during opening and closing of the sash or leaf.

It is recommended that fasteners / fixings used in normal applications should withstand 240 hours salt spray test when tested to BS 7479. It is then recommended that fasteners / fixings used in coastal or heavily polluted regions of the country should withstand a 500 hours salt spray test when tested to BS 7479, and where prolonged guarantees are being offered this minimum should also be considered. It is recommended that evidence of independent test certificates by a UKAS approved test house be obtained to demonstrate conformity with the above.

## 4. Rivets

With some framing materials there is a trend away from the use of rivets for attaching hardware during the fabrication of frames. Certain rivets after application leave holes through their centres, which permit the ingress of water. With PVC-U where water would penetrate into an undrained chamber or onto reinforcement, these holes should be sealed by proprietary method.

## 5. Screws

All screws should be chosen with their application in mind. Guidance can be found in GGF data sheet 6.8.

For further advice on selecting the correct product, contact the supplier.

## 6. Hardware attachment

To ensure the hardware operates correctly it is important that the points listed below are followed during its installation.

Staff should be trained in the correct installation procedures. Where jigs are available, these must be used to ensure the correct location of relevant components.

Products should be fitted in compliance with the system / hardware suppliers' recommendations.

All hardware must be operated several times to ensure the correct functions and engagement of all parts.

Friction stays should ideally be fitted into the correct locating upstands / Eurogrooves.

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All hardware positions should be defined by the system company to achieve the weather seal compression required.

All fixing holes provided must be used.

## 7. Site installation

After final installation of the window or door on site, it is important to ensure that there is no obstruction between the frame and the hardware, that the operation of all hardware is checked, and the hardware is cleaned of any site debris and protected from further damage. Carrying out these operations will indicate any further adjustments, which may be required to ensure the adequate weathersealing is achieved.

Hardware should be lubricated in compliance with the manufactures instructions before the installer leaves the site.

Protectively coated screws and fasteners should not come into contact with wet or damp cement or plaster or acrylic fillers, as this will attack the coating and render it inoperative.

## 8. Maintenance

To obtain maximum performance and durability from the hardware installed, it is important that the end user is advised of the simple periodic maintenance which must be carried out.

Maintenance should be carried out more frequently in coastal areas or those, which are subject to high levels of pollution.

Parts exposed when the window/door is opened should be wiped down to remove residue of old lubrication, swarf and grime. Sealing cams and strikers should be given a minute smear of petroleum jelly or equivalent. Sliding bars and the faceplate of gears should be lubricated with suitable lubricant to manufactures recommendation.

In the case of friction stays, manufacturer's lubrication and adjustment instructions must be adhered to strictly.

All fixings should be checked periodically for tightness and security and adjusted where necessary by a suitably qualified person.

Handles or other items, which are visible when the sash is closed, should be cleaned with a mild solution of warm soapy water, applied with a soft cloth. They should be dried thoroughly.

Ammonia and silicon based and abrasive based cleaners should not be used on any hardware or fixings.

These recommendations assume the window/door has been manufactured to a standard not less than those set out in the appropriate standard /code of practice, and that operations function correctly.

It should be noted that Tannic acid can be found within certain species of wood e.g. oak. This acid can be corrosive on hardware.

## 9. References.

British Standards

BS 7412: 2002 Plastic windows made from unplasticized polyvinyl chloride (PVC-U) extruded hollow profiles. Specification

BS 4873: 1986 Specification for aluminium alloy windows

BS 644: 2003 Timber windows. Factory assembled windows of various types. Specification

BS EN 1670: 1998 Building Hardware. Corrosion resistance. Requirement and test method.

BS 7479: 1991, ISO 9227: 1990 Method for salt spray corrosion tests in artificial atmospheres

Product Approval Specifications

PAS 23-1: 1999 General performance requirements for door assemblies. Single leaf, external door assemblies to dwellings.

GGF Data Sheets

Data sheet 6.8 2004 - Guidelines for the selection, installation and maintenance of screws and fasteners for the window and door industries.

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# Hardware Specification Document Guidelines for the Selection, Installation and Maintenance of Screws and Fasteners for the Window and Door Industries

6.8 SEPTEMBER 2004

## 1. Scope

This guidance document has been prepared by the Technical Committee of the Hardware Manufacturers Group.

It provides information to assist in the correct selection, specification and maintenance of screws and fasteners. The objective of this is to consolidate the various trade standards.

## 2. General

It is necessary to comply with the relevant British Standards for each of the framing materials that are being considered, BS 7412 for PVC-U windows, BS 4873 for aluminium windows, BS 644 for timber windows and PAS 23 for doors.

All products must comply with the relevant Building Regulations.

With screws, particular care should be taken with regard to head, thread and point design as well as corrosion resistance. Although there is no specified minimum requirement in BS 7412 for corrosion resistance, the Glass and Glazing Federation suggest a minimum of 240 hours, thereby complying with BS EN 1670 Grade 4. For coastal or heavily polluted regions of the country, or where prolonged guarantees are being offered, it is recommended that screws and fixings should withstand a 500 hours salt spray test when tested in accordance with BS 7479. It is recommended that evidence of independent test certificates by a UKAS approved test house be obtained to demonstrate conformity with the above.

It is recommended that a screwdriver speed of 1500 - 2000 rpm be employed, as this will cover the vast majority of screw applications. It is important that the torque of the screwdriver is set in accordance with the framing material being used, to ensure that neither screw heads nor threads nor framing material are damaged. Care should always be taken to insert screws at right angles to the substrate surface. Care should be taken to ensure that the correct screwdriver bit is utilized to avoid damage to the screw heads.

If in doubt consult your supplier for advice.

## 3. Selection

Consideration should be given to the end application when selecting screws and fasteners.

Care in selection should also be taken where high security fittings are involved, to ensure optimum performance of the hardware is achieved. For guidance on material selection reference should be made to section 6 - materials.

### 3.1 Rivets

Where it is decided that the use of rivets is appropriate, they will generally be found to be one of FOUR types:

- Standard open end
- Multi-grip open end
- Peel type with either countersunk or dome head
- Standard sealed type

The diameter, length and head form are determined by specific application.

Note: certain rivets, after application, leave holes through their centres, which could permit the ingress of water. With PVC-U windows and doors, where moisture penetration would be into an undrained chamber or onto reinforcement, these holes should be sealed by a proprietary method.

See table 1 for rivet types in both unset and set conditions.

### 3.2 Screws

All screws should be chosen with their application in mind. Where screws are to be replaced, such as in retrofit applications, suitably sized repair screws should be used. It must be appreciated that screws from different manufacturers and countries may have their own individual specifications.

Where organically coated screws are selected, care should be taken by the fabricator to obtain these screws with head recesses which have not been filled with the organic coating.

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See table 2 for details of heads, threads, points and applications.

## 4. Maintenance

No general maintenance should be required with screws and fasteners, although light oiling will never go amiss. Contact with domestic or industrial ammonia based solvents should be avoided.

## 5. Fixing

Protectively coated screws and fasteners should not come into contact with wet or damp cement or plaster, or acrylic fillers or their fumes, as these will attack the coating and render it inoperative.

## 6. Materials

From analysis on the results of independent tests (Salt Spray and Drill Application tests) the following information about material is given to assist the selection of screws and fasteners.

### 6.1. Carbon Steel

Needs protective coating for 240 hours corrosion resistance.

Can self-drill into aluminium and steel reinforcement.

Not normally recommended for attachment of stainless steel fittings because of the risk of reduced corrosion resistance due to electrolytic reaction between dissimilar metals.

Magnetic.

### 6.2 Martensitic: - Grade 410 - 100% stainless steel

Cosmetic coating will prevent pitting. Does not require any protective coating for 500 hours corrosion resistance.

Can self-drill into aluminium and steel reinforcements.

Suitable for the attachment of stainless steel fittings.

Magnetic.

### 6.3 Austenitic: - Grade 302 / 304 - 100% stainless steel

Does not require any protective coating for 500 hours corrosion resistance.

Can self-drill into PVC-U.

Suitable for the attachment of stainless steel fittings.

Non magnetic.

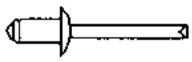
6.4 Bi-metallic: - austenitic stainless steel head and partial thread with a carbon steel drill tip and initial threads to self-drill and self-tap into reinforcement. Only the austenitic portion of the fastener should be in contact with the hardware and reinforcement, to reduce the risk of failure.

If the carbon steel portion is exposed, it requires protective coating for 500 hours corrosion resistance.

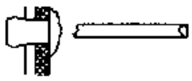
Suitable for the attachment of stainless steel fittings.
Non magnetic head
.

If carbon steel fasteners with a suitable protective coating are selected, it should be noted that white corrosion deposits may form on the fastener during its service life. This type of corrosion is not detrimental to the overall performance of the fastener and can be considered acceptable, as it is the protective coating which is corroding, and not the base material of the product.

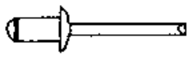
TABLE 1 - RIVET SELECTION



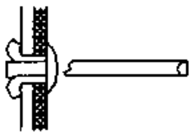
A typical standard open-ended rivet in unset condition.



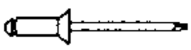
A typical standard open-ended rivet in set condition.



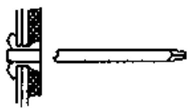
A typical dome headed peel type rivet in unset condition.



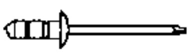
A typical dome headed type peel rivet in set condition.



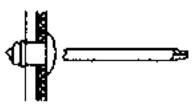
A typical countersunk peel type rivet in unset condition.



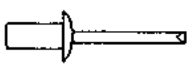
A typical countersunk peel type rivet in set condition.



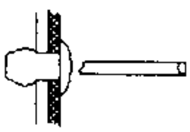
A typical multi-grip open-ended peel rivet in unset condition.



A typical multi-grip open-ended rivet in set condition.



A typical standard sealed rivet in unset condition.



A typical standard sealed rivet in set condition.

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TABLE 2 - SCREW SELECTION

A typical countersunk woodscrew. The diameter and length are determined by the specific application.

A typical pan headed woodscrew. The diameter and length are determined by the specific application.

A typical pan headed, self-tapping screw for use in the steel or aluminium window and door industries. The diameter and length are determined by the specific application.

A typical countersunk machine screw that has uses in PVC-U, steel, timber and aluminium window and door industries. The diameter and length are determined by the specific application.

A typical facet headed, metric threaded, self-drilling screw for the retention of galvanised steel reinforcements to PVC-U profiles. The diameter and length are determined by the specific application.

A ribbed headed, self-tapping threaded, self-drilling screw for the retention of aluminium or galvanised steel reinforcements to PVC-U profiles. The diameter and length are determined by the specific application.

A typical single high threaded, countersunk screw with gimlet point, for the retention of hardware to unreinforced PVC-U profile. The diameter and length are determined by the specific application.

A typical high / low threaded countersunk screw with gimlet point, for the retention of hardware to unreinforced PVC-U profile. The diameter and length are determined by the specific application.

A typical metric threaded countersunk screw with self-drilling point, for the retention of hardware to steel windows and doors, galvanised steel reinforced PVC-U profile. The diameter and length are determined by the specific application.

A typical self-tapping threaded countersunk screw with a self drilling point, for the retention of hardware to aluminium windows and doors, or aluminium or galvanised steel reinforced PVC-U profile. May not be suitable for multi-wall applications. The diameter and length are determined by the specific application.

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A typical pan headed, self-tapping threaded screw with self-drilling point suitable for the retention of hardware to aluminium windows and doors, or aluminium or galvanised steel reinforced PVC-U profile. The diameter and length are determined by the specific application.

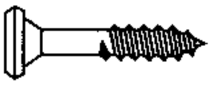
A typical shallow pan headed, single high threaded screw with gimlet point, suitable for the retention of friction stays to unreinforced PVC-U windows or timber windows. The diameter and length are determined by the specific application.

A typical shallow pan headed, high / low threaded screw with gimlet point, suitable for the retention of friction stays to unreinforced PVC-U windows. The diameter and length are determined by the specific application.

A typical shallow pan headed, high / low threaded screw with spoon point, suitable for the retention of friction stays to unreinforced PVC-U windows. The diameter and length are determined by the specific application.

A typical shallow pan headed, self-tapping threaded, and self-drill pointed screw for the retention of friction stays to steel and aluminium windows, aluminium or galvanised steel reinforced PVC-U windows. The diameter and length are determined by the specific application.

A typical shallow headed, twin high threaded, self drill pointed screw for the retention of friction stays to steel or aluminium windows, or aluminium or galvanised steel reinforced PVC-U windows, or unreinforced PVC-U windows. This style of screw usually has a thread diameter in the region of 4.8mm, and is frequently used as repair screw, as well as original equipment. The diameter and length are determined by the specific application.



A typical screw used for the mechanical jointing of all types of windows and doors. The diameter and length are determined by the specific application.

## 7. References.


### British Standards

BS 7412: 2002 Plastics windows made from unplasticized polyvinyl chloride (PVC-U) extruded hollow profiles. Specification.

BS 4873: 1986 Specification for aluminium alloy windows.

BS 644: 2003 Timber windows. Factory assembled windows of various types. Specification.

BS EN 1670: 1998 Building hardware corrosion resistance requirements and test methods.

BS 7479: 1991, ISO 9227: 1990 Method for salt spray corrosion tests in artificial atmospheres.

### Product Approval Specifications

PAS 23-1: 1999 General performance requirements for door assemblies. Single leaf, external door assemblies to dwellings.

### GGF Data Sheets

Data Sheet 6.7: 2004 Guidance for the selection, installation and maintenance of hardware for the window and door industries.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# Specification for the Performance of Door Assemblies

6.9 NOVEMBER 1997

This specification has been developed by the GGF, in association with other Trade Association, to provide a method for assessment of the performance of door assemblies.

**Foreword**

It has been developed because of the current lack of performance for doors available through the normal sources.

In order to ensure that all materials currently available for use in the manufacture of doors are covered, the GGF has involved other Trade Associations with expertise of the particular materials concerned.

It is intended that this should be an evolving specification reflecting current design and material requirements. Accordingly it will be subject to review and amendments as necessary.

**Contents**



**2. Scope**

This specification details the test method and acceptance criteria applicable to domestic type single leaf, single swing, external residential door assemblies, inward or outward opening, with or without side panels, and fan lights being integral or coupled. The performance requirements in this specification are not material specific. Any components used in door assemblies shall conform to the relevant British Standard.

The specification excludes double leaf doors, double swing doors, sliding doors, sliding folding doors, tilt and slide doors, and pivoted doors.

**3. Definitions.**

For the purpose of this specification the following definitions apply.

**3.1 Door**

All components for closing an opening in a wall that allows access or passage and may admit light when closed.

**3.2 Door Assembly**

A complete unit as installed comprising door frame and a door leaf together with its essential hardware which may be supplied from separate sources.

**3.3 Door Leaf**

An element which when fitted with hinges or pivots in a door frame forms part of a door assembly.

**3.4 Door Frame**

Part of a door assembly in which the door leaf moves.

**3.5 Hardware**

All the devices attached to structural members to facilitate opening, closing or making secure the door leaf in the frame such as hinges, dog bolts, door bolts locks and latches receivers, door furniture, and profile cylinder.

**3.6 Latches**

Elements of hardware attached to a door leaf which can secure the door leaf to the door frame by means of a bolt, latch or lock, which can be finger or hand operated.

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### 3.7 Finger Operated
Equipment or hardware operated by fingers only without palm contact. It may or may not include a key.

### 3.8 Hand Operated
Equipment or hardware operated by use of the full hand including palm contact. It may or may not include a key.

### 3.9 Cycle
Set of operations involving the opening of a door leaf including the unlocking and the release of all fasteners, moving open to the required extent, returning to the closed position and re-engaging of all fasteners and re-locking.

### 3.10 Operating Device
Item of hardware enabling user to release and move a door leaf.

### 3.11 Test Velocity
The test velocity is that which can be measured on the closing edge of the member of the sample under test, and is measured in metres per second (m/s).

## 4. Assessment Procedure

### 4.1 Product Range
The product range must be defined prior to the selection of the test samples. The definition will include:-
(a) Product design specification, including profiles, beads, hardware, infills and reinforcements.
(b) Size range and configurations.
(c) Installation requirements
(d) Construction of any panels which may incorporate an opening vent.
(e) Locking device options
(f) Low threshold options

### 4.2 Sample Selection
For type testing, a suitable number of samples shall be selected which represent the most adverse and vulnerable aspects of a product range. Within each range a minimum of two samples is required. The following list, which is not exhaustive, identifies features that require consideration,
(a) Distance between securing points which fix the leaf to the outer frame.
(b) Directions of openings.
(c) Glazing options e.g. single or double glazed, construction or infill panels.
(d) Glazing installation methods.
(e) Range of sizes.

### 4.3 Sequence of Tests
The following test sequences shall be applied to separate samples.

| Test Sequence 1 | Section |
|---|---|
| (a) Operating forces. | 6.2 |
| (b) Air permeability | 6.1.1 |
| (c) Watertightness. | 6.1.2 |
| (d) Wind resistance | 6.1.3 |
| (e) Repeat air permeability | 6.1.1 |
| (f) Repeat watertightness | 6.1.2 |
| (g) Repeat operating forces | 6.2 |
| (h) Resistance to vertical load | 6.3 |
| (i) Resistance to static torsion | 6.4 |
| (j) Slam shut test | 6.7 |
| (k) Closure against obstruction | 6.8 |
| (l) Abusive forces on handles | 6.9 |
| (m) Resistance to soft and heavy body impacts | 6.5 |
| (n) Resistance to hard body impacts | 6.6 |

| Test Sequence 2 | Section |
|---|---|
| (a) Operating forces | 6.2 |
| (b) Mechanical durability | 6.10 |
| (c) Resistance to climatic variation | 6.12 |
| (d) Basic security test | 6.11 |

## 5. Performance Requirements

### 5.1 Weather Performance Requirements

### 5.1.1 Guidance to Selection and Specification of Door Assemblies for Weathertightness

It is assumed that most door assemblies within the scope of this specification will be at ground level, and that design wind pressures will not exceed 800 Pa. This will not be so where locations are in exposed positions or upper floors providing access to a balcony. In these situations the design wind pressure should be calculated by the methods described in BS 6399 Part 1.

5.1.2 Air Permeability
The air permeability shall be as specified for the appropriate exposure category in Table 1. The air permeability requirement has been determined by the following:
(a) The exposure category (design wind pressure).
(b) The heat loss that can be accepted.
(c) The health and comfort of the occupants.
For fixed lights the average leakage rate shall not exceed 1m 3 / per h per metre length of visible perimeter of infill when tested at the same pressures as the door.
Where a door assembly contains a fixed light (side and /or fan) and the air flow is within the permissible limits for the door assembly, there is no requirement to test the fixed light separately.

### 5.1.3 Watertightness
The watertightness shall be as specified for the appropriate exposure category in Table 1. There shall be no leakage during the test up to and at the test pressure class given in Table 1. The acceptability of unclassified performance would be appropriate, for example, where the door assembly is protected from driving rain by a porch or recessed into the reveal, or protecting it by a porch, may also be necessary where low level thresholds are required for wheel chair access for use by the disabled. It should be noted that in any specification for watertightness class, the ability of the glazing system to prevent water entering the rebate area, or to be drained from it, is not assessed by the tests described in this standard.

### 5.1.4 Wind Resistance

Where the design wind pressure is 800 Pa or less the exposure category is given in table 1.

For door assemblies with side screens the design wind pressure at which maximum deflection is likely to occur shall be stated by

**Table 1. Exposure catagories**

| Exposure category | Test Pressure class | | |
|---|---|---|---|
| Design wind pressure Pa | Air permeability* | Watertightness** | Wind Resistance*** |
| 800U | No requirement | No requirement | 800 Pa |
| 800X | Up to 200 Pa (graph A) | No requirement | 800 Pa |
| 800 | Up to 200 Pa | 100 Pa | 800 Pa |
| Over 800 | Up to 300 Pa (graph B) | 200 Pa | Equal to actual wind pressure |

**Note:** Products categorised with a U requirement need only meet a Wind resistant class. Products classified with a X need not meet any requirement for watertightness.

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the manufacturer. For design wind pressures over 800 Pa, the actual pressure should be stated, and this should be the maximum to which the door assembly is exposed.
The deflection of members such as couplings, glazing bars or meeting styles shall be limited to 1/125 of the span. Such members retaining an insulated glass unit shall not deflect more than 1/175 of the span.
After wind resistance testing there shall be no permanent damage.
No permanent damage will be deemed to have occurred if:
(a) the performance level of fixed lights for air permeability does not increase by more than 1m3/h per metre length of open joint for the initial values of up to 5m3/h per metre length or 2m3/h per metre length of opening joint for initial values over 5m3/h per metre length of opening joint.
(b) the performance value for air permeability is that required in Table 1 for the test pressure class achieved in the initial tests.
(c) the performance level for watertightness is that required in Table 1 for the test pressure class achieved in the initial test.

#### 5.1.5 Classification

The watertightness shall be determined when the door assembly has been tested in accordance with clause 6.1 and classified according to the exposure categories given in Table 1. The test pressure for all requirements shall be attained, or exceeded, by a door for the door to be included in that exposure category.

* A test pressure class of 600 Pa (see figure 1, Graph C of BS 6375pt 1) is applicable when stringent levels of performance are required, for example when exceptionally airtight doors are necessary as in air conditioned buildings, especially when opening directly into a habitable room. Where there is such a requirement, the exposure category should be suffixed with "Special" e.g. 800 special.

** The watertightness test pressure classes given cover most situations. Assemblies of higher performance than stated in the table should be considered where the assembly is located in exposed situations, at high level on the building and/or directly into a habitable room. A classification of "No Requirement" would be inappropriate for residential doors in some situations.

*** In wind resistance tests, where deflection is measured, e.g. in the case of door assemblies with side panels, the test panels, the test pressure for that limiting deflection shall be stated, by the manufacturer, where it is greater than 800 Pa.

### 5.2 Mechanical Performance

#### 5.2.1 Operating Forces

Operating forces acting on door assemblies shall be appropriate for their intended use. When tested in accordance with clause 6.2, the assembly shall meet the following requirements.
i) Latching forces < or = 80N.
ii) Force required to initiate movement < or = 70N
iii) Locking and unlocking forces:
(a) Hand operated hardware force < or = 75 N.
(b) Finger operated hardware force < or = 30 N.
(c) Key operation torque < or = 2 Nm.

#### 5.2.2 Resistance to Vertical Loads

Door assemblies shall be tested in accordance with clause 6.3. This specifies the method to be used to determine the permanent deformation caused when a vertical load is applied to the free edge of an open door leaf fixed in its own frame. The load to be applied shall be 500 N. For an assembly to meet this requirement any residual deformation shall not prevent normal operation. Operating forces shall continue to meet the requirements of 5.2.1.

#### 5.2.3 Resistance to Static Torsion

Door assemblies shall be tested in accordance with clause 6.4. This specifies the method to be used to determine the permanent deformation caused when static stress in torsion is applied to a closed door leaf fixed in its own frame.
The load applied shall be 350N. For a door to meet this requirement, any residual deformation shall not prevent normal operation of the door. Operating forces shall continue to meet the requirements of 5.2.1.

#### 5.2.4 Resistance to Soft and Heavy Body Impact

Door assemblies shall be tested in accordance with clause 6.5. This specifies the method used to determine the damage caused by striking the face of a closed door leaf, fixed in its own frame, with a soft and heavy body. The impact energy to be applied shall be 150 J.
It shall be applied three times to the opening face and three times to the opening face of the door leaf.

**Note:** When the impact is applied to the opening face, the test stresses the door leaf itself. When applied to the closing face the test is used to assess the hardware, its fixing arrangements, and the ability of the door leaf to retain the hardware.
Operating forces shall continue to meet the requirements of clause 5.2.1.
No component of the assembly shall exhibit any visible failure. Glazed areas shall comply with requirements of BS 6262.

#### 5.2.5 Resistance to Hard Body Impact

The door leaves shall be tested in accordance with Clause 6.6. This specifies the method to be used to determine the damage caused to door a leaf by the impact of a hard object. The impact energy to be applied shall be 8 J.
The requirements to meet this specification are:-
(a) the mean value of the diameters of the indentations caused will not exceed 20mm, and
(b) the mean value of the depth of indentations caused shall not exceed 2mm. The maximum value shall not exceed 3mm.

#### 5.2.6 Slam Shut Test

The test specified in clause 6.7 shall be used to determine the resistance of the door assembly to abuse caused by slamming. After testing in accordance with clause 6.7, the operating forces shall continue to meet requirements of clause 5.2.1. No component shall exhibit visible failure.

#### 5.2.7 Closure against obstructions

The test specified in clause 6.8 shall be used to determine the resistance of a door assembly to the closure of the door leaf against small objects such as toys, which may be accidentally trapped between the frame and leaf. When tested in accordance with clause 6.8, the assembly shall withstand an applied force of 200 N.
Operating forces shall meet the requirement of clause 5.2.1. No component of the assembly shall exhibit any visible failure.

#### 5.2.8 Abusive forces on handles

A door leaf should resist abusive forces applied to the handle. When tested in accordance with clause 6.9 the assembly shall withstand an applied force of 500 N
Operating forces shall meet the requirement

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of clause 5.2.1 and there shall be no loosening of the handle fixings, or visible damage to the handle assembly.

### 5.3 Performance in Use

#### 5.3.1 General

In order that the door assembly shall perform satisfactorily, it shall be constructed and installed in accordance with designer's instructions.

#### 5.3.2 Mechanical Durability

The repeated operation of the full locking cycle, including opening and closing of doors, should neither damage them nor impair their performance, having regard to normal maintenance.

Testing shall be carried out in accordance with clause 6.10. Following the completion of 50,000 cycles, the operating forces shall meet the requirement of clause 5.2.1.

#### 5.3.3 Basic Security

Glazing systems shall be designed so that the infill cannot be removed from the outside within 3 minutes when tested in accordance with clause 6.11.

#### 5.3.4 Resistance to climatic variation

A door should not bow or twist to the point where its performance requirements cannot be met. When subjected to the test regime described in clause 6.12, and measured in accordance with prEN 952, a door will be considered acceptable if the operating forces measured during the test do not exceed those given in clause 5.2.1, and its distortion characteristics after the test do not exceed the criteria set out in Table2.

Table 2

| Distortion Limits | |
|---|---|
| Parameter | Maximum value |
| Twists | 8 mm |
| Bow | 8 mm |
| Cup | 4mm |

### 5.4 Special Aspects

#### 5.4.1 General

Where appropriate to a specific requirement, the agreed performance should be assessed in accordance with one of the following;

#### 5.4.2 Acoustic Performance

Determined in accordance with BS EN ISO 140-3 (1993)

#### 5.4.3 Thermal Performance

Determined in accordance with BS 874 Part 3 or an approved calculation method.

#### 5.4.4 Fire Performance

Ignitability – determined in accordance with BS 476 Part 12.

## 6. Testing

### 6.0 General

#### 6.01 Test Samples

Unless stated otherwise, all test samples shall comprise of a complete door assembly, including any associated glazing, hardware, and other accessories, details of which should be recorded and included in the test report. Any glazing shall comply with BS 6262. If glass breakage occurs without damage to the frame members, the unit can be reglazed once and retested.

#### 6.0.2 Sample conditioning

Unless stated otherwise, the test sample should be stored and tested in an environment within the range of 15° to 30°C and 25 to 75% RH, for a minimum of 24 hours.

#### 6.0.3 Sample Preparation

The sample, shall be fixed into a suitable sub-frame using fixings to replicate the manufacturer's specification. The sub-frame should then be mounted into a test frame which is sufficiently rigid to withstand the test loads without deflection which could influence the test result.

#### 6.0.4 Weathertightness Test Preparation

During weather performance testing, permanent ventilators and key escutcheon shall be sealed before commencing. If present, trickle ventilators and letter plates shall be closed, but not additionally sealed.

### 6.1 Weathertightness

#### 6.1.1 Test for air permeability

Doors assemblies shall be tested in accordance with BS 5368: Part 1 with the pressure applied to the outside face of the door only.

For all types of door assembly, the air flow passing through the specimen at each test pressure difference applied in BS 5368: Part 1, shall be expressed as an average leakage rate per metre length of opening joint visible on the inner face of the specimen.

#### 6.1.2 Test for Watertightness

Door assemblies shall be tested in accordance with BS 5368 Part 2 using the preferred spray method No 2.

#### 6.1.3 Test for wind resistance

Door assemblies shall be tested by the methods described in BS 5368: Part 3. The preparation gust (pl) shall be 500 Pa. The repeated positive and negative pressure gusts (p2) shall be 800 Pa or the greater declared design wind pressure.

The deformation test described in 9.1 of BS 5368 Part 3 is omitted, but the deflection of members shall be measured during the repeated positive and negative pressure test. To fulfill the requirements of the safety test described in 9.3 of BS 5368 Part 3 any permanent residual deformation, damage or functional defects shall be noted.

On completion of the wind resistance test the door shall be opened and closed 5 times.

### 6.2 Operating Forces

The measurement of the minimum force or torque required to engage or disengage the hardware (locks, handles etc.) or commence opening and complete closing of the door leaf shall be determined as follows: -

#### 6.2.1 Equipment

Means shall be provided for the application of forces to manipulate the hardware uniformly and without stock.

| Required Load (N) | Increments |
|---|---|
| ≤1.0 | 1(±0.IN) |
| ≤10N | 10(±1N) |

#### 6.2.2 Procedure

##### 6.2.2.1 Preparation

Tests shall be performed after manual operation of all moving parts five times.

##### 6.2.2.2 Procedure to determine the closing force to latch

Open the door leaf for a distance of 200mm, and measure the force required to engage the latching mechanism. Make five measurements of the peak load at the operating point, and take the mean as the latching force.

##### 6.2.2.3 Procedure to determine the force to operate the opening device

##### 6.2.2.3.1 Procedure

Handles should be placed by a suitable torque driver acting on the handle spindle. Apply a

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torque in the direction to release, unlock and lock the hardware.
Keys should be operated by a suitable torque driver.
Make five measurements of the peak load during the operation of the device, and take the mean for each test undertaken.

**6.2.2.3. 2 Determination of force for hand and finger operated hardware**

The force required to operate the device shall be calculated by dividing the mean torque measured in clause 6.2.2.3.1 by one of the following, as appropriate:
a) The length of the handle (in metres), measured from spindle centre to the end.
b) The maximum diameter (in metres) of the knob.

**6.2.2.4 Procedure to determine the force to commence motion**

With all the hardware disengaged, apply a load to the operating point to initiate movement of the door leaf. Make five measurements of the peak load, and take the mean as the force to commence motion.

**6.3 Resistance to Vertical Loads**

**6.3.1 Equipment**

A suitable loading device accurate to 2%.

**6.3.2 Procedure**

Without any vertical restraint, position the door at an angle of 90(+5-0)° to the plane of the frame. All loads shall be carefully applied and removed in 100 N ±2% maximum increments and over a minimum of 1 second for each increment, or the equivalent rate if continuous, in order to avoid dynamic effects. The load attachment point is at the handle position.
After removal of the load, measure the operating forces in accordance with clause 6.2.

**6.4 Resistance to Static Torsion**

**6.4.1 Loading Equipment**

A suitable loading device accurate to 2%.

**6.4.2 Procedures**

The door leaf shall be in the closed position and all locking hardware including latch mechanisms disengaged. Restrain one corner of the opening side of the leaf at a position 50mm from the edge. Apply a force of 350 N in the direction of opening on the unrestrained corner of the opening side. The load should be maintained for 60(±5) seconds, and then removed without shock.

All loads shall be carefully applied and removed in 100 N maximum increment, for a minimum of 1 second for each increment, or the equivalent rate if continuous, in order to avoid dynamic effects.
After removal of the load, measure the operating forces in accordance with clause 6.2.

**6.5 Resistance to Soft and Heavy Body Impact**

**6.5.1 Equipment**

An impactor of total mass 30 kg ± 2%, consisting of a spheroconical leather bag of diameter approximately 350 mm, containing dry sand of apparent density approximately 1500 kg/m$^3$ which passes through a sieve of 2 mm mesh.
A device for measuring the drop height of the impactor to an accuracy 5%.

**6.5.2 Procedure**

The leaf of the door assembly to be tested shall be closed and latched only. Identify the impact point. This shall occur at the centre of the door leaf. Where the impact point coincides with any hardware, this shall be removed.
The sample shall be impacted three times against the direction of opening, followed by a further three impacts in the direction of opening.
Suspend the impactor so that at rest it makes light contact with the surface of the door leaf, and with its centre of gravity opposite to, and at the height of, the impact point. Raise the impactor to a height of 500 (+10) mm above the height of the impact point. Release the impactor so that it strikes the leaf at the impact point.

**Note:** Repetition of this operation will necessitate re-shaping of the impactor. The angle at which the impactor is raised should not exceed 30 degrees. After the last impact , measure the operating forces in accordance with clause 6.2 and examine all components for visible evidence of mechanical failure.

**6.6 Resistance to Hard Body Impact**

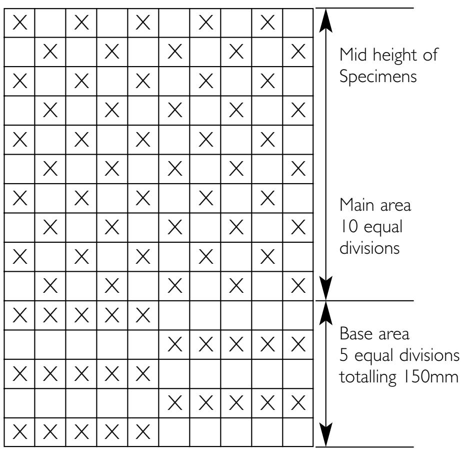
**6.6.1 Equipment**

A 50(±1) mm diameter steel ball of known weight, with appropriate release apparatus.
A device capable of measuring depth with an accuracy of not less than 0.05 mm.
A length measuring device accurate to 0.5 mm.

**6.6.2 Procedure**

Mount the door leaf horizontally, with rigid supports under the long edges resting on the solid base.
Select one of the four aiming patterns shown in (Figure1) such that the theoretically weakest point is included, and mark the 15 impact points on the surface of the door leaf.
Any area of glass infill shall be omitted from the test, thereby reducing the number of impact points.
Impacts points in the topmost row of rows of the aiming pattern shall also be omitted where the height of the door leaf is less than 2000 mm. The test area is not extended where the height is more than 2000 mm.
**Note:** To facilitate the setting out of the aiming pattern, templates may be made for standard sized door leaves in accordance with figure 1. Holes of approximately 8 mm diameter are drilled in the centres of the numbered rectangles so that a marker pen can be used

**Figure 1 Aiming patterns for hard body impact test**




X = Potential aiming point
(a) Principles of pattern construction

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | 2 | | 3 | | Y | | 4 | |
| | 4 | | 1 | | 2 | | Y | | 3 |
| 3 | | Y | | 4 | | 1 | | 2 | |
| | Y | | 3 | | 4 | | 2 | | 1 |
| Y | | 3 | | 2 | | 4 | | 1 | |
| | 2 | | Y | | 1 | | 3 | | 4 |
| 2 | | 4 | | 1 | | 3 | | Y | |
| | 1 | | Y | | 3 | | 4 | | 2 |
| 4 | | 1 | | Y | | 2 | | 3 | |
| | Y | | 2 | | 4 | | 1 | | 3 |
| 1 | 3 | Y | 4 | 2 | | | | | |
| | | | | | 3 | 1 | 4 | 2 | Y |
| 2 | 4 | 1 | 3 | Y | | | | | |
| | | | | | Y | 2 | 3 | 1 | 4 |
| Y | 3 | 2 | 4 | 1 | | | | | |

Y = Remaining sub-areas
(b) Four possible aiming patterns

to indicate the selected aiming pattern on the face of the door leaf.
Position the release apparatus vertically over each of the impact points in turn, and drop the steel ball from a height, measured from its underside to the surface of the door leaf, which corresponds to the required impact energy. Where an imprint is left by any impact, within 30 minutes measure the maximum depth of the indention to the nearest 0.1 mm.

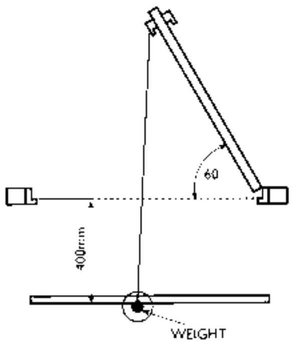
Where impacts occur at points where the surface is uneven, e.g. at mouldings, only a more general assessment of damage may be possible. Repeat the procedure for the other face of the door leaf if the construction is not systematical.

**6.7 Slam Shut tests**

**6.7.1 Equipment**
A light, strong line.
A steel bar, 25 mm diameter, of suitable length.
A 15 kg (±2%) weight

**6.7.2 Procedure**
The door leaf should be closed from being 60° open, by the descent of the 15 kg mass (see Figure 2). The line should be attached to the door leaf at the door handle, or if this is more than 150 mm from the lock side edge, at some point within 15 mm of that, at the level of the handle.

Figure 2 Slam Shut Test



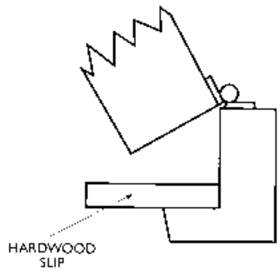

The line should be arranged to pass horizontally from the door leaf, and then over the steel bar arranged horizontally, with its axis parallel to the plane of the doorframe. The bar should be arranged approximately 400 mm from the leaf face when the leaf is closed, and to span the width of the door set. The line should descend vertically from the bar, and carry the 15 kg weight at its lower extremity. The length of line should be arranged so that as the door is closed by the action of the descending weight, the weight strikes a platform so removing tension from the line just prior to the instant of closing.
The door leaf should be opened to 60° (± 5°), then slammed by the action of the descending weight. The slamming operation is repeated 20 times.
After the last cycle, measure the operating forces in accordance with clause 6.2.

**6.8 Closure against obstruction**

**6.8.1 Equipment**
A hardwood block 50 mm x 50 mm x 10 mm, of mass between 15 g and 20 g.
A suitable loading device accurate to 2%.

**6.8.2 Procedure**
The hardwood block should be placed in the gap between the leaf and the bottom of the hinge side jamb of the test frame to hold the door leaf ajar. Insert the block from the closing face, with its plane vertical and parallel to the door frame (see Figure 3).
Apply a progressively increasing force to the lock side edge at handle height until 200 N is reached. The force shall act perpendicular to the plane of the frame.
After removal of the load, measure the operating forces in accordance with clause 6.2.

Figure 3 Closure against obstruction




**6.9 Abusive forces on handles**

**6.9.1 Equipment**

A suitable loading device accurate to ±2%.

**6.9.2 Procedure**
The test should be applied to all handle types on the most accessible face. The leaf of the test assembly should be closed and latched, but not locked or bolted.
Progressively and without shock apply a load of 500 N to the handle. The load should be applied perpendicular to, and away from, the face of the door leaf for 60 (± 5 seconds). The load should then be removed without shock.
Lever handles shall be tested with the load applied at a point mid-way between the centre of the spindle and the end of the lever, or 50 mm from the end of the lever if greater.
Twist handles shall be tested with the load acting at the centre of the spindle.
Pull handles shall be tested at the mid point of the length.
After removal of the load, measure the operating forces in accordance with clause 6.2, and examine the handle for evidence of loosening of fixings.

**6.10 Mechanical Durability**

**6.10.1 Equipment**
Suitable apparatus to operate the locking and opening equipment, on the door leaf.
Masses and scales accurate to 2%.
Equipment to measure the velocity of the door accurate to 5%.
Force gauge and torque meter accurate to ±3%.

**6.10.2 Procedure**
The leaf of the test specimen is opened to the required resting position, and is then brought to the closed position and its lock and fasteners secured before rest. This cycle is repeated for the specified number of times, or until failure. The test velocity shall be 0.5 (±0.05)m/s.
The operating equipment shall act at the position of normal operation, and where possible shall be supported by the test surround. The loads applied by operating equipment shall be within the range of the specified operating forces, and shall be applied via the operating device, which shall be balanced so that the dead load applied on the operating point does not increase in any position the weight of the leaf by more than 5%.
Adjustment and lubrication in accordance with the door manufacturers' published instructions shall be carried out before and during the test, but a frequency of not less than 5,000 cycles.
With the test specimen installed in accordance with clause 6.3, the door leaf shall be subjected manually to 5 operating cycles before taking initial measurements. Door leaves should be operated from the closed position to an open position of 90° ± 10°, or to the stopping position of the restrictor if this occurs at less than 90°. A dynamic force should be applied at both opening and closing elements of the cycle. The fasteners should be released by the operating equipment and the leaf is set into motion as continuously as possible, so as to reach the test velocity between 20° to 60°

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(or 20% to 60%) of the stroke of the leaf, and to continue at that velocity to the end of the stroke.
The door leaf is set in motion from the open to the closed position in the same manner as described above. The door leaf shall come to a stop on the closing member of the frame at the test velocity. In the closed position the fasteners and the locking devices shall be fully secured. This is completed either when mechanical failure occurs or when the specified number of cycles has been carried out. In the event of interruption of testing, the cycle can be restarted after examination for failure. After completion of the required number of cycles, measure the operating forces in accordance with clause 6.2.

**6.11 Basic Security Test**

**6.11.1 Equipment**
Two paint scrappers
One flat blade screwdriver, length 200 mm, blade width 7 mm.
One flat carpenter's chisel, blade width 25 mm.

**6.11.2 Procedure**
Attempts should be made to gain entry from the exterior face using the tools specified in 6.11.1 by the removal of gaskets, beads, any security devices and the infilling.

**6.12 Resistance to Climatic Variation**

**6.12.1 Equipment**
Two climatic chambers.
Measuring devices.
A mounting system for the door frame.

**6.12.2 Humidity**
**6.12.2.0** This test is only applicable to those doors which contain hygroscopic materials.
**6.12.2.1** The bow, cup and twist of the door leaf is determined prior to the test by the method described in prEN 952
**6.12.2.2** The door assembly shall be installed in the mounting system, in the orientation specified by the applicant and the door closed but not locked.
**6.12.2.3** The door assembly shall be exposed to the climate indicated in Table 3 until final deformation has been reached. The test climate shall be maintained for at least 7 days, and terminated at 28 days or when the increase in deformation during three successive days is less than 0.1 mm per day.
**6.12.2.4** The operating forces, as defined in clause 6.2, shall be measured immediately prior to termination of test conditions.
**6.12.2.5** At the end of the period the door shall be opened and the resultant bow, cup and twist measured.

**6.12.3 Thermal Test**
**6.12.3.1** The door assembly shall be conditioned in an equilibrium environment for at least 7 days.
**6.12.3.2** The bow, cup and twist of the door leaf is determined prior to the test by the method described in prEN 952.
**6.12.3.3** The door assembly shall be installed in the mounting system in the orientation specified by the applicant and the door closed but not locked.
**6.12.3.4** Heat the external face of the door with filament lamps for 24 hours. The temperature required in Table 4 shall be reached within 2 hours and maintained constant during the test.
**6.12.3.5** The operating forces, as defined in clause 6.2, shall be measured immediately prior to the termination of test conditions.
**6.12.3.6** At the end of the period the door shall be opened and allowed to return to ambient conditions. The resultant bow, cup and twist shall be measured.

**7. References**


| | |
|---|---|
| DD171 | Guide to specifying performance requirements for hinged or pivoted doorsets |
| BPF/GGF | Trade Standard for Doors. |
| prEN 952 | Door leaves - General and Local Flatness - Measurement Method |
| BS476 Pt12 | Methods of test for ignitability of products by direct flame impingement |
| BS874 Pt3 | Test for thermal transmittance and conductance. |
| BS5368 Pt 1 | Air permeability test |
| BS5368 Pt 2 | Watertightness test under static pressure |
| BS5368 Pt 3 | Wind resistance test |
| BS6262 | Glazing for buildings |
| BS6375 Pt 2 | Specification for operation and strength characteristics |


Table 3
Humidity Test Climates

| Internal face | | External face | |
|---|---|---|---|
| Air Temperature | RH | Air Temperature | RH |
| 23 (±2)°C | 30(±5)% | 3(±2)°C | 65(±5)% |

Table 4
Thermal Test Climates

| Internal face | External face |
|---|---|
| Chamber Air Temperature | Sample Surface Temperature |
| 25 ±2°C | +55°C ±5-0°C |

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# Guidance for Surveyors and Installers for the Provision of Trickle Ventilation and Other Forms of Ventilation for Replacement Windows within England and Wales

6.10 October 2007

The Building Regulations Requirement F1 - Means of ventilation, states:

"F1. There shall be adequate means of ventilation provided for people in the building".

**When assessing a property for replacement windows the following should be considered regarding the use of trickle ventilators and other forms of ventilation within replacement windows:**

**1.** For replacement windows, trickle ventilators are not mandatory unless the existing windows have them, however it is always good practice to consider their use when replacing windows. Alternatively trickle ventilators may be replaced by an air brick, if the amount of ventilation is not compromised.

**2.** Any replacement ventilators must be no smaller in geometric open area than the existing ventilators. If the geometric area is not known, habitable rooms should have trickle ventilator of 5000mm$^2$ equivalent area and wet rooms should have 2500mm$^2$ equivalent area.

**3.** Although not mandatory, increasing ventilation by the provision of new or additional ventilators to maintain good air quality should be considered between the supplier and the customer (ref: GGF publication "Advice to consumers regarding ventilation when replacing windows").

**4.** Two stage locking handles (Night vents) are an acceptable form of trickle ventilation, where security is not compromised and draughts will not create a problem. This would usually mean not on the ground floor or any other vulnerable location.

If an existing window has a two stage locking handle, the replacement window should either have trickle vents or two stage locking handles (or both) or the room should have an air brick fitted.

**5.** Controllable ventilators should have accessible controls available for the user.

**6.** The provision of permanent ventilators for combustion appliances is a different matter and compliance with Approved Document J is mandatory

**Note:**
It is important to remember that when carrying out building work (including replacing windows) builders and installers are under an obligation to ensure that, once work is completed, the building as a whole continues to comply with F1, or is no less compliant than it was before the work commenced.
If ventilation in a particular building is materially worsened as a result of installing replacement windows, Part F will require that compensatory provision for ventilation is made.

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# Design, Installation and Performance of Secondary Sashes made of Aluminium, uPVC or Wood

6.12 MAY 1990

1. Scope

This document deals with secondary sashes fitted to the room side of primary windows and which have frames made from aluminium, uPVC or wood or a combination of these materials. It includes all forms with opening and/or fixed panels containing glass or plastics sheet glazing materials.

2. Definitions

For the purpose of this Standard the following definitions apply:

2.1 **Batten.** A length of wood fixed to an internal reveal of a window opening or to the primary window, or to which the outer frame or panel is fixed or secured.

2.2 **Glazing material.** A material that produces a joint between the glass or plastics and the surround. (Not to be confused with glass or plastics sheet glazing materials.)

2.3 **Hardware.** Fittings which are used to operate and/or secure the panels.

2.4 **Outer frame.** The fixed perimeter frame of a secondary sash which, in some designs, is necessary to support the panel or panels.

2.5 **Plastics sheet glazing materials.** A rigid sheet of plastics, used for making the secondary sash.

2.6 **Panel.** The glazed frame of a secondary sash.

2.7 **Primary window.** The existing window which, after the installation of a secondary sash, will form the outer unit of the double or multiple glazing system.

2.8 **Rail.** A horizontal member of a panel of a vertically sliding secondary sash.

2.9 **Secondary sash.** A panel or panels, sometimes with an outer frame, fitted on the room side of a primary window, to provide improved thermal and/or sound insulation.

2.10 **Stile.** A vertical member of a panel of a horizontally sliding secondary sash.

2.11 **Sub frame.** A frame, usually of wood, fixed on the room side of a primary window to which either the outer frame or panel is fixed or secured.

2.12 **Venting.** Making special provision for air infiltration through the primary window into the cavity between the window and the secondary sash.

2.13 **Weatherstripping.** Material fitted to the outer frame or to the panels to reduce air penetration.

3. General Principles

3.1 Purpose

Secondary sashes supplement primary windows for the purposes of providing improved thermal and/or sound insulation and in some cases, depending on the lack of airtightness of the primary windows to which they are fitted, of reducing air infiltration into the room. It should be noted that the installation of secondary sashes will affect the number of air changes in the rooms and the internal air tempera-ture and, although they will provide thermal insulation, a reduction in condensation on the glazing may not be achieved.

3.2 **Types of secondary sashes.** Depending on the type and design of the primary window, secondary sashes may consist of:

(1) panels which are hinged or easily removable, fitted directly into the primary window, or fitted to an outer frame.

(2) panels which slide either horizontally or vertically within an outer frame.

3.3 **Size and arrangement of panels.**

For aesthetic reasons, secondary sashes should be sub-divided into a number of panels in such a way that their horizontal and/or vertical members align with members in the primary windows. However, this may not be practical, or further sub-division may be necessary to restrict the size of the panels so that they:

(1) are capable of being cleaned. (Consider strength, weight of panel, reach. See also 3.6.)

(2) are efficiently sealed when closed. (Consider strength of panel, number o fixings.)

(3) will resist the wind loading. (Consider strength of panel number of fixings.)

(4) will comply with operating force requirements. (Consider strength of panel, weight of panel.)

(5) will permit access to the primary window opening lights. (see 3.7.)

3.4 **Safety When Handling Panels.**

Any panel which is removable for cleaning should generally be restricted in weight to approximately 30Kg maximum, to allow it to be handled by two persons with a reasonable degree of safety. Where there is a specific customer requirement which will exceed this limit, he must be advised of the total weight involved and his acceptance must be obtained.

Where there is a requirement for the panel to be removable by one person, its weight should be reduced substantially. These limits are for a normal domestic situation. For non-domestic situations where removal of the panel will be carried out by professionals, these limits can be increased.

3.5 **Perimeter sealing.**

It is important that the secondary sash

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assembly (outer frame and panels (when closed)) are as efficiently sealed as practicable against air penetration, to minimise the amount of warm air entering the space between the panels and the primary window, and to minimise the entry of colder air into the room. The primary window when closed will normally provide sufficient air infiltration to allow the cavity to breathe to the outside air without additional venting. (See 6.5.)

### 3.6 Access for cleaning.

The arrangement of the panels, their size, type and location in relation to the primary window, should allow both surfaces of the glazing in the panels and the inner surface of the primary window to be cleaned from within the room. Where the outer surface of the primary window is cleanable from inside, the fitting of secondary sashes should not make this impractical unless otherwise agreed with the customer.

### 3.7 Provision of Ventilation.

Where provision is to be made for ventilation, this should be by either sliding or hinged panels, positioned also to provide access to allow the outer window to be opened. The fitting of the secondary sash should not impede the operation of the primary opening lights unless otherwise agreed with the customer.

### 3.8 Provision of escape in emergency.

The GGF recommends that its members and their agents will always draw the attention of potential customers to the absence of means of escape, and will have available in their product range opening replacement and opening secondary windows which will provide the means of escape, if required by the customer.

## 4. Specification

### 4.1 Materials

#### 4.1.1 Aluminium.

Extruded aluminium members shall be fabricated from designated treated alloys 6063TB, 6063TE, or 6063TF complying with requirements of BS 1474, or from special alloys required when integral colour anodising is to be carried out. The aluminium profiles used in the construction of the outer frames and panels shall be not less than 1.2mm thick, except for details such as nibs, interlocks, etc., which may be thinner.

The finish of the aluminium should be:

(1) anodised to BS 1615 and having a minimum thickness of 5 microns.

(2) Stoved organic finish to BS 4842.

#### 4.1.2 uPVC

Extruded members shall be of a suitable formulation which is chemically stable during extrusion and resistant to chemical attack and weathering. The colour shall be stable. No finish is necessary.

#### 4.1.3 Wood.

The quality shall comply with the requirements of BS 1186 Part 1. The workmanship shall comply with the requirements of BS 1186 Part 2.

The wood shall be treated as necessary to render it substantially durable. Advice on preservation of timber may be obtained from BRE Technical Note 24.

#### 4.1.4 Joint sealing materials.

The perimeter of the outer frame and the corner joints in that frame and in the panels shall, where necessary, be sealed against air penetration with joint sealing materials which will withstand stresses during assembly, transportation, installation and normal use.

#### 4.1.5 Hardware.

Hinges, handles, thumb turns and similar devices shall be of materials resistant to, or suitably protected against, atmospheric corrosion and shall not react with adjacent materials and finishes.

#### 4.1.6 Weatherstripping.

The weatherstripping shall be of materials which do not react adversely with the panel and frame materials and finishes.

#### 4.1.7 Fastenings and fixings.

All screws and other fastenings and fixings shall be compatible with the materials with which they are in contact and shall be corrosion resistant. However, this requirement does not apply to timber secondary sashes and sub-frames which are adequately protected by paint.

#### 4.1.8 Glass and plastics sheet glazing materials.

The type and quality of the glass shall be in accordance with BS 952, and that of plastics sheet glazing materials shall be in accordance with BS 6262.

Glazing thickness shall be in accordance with BS 6262 for the appropriate wind loading and safety requirements. (See also Appendix A for a guide to suitable glass thicknesses.)

#### 4.1.9 Glazing materials.

Glazing gaskets shall be of such materials as neoprene, EPDM rubber to BS 4255 Part 1 and Part 2, or plasticised PVC. (note: Plasticised PVC must not be used with plastics sheet glazing materials.)

Other glazing materials shall be in accordance with BS 6262.

### 4.2 Construction

#### 4.2.1 Outer frame and panel joints.

Corner joints may be stepped or flush. In aluminium or uPVC constructions, the surfaces of flush joints formed by mechanical means (e.g. screwing or cleating) may deviate from the same plane only within the limitations imposed by the extrusion tolerances. Joints in wood which are designed to be flush, shall be sanded flush if they would otherwise deviate from the same plane.

#### 4.2.2 Sliding Panels.

With the exception of interlocking portions of meeting rails and stiles:

(1) aluminium or softwood sliding panels shall not slide directly upon or against outer frames of the same material.

(2) uPVC sliding panels shall not slide directly upon uPVC outer frames. Hardwood panels may slide upon or against hardwood outer frames. Vertically sliding panels shall be supported on balancing devices, or they may be prevented from dropping by spring loaded bolts at both jambs which locate against stops provided at intervals in the outer frame jambs.

#### 4.2.3 Hinged and removable panels.

The hinges on hinged panels and bearing devices on removable panels shall be capable of supporting the panel during its normal use.

#### 4.2.4 Safety.

It shall not be possible for any panel to become unintentionally disengaged when operated normally without abuse.

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**4.2.5 The finished installation.**

The panels, including any exposed edges to the glazing and outer frame, shall be free from any sharp edges, burrs and the like that might be a hazard to the user.

**5. Performance**

**5.1 Air penetration.**

Air penetration through the secondary sash shall be minimised by providing:

(1) a virtually airtight seal round the perimeter of the subframe or outer frame.

(2) sealing any frame corners which would otherwise cause air infiltration through them.

(3) effective performance of the seals around the perimeter of the panels. It shall be appreciated that the performance of these seals may be limited by the need for ease of operation, and that small gaps are inevitable at the ends of the meeting rails or stiles.

**5.2 Wind resistance.**

The secondary sash shall resist the wind loading, calculated in accordance with BS CP3 Chapter V Part 2 without permanent deformation and with a maximum deflection of 1/125th of the span of panel framing members.

**5.3 Ease of sliding.**

For horizontally sliding panels, the initial force to be applied to the operating handle (wherever located), or one-third of the way up the stile in cases where the handle grip is incorporated in the section forming the stile, shall not exceed whichever is the greater of 120N or 120N per quare metre of panel. Thereafter, a force not exceeding the greater of 80N or 80N per square metre of panel shall be capable of maintaining the panel in motion.

For vertically sliding panels hung on balances, the initial force shall not exceed the greater of 180N or 180N per square metre of panel. Thereafter a force not exceeding the greater of 120N or 120N per square metre of panel shall be capable of maintaining the panel in motion. The force shall be applied at the mid point of the bottom rail.

For vertically sliding panels not hung on balances the weight of each panel should not exceed 6Kg.

**5.4 Thermal insulation.**

As the design of secondary sashes is such that the cavity between the glazing of the primary window and that of the secondary sash is at least 19mm, the U value may be assumed to be 2.9 W/m$^2$ °C. Venting of the cavity to the outside (See 3.5) should have no significant effect on the thermal insulation.

**5.5 Accoustic performance.**

Assuming the secondary sash has air penetration restricted as described in 5.1, the acoustic performance which can be expected from the combination of the primary window and a glass secondary sash, based on laboratory tests, has been determined as follows, assuming a sound absorbent lining is fitted to the reveals:

| Primary window glass (mm) | Cavity (mm) | Secondary sash glass (mm) | Approx dB reduction |
|---|---|---|---|
| 4 | 100 | 4 | 38 |
| 4 | 200 | 4 | 40 |
| 4 | 200 | 6 | 42 |
| 6 | 200 | 6 | 44 |

Note 1. For comparison: primary window alone, 4mm annealed glass – 25dB, 6mm annealed glass – 27 dB.

Note 2. The approximate dB reductions quoted for glass are also valid for plastics sheet glazing materials.

**6. Installation**

**6.1 Care of property.**

Before proceeding with any work the customer should remove any furniture fixtures and fittings from areas where they might otherwise be damaged during the installation.

Sufficient dust sheets or protective coverings should be used and the utmost care should be taken to avoid dirtying of, or damage to, floor coverings and to the decorated surfaces adjacent to the windows. Some damage adjacent to the installation may be unavoidable, but reasonable care must be taken to keep this to a minimum.

On completion, the site should be left in a clean and tidy condition. The Code of Good Practice of the Glass and Glazing Federation should be strictly observed, particularly in respect of the protection of the property in which the installation is taking place.

The customer's attention should be drawn to the installer's Terms of Contract.

**6.2 Provision for fixing.**

**6.2.1 Fixing direct to the primary window frame.**

Where the width of the flat inside surface of the window frame is insufficient to provide a proper seating for the weatherstripping in the panels and for the fitting of hinges or other fitments, the surface may be extended by the application of wood beading. Similarly, wood may be added to provide a flush surface where the existing frame members are not in alignment.

**6.2.2 Fixing to the reveals of the window opening.**

Where it is not possible to fix the secondary sash direct to the primary window, or where a wider cavity is required for the purpose of sound insulation, a timber sub-frame or timber battens may be fixed to the aperture. The joint between the timber and the surfaces of the aperture should be sealed against air penetration with mastic, sealant, foam strip or other suitable materials.

If a sealant is used, acrylic water-based sealant is particularly suitable for this purpose as it can be decorated.

**6.3 Fixed the outer frames (where applicable).**

The perimeter joint to the window frame, sub-frame or battens should be sealed against air penetration either by mastic, sealant, foam strip or by mechanical means (e.g. by an aluminium nib forced into a groove in the timber), as appropriate to the design

For secondary sashes which contain horizontally sliding panels, it may be necessary to fit a support under the sill member of the outer frame to prevent deflection of this member when the weight of both panels occurs centrally on the sill member.

The outer frame should be fixed square, plumb and without any bow, within limits which allow the panels to operate or be removed freely and without loss of

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airtightness performance due to the weatherstripping not being in full contact over its width.

**6.4 Fixing of fitting the panels.**

**6.4.1 Fixing to primary windows, sub-frames or battens.**
Hinged or removable panels should be fixed using a sufficient number of fittings such as hinges, thumbturns and other retaining devices to:
(a) provide a continuous weatherstripping contact to achieve the necessary airightness performance, and
(b) adequately support the panels in the closed position and, in the case of hinged panels, also when they are open for cleaning or ventilation. The panels should be fixed plumb and square and with adjacent panels aligning with one another. There may be, however, limitations imposed by deviations in the shape of the primary windows, e.g. they may be out-of-square.

**6.4.2 Fitting to outer frames.**
Sliding or removable panels should be fitted into the outer frame(s) in such a way that:
(a) they provide a continuous weatherstripping contact to achieve the necessary airtightness performance.
(b) they will not accidentally become dislodged,
(c) they can be readily removed, if required,
(d) they operate as intended.

**6.5 Venting the cavity.**
Where it is considered necessary to make provision in the primary window to vent the cavity, the customer should be informed and his agreement obtained before proceeding with any modification to the primary window.

**6.6 Decoration.**
Unless otherwise agreed with the customer, decoration will be confined to an initial coat of paint, varnish or stain to any timber supplied and fitted.

**Appendix A: Guide to Suitable Glass Thicknesses**
Secondary sashes may be subjected to the same wind loads as the primary windows because the latter may be left open, or because the cavity between them may be vented to the outside.

When calculating the wind loading as described in 4.1.8, it will be found that most (but not all) low rise buildings are subjected to loads of up to 1000N/m². A manufacturer may avoid the procedure of calculating the wind loading for each contract by selecting and using a loading which will be adequate for any contract carried out within an area selected by him, i.e. by always using the maximum loading which can occur within that area.

The following chart gives typical examples of thicknesses of **glass** according to area of pane, suitable to resist the wind loading. However, smaller sizes than those shown in the chart will often be necessary in the interests of safety when closed or when the panels are being handled, or if the deflection when using this glass exceeds the limits laid down in 5.2. Attention is drawn to Clauses 4.7 and 5.7 on Safety in BS 6262,

**Examples of Maximum Glass Pane Sizes to Resist Different Wind Pressures**

| | Square panes | | | | Rectangular panes (3:1 aspect ratio) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 3mm | | 4mm | | 3mm | | | 4mm | | |
| Wind Pressure N/m² | Area m² | L mm | Area m² | L mm | Area m² | l mm | L mm | Area m² | l mm | L mm |
| 600 | 1.8 | 1350 | 3.4 | 1840 | 2.4 | 890 | 2670 | 4.4 | 1210 | 3630 |
| 700 | 1.5 | 1220 | 2.9 | 1700 | 2.1 | 830 | 2490 | 3.8 | 1120 | 3360 |
| 800 | 1.3 | 1140 | 2.5 | 1580 | 1.8 | 770 | 2310 | 3.3 | 1050 | 3150 |
| 900 | 1.2 | 1090 | 2.3 | 1510 | 1.6 | 730 | 2190 | 3.0 | 1000 | 3000 |
| 1000 | 1.1 | 1050 | 2.0 | 1410 | 1.4 | 680 | 2040 | 2.7 | 950 | 2850 |

**Key:** L = Longer side if rectangular panes, or length and height of square panes.
l = Shorter side of rectangular panes.

Areas and lengths have been derived from BS 6262 with the figures rounded.

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# Non-Vertical Overhead Glazing: Guide to the Selection of Glass from the Point of View of Safety

7.1 October 2015

**Contents**



## Introduction

Whenever materials are used overhead, especially at high level, there will always be a risk, however small, of injuries to persons caused by falling material.

Glass has been used in overhead glazing for more than a hundred years, and is very safe provided that the right glass is used in the right place.

## 1 Scope

This GGF Data Sheet gives recommendations for the selection of glass for use in non-vertical overhead glazing with respect to the safety of persons underneath. The recommendations are intended to reduce the risk of injury from falling broken glass.

NOTE: Information is also given with respect to the use of adhesive backed polymeric film for the enhancement of the performance of existing glazing.

This GGF Data Sheet does not consider the risk of injury from objects falling through the glass. However, consideration at design stage may enable selection of suitable glazing materials/measures to mitigate this situation.

This GGF Data Sheet does not consider the risk of injury to persons who may fall onto the non-vertical (sloping) overhead glazing.

NOTE: Persons most likely to be at risk would be construction, maintenance and/or cleaning operatives. For information see BR 471.

This GGF Data Sheet does not cover the following:-

- Glazing with plastics glazing sheet materials (see BS 5516-2).
- Glazing of protective barriers / balustrades (see BS 6180, and GGF Data Sheet 7.2 Guidelines for the use of glass in protective barriers)
- Glazing for greenhouses (see BS 5502-21)
- Glazing of Conservatories (see GGF A Guide to Good Practice in the Specification and Installation of Conservatories within the United Kingdom)
- Maintenance

## 2 Definitions

### 2.1 Non-vertical overhead glazing

Glazing above head height which is either horizontal or inclined at an angle to the horizontal up to 75°, and where there is general access to the areas beneath the glazing.

### 2.2 Greenhouse

Glazed structure intended for horticultural use, and not for human habitation, recreation or retail activities. It may be freestanding or attached to another structure, but is not used as a means of access to a dwelling.

### 2.3 Protective barrier / balustrade

Any element of building or structure intended to prevent persons from falling and to retain, stop or guide persons

## 3 Design considerations

Glass breakage may occur for many reasons, including the following:-

- Excessive loads (wind, snow, self-weight, maintenance loads).
- Inadequate framing or other glazing systems.
- Incorrect glazing procedures.
- Impact by falling, wind-borne, or thrown objects.
- The higher thermal stresses encountered in non-vertical overhead glazing.
- Malicious attack.
- Damaged or defective glass.

NOTE: The above list is not exhaustive

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Careful design, together with proper workmanship, reduces the likelihood of problems arising.

The breakage of glass in non-vertical overhead glazing is a rare occurrence. The risk of injury from falling broken glass may be reduced in several ways and, when selecting glass to provide an appropriate degree of human safety, the designer or specifier should consider the level of risk which is acceptable in a particular situation, taking into account the intended use of the building.

Risk analysis should be based on the following:

- Likelihood of people being present beneath the glazing;
- Potential for glazing breakage;
- Post breakage behaviour of the glazing material;
- Consequences of glazing failing.

NOTE: Further information can be obtained from BR 471. BRE report entitled 'Sloping Glazing – Understanding the risks'.

### 4 Glass and breakage characteristics

In order to assist designers and specifiers in the selection of the most appropriate glazing, the breakage characteristics and associated properties of the most commonly used types of glass are described below:

NOTE: The applicable standards for the commonly used glass types can be found in the bibliography.

**4.1 Laminated safety glass** (see GGF Data Sheet 4.11: laminated glass and laminated safety glass)

When laminated safety glass is broken, the pieces of glass are held together by the interlayer(s) and are likely to remain in position, and continue to provide short-term weather resistance.

NOTE 1: "Laminated safety glass" is a laminated glass that has an impact classification in accordance with EN 12600.

NOTE 2: "Laminated safety glass" includes laminated annealed safety glass, laminated thermally treated safety glass

NOTE 3: The post breakage behaviour of laminated thermally toughened, laminated heat soaked thermally toughened and laminated heat strengthened glass needs special consideration.

**4.2 Thermally treated glass** (see GGF Data Sheet 4.4.1: Thermally treated soda lime silicate glass products)

This covers glass products that have been subjected to a thermal treatment process. It includes the following:

- Thermally toughened soda lime silicate safety glass;
- Heat soaked thermally toughened soda lime silicate safety glass;
- Heat strengthened soda lime silicate glass.

**4.2.1 Thermally toughened soda lime silicate safety glass** (see GGF Data Sheet 4.4: Quality standard for toughened glass)

Thermally toughened soda lime silicate safety glass is stronger than ordinary annealed glass of equal thickness and is therefore comparatively difficult to break. In addition, thermally toughened soda lime silicate safety glass will withstand the maximum thermal stress associated with solar radiation.

NOTE 1: Thermally toughened soda lime silicate safety glass may contain nickel sulfide inclusions which could cause spontaneous breakage, although the risk of this happening is very low.

NOTE 2: Information on nickel sulfide inclusions can be found in GGF Data Sheet 4.4.2: Thermally treated soda lime silicate glass products – Spontaneous breakage.

**4.2.2 Heat soaked thermally toughened soda lime silicate safety glass** (see GGF Data Sheet 4.4.1)

Heat soaked thermally toughened soda lime silicate safety glass has the same properties and breakage characteristics as thermally toughened soda lime silicate safety glass. However, the incidence of spontaneous breakage due to nickel sulfide inclusions is negligible.

**4.2.3 Heat strengthened soda lime silicate glass** (see GGF Data Sheet 4.4.1: Thermally treated soda lime silicate glass products)

Heat strengthened soda lime silicate glass will withstand the thermal stresses associated with solar radiation, but it breaks in a manner similar to annealed glass.

The built-in stresses in heat strengthened soda lime silicate glass, which are lower than those in thermally toughened soda lime silicate safety glass, make it much less susceptible to spontaneous breakage due to nickel sulfide inclusions.

### 4.3 Wired Glass / Safety Wired Glass

When wired glass is broken, the wire will hold most pieces of the glass together, thereby preventing them from falling.

### 4.4 Annealed Glass

When annealed glass is broken, it tends to break into dagger-like pieces.

### 5 Post breakage behaviour of glass

The behaviour of glass after breakage is a major consideration when selecting an appropriate glass specification.

### 5.1 Laminated safety glass

Generally laminated safety glass will remain in place after breakage. However, laminated safety glass incorporating thermally treated glass has to be considered in more detail.

### 5.1.1 Laminated thermally toughened soda lime silicate safety glass

When thermally toughened soda lime silicate safety glass breaks it has negligible stiffness/rigidity. Therefore there is a possibility that the laminated pane may become dislodged.

NOTE: If both leafs of thermally toughened soda lime silicate safety glass are broken the laminated pane will probably fall.

### 5.1.2 Laminated heat soaked thermally toughened soda lime silicate safety glass

The post breakage behaviour is the same as laminated thermally toughened soda lime silicate safety glass (see 5.1.1.).

### 5.1.3 Laminated heat strengthened soda lime silicate glass

As heat strengthened soda lime silicate glass breaks in a manner similar to annealed glass there will be sufficient remaining stiffness/rigidity. Therefore even if both leafs are broken it should remain in place

NOTE: The ability of a broken pane to remain in situ is dependent upon the loads being applied.

#### 5.1.4 Laminated heat strengthened /toughened glass.

A laminated glass that comprises one leaf of heat strengthened glass and one leaf of thermally toughened/heat soaked thermally toughened glass has a composite behaviour.

If the heat strengthened glass remains unbroken the laminated glass pane will remain in situ even if the thermally toughened pane is broken.

If the heat strengthened pane breaks the laminated glass will remain in situ as long as the thermally toughened pane remains unbroken.

### 5.2 Thermally treated glass

#### 5.2.1 Thermally toughened soda lime silicate safety glass

When broken, thermally toughened soda lime silicate safety glass fractures into small, relatively harmless pieces, which are likely to fall. Thicker toughened glass, when broken, will exhibit a greater tendency for the small pieces to stay together and fall in a cluster.

#### 5.2.2 Heat soaked thermally toughened soda lime silicate safety glass

The post breakage behaviour is the same as thermally toughened soda lime silicate safety glass (see 5.2.1).

#### 5.2.3 Heat strengthened soda lime silicate glass

Heat strengthened soda lime silicate glass breaks in a manner similar to annealed glass and will therefore probably fall out.

NOTE: Depending upon the angle of the glazing and the imposed loads there is a slight possibility that the glass may lock together and not fall out.

### 5.3 Wired glass / Safety Wired Glass

The wire generally will hold most pieces of the glass together, thereby preventing them from falling

### 5.4 Annealed glass

Broken annealed glass will fall out.

## 6 Selection of glass for use overhead

The minimum acceptable requirements are as given below:-

NOTE: Thermally toughened soda lime silicate safety glass or heat soaked thermally toughened soda lime silicate safety glass should not be used over swimming pools, etc, either in single glazing or as the lower pane in insulating glass units.

### 6.1 Glazing at a height up to five metres above floor level

#### 6.1.1 Single glazing

This should ideally be glass that remains in position post breakage, i.e. laminated safety glass, wired glass.

The following can also be considered: thermally toughened soda lime silicate safety glass, heat soaked thermally toughened soda lime silicate safety glass.

#### 6.1.2 Insulating glass units

The lower pane should ideally be glass that remains in position post breakage, e.g. laminated safety glass.

If the lower pane is thermally toughened soda lime silicate safety glass or heat soaked thermally toughened soda lime silicate safety glass, then the upper pane should also be one of the types of glass given in 6.1.1.

NOTE: If the lower pane of an insulating glass unit is thermally toughened soda lime silicate safety glass or heat soaked thermally toughened soda lime silicate safety glass, the upper pane must not be monolithic annealed glass nor heat strengthened glass.

### 6.2 Glazing at a height over five metres and up to 13 metres above floor level

#### 6.2.1 Single glazing

This should be laminated safety glass or wired glass.

Alternatively, heat soaked thermally toughened soda lime silicate safety glass or thermally toughened soda lime silicate safety glass, provided it is not more than six millimetres thick and not more than 3 m² in area, may be considered;

#### 6.2.2 Insulating glass units

The lower pane should be one of the types of glass given in 6.2.1 including the size and area restriction on heat soaked thermally toughened soda lime silicate safety glass and thermally toughened soda lime silicate safety glass.

If the lower pane is thermally toughened soda lime silicate safety glass or heat soaked thermally toughened soda lime silicate safety glass, then the upper pane should also be one of the types of glass given in 6.2.1.

### 6.3 Glazing at a height over 13m above floor level

#### 6.3.1 Single glazing

This should be laminated safety glass;

#### 6.3.2 Insulating glass units

The lower pane should be laminated safety glass

## 7. Enhancement of existing overhead glazing

Information with respect to the use of adhesive backed polymeric film for the enhancement of the performance of existing glazing can be found in GGF Data Sheets 5.18.3: GGF recommendations for adhesive backed polymeric film applied to glass: Definitions, descriptions and components, 5.18.4: GGF recommendations for adhesive backed polymeric film applied to glass in the overhead position for containment of glass in the event of failure: Types of systems and precautions in use, and 5.18.5.: GGF recommendations for adhesive backed polymeric film applied to glass in the overhead position for containment of glass in the event of failure: Test method, These also give information on the use of edge retention systems.

**Bibliography**

**EN 12150:** Glass in building – Thermally toughened soda lime silicate safety glass

**EN 14179:** Glass in building – Heat soaked thermally toughened soda lime silicate safety glass

**EN 14449:** Glass in building – laminated glass and laminated safety glass – evaluation of conformity

**EN ISO 12543:** Glass in building – Laminated glass and laminated safety glass

**BS 5502-21:** Buildings and structures for agriculture – Part 21: Code of practice for selection and use of construction materials

**GGF Data Sheets:**

**4.4:** Quality of thermally toughened soda lime silicate safety glass for building

**4.4.1:** Thermally treated soda lime silicate glass products

**4.4.2:** Thermally treated soda lime silicate glass products – Spontaneous breakage

**4.11:** Laminated glass and laminated safety glass

**5.18.3:** GGF recommendations for adhesive backed polymeric film applied to glass: Definitions, descriptions and components

**5.18.4:** GGF recommendations for adhesive backed polymeric film applied to glass in the overhead position for the containment of glass in the event of failure: Types of systems and precautions in use

**5.18.5:** GGF recommendations for adhesive backed polymeric film applied to glass in the overhead position for the containment of glass in the event of failure: Test method

**7.2:** Guidelines for the Use of Glass in Protective Barriers

**Other Publications:**

GGF's A Guide to Good Practice in the Specification and Installation of Conservatories within the United Kingdom

BRE Report BR 471: Sloping Glazing – understanding the risks by David Kelly, Stephen Garvin and Ian Murray

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# Guidelines for the Use of Glass in Protective Barriers

7.2 November 2014

**Contents**



## Introduction

Glazing in protective barriers can be regarded as a 'safety risk' if an individual can accidentally come into contact with it.

There are two specific risks that need consideration and these are:

- Cutting and piercing injuries resulting from accidental impact;
- Falling through the glazing if the impact causes breakage

NOTE: Injuries resulting from walking into unseen glazing is excluded from this Data Sheet. This risk can be alleviated by the use of appropriate manifestation. Advice on manifestation can be found in BS 6262-4:2005, GGF Publication 'The Right Glazing in the Right Place' and the applicable Building Regulations.

## 1. Scope

This Data Sheet covers the use of glass in protective barriers (generally referred to as balustrades) that are designed to offer protection to people where a difference in height constitutes a falling risk.

It covers:

**a.** Full height protective barriers

**b.** Balustrades with glass infill panels

- **i.** Fully framed
- **ii.** Edge supported
- **iii.** Point/clip supported

**c.** Free standing glass protective barriers

As well as giving the basis of design there is an Annex that covers the situation with respect to conformity with Building Regulations in the United Kingdom.

It does not cover curved glass when used in the above applications.

## 2. Definitions and Descriptions

NOTE: Definitions 2.1.1, 2.1.2, 2.1.3 and Figure 1 are reproduced from the appropriate Building Regulations eg Approved Document K.

### 2.1 Definitions

### 2.1.1 Barrier

Any element of building or structure intended to prevent persons from falling and to retain, stop or guide persons

### 2.1.2 Datum

Finished level on which people may stand, e.g. floor, roof, balcony, pitch line of stairs external ground, etc. (see Figure 1)

### 2.1.3 Design level

Level at which the horizontal force on the barrier is assumed to act for the purpose of design (see Figure 1)

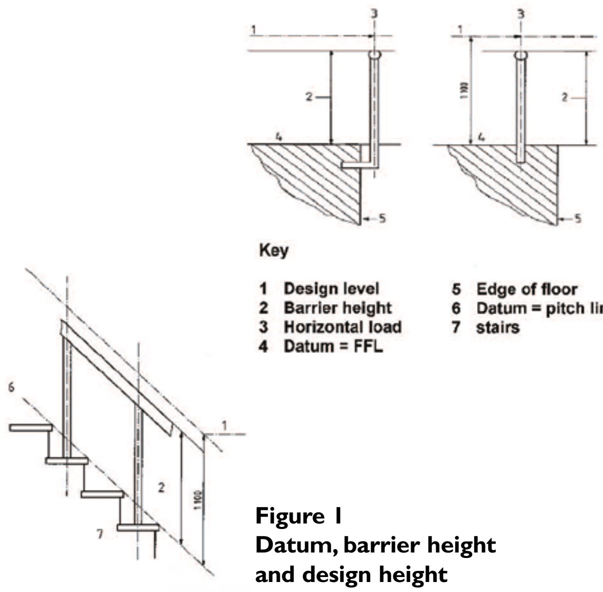


**Figure 1**
**Datum, barrier height and design height**

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### 2.1.4 Line load

Load, i.e. horizontal force, which is applied at the design height

### 2.1.5 Uniformly distributed load

Load, e.g. wind loading, applied over the entire surface area of the pane

### 2.1.6 Concentrated load

Load applied over a small area

### 2.1.7 Impact load

The load applied when a person falls against the barrier.

### 2.1.8 Containment

Ability of glazing when subjected to impact loading to resist penetration and hence prevent people from falling through it.

NOTE 1: Thermally toughened safety glass will provide containment when under the applicable impact test it does not break.

NOTE 2: Laminated safety glass will provide containment when under the applicable impact test it either does not break or breaks safely.

NOTE 3: Applicable impact test method, i.e. EN 12600.

### 2.1.9 Baluster

Post supporting the handrail in a balustrade.

### 2.1.10 Handrail

Rail acting as a guard or support to be held by hand in a balustrade.

NOTE: It enables the line load to be transmitted to the structure without stressing the glass. With the exception of free standing protective barriers ie 2.2.3 the handrail shall be connected to the balusters.

## 2.2 Descriptions

### 2.2.1 Full height protective barrier

These can take many forms and are not necessarily composed of full floor to ceiling glass/glazing. If any part of a glazed structure, whether it forms the whole or part of a wall element, extends below the minimum barrier height given in 4.5 it is classed as a full height barrier. See Figure 2.

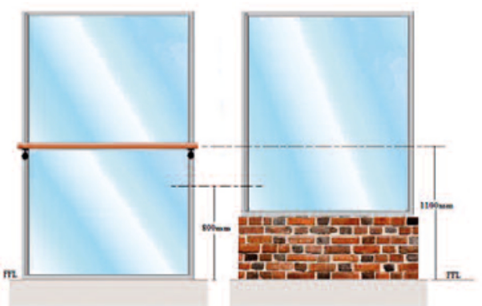

**Figure 2 Examples of full height protective barriers**

NOTE: Compliance can be achieved by: installing an appropriate handrail; or ensuring that the glass specification will withstand the appropriate loading.

### 2.2.2 Barrier with glass infill panel

This type of protective barrier comprises the main frame, i.e. handrail and balusters, which carry the appropriate loads. The glass is used to form the infill panel and provides no support to the main frame. Handrail loads are not transferred to the glass infill.

There are four main types of infill panels (see figure 3):

- Fully framed;
- Two edge framed
- Clip fixed
- Bolt fixed

The two edge frames, clips and bolts can relate to infill panes in either landscape or portrait format.

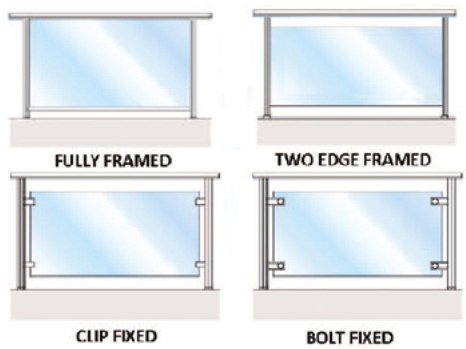


**Figure 3 Examples of infill panels**

NOTE: The application of a structural sealant between adjacent panes of glass does not change the support condition.

### 2.2.3 Free-standing glass protective barrier

This type of protective barrier consists of glass panes affixed, e.g. clamped or bonded, to the structure along the bottom edge (see figure 4). A handrail is generally attached to the top edge of the glass and there are no balusters.

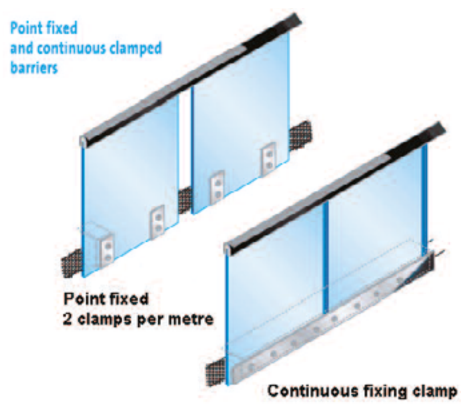


**Figure 4 Examples of free-standing protective barriers**

## 3. Design Considerations

### 3.1 Assessment

When assessing the need for a barrier and the type of barrier to be provided, consideration should be given to the likely hazards, building use and the risks to building users.

Where, in a building, more than one use of the building is anticipated, either the barrier design should be chosen to suit the worst case, or more than one type of barrier should be provided, as appropriate, to the location.

### 3.2 Difference in levels

The protective barrier shall provide guarding when the following apply:

- In dwellings where the difference in adjacent level is > 600mm;
- In building other than dwellings where the difference is:

    On stairs greater than two risers;

    Other location > 380mm

### 3.3 Other considerations

The barrier selected shall be designed so as to minimise the risk of persons falling, rolling, sliding or slipping through gaps in the barrier and/or the infill.

Where barriers are used when children under five are present the gap in the barrier shall not exceed 100mm. This dimension is given with the applicable Building Regulation.

NOTE 1: The 100mm is to prevent the child being held fast by the guarding (see applicable Building Regulation in Bibliography [B1])

NOTE 2: Any guarding protecting glazing has to prevent a sphere of 75mm diameter touching the glazing (see applicable building regulation in Bibliography [B1])

NOTE 3: The break safe criteria for laminated safety glass and wired safety glass are that no opening through which a 76mm diameter sphere can pass. (see EN 12600)

N.B: Care should be taken to consider the possible deflection under loading.

## 4. Design Criteria

### 4.1 Introduction

The presence of protective barriers may be one of guidance for persons moving about a building. However, the majority of protective barriers are positioned to prevent persons from falling from the edges of floors, stairs, elevated walkways and roofs.

The main requirement of a protective barrier is, therefore, to provide containment. It performs this function by being able to resist the likely applied forces without excessive deflection and without being penetrated.

The forces to be resisted are generally described as follows:

- **Line load** is related to the possibility of persons leaning against the barrier, applying a force normal to a conventional barrier at the top edge. It is generally given in the form of kN/m run, applied at a height above finished floor level, i.e. datum, roughly equivalent to the waist height of an adult
- **Uniformly distributed load** (UDL) is related to the pressure exerted on the infill area (that part of the barrier below the position of application of the line load). It is generally given in the form of kN/m², applied over the entire infill area.
- **Concentrated load** takes into account any non-uniformity of the load applied to the infill and may also represent a static equivalent to a localised human impact (from hand, knee, elbow, etc.). It is generally given in the form of kN, applied at the most vulnerable position on the infill area.

NOTE 1: Line and concentrated loads are given in Eurocode EN 1991-1-1 and are the subject of a National Annex.

NOTE 2: Uniformly distributed loads are given in Eurocode EN 1991-1-4 and are the subject of a National Annex.

NOTE 3: Minimum horizontal imposed loads for parapets, barriers and balustrades are provided in Table 2 of BS 6180: 2011

N.B: Barriers shall be designed to resist the most unfavourable likely imposed loads, i.e. line and concentrated; and wind loads without unacceptable deflections or distortions.

### 4.2 Load values

The value of the design loads shall relate to the building usage. Buildings with higher usage levels will generally be designed to higher load levels.

The design loads and building usage categories can be found in applicable national Building Regulations.

### 4.3 Impact loading

In addition to the loading requirements given in 4.1, which are applicable to any design of barrier, where glass is used, the performance under impact must be considered.

Impact performance of glazing is determined under material testing. In Europe the appropriate standard is EN 12600. The classification of flat glass under this test method is presented as follows:

**$\alpha(\beta)\Phi$**

Where:

**$\alpha$** is the highest drop height class at which the product either did not break or broke in accordance with a) or b) of EN 12600: 2002, Clause 4;

**$\beta$** is the mode of breakage (see Annex A of EN 12600);

**$\Phi$** is the highest drop height class at which the product either did not break or broke in accordance with a) of EN 12600: 2002, Clause 4.

### 4.4 Impact classes

The energy level of an impact will vary according to the position of the barrier relative to the unhindered distance a body can travel in a direction perpendicular to the surface of the protective barrier (free path - see figure 5).

The minimum impact classes that shall be used are dependent upon the glass type and the free path.

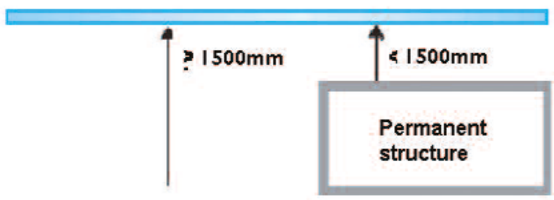


**Figure 5 Free path**

For glass to be used within a free-standing glass protective barrier, or a barrier with a glass infill panel it MUST give containment. Therefore the impact classes that shall be used are as follows:

- Free path up to 1500mm
    - Thermally toughened safety glass minimum 3(C)3, i.e. 6mm
    - Laminated safety glass minimum 3(B)3, i.e. 6.4mm
- Free path over 1500mm
    - Thermally toughened safety glass 1(C)1, i.e. 10mm
    - Laminated safety glass 1(B)1, i.e. 6.8mm

### 4.5 Barrier heights

The heights of barriers above datum are shown in Figure 1. These are given below:

- Single family dwelling
    - Barriers in front of a window 800mm
    - Stairs, landings, ramps, edges of internal floors 900mm
    - External balconies, edges of roofs 1100mm

All other uses

- Barriers in front of a window 800mm
- Stairs 900mm
- Other positions 1100mm
- Balconies and stands, etc. having fixed seating within 530mm of the barrier (see figure 6) 800mm

NOTE: BS 6180:2011 gives the following barrier height/ building usage:

- Balconies and stands, etc. having fixed seating within 530mm of the barrier provided the sum of the barrier width and the barrier height is greater than 975mm

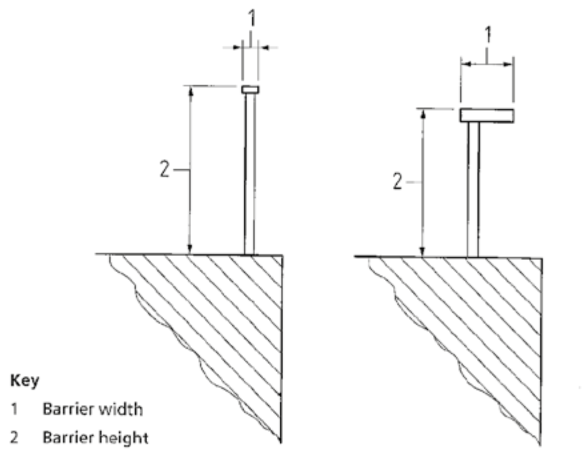


**Figure 6 Height and width of barriers in front of fixed seating**

## 5. Barrier Types

### 5.1 General

The details below relate to the most commonly used types of barriers.

There are other commercial systems available that can equally provide a suitable barrier.

### 5.2 Full height glazed protective barrier

#### 5.2.1 General

This is where glazing as part of an internal or external wall protects a difference in level. The glass may be glazed on 4-edges, 2-edges or be bolt fixed. It may be single glazing or insulating glass units.

#### 5.2.2 Loading

Glass partially or totally below the barrier height shall be designed to satisfy the appropriate design criteria. Any part of a glass pane below the barrier height shall sustain the infill loads. Where the barrier height is coincident with the glass, the glass shall also sustain the line load applied at the appropriate height.

N.B. The glass shall have an impact performance classification in accordance with the safety glazing recommendations given in BS 6262-4 i.e. have an appropriate EN12600 classification. Using a thin glass, e.g. 4mm toughened Class 1(C)1, does not necessarily mean that the glass is capable of carrying all applicable loads.

NOTE: The choice of glazing type and thickness requires consideration of other factors such as wind loading, etc.

#### 5.2.3 Deflection

The deflection of the glass, when it is subjected to the design loads, shall be limited to L/65 or 25mm, taking L as the longest dimension of the glass.

### 5.3 Barrier with glass infill panel

#### 5.3.1 General

In this type of protective barrier, the main frame, comprising of the handrail and baluster, is designed to withstand the line loads applied to the hand rail, and the glass is used to form the infill panels. The glass in no way provides any support to the main frame, and the handrail loads are not transferred to the glass.

#### 5.3.2 Loading

The glass infill panel shall carry the applicable loads, i.e. UDL and concentrated.

With external applications the wind loading shall also be considered.

#### 5.3.3 Support conditions

#### 5.3.3.1 Fully framed (see figure 7)

The frame section shall give a minimum of 15mm edge cover to the glass

**Figure 7 Fully framed infill panel**

#### 5.3.3.2 Two-edge framed (see figure 8)

The frame section shall give a minimum of 15mm edge cover to the glass on those edges that are framed.

**Figure 8 Two–edge framed infill panel**

#### 5.3.3.3 Clip Fixed (see figure 9)

The clips should be positioned around the periphery of the infill panel, at a maximum spacing of 600 mm. Each clip should be not less than 50 mm in length and should give a minimum depth of cover to the glass of 25 mm.

Depending upon the actual number, size and spacing of the clips, the glass may be considered fully framed or two-edge framed.

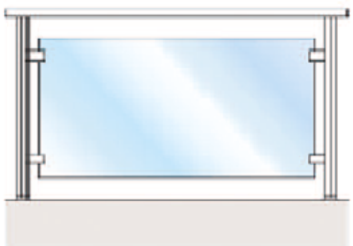

**Figure 9 Clip fixed infill panel**

NOTE: This example shows a two edged framed panel. The addition of clips along top and bottom edge would be considered as fully framed.

#### 5.3.3.4 Bolt fixed (see figure 10)

The design of the bolt fixings is detailed in clause 7.2 of BS 6262-6: Glazing for building – Part 6: Code of practice for special applications

**Figure 10 Bolt fixed infill panel**

#### 5.3.4 Deflection

The deflection of the glass, when it is subjected to the design loads, shall be limited to L/65 or 25mm, taking L as the maximum span between the supporting points, unless the pane is fully framed, in which case L is the longer dimension of the glass.

### 5.4 Free-standing glass protective barrier

#### 5.4.1 General

In this type of protective barrier, the glass is designed to withstand all the design loads. Each glass pane is either clamped or adhesively fixed to the structure along its bottom edge, the handrail is attached to the top edge of the glass, and there are no balusters.

The design of the clamping is detailed in clause 7.2.3 of BS 6262-6: Glazing for building – Part 6: Code of practice for special applications

#### 5.4.2 Loading

All barriers loads, i.e. UDL, concentrated and line loads, shall be carried by the glass pane. In external applications wind loading shall also be considered.

#### 5.4.3 Deflection

The deflection of the glass, when it is subjected to the design loads shall be limited to L/65 or 25mm, taking L as the distance between the clamping and the top edge of the plate.

## 6. Glass Types

### 6.1 General

The type and thickness of glass shall be chosen to suit the design of the protective barrier and the applicable loads.

### 6.2 Glass types

The following glass types are suitable for installation into protective barriers; subject to the limitations given in 6.3

- Thermally toughened soda lime silicate safety glass in accordance with EN 12150-2;
- Heat soaked thermally toughened soda lime silicate safety glass in accordance with EN 14179-2;

- Laminated safety glass in accordance with EN 14449;
- Laminated thermally toughened soda lime silicate safety glass in accordance with EN 14449;
- Laminated heat soaked thermally toughened soda lime silicate safety glass in accordance with EN 14449.
- Laminated heat strengthened soda lime silicate safety glass in accordance with EN 14449
- Safety rated wired glass in accordance with EN 572-9

NOTE: Thermally toughened safety glass and heat soaked thermally toughened safety glass are available for other glass compositions, e.g. borosilicate, alkaline earth silicate.

### 6.3 Limitations

Some types of laminated safety glass can only be used fully framed, i.e. in full height glazing or in barriers with fully framed infill panels.

NOTE: Laminated thermally treated glasses may be used without being fully framed.

Safety rated wired glass can only be considered for fully framed full height barrier situations.

All other glass types detailed above are suitable for installation in conventional systems.

## 7. Installation

Care should be taken to ensure there is no glass to metal contact. The major points are as follows:

- Gaskets shall be used when the glass is glazed into channels
- When glazed using clips, appropriate material shall be used to prevent the clips contacting the glass surface
- Point fixed panes require the use of a bush around the bolt and incompressible gasket between the spreader plates and the glass.

NOTE: Information on design of point support fixings can be found in BS 6262-6'

## Bibliography


### B1 United Kingdom Building Regulations:

England –

Approved Document K: 2013 - Protection from falling, collision and impact

K1 Stairs, ladders and ramps

K2 Protection from falling

K4 Protection against impact with glazing

K5 Additional provisions for glazing in buildings other than dwellings

Wales –

Approved Document K – Protection from falling, collision and impact – Parts K1, and K2

NOTE: Formerly England & Wales AD K

Approved Document M – Access to and use of buildings

NOTE: Formerly England & Wales Approved Document M– 2004 incorporating 2010 amendments

Approved Document N – Glazing - Safety in relation to impact, opening and cleaning – Part N1 and N2

NOTE Formerly England & Wales Approved Document N – 1998 incorporating 2000 and 2010 amendments

Scotland –

Building (Scotland) Regulations Technical Handbook – Domestic and Non-Domestic – Section 4 - Safety

Section 4.4 – Pedestrian protective barriers

Section 4.8 – Danger from accidents

Northern Ireland –

The Building Regulations (Northern Ireland) Statutory Rules – Technical Booklet H – Stairs, ramps, guarding and protection from impact

The Building Regulations (Northern Ireland) Statutory Rules – Technical Booklet V - Glazing

### B2 British Standards

BS 6180: 2011: Barriers in and about buildings – Code of practice

BS 6262-4: 2005 Glazing for buildings – Part 4: Safety related to human impact – Code of practice

BS 6262-6: 2005 Glazing for buildings – Part 6: Code of practice for special applications

### B3 European Standards

EN 572-9: Glass in building – Basic soda lime silicate glass products – Part 9: Evaluation of conformity/Product standard

EN 1863-2: Glass in building – Heat strengthened soda lime silicate glass – Part 2: Evaluation of conformity/Product standard

EN 12150-2: Glass in building – Thermally toughened soda lime silicate safety glass – Part 2: Evaluation of conformity/Product standard

EN 12600: Glass in building – Pendulum test – Impact test method and classification for flat glass

EN 13024-2: Glass in building – Thermally toughened borosilicate safety glass – Part 2: Evaluation of conformity/product standard

EN 14179-2: Glass in building – Heat soaked thermally toughened soda lime silicate safety glass – Part 2: Evaluation of conformity/Product standard

EN 14321-2: Glass in building – Thermally toughened alkaline earth silicate safety glass – Part 2: Evaluation of conformity/product standard

EN 14449: Glass in building – Laminated glass and laminated safety glass – Evaluation of conformity/Product standard

EN 15682-2: Glass in building – Heat soaked thermally toughened alkaline earth silicate safety glass – Part 2: Evaluation of conformity/product standard

BS EN 1991-1-1: EUROCODE 1: Part 1-1, General actions – Densities, self-weight and imposed loads

BS EN 1991-1-4: EUROCODE 1: Part 1-4, General actions – Wind actions

### B4 Other Documents

Young, Warren C. and Raymond Roark. Roark's Formula for Stress and Strain. 8th Edition, McGraw-Hill 2012

## Annex A Conformity with U.K. Building Regulations

### A.1 General

The Building Regulations [B1] in the United Kingdom incorporate requirements to provide barriers when it is necessary to protect people in and about buildings from falling.

NOTE: All tables contained within this Annex have been prepared to summarise the requirements. However, they are not part of the Building Regulations.

### A.2 Building occupancy classes

The Building Regulations [B1] classify building types and usage with relationship to applicable imposed loads for protective barriers. Table A1 shows occupancy types that have the same applied loads.

| Class | Occupancy |
|---|---|
| 1 | Domestic and Residential – single family dwellings<br>Office and Work Areas – light pedestrian traffic routes |
| 2 | Domestic and Residential – multi-occupancy, balconies and edges of roofs<br><br>Office and Work Areas – areas not susceptible to over crowding<br><br>Areas without obstacles for moving people and not susceptible to over crowding – stairs, landing, corridors, and balconies |
| 3 | Areas where people might congregate – areas having fixed seating within 530mm of the barrier<br><br>Areas with tables or fixed seating – restaurants and bars<br><br>Areas susceptible to over crowding – footways or footpaths less than 3 metres wide, adjacent to sunken areas<br><br>Retail areas – all retail areas including banks, building societies or betting shops |
| 4 | Areas susceptible to over crowding – theatres, cinemas, shopping malls, assembly areas. Footways or pavements greater than 3 metres wide adjacent to sunken areas |

**Table A1 Classification of building occupancy types by barrier loadings.**

### A.3 Applicable loadings

Table A2 gives the applicable loadings dependant upon the building occupancy classification (see table A1).

| Building Occupancy Class | Design Loads | | |
|---|---|---|---|
| | Line load in kN/m run applied 1100mm above finished floor level | UDL in kN/m² applied to the whole of the infill panel below the line load height | Concentrated load in kN applied to any part of the infill panel below the line load height |
| 1 | 0.36 | 0.5 | 0.25 |
| 2 | 0.74 | 1.0 | 0.5 |
| 3 | 1.5 | 1.5 | 1.5 |
| 4 | 3.0 | 1.5 | 1.5 |

**Table A2 Design loads for protective barriers**

### A4 Sizes of glass that comply with the design loads of protective barriers

### A4.1 General

The size of glass panels that will carry the loads given in Table A2 are dependant upon the type of barrier and support conditions.

### A4.2 Full height barriers

Table A3 gives information on single glazed full height barriers.

| Building Occupancy Class | Nominal Glass thickness (mm) | Area in m² for glass type | | |
|---|---|---|---|---|
| | | Laminated Safety Glass | Thermally Toughened Safety Glass | Safety Wired Glass |
| 1 | 6<br>8<br>10<br>12<br>≥15 | 3.2<br>5.7<br>9.0<br>12.2<br>No limit | 3.6<br>5.8<br>9.0<br>12.2<br>No limit | 2.8 |
| 2 | 6<br>8<br>10<br>12<br>15<br>16<br>≥19 | 1.0<br>3.6<br>6.2<br>9.0<br>-<br>12.2<br>No limit | 2.4<br>4.0<br>6.2<br>9.6<br>12.2<br>-<br>No limit | n/a |
| 3 | 6<br>8<br>10<br>12<br>15<br>16<br>19<br>20<br>≥24 | n/a<br>n/a<br>n/a<br>0.8<br>-<br>10.2<br>-<br>17.6<br>No limit | n/a<br>0.5<br>4.0<br>5.7<br>9.0<br>-<br>15.2<br>-<br>No limit | n/a |
| 4 | any | n/a | n/a | n/a |

**Table A3 Maximum allowable pane sizes for single glazed full height barriers**

N.B. This table has recently been amended to reflect the revision of Roark's Formulas for Stress and Strain.

NOTE 1: Glass panes within these sizes will satisfy the design criteria irrespective of shape and for glazing methods which support the glass panel on all edges.

NOTE 2: Compliance with this table does not necessarily indicate suitability for purpose. The thickness and type of glass pane that can be used may also be affected by other criteria, e.g. wind loads, and these should also be taken into account when selecting the glass.

NOTE 3: Thermally toughened safety glass should comply with EN 12150 and have a classification according to EN 12600 of 1(C)

NOTE 4: Laminated safety glass should comply with EN 14449 and have a classification according to EN 12600 of 3(B)

NOTE 5: Laminated safety glass is assumed to be symmetrical, i.e. nominal 6mm comprises two leaves of 3mm glass.

### A4.3 Full height barriers

Table A4 gives information on full height barriers - glazed with insulating glass units.

The following notes apply

NOTE 1: The outer leaf may be one of the following:-

- Annealed float Glass
- Laminated Safety Glass
- Heat strengthened float glass

NOTE 2: The outer leaf may be one of the following:-

- Annealed float Glass
- Laminated Safety Glass
- Heat strengthened float glass
- Thermally toughened float safety glass

| Building Occupancy Class | IGU configurarion (mm) | Area in m² for glass type | | |
|---|---|---|---|---|
| | | Laminated Safety Glass - Inner leaf Outer leaf See Note 1 | Thermally Toughened Float Safety Glass Inner leaf. Outer leaf See note 2 | Laminated Inner leaf / Toughened Outer leaf |
| 1 | 4+4<br>6+6<br>8+8<br>10+10 | n/a<br>4.4<br>9.0<br>14.4 | 2.2<br>4.8<br>9.0<br>15.2 | n/a<br>4.8<br>9.0<br>14.8 |
| 2 | 4+4<br>6+6<br>8+8<br>10+10 | n/a<br>2.8<br>5.2<br>9.0 | 0.15<br>3.2<br>5.5<br>9.0 | n/a<br>3.0<br>5.5<br>9.0 |
| 3 | 4+4<br>6+6<br>8+8<br>10+10 | n/a<br>n/a<br>n/a<br>0.15 | n/a<br>n/a<br>1.4<br>5.2 | n/a<br>n/a<br>n/a<br>0.15 |
| 4 | 4+4<br>6+6<br>8+8<br>10+10 | n/a<br>n/a<br>n/a<br>n/a | n/a<br>n/a<br>n/a<br>3.2 | n/a<br>n/a<br>n/a<br>n/a |

**Table A4 Maximum allowable pane sizes for insulating glass units in full height barriers**

NB This table has recently been amended to reflect the revision of Roark's Formulas for Stress and Strain

NOTE 1: Glass panes within these sizes will satisfy the design criteria irrespective of shape and for glazing methods which support the glass panel on all edges.

NOTE 2: Compliance with this table does not necessarily indicate suitability for purpose. The thickness and type of glass pane that can be used may also be affected by other criteria, e.g. wind loads, and these should also be taken into account when selecting the glass.

NOTE 3: Thermally toughened safety glass should comply with EN 12150 and have a minimum classification according to EN 12600 of 1(C)3

NOTE 4: Laminated safety glass should comply with EN 14449 and have a minimum classification according to EN 12600 of 3(B)3

NOTE 5: Laminated safety glass is assumed to be symmetrical, i.e. nominal 6mm comprises two leaves of 3mm glass.

NOTE 6: Annealed float glass should comply with EN 572-2.

NOTE 7: Some of the sizes indicated may not be practical from a manufacturing or handling perspective. Please contact the unit supplier for information on their maximum available sizes."

NOTE 8: the minimum impact classification will depend on free path. See Clause 4.4

NOTE 9: For insulating glass units the loads can be shared between the individual leaves.

N.B. In the case of insulating glass units the loads can be shared between the individual leaves. Advice should be sought from the unit manufacturer.

### A4.4 Barriers with glass infill panels

Table A5 gives information on fully framed glass infill panels. It covers toughened safety glass and laminated safety glass.

| Infill loading criteria | | Nominal glass thickness mm | | Maximum size mm |
|---|---|---|---|---|
| Concentrated Load kN | UDL kN/m² | Toughened safety glass | Laminated safety glass | |
| 0.25 | 0.5 | 6 | 6.4 | 2.0 |
| 0.5 | 1.0 | 6 | 8.4 | 2.0 |
| 1.5 | 1.5 | 10 | 12.4 | 0.8 |

**Table A5 Allowable thickness for fully framed infill panels**

NOTE 1: Thermally toughened safety glass should comply with EN 12150 and have a classification according to EN 12600 of 1(C)1.

NOTE 2: Laminated safety glass should comply with EN 14449 and have a classification according to EN 12600 of 2(B)2.

NOTE 3: Glass panes within these sizes will satisfy the design criteria irrespective of shape and for glazing methods which support the glass panel on all edges.

NOTE 4: Compliance with this table does not necessarily indicate suitability for purpose. The thickness and type of glass pane that can be used may also be affected by other criteria, e.g. wind loads, and these should also be taken into account when selecting the glass.

NOTE 5: Laminated safety glass is assumed to be symmetrical, i.e. nominal 6mm comprises two leaves of 3mm glass.

**Table A6 gives information on two-edge framed infill panels with thermally toughened soda lime silicate safety glass**

| Infill loading | | Panel Width mm | Span Limits mm | | | |
|---|---|---|---|---|---|---|
| UDL kN/m² | Concentrated Load kN | | 6mm * | 8mm * | 10mm | 12mm |
| 0.5 | 0.25 | 300<br>500<br>700<br>900 | 900<br>1150<br>1350<br>1350 | 1450<br>1750<br>1750<br>1750 | 1900<br>2100<br>2100<br>2100 | 2300<br>2400<br>2400<br>2400 |
| 1.0 | 0.5 | 300<br>500<br>700<br>900 | 600<br>750<br>900<br>950 | 1000<br>1250<br>1450<br>1450 | 1450<br>1750<br>1750<br>1750 | 1800<br>2050<br>2050<br>2050 |
| 1.5 | 1.5 | 300<br>500<br>700<br>900 | n/a<br>n/a<br>n/a<br>n/a | n/a<br>n/a<br>n/a<br>n/a | 550<br>950<br>1150<br>1300 | 900<br>1400<br>1600<br>1700 |

**Table A6 Maximum allowable spans for two-edge framed thermally toughened safety glass infill panels.**

Where:

Span is distance between supports which can be on either the vertical or horizontal edges of the pane;

Pane width is either horizontal or vertical dimension depending upon orientation of pane and 90° to the span.

NOTE 1: n/a = not applicable for this load category

NOTE 2: * = Possibly not suitable for free paths greater than 1500mm, unless the glass complies with Note 3 with respect to EN 12600 classification.

NOTE 3: Thermally toughened safety glass should comply with EN 12150 and have a classification according to EN 12600 of 1(C)1.

NOTE 4: Compliance with this table does not necessarily indicate suitability for purpose. The thickness and type of glass pane that can be used may also be affected by other criteria, e.g. wind loads, and these should also be taken into account when selecting the glass.

### A4.5 Free standing glass protective barriers

Table A7 gives information on free standing glass protective barriers see 2.2.3. The glasses used are thermally toughened soda lime silicate safety glass or laminated thermally toughened soda lime silicate safety glass. They may be heat treated.

Laminated thermally toughened soda lime silicate safety glass shall have a handrail to give protection in case of glass breakage.

Laminated thermally toughened soda lime silicate safety glass may be installed without a handrail as the design incorporates two panes of glass. If a pane is broken the unbroken pane will continue to give containment.

**Table A7 Thickness of glass required for single glazed free standing glass protective barriers**

| Building Occupancy Class | Thickness in mm for glass type | | | | |
|---|---|---|---|---|---|
| | Thermally Toughened Safety Glass | Toughened/ Laminated Safety Glass using PVB interlayer | | Toughened/Laminated Safety Glass using Ionoplast interlayer | |
| | With Handrail | With Handrail | Without Handrail | With Handrail | Without Handrail |
| 1 | 12 | 15.5 | 17.5 | 13.5 | 17.5 |
| 2 | 15 | 19.5 | 21.5 | 15.5 | 19.5 |
| 3 | 19 | 23.5 | 31.5 | 19.5 | 25.5 |
| 4 | 25 | 28.5 | 39.5 | 25.5 | 31.5 |

NOTE 1: The thicknesses stated in Table A5 are based upon glass width of 1200mm, exposed glass height 1100mm, and suitable base clamp.

NOTE 2: For other glass sizes, consult the manufacturer.

# Guidelines for the Use of Glass in Floors and Stairs

7.3 July 2013

**Contents**



## Introduction

Glass floors and stairs are manufactured from a combination of glasses designed to create a walkable structure in association with structural supports.

They are designed for pedestrian use only.

The use of glass for these applications allows the interplay of transparency, reflection and refraction of light.

## 1. Scope

This Data Sheet covers the use of glass in floors and stairs for pedestrian traffic in internal/external environments and domestic/non-domestic applications.

Comment will be made when the floor has to act as a compartment element in case of fire.

It will give the basis of design together with information on selection of glass types and methods of installation.

Detail on anti-slip finishes and other safety matters will be considered.

## 2. Definitions

NOTE 1: The majority of these definitions have been taken from England Building Regulation K: 2013

NOTE 2: A drawing showing these terms is shown in Appendix 1

### 2.1 Uniformly distributed load (UDL)

Load, e.g. wind, snow, applied over the entire surface of the pane.

### 2.2 Concentrated load

Load applied over a small area.

### 2.3 Normal-use stair

Stair intended for use by all users in or connected to a building

### 2.4 Private stair

Stair within a dwelling, intended for use only by occupants and visitors.

### 2.5 Alternating tread stair

A stair with paddle-shaped treads where the wide portion is on alternate sides on consecutive treads.

### 2.6 Helical stair

Stair in a helix around a central void.

### 2.7 Spiral stair

Stair in a helix around a central column.

### 2.8 Nosing

The leading edge of a stair tread.

### 2.9 Going

The depth from front to back of a tread less any overlap with the next tread above.

### 2.10 Rise

The height between consecutive treads

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### 2.11 Pitch

The angle of inclination between the horizontal and the line connecting the nosings of a stair.

### 2.12 Flight

Continuous series of steps or a continuous slope between landings

### 2.13 Stair width

The clear width between the walls or balustrades.

### 2.14 Tapered tread

A step in which the going reduces from one side to the other.

### 2.15 Ponding

Deflection of the pane that will allow collection of unwanted water.

### 2.16 Sacrificial layer

This is a pane of glass that is expressly used to protect the structural component from damage, e.g. scratching, etc.

NOTE: This type of layer is designed to be easily replaceable

### 2.17 Redundant layer

This is a pane within the construction that allows the floor/stair tread to continue to support the designed loads should one of the panes be broken.

## 3. Design Considerations

### 3.1 Assessment

Firstly it is necessary to consider the location of the floor/stair case and whether it spans a dangerous drop. Breakage of the floor/stair tread could result in a fall from a high level or cause injury even when the drop is quite small.

The nature of the building and the likely behaviour of its users must be taken into account, with drops in excess of 380mm being classified as dangerous. This is especially important when considering glass floors or stair treads.

Other points for consideration are as follows:

- Likelihood of persons walking on the floor/stair tread with wet footwear;
- Application of point or concentrated loadings with hard objects with small contact area, e.g. castors on furniture.
- Thermal stress if artificial lighting is installed beneath the floor/stair tread; or if used in an external application subject to solar radiation.
- Modesty when persons can access beneath the floor or stair;
- When positioned the user has a view of a large exposed area;
- In specific applications the floor may also need to offer appropriate fire resistance.
- Consideration of secondary protection in instances when the floor may be subjected to excess footfall or movements across it, e.g. office furniture, etc.

### 3.2 Specifics

The following can be regarded as 'hazards' that require specialist consideration:

| Hazard | Solution |
|---|---|
| Potential for exposure to water and slipping | Careful selection of surface finish and appropriate slip resistance |
| Potential for breakage from impact by falling or thrown objects | Careful design specification possibly including 'sacrificial' layer. |
| Potential for glazing failing/ breaking | Consideration of the post-breakage behaviour of the chosen glass specification |
| Necessity of refurbishment or replacement | Consideration of both glass, glazing design and access. |
| Possibility of deflection that could cause ponding and/or be visually disturbing | Consideration of both glass thickness and support stiffness |
| Frequency of use and impact on using alternative routes in the building; | Careful design specification. |

## 4. Design Criteria

### 4.1 General

This non-exhaustive list details the prime consideration:

- Internal or external application;
- Building use category (including change of use)
- Overall size and dimensions;
- Deflection of the glass/system;
- Loading;
- Depth of drop;
- Glass specification;
- Surface finish;
- Fixing substrate;
- Support structure.

Generally the design of glass floors/stair treads ensures that breakage of one leaf does not compromise the performance of the component, i.e. the inclusion of a 'redundant' leaf. Therefore a fall is unlikely unless there is total/catastrophic failure of the system.

Two British Standards are relevant to the use of glass in floors and stair treads:

- EN 1991-1-1:2002: Eurocode 1: Actions on structures - General actions - Densities, self-weight, imposed loads for buildings together with the UK National Annex, NOTE: This standard specifies the design floor loads for the specific use of the building

- BS 5395-1:2010: Stairs: Code of practice for the design of stairs with straight flights and winders.

NOTE: This standard refers to the danger of slippage and specifies minimum coefficients of friction

The loads considered are the uniformly distributed load (UDL) and the concentrated load. It is usually the concentrated load that will determine the glass thickness, so care must be taken to specify the correct figure from the national annex of EN 1991-1-1.

Traditional glass flooring has been fully supported by its edges and never at a mid-point. The strength of the supports must be calculated by a competent structural engineer, with the deflection of the frame limited to an appropriate value for the glass type.

Glass technology has improved, coupled with the development of structural interlayers, e.g. ionomers. This gives greater performance and provides increased stiffness; therefore alternative support configurations can now be considered.

Using a combination of increased glass and interlayer strength, laminated glass floors can be designed having point support systems or minimal traditional supports.

## 5. Glass Types

### 5.1 General

The type and thickness of glass shall be selected to suit the design taking into consideration all of the critical factors from the initial assessment.

### 5.2 Glass types

The following glass types are suitable for installation into floors without a drop below:

- Annealed soda lime silicate float glass in accordance with EN 572-9.

NOTE: The required thickness will depend upon size, aspect ratio and loading.

The following glass types are suitable for installation into floors and stair treads with a drop below:

- Laminated annealed safety glass in accordance with EN 14449;
- Laminated thermally toughened soda lime silicate safety glass in accordance with EN 14449;
- Laminated heat soaked thermally toughened soda lime silicate safety glass in accordance with EN 14449.
- Laminated heat strengthened/thermally toughened soda lime silicate safety glass in accordance with EN 14449
- Laminated heat strengthened/heat soaked thermally toughened soda lime silicate safety glass in accordance with EN 14449

NOTE 1: Floors that are subjected to significant levels of solar radiation would usually preclude the use of annealed glass types for reasons of thermal safety;

NOTE 2: Thermally toughened soda lime silicate safety glass should be in accordance with EN 12150;

NOTE 3: Heat soaked thermally toughened soda lime silicate safety glass should be in accordance with EN 14179;

NOTE 4: Heat strengthened soda lime silicate glass should be in accordance with EN 1863;

NOTE 5: Thermally toughened safety glass and heat soaked thermally toughened safety glass are available for other glass compositions, e.g. borosilicate, alkaline earth silicate.

## 6 Glass Strength Considerations

### 6.1 General

The final glass specification should have sufficient strength to withstand the appropriate floor loadings given in the UK national annex to EN 1991-1-1:2002.

In addition it is important to consider the deflection of the final design, particularly when the glass is supported on less than four edges. In such cases it is possible to consider glass specifications that have sufficient strength, but results in a floor that unnerves people due to excessive deflection.

### 6.2 Selection of glass for use in floors

Glass should be provided that is suitable for normal pedestrian use and so can be walked upon safely and with a degree of confidence withstanding the relevant design loads from EN 1991-1-1:2002.

It is never feasible to ensure that glass will not fracture under sufficiently extreme abuse. Consequently a redundant ply of glass in a laminated construction is imperative to provide the appropriate level of post fracture behaviour.

Contact with hard objects such as glass, metal and stones should be avoided at all times.

Over a period of time the top surface is likely to deteriorate depending upon the amount of pedestrian traffic and type of footwear used.

NOTE: The incorporation of a sacrificial top layer means that when the visual deterioration becomes unacceptable, only the sacrificial layer requires replacing.

The top surface finish of the glass can be modified to achieve an appropriate level of slip resistance.

Tables 1 to 5 provide some suggested glass types that have sufficient strength for a number of load cases.

| U D L (kN/m2) | Concentrated load (kN) | Glass thickness | Specific use |
|---|---|---|---|
| 1.5 | 2.0 | 15 | Domestic |
| 2.5 | 2.7 | 15 | Office |
| 2.0 | 3.0 | 19 | Restaurant |
| 4.0 | 3.6 | 25 | Retail |
| 4.0 | 4.5 | 25 | Museum |
| Thickness of annealed glass complying with EN 572-9 | | | |

**Table 1 – Thickness of annealed glass, without a drop below, uniformly and continuously supported, with a size of 1500 x 1000mm**

| U D L (kN/m2) | Concentrated load (kN) | Glass make-up | Specific use |
|---|---|---|---|
| 1.5 | 2.0 | 19 + 19 | Domestic |
| 2.5 | 2.7 | 25 + 15 | Office |
| 2.0 | 3.0 | 25 + 19 | Restaurant |
| 4.0 | 3.6 | 25 + 25 | Retail |
| 4.0 | 4.5 | 25 + 25 | Museum |
| Thickness of annealed laminated glass complying with EN 14449 | | | |

**Table 2 – Thickness of laminated annealed glass, supported along all four edges, with a size of 1500 x 1000mm**

| U D L (kN/m2) | Concentrated load (kN) | Glass make-up | Specific use |
|---|---|---|---|
| 1.5 | 2.0 | 12 + 12 | Domestic |
| 2.5 | 2.7 | 15 + 15 | Office |
| 2.0 | 3.0 | 15 + 15 | Restaurant |
| 4.0 | 3.6 | 19 + 19 | Retail |
| 4.0 | 4.5 | 19 + 19 | Museum |
| Thickness of laminated thermally toughened glass complying with EN 14449 and EN 12150 | | | |

**Table 3 – Thickness of laminated toughened glass, supported along all four edges, with a size of 1500 x 1000mm**

| U D L (kN/m2) | Concentrated load (kN) | Glass make-up | Specific use |
|---|---|---|---|
| 1.5 | 2.0 | 10 + 10 + 10 | Domestic |
| 2.5 | 2.7 | 12 + 10 + 12 | Office |
| 2.0 | 3.0 | 12 + 10 + 12 | Restaurant |
| 4.0 | 3.6 | 15 + 10 + 15 | Retail |
| 4.0 | 4.5 | 15 + 10 + 15 | Museum |
| Thickness of laminated toughened / heat strengthened / toughened glass complying with EN 14449, EN 12150 & EN 1863 | | | |

**Table 4 – Thickness of laminated toughened / heat strengthened / toughened glass, supported along all four edges, with a size of 1500 x 1000mm**

| U D L (kN/m2) | Concentrated load (kN) | Glass make-up | Specific use |
|---|---|---|---|
| 1.5 | 2.0 | 10 + 10 + 10 | Domestic |
| 2.5 | 2.7 | 12 + 12 + 12 | Office |
| 2.0 | 3.0 | 12 + 12 + 12 | Restaurant |
| 4.0 | 3.6 | 15 + 15 + 15 | Retail |
| 4.0 | 4.5 | 15 + 15 + 15 | Museum |
| Thickness of laminated toughened glass complying with BS EN 14449 & BS EN 12150 | | | |

**Table 5 – Thickness of laminated toughened glass, supported along two 1500mm edges, with a span between supports of 1000mm**

### 6.3. Selection of glass for use in stairs

To ensure the safe use of stairs there are specific recommendations for the width, rise and going, which can be found in BS 5395-1.

A summary of these dimensions is shown in table 5.

| Stair category | Rise (mm) | | Going (mm) | | Stair clear width (mm) |
|---|---|---|---|---|---|
| | Min. | Max. | Min. | Max. | Min. |
| Private stair | 150 | 200 | 250 | 400 | 800* |
| Normal-use stair | 150 | 180 | 300 | 450 | 1000* |

**Table 5 – Recommended sizes for straight stairs and winders**

Note*: For regular two-way traffic, the minimum stair clear width is 1000mm

Note**: For hospitals, the minimum stair clear width is 1200mm

Once the appropriate size and geometry of the stairs have been decided, the advice given in 6.2 relating to conventional glass floors, can be applied to stair design.

NB: Exposed nosings of glass stair treads can be particularly vulnerable to damage. For high pedestrian foot traffic areas it is recommended that nosings be protected to avoid accidental damage of any exposed glass edges/corners.

## 7. Post breakage of glass

### 7.1 Annealed glass floors

Providing that the glass floor is designed, manufactured and installed in accordance with this Data Sheet, and then if breakage occurs the glass is likely to lock together. This will mean that there is no penetration that will allow a drop into the space below.

However, broken glass should be replaced immediately and access prohibited.

### 7.2 Annealed laminated floors/stair treads

Providing the glass floor/stair tread is manufactured from laminated annealed glass, and is suitably supported around the perimeter, the post fracture behaviour is one that retains a significant degree of its inherent strength and is likely to resist displacement or penetration.

These qualities make this particular specification advantageous when the glass is located inside a building and is still required to perform the function of supporting people.

### 7.3 Thermally treated laminated floors/stair treads

When considering laminated thermally treated glass there is often the potential for a reduction in overall glass thickness.

It should be noted that a reduction in thickness will be followed by an increase in glass deflection, and can be particularly noticeable following the fracture of one of the plies in the laminate construction.

Failure of any single ply in the specifications considered in tables 2 & 4 will rarely be critical when solely considering the ability of the remaining glass to withstand the appropriate load, as all such constructions have a "redundant ply."

This is unlikely to be the case following any additional ply failure. However with the development of structural interlayers giving stronger performance and providing increased stiffness, an improved post breakage characteristic can be realised.

Table 3 relates to laminated thermally treated glass construction, incorporating a heat strengthened ply. This is advantageous when considering the post breakage behaviour should fracture of a toughened ply occurs.

NB: Irrespective of glass make-up in all cases a replacement panel should be prioritised immediately following fracture.

NOTE: The ability of a broken pane to remain in situ is dependent upon the loads being applied, the glass type, the support condition, the number of fractured plies and the type of interlayer in the construction. The manufacturer should be consulted for information on the post fracture behaviour.

## 8 Selection of glass for slip resistance

As the surface of glass has a smooth fire polished finish there is a very low friction grip between glass and most footwear even in normal dry conditions.

Should the surface of glass become wet, there is the potential for an extremely hazardous condition, which requires consideration alongside strength and post fracture behaviour.

Sandblasting is a common technique used to provide slip resistance either by an all-over treatment or by deep sandblasting to raise dots on the glass surface.

A ceramic frit containing a fine hard grit can be applied and fired into the top surface to provide a reduced risk of slipping.

Floors near entrance areas may be walked upon by people with wet footwear with external floors presenting the highest risk of slipping. For these and other hazardous areas the slip resistant treatment is critical.

For external floors, deflection inherent in the glass may lead to ponding when large sizes are considered.

BS 5395-1:2010 Stairs. Code of practice for the design of stairs with straight flights and winders, makes reference to the danger of slippage and specifies minimum coefficients of friction that could equally be applied to glass floors

## 9 Framing and Installation

### 9.1 General

Traditional glass flooring should be fully supported by its edges and never at a mid-point, see figure 1.

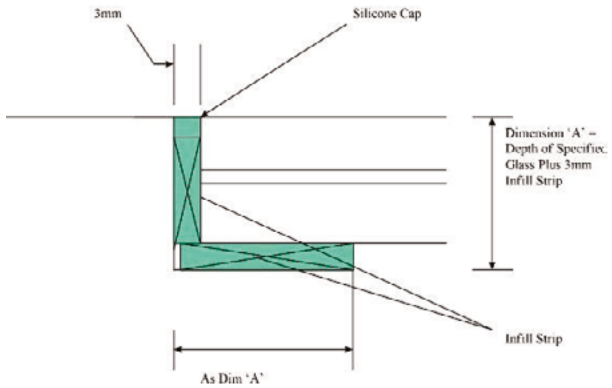



Figure 1 Example of glass floor

### 9.2 Glass floors/stair treads

As glass technology has improved coupled with the development of structural interlayers giving stronger performance and providing increased stiffness, alternative support configurations can now be considered. Using a combination of increased glass and interlayer strength, laminated glass floors can have point support systems or minimal traditional supports.

The final glass specification should have sufficient strength to withstand the appropriate floor loadings given in the UK national annex to BS EN 1991-1-1:2002. In addition it is important to consider the deflection of the final design, particularly when the glass is supported on less than four edges. In such cases it is possible to consider glass specifications that have sufficient strength, but results in a floor that unnerves people due to excessive deflection

### 9.3 Frame and Installation

The frame should provide continuous support to the perimeter of each individual element of glazing, and must be capable of withstanding both the design loading and the self-weight of the glass without excessive deflection.

The frame may be of metal, masonry or wood and the glass must be cushioned from it by 3mm thick neoprene rubber or other material with a Shore A hardness of 60.

The clearance between the edge of the glass and the frame, or between adjacent glasses, should be 3mm minimum and infill strips of a material such as wood, cork or neoprene, should be inserted to finish just below the upper surface of the glass.

To provide a flush finish a compatible high-grade synthetic rubber, polysulphide or silicone sealant can be used as a top pointing

### 9.4 Supporting structure

The strength of the supports must be calculated by a structural engineer, with the deflection of the frame limited to an appropriate value for the glass type

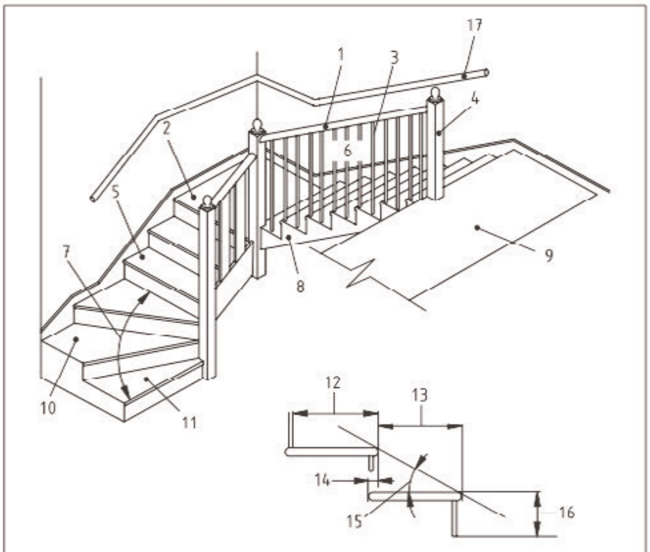
### 10 Building Regulations and Standards

The Building Regulations, see Bibliography [1], cover stairs but does not cover floors. None of the regulations say anything about glass in these applications. However, the regulations are not material specific so they can be applied to glass.

British Standards BS 5395 – Parts 1 and 2 cover the specification and design of stairs. The use of glass treads is not covered by these standards.

### Appendix 1 Drawing from BS 5395-1

Figure 1 Stair terminology




Key
1 Guarding top-rail
2 Quarter landing
3 Baluster
4 Newel
5 Flier
6 Stair balustrade
7 Winder flight
8 Cut string
9 Landing
10 Kite winder
11 Winder
12 Tread width
13 Going
14 Overlap
15 Pitch
16 Rise
17 Handrail

*NOTE On design drawings, arrows placed on the walking line indicate upward movement.*

- **Bibliography**

B1 United Kingdom Building Regulations:

England –

Approved Document K: 2013 – Protection from falling, collision and impact – Parts K1, and K2

Wales –

Approved Document K – Protection from falling, collision and impact – Parts K1

NOTE: Formerly England & Wales AD K

Scotland –

Building (Scotland) Regulations Technical Handbook – Domestic and Non-Domestic – Section 4 - Safety

Section 4.4 – Pedestrian protective barriers

Section 4.8 – Danger from accidents

Northern Ireland –

The Building Regulations (Northern Ireland) Statutory Rules – Technical Booklet H – Stairs, ramps, guarding and protection from impact

B2 British Standards

BS 5395-1: 2010: Stairs. Code of practice for the design of stairs with straight flights and winders

BS 5395-2: 1984: Stairs. Code of practice of helical and spiral stairs

B3 European Standards

EN 14179-2: Glass in building – Heat soaked thermally toughened soda lime silicate safety glass – Part 2: Evaluation of conformity/Product standard

EN 1863-2: Glass in building – Heat strengthened soda lime silicate glass – Part 2: Evaluation of conformity/Product standard

EN 12150-2: Glass in building – Thermally toughened soda lime silicate safety glass – Part 2: Evaluation of conformity/Product standard

EN 12600: Glass in building – Pendulum test – Impact test method and classification for flat glass

EN 13024-2: Glass in building – Thermally toughened borosilicate safety glass – Part 2: Evaluation of conformity/product standard EN 14179-2: Glass in building – Heat soaked thermally toughened soda lime silicate safety glass – Part 2: Evaluation of conformity/Product standard

EN 14321-2: Glass in building – Thermally toughened alkaline earth silicate safety glass – Part 2: Evaluation of conformity/product standard

EN 14449: Glass in building – Laminated glass and laminated safety glass – Evaluation of conformity/Product standard

EN 15682-2: Glass in building – Heat soaked thermally toughened alkaline earth silicate safety glass – Part 2: Evaluation of conformity/product standard

EN 1991-1-1: EUROCODE 1: Part 1-1, General actions – Densities, self-weight and imposed loads

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# GGF Data Sheet: Security Glazing – Part 1: Definitions and Description

8.1.1 May 2016

**Contents**



## Foreword

GGF Data Sheet series 8.1 covers the use of security glazing in buildings. It comprises the following parts:

Part 1: Definitions and Description

Part 2: Manual Attack Resistant Glazing

Part 3: Bullet Resistant Glazing

Part 4: Explosion Resistant Glazing

Part 5: Framing and Installation

## Introduction

This GGF Data Sheet 8.1.1 assesses security glazing products/ framing systems that are applicable to use in buildings.

## 1. Scope

This GGF Data Sheet 8.1.1 defines security glazing, describes security glazing and references all applicable standards and associated documents.

Attack using fire is not included and protection against fire is dealt with in the GGF publication – A Guide to Best Practice in the Specification and Use of Fire-Resistant Glazed Systems.

## 2. Definitions and Description

### 2.1 Definitions

NOTE: The definitions used in this GGF Data Sheet have, where possible, been taken from European and International standards.

#### 2.1.1 Security

Means whereby the fear of harm and/or damage is removed or reduced.

#### 2.1.2 Physical security

Protection offered by a barrier creating separation between the threat, and persons and/or property.

#### 2.1.3 Security glazing

Glazing, framing and fixing system designed to withstand a specified type and level of attack.

#### 2.1.4 Security glazing product

Glazing product that provides a specific resistance to the actions of force.

#### 2.1.5 Actions of force

Specific actions either deliberate or accidental that may result in injury to persons and/or damage to property.

#### 2.1.6 Security framing

Framing system, window, door, etc. designed to resist a specified type and level of attack.

### 2.2 Description

#### 2.2.1 Actions

##### 2.2.1.1 Manual attack

A deliberate action on the part of a person made with the intention of creating an opening in the security glazing product by the use of manually held implements or by the use of thrown objects.

##### 2.2.1.2 Ballistic attack

A deliberate action on the part of a person made with the intention of threatening or causing personal injury by the use of firearms.

##### 2.2.1.3 Explosion Pressure

An action, either deliberate or accidental, that may cause personal injury, material damage to buildings, property, etc. as the result of an explosive blast.

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### 2.2.2 Security glazing products

#### 2.2.2.1 Manual attack resistant glazing

Security glazing designed to resist attack and to delay access to a protected space for a short period of time (BS 5544, EN 356).

NOTE 1: Manually held implements such as axe, crowbar, pickaxe, etc.

NOTE 2: Thrown objects such as bricks, street furniture, etc.

#### 2.2.2.2 Bullet resistant glazing

Security glazing product that affords a defined resistance against the firing of specified weapons and ammunition (BS 5051, EN 1063).

#### 2.2.2.3 Blast resistant glazing

Security glazing designed to reduce the injurious effects or damage to property of accidental or intentional blast forces (EN 13541, ISO 16933, ISO 16934).

## 3. Standards and Reference Documents

### 3.1 Standards

#### British Standards

**BS 5051** Bullet-resistant glazing – Specification for glazing for interior use (only applicable for plastics glazing sheet materials)

**BS 5357** Code of practice for installation and application of security glazing

**BS 5544** Specification for anti-bandit glazing (glazing resistant to manual attack) (only applicable for plastics glazing sheet materials)

**BS 6262-3** Glazing for buildings – Code of practice for fire, security and wind loading

#### British/European Standards

**BS EN 1627** Pedestrian doorsets, windows, curtain walling, grills and shutters – Burglar resistance – Requirements and classification

**BS EN 1628** Pedestrian doorsets, windows, curtain walling, grills and shutters – Burglar resistance – Test method for the determination of resistance under static loading

**BS EN 1629** Pedestrian doorsets, windows, curtain walling, grills and shutters – Burglar resistance – Test method for the determination of resistance under dynamic loading

**BS EN 1630** Pedestrian doorsets, windows, curtain walling, grills and shutters – Burglar resistance – Test method for the determination of resistance to manual burglary attempts

NOTE: These four Standards include a national annex.

#### European Standards

**EN 356** Glass in building – Security glazing – Testing and classification of resistance against manual attack

**EN 1063** Glass in building – Security glazing – Testing and classification of resistance against bullet attack

**EN 1522** Windows, doors, shutters and blinds – Bullet resistance – Requirements and classification

**EN 1523** Windows, doors, shutters and blinds – Bullet resistance – Test method

**EN 12600** Glass in building – Pendulum test – Impact test method and classification for flat glass

**EN 13123-1** Windows, doors and shutters – Explosion resistance – Requirements and classification – Part 1: Shock tube

**EN 13123-2** Windows, doors and shutters – Explosion resistance – Requirements and classification – Part 2: Range test

**EN 13124-1** Windows, doors and shutters – Explosion resistance – Test method – Part 1: Shock tube

**EN 13124-2** Windows, doors and shutters – Explosion resistance – Requirements and classification – Part 2: Range test

**EN 13541** Glass in building – Security glazing – Testing and classification of resistance against explosion pressure

**EN 14351-1** Windows and doors – Product standard, performance characteristics – Part 1: Windows and external pedestrian doorsets without resistance to fire and/or smoke leakage characteristics

**EN 14351-2** Windows and doors – Product standard, performance characteristics – Part 2: Internal pedestrian doorsets without resistance to fire and/or smoke leakage characteristics

**EN 14449** Glass in building – Laminated glass and laminated safety glass – Evaluation of conformity/Product standard

**EN 15752-1** Glass in building – Adhesive backed polymeric film – Part 1: Definition and description

**EN 15755-1** Glass in building – Adhesive backed polymeric filmed glass – Part 1: Definition and description

**EN ISO 12543-2** Glass in building – Laminated glass and laminated safety glass – Part 2: Laminated safety glass

**EN ISO 12543-3** Glass in building - Laminated glass and laminated safety glass – Part 3: Laminated glass

#### International Standards

**ISO 16933** Glass in buildings – Explosion resistant security glazing – Test and classification for arena air-blast loading

**ISO 16934** Glass in buildings – Explosion resistant security glazing – Test and classification by shock-tube loading

**ISO 16935** Glass in building – Bullet-resistant security glazing – Test and classification

**ISO 16936-1** Glass in building – Forced entry security glazing – Part 1: Test and classification by repetitive ball drop

**ISO 16936-2** Glass in building – Forced entry security glazing – Part 2: Test and classification by repetitive impact of a hammer and axe at room temperature

**ISO 16936-3** Glass in building – Forced entry security glazing – Part 3: Test and classification by manual attack

**ISO 16936-4** Glass in building – Forced entry security glazing – Part 4: Test and classification by pendulum impact under thermally and fire stressed conditions

### 3.2 Reference documents

**LPS 1175** Loss Prevention Standard – Requirements and testing procedures for the LPCB approval and listing of intruder resistant building components, strongpoints, security enclosures and free-standing barriers

**LPS 1270** Loss Prevention Standard – Requirements and testing procedures for the LPCB approval and listing of intruder resistant security glazing

**PAS 24:2016** Enhanced security performance requirements for doorsets and windows in the UK

**GSA** US General Service Administration – Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loadings

**Paper ID 12892** International Standards for Blast Resistant Glazing – Nicholas F Johnson – Symposium on Building Security in an Age of Terrorism

**GGF Data Sheet 4.11** Laminated Glass and Laminated Safety Glass

## 4. Security Glazing Products

The following products can be classified as security glazing products:

### 4.1 Laminated security glass

A laminated glass or laminated safety glass product (for definition see clauses 4.1.1 and clause 4.1.2) that when tested can meet the requirements of one and/or more of the security glazing test standards, see 4.1.3 to 4.1.5.

### 4.1.1 Laminated glass

A laminated glass is one that conforms to the definition given in EN ISO 12543-3 and meets the appropriate durability tests as given in EN ISO 12543-4.

### 4.1.2 Laminated safety glass

A laminated safety glass is one that conforms to the definition given in EN ISO 12543-2 and meets the appropriate durability tests as given in EN ISO 12543-4. It will require a pendulum impact performance classification in accordance with EN 12600.

NOTE 1: Not all laminated glass/laminated safety glass can be classified as a laminated security glass.

NOTE 2: Laminated glass and laminated safety glass when CE marked comply with EN 14449.

NOTE 3: Information on laminated glass and laminated safety glass is given in GGF Data Sheet 4.11 Laminated Glass and Laminated Safety Glass.

### 4.1.3 Manual attack resistant laminated glass

The performance requirements are as specified in EN 356.

### 4.1.4 Bullet resistant laminated glass

The performance requirements are as specified in EN 1063.

### 4.1.5 Blast resistant laminated glass

The performance requirements are as specified in EN 13541.

### 4.2 Plastics glazing sheet materials (PGSM)

Monolithic or multi-wall sheet manufactured from specific polymeric materials, e.g. polycarbonate, modified acrylic. The performance under the security glazing test standards will be influenced by polymer type, thickness, size and framing system.

NOTE 1: Plastics glazing sheet material is not covered by the EN testing standards.

NOTE 2: Testing and classification, of plastics glazing sheet materials, with respect to bullet resistance and manual attack resistance will have to be in accordance with the requirements of BS 5051 and BS 5544 respectively.

NOTE 3: Explosion resistance can be determined by testing plastics glazing sheet materials in a frame (see EN 13124-2).

### 4.3 Glass/plastic composites

These are composite products manufactured from glass and plastics glazing sheet materials. Security performance can be determined in accordance with the EN standards.

NOTE 1: These are sometimes referred to as laminated glasses, or laminated glass composites.

NOTE 2: The security performance is enhanced by the plastics glazing sheet materials.

NOTE 3: Some of the glass components are there to supply abrasion and/or weathering resistance.

### 4.4 Adhesive backed polymeric filmed glass

A glass that has had an adhesive backed polymeric film applied to increase the performance. (see EN 15755-1).

NOTE 1: The application of an appropriate adhesive backed polymeric film can turn a non-classifiable glass substrate into one that can be classified, or increase the level and/or type of classified performance with regards to the security performance.

NOTE 2: The act of applying (laminating) an adhesive backed polymeric film to a glass substrate does not mean that this product can comply with EN ISO 12543.

## 5. Compliance with the Construction Products Regulation (CPR)

Any glazing product that is covered by an official mandate under the CPR, when placed on the European market, should comply with the applicable harmonized European standard (hEN).

Conformity relates not only to the performance of the product, i.e. Type Testing, but also the Factory Production Control including on-going inspection and surveillance, i.e. the System of Attestation of Conformity.

Details of the applicable hENs, together with information on the Assessment and Verification of Constancy of Performance (AVCP) - formally system of attestation of conformity - are given in GGF Data Sheets 8.1.2 to 8.1.4.

## 6. Applicable Building Regulations

England – Approved Document Q – Security – dwellings

Scotland – Technical handbook 4.13 – Security

NOTE: These regulations only apply to domestic buildings.

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# GGF Data Sheet: Security Glazing - Part 2: Manual Attack Resistant Glazing

8.1.2 May 2016

**Contents**



## Foreword

GGF Data Sheet series 8.1 covers the use of security glazing in buildings. It comprises the following parts:

Part 1: Definitions and Description

Part 2: Manual Attack Resistant Glazing

Part 3: Bullet Resistant Glazing

Part 4: Explosion Resistant Glazing

Part 5: Framing and Installation

## Introduction

This GGF Data Sheet 8.1.2 assesses security glazing products that are more familiarly known as "anti-bandit" and "anti-vandal" glazing products.

NOTE: It is not intended that the test methods be associated with the terms "anti-bandit" or "anti-vandal", particularly since these terms can be only loosely defined and there is considerable overlap in their definition.

## 1. Scope

This GGF Data Sheet 8.1.2 details test and classification methods for security glazing that can be described as manual attack resistant glazing.

## 2. Definitions and Description

The definitions and descriptions contained within GGF Data Sheet 8.1.1 Security Glazing - Part 1: Definitions and Descriptions apply. The following are specific to this GGF Data Sheet 8.1.2.

### 2.1 Definitions

#### 2.1.1 Security glazing

Glazing, framing and fixing system designed to withstand a specified type and level of attack.

#### 2.1.2 Security glazing product

Glazing product that provides a specific resistance to the actions of force.

#### 2.1.3 Actions of force

Specific actions either deliberate or accidental that may result in injury to persons and/or damage to property.

### 2.2 Description

#### 2.2.1 Actions

##### 2.2.1.1 Manual attack

A deliberate action on the part of a person made with the intention of creating an opening in the security glazing product by the use of manually held implements or by the use of thrown objects.

#### 2.2.2 Security glazing products

Security glazing designed to resist attack and to delay access to a protected space for a short period of time (BS 5544, EN 356).

NOTE 1: Manually held implements such as axe, crowbar, pickaxe, etc.

NOTE 2: Thrown objects such as bricks, street furniture, etc.

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## 3. Standards and Reference Documents

### 3.1 Standards

**British Standards**

**BS 5544** Specification for anti-bandit glazing (glazing resistant to manual attack) (only applicable for plastics glazing sheet materials)

**BS 6262-3** Glazing for buildings – Code of practice for fire, security and wind loading

**European Standards**

**EN 356** Glass in building – Security glazing – Testing and classification of resistance against manual attack

**EN 14449** Glass in building – Laminated glass and laminated safety glass – Evaluation of conformity/Product standard

**EN 15755-1** Glass in building – Adhesive backed polymeric filmed glass – Part 1: Definition and description

**European/International Standards**

**EN ISO 12543-2** Glass in building – Laminated glass and laminated safety glass – Part 2: Laminated safety glass

**EN ISO 12543-3** Glass in building – Laminated glass and laminated safety glass – Part 3: Laminated glass

**International Standards**

**ISO 16936-1** Glass in building – Forced entry security glazing – Part 1: Test and classification by repetitive ball drop

**ISO 16936-2** Glass in building – Forced entry security glazing – Part 2: Test and classification by repetitive impact of a hammer and axe at room temperature

### 3.2 Reference documents

**LPS 1270** Loss Prevention Standard – Requirements and testing procedures for the LPCB approval and listing of intruder resistant security glazing

**PAS 24** Enhanced security performance requirements for doorsets and windows in the UK

## 4. Principles of Testing Manual Attack Resistant Glazing

### 4.1 General

Historically anti-bandit glazing was used in shop windows, e.g. jewelers, to save merchandise from the traditional 'smash and grab' thief. Its use was then extended to screens, e.g. post office, building societies, etc., to protect staff from thrown objects, including acid, ammonia etc., and manually wielded weapons.

Therefore the products were tested and classified by means of simple pass/fail testing using a drop ball test (see BS 5544). This method did not allow for the differentiation, and hence classification, of varying thicknesses/make-up of security glazing. Clients were requiring a more clearly defined level of protection, i.e. specific penetration resistance, as over the years the criminal fraternity has used more and more sophisticated attack methods, e.g. angle grinders, circular saws, thermic lances, etc.

It is worth noting that the test methods referred to in this GGF Data Sheet do not reproduce the conditions of real human attack, but are intended to give a classification of comparative resistance.

Present day thinking is that there is no single test that will cover the wide range of resistances to attack required. The European standard (EN 356) uses two separate test methods to give a progressive range of categories of resistance.

### 4.2 Manual attack using tools

The use of 'human intervention' testing, i.e. a man with a specific set of tools, is not generally considered as a reproducible test methodology. Not withstanding this there are a number of standards that use this methodology (see Annex A).

### 4.3 Framing/installation

For a manual attack resistant glazing to perform up to expectations it must be installed into an appropriately designed and fixed framing/glazing system. (See GGF Data Sheet 8.1.5 Security Glazing Part 5: Framing and Installation).

## 5. Test Methods

### 5.1 BS 5544

#### 5.1.1 General

This test method, now only applicable to plastics glazing sheet materials, uses the ability of the product to resist penetration by the steel ball.

#### 5.1.2 Details of test

This test is 5 impacts from 3 m and 1 impact from 9 m. The impactor is a hardened steel ball with a mass of (2,260 ± 20) g and a diameter of approximately 82 mm. The impacts of the ball drops shall be within a 125 mm diameter circle in the approximate centre of the test specimen. Test specimen size is 600 mm x 600 mm.

NOTE 1: This British Standard has been withdrawn in respect to the testing of glass products and replaced by EN 356.

NOTE 2: This British Standard is obsolete. However, it is still the method for testing and classifying plastics glazing sheet materials.

### 5.2 EN 356

#### 5.2.1 General

The European test method (EN 356) consists of the following:

- Ball drop tests with a range of drop heights, and number of impacts;
- Hammer/axe tests with a range of strike number

The ball drop tests have been used for the protection of both persons and property. The hammer/axe test is fundamentally for the protection of property.

NOTE 1: The hammer/axe test has been designed for the classification of security glazing that will withstand attack by weapons such as ice-axes.

NOTE 2: There are International standards, i.e. ISO 16936-1 and ISO 16936-2, that are generally equivalent to EN 356.

### 5.2.2 Detail of test

The test specimen size is (1100±5) mm x (900±5) mm.

#### 5.2.2.1 Ball drop test

Impactor is a (4.11±0.06) kg steel sphere of diameter (100±0.2) mm

The applicable drop height for the various classifications is given in Table 1.

| Category of resistance | Drop Height mm |
|---|---|
| P1A | 1500 ± 50 |
| P2A | 3000 ± 50 |
| P3A | 6000 ± 50 |
| P4A | 9000 ± 50 |
| P5A | 9000 ± 50 |

**Table 1:** Test drop heights for P1A to P5A

For categories P1A, P2A, P3A and P4A, the impactor shall be dropped on to each test piece three times from the same height, in such a way that the impact positions form the pattern of an equilateral triangle with a side length of (130 ± 20) mm around the geometric centre of the test piece, with one side of the triangle parallel to a short side of the specimen. The impact position opposite to this side of the triangle shall be hit first.

For category P5A, the above procedure shall be repeated a total of three times on each test piece, giving nine impacts, three on each point of the triangle.

#### 5.2.2.2 Hammer/axe test

This test aims to produce a 400 mm x 400 mm opening in the security glazing. Initially the glazing is impacted with the hammer to break up the glass and then with the axe to cut out the opening.

Table 2 gives the number of strikes, total of hammer blows and axe strokes, to allow for a particular category of resistance.

| Category of resistance | Total number of strikes |
|---|---|
| P6B | 30 to 50 |
| P7B | 51 to 70 |
| P8B | over 70 |

**Table 2:** Number of strikes for P6B to P8B

### 5.2.3 Applicability of test method for plastics glazing sheet material

EN 356 is only applicable to glass and/or glass/plastic composites.

However, the test method may be applied to plastics glazing sheet materials. The ball drop test method can be used as specified. The hammer/axe test has to be modified as the hammer strokes will have no effect on the classification and should be ignored.

### 5.3 ISO 16936 - Part 1 and Part 2

These International Standards are generally equivalent to EN 356. ISO 16936-1 deals with ball drop testing and ISO 16936-2 with the hammer/axe test.

ISO 16936-1 contains an informative annex referring to testing, for exterior use, at extreme temperatures, i.e. -20 °C or +40 °C.

## 6. General Performance of Products

Manual attack resistant glazing can be an important deterrent to ensure the security of property and occupants in a building.

The level of risk and regulatory requirements determine the necessary level of protection, and thus the type of manual attack resistant glazing. Different levels of resistance can be obtained by varying the number and/or thickness of each of the components.

Typical glass/pvb product thicknesses to meet the desired level of resistance are shown in Table 3.

| Category of resistance | Thickness mm |
|---|---|
| P1A | 6.8 |
| P2A | 8.8 |
| P3A | 9.1 |
| P4A | 9.5 |
| P5A | 10.3 |
| P6B | 15.3 |
| P7B | 22.3 |
| P8B | 26.7 |

**Table 3:** Typical products for EN 356 performance

However, the actual thickness for a specific classification will be dependent upon the laminated glass supplier. The use of other components, such as EVA or resin inter-layers, may have an effect on the overall product thickness. Glass/polycarbonate composites could reduce the overall thickness from those in Table 3.

NOTE 1: Information on adhesive backed polymeric filmed glass can be found in GGF Data Sheet 5.18.3: GGF Recommendations for Adhesive Backed Polymeric Films applied to Glass: Definitions, descriptions and components.

NOTE 2: The manufacturer of the adhesive backed polymeric security film should be contacted for details on performance and application.

## 7. Compliance with the Construction Products Regulation

The two product types that could be regarded as manual attack resistant glazing are plastics glazing sheet material and laminated glass/laminated safety glass.

NOTE: Plastics glazing sheet material does not have a harmonized European Standard and therefore cannot be deemed to meet the Construction Products Regulation.

For laminated glass/laminated safety glass to be placed on the market with a claimed performance to the Essential Characteristic --"Safety in use – Burglar resistance: Shatter properties and resistance to attack" the product is under an Assessment and Verification of Constancy of Performance (AVCP) – Level 3.

This means the following:

- Manufacturer implements factory production control (FPC) as per standard;
- Manufacturer selects test specimens;
- Type testing to show conformity with product standard, i.e. EN ISO 12543, by a Notified Testing Body;
- Type testing to EN 356 undertaken by a Notified Testing Body;
- Manufacturer responsible for on-going product conformity.

## 8. Applicable Building Regulations

England – Approved Document Q – Security – dwellings

*Q1 Unauthorised access*

*"Reasonable provision must be made to resist unauthorised access to -*

*(a) Any dwelling*

*(b) Any part of a building from which access can be gained to a flat within the building*

*Requirement Q1 applies only in relation to new dwellings."*

Scotland – Technical handbook 4.13 – Security

*"Every building must be designed and constructed in such a way that doors and windows, vulnerable to unlawful entry, can be secured to deter housebreaking and protect the safety and welfare of occupants.*

*Limitation:*

*This standard applies only to domestic buildings."*

## Bibliography

**ISO 16936-3** Glass in building – Forced entry security glazing – Part 3: Test and classification by manual attack

**ISO 16936-4** Glass in building – Forced entry security glazing – Part 4: Test and classification by pendulum impact under thermally and fire stressed conditions

**GGF Data Sheet 5.18.3** GGF Recommendations for Adhesive Backed Polymeric Films Applied to Glass: Definitions, Descriptions and Components

## Annex A

Manual attack resistance testing using tools (Informative).

A.1 General

There are a number of standards that detail such testing methodologies. Their reproducibility is unproven and they are not supported by the glass industry.

A.2 Standards

The following standards use this methodology:

- ISO 16936-3
- ISO 16936-4
- LPS 1270

## Annex B

Other Standards dealing with manual attack/burglar resistance for windows, doors, etc. (Informative)

**BS EN 1627** Pedestrian doorsets, windows, curtain walling, grilles and shutters – Burglar resistance – Requirements and classification

**BS EN 1628** Pedestrian doorsets, windows, curtain walling, grilles and shutters – Burglar resistance – Test method for the determination of resistance under static loading

**BS EN 1629** Pedestrian doorsets, windows, curtain walling, grilles and shutters – Burglar resistance – Test method for the determination of resistance under dynamic loading

**BS EN 1630** Pedestrian doorsets, windows, curtain walling, grilles and shutters – Burglar resistance – Test method for the determination of resistance to manual burglary attempts

NOTE: These four Standards include a national annex.

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# GGF Data Sheet: Security Glazing – Part 3: Bullet Resistant Glazing

8.1.3 May 2016

**Contents**



## Foreword

GGF Data Sheet series 8.1 covers the use of security glazing in buildings. It comprises the following parts:

Part 1: Definitions and Description

Part 2: Manual Attack Resistant Glazing

Part 3: Bullet Resistant Glazing

Part 4: Principles of Testing Bullet Resistant Glazing

Part 5: Framing and Installation

## Introduction

This GGF Data Sheet 8.1.3 assesses security glazing products that are more familiarly known as 'bullet resistant' glazing products.

NOTE 1: These products are frequently and incorrectly referred to as 'bullet proof' glazing. No glazing product can be referred to as 'bullet proof' only 'bullet resistant'.

NOTE 2: Glazing products can only be called 'bullet resistant' as they are designed to resist a specific weapon/ammunition.

NOTE 3: The determination of performance of a 'bullet resistant' glazing product is undertaken using defined weapons/ammunition and strike patterns/number.

NOTE 4: The performance of a 'bullet resistant' glazing product under real attack may differ from that determined during testing and classification.

## 1. Scope

This GGF Data Sheet 8.1.3 details test and classification methods for security glazing that can be described as bullet resistant glazing.

## 2. Definitions and Description

The definitions and descriptions contained within GGF Data Sheet 8.1.1 Security Glazing - Part 1: Definitions and Descriptions apply. The following are specific to this GGF Data Sheet 8.1.3.

### 2.1 Definitions

#### 2.1.1 Security glazing

Glazing, framing and fixing system designed to withstand a specified type and level of attack.

#### 2.1.2 Security glazing product

Glazing product that provides a specific resistance to the actions of force.

#### 2.1.3 Actions of force

Specific actions either deliberate or accidental that may result in injury to persons and/or damage to property.

### 2.2 Description

#### 2.2.1 Actions

##### 2.2.1.1 Ballistic attack

A deliberate action on the part of a person made with the intention of threatening or causing personal injury by the use of firearms.

#### 2.2.2 Security glazing products:

##### 2.2.2.1 Bullet resistant glazing

Security glazing product that affords a defined resistance against the firing of specified weapons and ammunition (BS 5051, EN 1063).

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## 3. Standards and Reference Documents

### 3.1 Standards

### British Standards

**BS 5051** Bullet-resistant glazing – Specification for glazing for interior use (only applicable for plastics glazing sheet materials)

**BS 6262-3** Glazing for buildings – Code of practice for fire, security and wind loading

### European Standards

**EN 1063** Glass in building – Security glazing – Testing and classification of resistance against bullet attack

**EN 1522** Windows, doors, shutters and blinds – Bullet resistance – Requirements and classification

**EN 1523** Windows, doors, shutters and blinds – Bullet resistance – Test method

**EN 14449** Glass in building – Laminated glass and laminated safety glass – Evaluation of conformity/Product standard

**EN 15755-1** Glass in building – Adhesive backed polymeric filmed glass – Part 1: Definition and description

### European/International Standards

**EN ISO 12543-2** Glass in building – Laminated glass and laminated safety glass – Part 2: Laminated safety glass

**EN ISO 12543-3** Glass in building – Laminated glass and laminated safety glass – Part 3: Laminated glass

### International Standards

**ISO 16935** Glass in building – Bullet-resistant security glazing – Test and classification

## 4. Principles of Testing Bullet Resistant Glazing

### 4.1 General

The objective of bullet resistant testing is to classify, under given conditions, the performance of security glazing. Therefore testing is undertaken on specified test specimen sizes using weapon and ammunition, i.e. bullet, mass, velocity, chosen as representative of the threat perceived.

Testing is undertaken at a temperature range that is representative of indoor climates, e.g. 18 ± 5 °C.

The numbers of shots, the strike pattern and test range have been selected as a means of obtaining reproducible results that allow comparison between products.

Test specimens can be of either:

- Unitary construction, i.e. single pane of glazing that gives the bullet resistant performance, or
- Duplex construction, i.e. two panes that act together to give the bullet resistant performance.

Duplex constructions generally consist of a pane of bullet resistant glazing that stops penetration of the bullet but has spalling/splintering off the protected face and a secondary pane that acts as a spall/splinter shield, i.e. stops the spall/splinters impacting someone on the protected side.

NOTE: The orientation of the bullet resistant glazing must be known, i.e. the attack face being towards the weapon.

### 4.2 Framing/installation

For a bullet resistant glazing to perform up to expectations it must be installed into an appropriately designed and fixed framing/glazing system. (See GGF Data Sheet 8.1.5 Security Glazing Part 5: Framing and Installation.)

## 5. Test Methods

### 5.1 BS 5051

### 5.1.1 General

This test method, now only applicable to plastics glazing sheet materials, uses the ability of the product to resist penetration by the bullet.

This test method consists of six specified levels of ballistic attack with the following weapons:

- Three with hand guns
- Two with rifles
- One with shotgun

NOTE: For details of weapons/number of strikes/test range see Table 1.

### 5.1.2 Details of test

The test specimen size is (420 ± 5) mm x (420 ± 5) mm.

Details of performance classes, weapon types and calibres, test range and number of strikes are given in Table 1.

| Class | Weapon | Calibre | Range | Strikes |
|---|---|---|---|---|
| G0 | Handgun | 9 mm Parabel-lum | 3 m | 3 |
| G1 | Handgun | 0.357 Magnum | 3 m | 3 |
| G2 | Handgun | 0.44 Magnum | 3 m | 3 |
| R1 | Rifle | 5.56 | 10 m | 3 |
| R2 | Rifle | 7.62 | 10 m | 3 |
| S86 | Shotgun | 12 bore solid lead slug | 10 m | 1 |

**Table 1:** Bullet resistant glazing – Specification for glazing for interior use

For G0 to G2 the strike pattern is an equilateral triangle of 100+10/-0 mm per side with one shot per vertices.

For R1 and R2 the strike pattern is an equilateral triangle of 100+20/-0 mm per side with one shot per vertices.

For S86 the strike pattern is centre of test piece.

The tested specimens will pass the test if they comply with the following:

(a) Projectiles shall not pass through the test pieces;

(b) No fragments from projectiles shall perforate the witness cards;

(c) No fragments ejected from the glazing shall perforate the witness cards.

### 5.2 EN 1063

#### 5.2.1 General

The European test method (EN 1063) consists of nine specified levels of ballistic attack with the following weapons:

- Three with hand guns
- Four with rifles
- Two with shotguns

**NOTE: For details of weapons/ammunitions/strike pattern/number of strikes see Tables 2 and 3.**

The test determines whether:

a) Perforation of the test specimen by bullet or parts of the bullet has occurred; or

b) Perforation of the witness foil by glass splinters from the protected, non-attack, face has occurred

**NOTE: Attack face is the one designed to face the attack.**

#### 5.2.2 Detail of test

The test specimen size is (500 ± 5) mm x (500 ± 5) mm.

Details of performance classes, weapons, calibre and bullets are given in Table 2 for handguns and rifles and Table 3 for shotguns.

Table 3 also gives number of strikes.

| Class | Weapon | Calibre | Bullet |
|---|---|---|---|
| BR1 | Rifle | 0.22 LR | L/RN |
| BR2 | Handgun | 9 mm Parabellum | FJ1)/RN/SC |
| BR3 | Handgun | 0.357 Magnum | FJ2)/CB/SC |
| BR4 | Handgun | 0.44 Magnum | FJ2)/FN/FC |
| BR5 | Rifle | 5.56 x 45* | FJ2)/PB/SCP1 |
| BR6 | Rifle | 7.62 x 51 | FJ1)/PB/SC |
| BR7 | Rifle | 7.62 x 51** | FJ2)/PB/HC1 |

1) Full steel jacket (plated) 2) Full copper alloy jacket
* Twist length 178 mm ± 10 mm ** Twist length 254 mm ± 10 mm
L – Lead; CB – Coned bullet; FJ – Full metal jacket bullet; FN – Flat nose; HC1 – Steel hard core, mass 3.7 ± 0.1 g PB – Pointed bullet; RN – Round nose; SC – Soft core(lead) SCP1 – Soft core(lead) and steel penetrator

**Table 2:** Glass in building – Security glazing testing and classification of resistance against bullet attack – Rifles and handguns

| Class | Weapon | Calibre | Type | Strike |
|---|---|---|---|---|
| SG1 | Shotgun | 12/70 | SLS | 1 |
| SG2 | Shotgun | 12/70 | SLS | 3 |
| SLS – Solid Lead Slug – Brenneke - 31.0 ± 0.1 g | | | | |

**Table 3:** Glass in building – Security glazing testing and classification of resistance against bullet attack – Shotgun

For BR 1 to 7 the strike pattern is an equilateral triangle of 120 ± 10 mm per side with one shot per vertices.

For SG1 there is one shot in the centre of the test specimen.

For SG2 the strike pattern is an equilateral triangle of 125 ± 10 mm per side with one shot per vertices.

The test distance is 10 metres with the exception of BR 2 to BR4 where it is 5 metres.

Full details of the test procedure can be found in EN 1063.

#### 5.2.3 Classification

After the test has been undertaken the splinter collection box and witness foil is examined.

If the test specimens comply as follows:

1. No perforation of the glazing by the bullet or parts of the bullet and no perforation of the witness foil by glass splinters from the rear face.

This type of bullet resistant glazing shall be classified in the appropriate class with the additional mark: "NS" (no splinters).

2. No perforation of the glazing by the bullet or parts of the bullet, but with perforation of the witness foil by glass splinters from the protected face.

This type of bullet resistant glazing shall be classified in the appropriate class with the additional mark: "S" ("splinters").

#### 5.2.4 Applicability of test method for plastics glazing sheet material

EN 1063 is only applicable to glass and/or glass/plastic composites. The test method as described in EN 1063, may be applied to plastics glazing sheet materials.

However, the behaviour of plastics glazing sheet materials means any classification will carry the additional mark "NS".

### 5.3 ISO 16935

#### 5.3.1 General

The International test method (ISO 16935) consists of eight specified levels of ballistic attack with the following weapons:

- Three with hand guns
- Two with rifles
- Three with shotguns

There is also:

Class O, any weapon but following the test methodology, e.g. strike range, pattern, etc.

**NOTE: For details of weapons/ammunitions/strike pattern/number of strikes see Tables 4 and 5.**

The test determines whether:

a) No perforation of glazing but with perforation in the witness foil.

b) No perforation of the glazing, with loss of material from the non-attack surface but no perforations in the witness foil.

c) No perforation of the glazing, with no loss of material from the non-attack surface and no perforations in the witness foil.

### 5.3.2 Detail of test

The test specimen size is (500 ± 5) mm x (500 ± 5) mm.

Details of performance classes, weapons, calibre and bullets are given in Table 4 for handguns and rifles and Table 5 for shotguns.

| Class | Weapon | Calibre | Bullet |
|---|---|---|---|
| HG1 | Handgun | 9 mm Luger | FJ2)/RN/LC |
| HG2 | Handgun | 0.357 Magnum | JSP |
| HG3 | Handgun | 0.44 Magnum | FJ2)/FN/SC |
| R1 | Rifle | 5.56 x 45 | FJ2)/PB/SCP |
| R2 | Rifle | 7.62 x 51 | FSJ/PB/SC |
| FSJ – Full steel jacket(plated) FJ2 – Copper alloy jacket LC – Lead Core; FN – Flat nose; PB – Pointed bullet; RN – Round nose; SC – Soft Core; JSP – Jacketed Soft Point; SCP – Soft core lead with steel penetrator | | | |

**Table 4:** Glass in building – Security Glazing Testing and classification of resistance against bullet attack – Rifles and handguns

| Class | Weapon | Calibre | Type | Strike |
|---|---|---|---|---|
| SG1 | Shotgun | 12/70 | SLS | 1 |
| SG2 | Shotgun | 12/70 | SLS | 2 |
| SG3 | Shotgun | 12/70 | SLS | 3 |
| SLS – Solid Lead Slug – Brenneke - 31.0 ± 0.1 g | | | | |

**Table 5:** Glass in building – Security Glazing Testing and classification of resistance against bullet attack – Shotgun

For HG 1 to 3 the strike pattern is an equilateral triangle of 110 ± 10 mm per side with one shot per vertices;

For R1, R2 and SG3 the strike pattern is an equilateral triangle of 120 ± 10 mm per side with one shot per vertices;

For SG1 the strike is one shot in the centre of the test specimen

For SG2 the strike pattern is two shots at positions 60 ± 10 mm directly above and directly below the centre of the test specimen;

The test distance is 10 metres with the exception of HG1 to HG3 where it is 5 metres.

Full details of the test procedure can be found in ISO 16935.

### 5.3.3 Classification

Classification depends upon the performance of the worst test specimen. This means:

- If any test specimen is penetrated – the product can not be classified;
- If any test specimen meets 5.3.1 a) – the product is classified SPALL (S);
- If any test specimen meets 5.3.1 b) – the product is classified REDUCED SPALL (RS);
- If all test specimen meets 5.3.1 c) – the product is classified NO SPALL (NS).

## 6. General Performance of Products

Bullet resistant glazing can be an important deterrent to ensure the security of property and occupants in a building. An assessment of the level of risk determines the necessary level of protection, and thus the type of bullet resistant glazing. Different levels of resistance can be obtained by varying the number and/or thickness of each of the components.

Typical glass/pvb and glass/polycarbonate product thicknesses to meet the desired level of resistance are shown in the Table 6 below. However, the actual thickness for a specific classification will be dependent upon the laminated glass supplier.

| Class | Thickness (mm) Glass/pvb (S) | Thickness (mm) Glass/pvb (NS) | Thickness (mm) glass/ polycarb Composite (NS) |
|---|---|---|---|
| BR1 | 14 | | |
| BR2 | 22 | | |
| BR3 | 24 | | |
| BR4 | 33 | 54 | 21 |
| BR5 | 37 | 58 | 32 |
| BR6 | 50 | 71 | 38 |
| BR7 | 56 | 81 | |
| SG1 | 33 | 54 | 21 |
| SG2 | 50 | 71 | 38 |

**Table 6:** Typical products for EN 1063 performance

The use of other components, such as EVA or resin interlayers, may have an effect on the overall product thickness.

The application of an appropriate adhesive backed polymeric security film to the rear face of a bullet resistant glazing complying with EN 1063 could transform a splinters (S) product into a no splinters (NS) one.

NOTE 1: Information on adhesive backed polymeric filmed glass can be found in GGF Data Sheet 5.18.3 Recommendations for Adhesive Backed Polymeric Film Applied to Glass: Definitions, Descriptions and Components.

NOTE 2: The manufacturer of the adhesive backed polymeric security film should be contacted for details on performance and application.

## 7. Compliance with the Construction Products Regulation

The two product types that could be regarded as bullet resistant glazing are plastics glazing sheet material and laminated glass/laminated safety glass.

NOTE: Plastics glazing sheet material does not have a harmonized European Standard and therefore cannot be deemed to meet the Construction Products Regulation.

For laminated glass/laminated safety glass to be placed on the market with a claimed performance to the Essential Characteristic --"Safety in use – Bullet resistance: Shatter properties and resistance to attack" the product is under an Assessment and Verification of Constancy of Performance (AVCP) – Level 1 System of Attestation – Level 1. This means the following:

- Manufacturer implements factory production control (FPC) as per standard;
- Notified Certification Body examines FPC manual and inspects factory;
- Notified Certification Body selects test specimens;
- Type testing to show conformity with product standard, i.e. EN ISO 12543, by a Notified Testing Body;
- Type testing to EN 1063 undertaken by a Notified Testing Body;
- Manufacturer responsible for on-going product conformity;
- Notified Certification Body responsible for regular audits of FPC system.

## ANNEX A

Bullet-resistance testing using other weapons/ammunition, i.e. open classification and/or test temperatures

**(Informative)**

### A.1 General

There exist standards/regulations that require the testing using weapons, etc., other than those given in the European Standard, i.e. EN 1063.

Similarly there may be requirements for bullet resistant glazing for applications when the influence of the outside temperature needs to be considered, i.e. testing under extreme conditions at temperatures of -20°C or +40°C.

### A.2 Standard

The following standard details the methodology.

**ISO 16935** Glass in building – Bullet-resistant security glazing – Test and classification

# GGF Data Sheet: Security Glazing – Part 4: Explosion Resistant Glazing

8.1.4 May 2016

**Contents**



## Foreword

GGF Data Sheet series 8.1 covers the use of security glazing in buildings. It comprises the following parts:

Part 1: Definitions and Description

Part 2: Manual Attack Resistant Glazing

Part 3: Bullet Resistant Glazing

Part 4: Explosion Resistant Glazing

Part 5: Framing and Installation

## Introduction

This GGF Data Sheet 8.1.4 assesses security glazing products that are more familiarly known as 'blast-resistant' glazing products.

NOTE 1: These products are frequently and incorrectly referred to as 'blast/bomb proof' glazing. No glazing product can be referred to as 'blast/bomb proof' only 'blast-resistant'.

NOTE 2: Explosion-resistant glazing can also be referred to as security glazing – resistance against explosion pressure.

## 1. Scope

This GGF Data Sheet 8.1.4 details test and classification methods for security glazing that can be described as explosion-resistant glazing.

## 2. Definitions and Description

The definitions and descriptions contained within GGF Data Sheet 8.1.1 Security Glazing - Part 1: Definitions and Descriptions apply. The following are specific to this GGF Data Sheet 8.1.4.

### 2.1 Definitions

#### 2.1.1 Security glazing

Glazing and framing system designed to withstand a specified level of attack.

#### 2.1.2 Security glazing product

Glazing product that provides a specific resistance to the actions of force.

#### 2.1.3 Actions of force

Specific actions either deliberate or accidental that may result in injury to persons and/or damage to property.

### 2.2 Description

#### 2.2.1 Actions

##### 2.2.1.1 Explosion pressure

An action, either deliberate or accidental, that may cause personal injury, material damage to buildings, property, etc. as the result of an explosive blast.

#### 2.2.2 Security glazing products

##### 2.2.2.1 Blast resistant glazing

Security glazing designed to reduce the injurious effects or damage to property of accidental or intentional blast forces (EN 13541, ISO 16933, ISO 16934).

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## 3. Standards and Reference Documents

### 3.1 Standards

**British Standards**

**BS 6262-3** Glazing for buildings – Code of practice for fire, security and wind loading

**European Standards**

**EN 13541** Glass in building – Security glazing – Testing and classification of resistance against explosion pressure

**EN 14449** Glass in building – Laminated glass and laminated safety glass – Evaluation of conformity/Product standard

**EN 15755-1** Glass in building – Adhesive backed polymeric filmed glass – Part 1: Definition and description

**International Standards**

**ISO 16933** Glass in buildings – Explosion resistant security glazing – Test and classification for arena air-blast loading

**ISO 16934** Glass in buildings – Explosion resistant security glazing – Test and classification by shock-tube loading

### 3.2 Reference documents

GSA: US General Service Administration - Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loadings

Paper ID 12892: International Standards for Blast Resistant Glazing – Nicholas F Johnson – Symposium on Building Security in an Age of Terrorism

## 4. Principles of Testing Explosion Resistant Glazing

### 4.1 General

The objective of explosion-resistant testing is to classify, under given conditions, the performance of security glazing.

There are two methods of producing a 'blast wave' that is equivalent to a given explosion. These are:

- Shock tube
- Open arena – air blast

NOTE 1: The European standard, EN 13541, is a 'shock tube' test method.

NOTE 2: There is currently no European standard for 'open arena' testing of glass products.

NOTE 3: There are European standards for windows, doors and shutters; EN 13123 for the requirements and classification; and EN 13124 for the test method. These standards use both 'shock tube' and 'open arena' test methods.

NOTE 4: The International standards, ISO 16933 and ISO 16934, cover 'open arena' and 'shock tube' test methods respectively.

#### 4.1.1 Shock tube

This is a facility which simulates explosive blast waves to load test specimens with consistency, control and repeatability. Shock tube tests provide an economic means to simulate relatively long-duration blast shock waves representing the effects of large explosive devices at some distance.

NOTE: The results can be assessed against broadly comparable arena tests.

#### 4.1.2 Open arena – air blast

This is a test method whereby test specimens are subjected to real explosive blast in an open air arena. The test specimens experience the following:

- Positive phase, which is characterised by a nearly instantaneous rise to a maximum pressure followed by an exponential decay to ambient pressure
- Negative phase, immediately following the positive phase, during which the pressure decreases below ambient for a period of time before returning to ambient

Information on blast wave characteristics is given in Annex A.

### 4.2 Framing/installation

For an explosion resistant glazing to perform up to expectations it must be installed into an appropriately designed and fixed framing/glazing system. (See GGF Data Sheet 8.1.5 Security Glazing Part 5: Framing and Installation).

## 5 Test Methods

### 5.1 EN 13541

#### 5.1.1 General

*This is a shock tube test method.*

The classification of explosion pressure resistance is based on the maximum positive pressure of the reflected shock wave and the duration of the positive pressure phase.

#### 5.1.2 Details of test

The test specimen size is (1100 ± 5) mm x (900 ± 5) mm.

Details of Classification Code, positive overpressure of the reflected blast wave (Pr) and duration of the positive pressure phase (t+) are given in Table 1.

| CODE | Characteristics of plane shock wave | |
|---|---|---|
| | Positive Overpressure (Pr) (kPa) | Duration of positive pressure phase (t+) (ms) |
| ER1 | $50 \leq Pr < 100$ | ≥ 20 |
| ER2 | $100 \leq Pr < 150$ | ≥ 20 |
| ER3 | $150 \leq Pr < 200$ | ≥ 20 |
| ER4 | $200 \leq Pr < 250$ | ≥ 20 |

**Table 1:** Classification Code, (Pr) and (t+)

#### 5.1.3 Classification

Each of the 3 test pieces shall comply with the following:

- The test pieces shall not have any "through" holes, from the front to the back
- There shall not be any opening between the clamping frame and the edges of the test piece

The security glazing will be classified as per the code in Table 1. It can have the following additional information:

- (S) Splinters ejected from the rear (protected side) of the glass
- (NS) No splinters ejected from the rear (protected side) of the glass

### 5.2 ISO 16934

#### 5.2.1 General

*This is a shock tube test method.*

The standard provides criteria for rating the level of damage to glazing from which can be assessed the **hazard** consequences to the area located behind the glazing.

There are six levels of hazard defined in the standard; i.e.

A (no break)

B (no hazard)

C (minimal hazard)

D (very low hazard)

E (low hazard)

F (high hazard)

#### 5.2.2 Details of test

The test specimen size is (1100 ± 5) mm x (900 ± 5) mm.

Details of Classification Code, peak pressure and duration of positive phase are given in Table 2.

| CODE | Characteristics of plane shock wave | |
|---|---|---|
| | Positive Overpressure (Pr) (kPa) | Duration of positive pressure phase (t+) (ms) |
| ER30(X) | 30 | ≥ 15 |
| ER50(X) | 50 | ≥ 20 |
| ER70(X) | 70 | ≥ 20 |
| ER100(X) | 100 | ≥ 20 |
| ER150(X) | 150 | ≥ 20 |
| ER200(X) | 200 | ≥ 20 |
| (X) = Hazard rating | | |

**Table 2:** Classification Code, (Pc) and (t+)

Full details of the test procedure, including determination of hazard rating, can be found in ISO 16934.

#### 5.2.3 Classification

Glazing shall be classed as "blast-resistant" to a given classification code, see Table 2, if it receives a hazard rating (X) of C;' minimal hazard' or safer.

Glazing may be classed as offering "hazard reduction" to a given classification code, see Table 2, if it receives a hazard rating (X) of between D ,'very low hazard' and E,'low hazard'.

### 5.3 ISO 16933

#### 5.3.1 General

*This is an open arena – air blast loading test.*

This standard provides a method of determining damage and hazard, as per ISO 16934, using real explosives.

#### 5.3.2 Details of test

The test specimens' vision size is 1000 mm x 800 mm.

NOTE: Vision size normally referred to as 'sight size'.

This standard tests for two different threat scenarios:

- Vehicle bomb
- Hand-carried satchel bomb

Tables 3 and 4 give the classification codes and criteria to define the explosion pressure.

| CODE | Positive Overpressure (Pr) (kPa) | Duration of positive pressure phase (t+) (ms) |
|---|---|---|
| EXV45(X) | 30 | 180 |
| EXV33(X) | 50 | 250 |
| EXV25(X) | 80 | 380 |
| EXV19(X) | 140 | 600 |
| EXV15(X) | 250 | 850 |
| EXV12(X) | 450 | 1200 |
| EXV10(X) | 800 | 1600 |
| (X) = Hazard rating | | |

**Table 3:** Classification criteria – Vehicle bombs

| CODE | Positive Overpressure (Pr) (kPa) | Duration of positive pressure phase (t+) (ms) |
|---|---|---|
| SB1 (X) | 70 | 150 |
| SB2 (X) | 110 | 200 |
| SB3 (X) | 250 | 300 |
| SB4 (X) | 800 | 500 |
| SB5 (X) | 700 | 700 |
| SB6 (X) | 1600 | 1000 |
| SB7 (X) | 2800 | 1500 |
| (X) = Hazard rating | | |

**Table 4:** Classification criteria – Hand-carried satchel bombs

As with ISO 16934 this standard also examines the hazard that results from the explosion blast.

Full details of the test procedure, including:

- Determination of hazard rating
- Charge weight and standoff distance

can be found in ISO 16933.

### 5.3.3 Classification

There is no classification as such. This standard only requires the stating of the Classification Code and the associated Hazard Rating.

## 6. General Performance of Products

Explosion resistant glazing can be an important feature to minimise the consequences of an accidental or criminal explosion to property and the occupants of a building. An assessment of the level of risk must be carried out to determine the necessary level of protection, and thus the type of explosion resistant glazing required.

The success of an explosion resistant product should be considered as its ability to absorb the energy without allowing threatening particles to enter the protected zone or transferring damaging loads to the building structure.

Thinner flexible constructions may perform better than thick rigid ones in this respect. Due to the expectation that the glass may break and deform to a high degree, the ability of the frame and glazing system to retain the loaded glass is critical to the function of explosion resistance.

(See GGF Data Sheet 8.1.5 Security Glazing Part 5: Framing and installation.)

Different levels of resistance can be obtained by varying the number and/or thickness of each of the components.

Typical glass/pvb product thicknesses to meet the desired level of resistance are shown in the Table 5 below. However, the actual thickness for a specific classification will be dependent upon the laminated glass supplier.

| Class | Thickness (mm) Glass/pvb (S) | Thickness (mm) Glass/pvb (NS) |
|---|---|---|
| ER1 | 10 | 18 |
| ER2 | 18 | 26 |
| ER3 | 31 | 39 |
| ER4 | 27 | 33 |

**Table 5:** Typical products for EN 13541 performance

The use of other components, such as EVA or resin interlayers, may have an effect on the overall product thickness. Glass/polycarbonate composites could reduce the overall thickness from those in Table 5.

The application of an appropriate adhesive backed polymeric security film could either make annealed glass capable of being classified or increase the classification obtained for a particular thickness of laminated glass.

The application of an approved edge retention system may be used to mechanically affix such adhesive backed polymeric security films to the frame/glazing. This will enhance the level of protection and minimise the hazard level. This is especially true where broken glass may otherwise be propelled out of the framing structure. The combination of the film and edge retention system should meet the relevant levels of performance and classification for use in blast protection.

NOTE 1: Information on adhesive backed polymeric filmed glass can be found in GGF Data Sheet 5.18.3 Recommendations for Adhesive Backed Polymeric Films applied to Glass: Definitions, Descriptions and Components.

NOTE 2: Specific information on blast mitigation using adhesive backed polymeric filmed glass can be found in GGF Data Sheet 5.18.6 Recommendations for Blast Mitigation: Adhesive Backed Polymeric Film Applied to Glass.

NOTE 3: The manufacturer of the adhesive backed polymeric security film should be contacted for details on performance and application.

## 7. Compliance with the Construction Products Regulation

The product type that could be regarded as explosion resistant glazing is laminated glass/laminated safety glass.

For laminated glass/laminated safety glass to be placed on the market with a claimed performance to the Essential Characteristic – "Safety in use – Explosion resistance: Impact behaviour and resistance to attack" the product is under an Assessment and Verification of Constancy of Performance (AVCP) – Level 1 System of Attestation – Level 1. This means the following:

- Manufacturer implements factory production control (FPC) as per standard;
- Notified Certification Body examines FPC manual and inspects factory;
- Notified Certification Body selects test specimens;
- Type testing to show conformity with product standard, i.e. EN ISO 12543, by a Notified Testing Body;
- Type testing to EN 13541 undertaken by a Notified Testing Body;
- Manufacturer responsible for on-going product conformity;
- Notified Certification Body responsible for regular audits of FPC system.

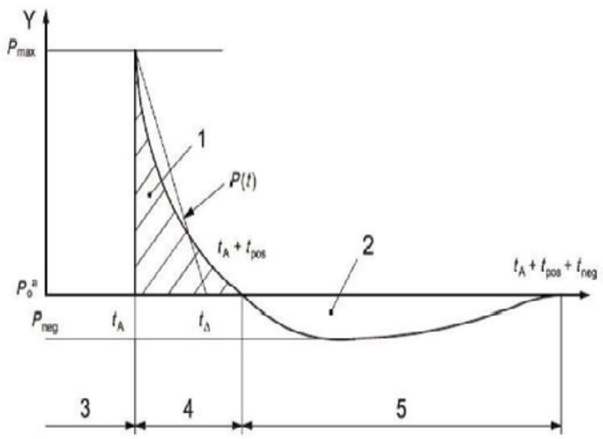
### Annex A: Blast wave characteristics

This informative annex on blast wave characteristics has been reproduced from ISO 16933 Annex B.

- Manufacturer responsible for on-going product conformity
- Notified Certification Body responsible for regular audits of FPC system

A blast wave can be generated by detonation of a high explosive. This results in a sudden release of energy that causes the air to be highly compressed and driven at supersonic speeds, during which air molecules cannot respond as they would to a normal input of energy.

As a result the air "shocks up" to form a blast wave. The blast wave is characterized at any given point by an instantaneous rise in pressure followed by a decay over a time period called the positive phase duration. See Figure B.1.




**Key**

x time after explosion
Y pressure

1 positive specific impulse, $i_{pos}$
2 negative specific impulse, $i_{neg}$
3 time of arrival $t_A$
4 positive phase duration, $t_{pos}$
5 negative phase duration, $t_{neg}$

a Ambient

**Figure B.1:** Blast shock-wave characteristics

### Bibliography

#### European Standards

**EN 13123-1** Windows, doors and shutters – Explosion resistance – Requirements and classification – Part 1: Shock tube

**EN 13123-2** Windows, doors and shutters – Explosion resistance – Requirements and classification – Part 2: Range test

**EN 13124-1** Windows, doors and shutters – Explosion resistance – Test method – Part 1: Shock tube

**EN 13124-2** Windows, doors and shutters – Explosion resistance – Requirements and classification – Part 2: Range test

#### GGF Data Sheets

**GGF Data Sheet 5.18.3** Recommendations for Adhesive Backed Polymeric Films Applied to Glass: Definitions, Descriptions and Components

**GGF Data Sheet 5.18.6** Recommendations for Blast Mitigation: Adhesive Backed Polymeric Films Applied to Glass

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# GGF Data Sheet: Security Glazing – Part 5: Framing and Installation

8.1.5 May 2016

**Contents**



## Foreword

GGF Data Sheet series 8.1 covers the use of security glazing in buildings. It comprises the following parts:

Part 1: Definitions and Description

Part 2: Manual Attack Resistant Glazing

Part 3: Bullet Resistant Glazing

Part 4: Explosion Resistant Glazing

Part 5: Framing and Installation

## Introduction

This GGF Data Sheet 8.1.5 assesses security framing/glazing systems and the installation of security glazing products.

## 1. Scope

This GGF Data Sheet 8.1.5 details test and classification methods for security framing together with advice on the installation of security glazing products.

## 2. Definitions and Description

The definitions and descriptions contained within GGF Data Sheet 8.1.1 Security Glazing Part 1: Definitions and Description apply. The following are specific to this GGF Data Sheet 8.1.4.

### 2.1 Definitions

#### 2.1.1 Security glazing

Glazing, framing and fixing system designed to withstand a specified type and level of attack.

NOTE: In BS 5357 this is referred to as 'complete installation'.

#### 2.1.2 Security glazing product

Gazing product that provides a specific resistance to the actions of force

#### 2.1.3 Actions of force

Specific actions either deliberate or accidental that may result in injury to persons and/or damage to property.

#### 2.1.4 Security framing

Framing system, window, door, etc. designed to resist a specified type and level of attack

### 2.2 Description

#### 2.2.1 Actions

##### 2.2.1.1 Manual attack

A deliberate action on the part of a person made with the intention of creating an opening in the security glazing product by the use of manually held implements or by the use of thrown objects.

##### 2.2.1.2 Ballistic attack

A deliberate action on the part of a person made with the intention of threatening or causing personal injury by the use of firearms.

##### 2.2.1.3 Explosion pressure

An action, either deliberate or accidental, that may cause personal injury, material damage to buildings, property, etc. as the result of an explosive blast.

#### 2.2.2 Security glazing products

##### 2.2.2.1 Manual attack resistant glazing

Security glazing designed to resist attack and to delay access to a protected space for a short period of time (BS 5544, EN 356).

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NOTE 1: Manually held implements such as axe, crowbar, pickaxe, etc.

NOTE 2: Thrown objects such as bricks, street furniture, etc.

**2.2.2.2 Bullet resistant glazing**

Security glazing product that affords a defined resistance against the firing of specified weapons and ammunition (BS 5051, EN 1063).

**2.2.2.3 Blast resistant glazing**

Security glazing designed to reduce the injurious effects or damage to property of accidental or intentional blast forces (EN 13541, ISO 16933, ISO 16934).

**2.2.3 Security framing**

**2.2.3.1 Manual attack resistant**

Framing that is tested and classified to withstand manual attack (BS EN 1627 to BS EN 1630).

**2.2.3.2 Bullet resistant**

Framing that is tested and classified to withstand ballistic attack (EN 1522 and EN 1523).

**2.2.3.3 Explosion resistant**

Framing that is tested and classified to withstand explosive pressure (EN 13123 – 1 & 2 and EN 13124 – 1 & 2).

## 3. Standards and Reference Documents

### 3.1 Standards

**British Standards**

**BS 5357** Code of practice for installation and application of security glazing

**BS 6262-3** Glazing for buildings – Code of practice for fire, security and wind loading

**British/European Standards**

**BS EN 1627** Pedestrian doorsets, windows, curtain walling, grills and shutters – Burglar resistance – Requirements and classification

**BS EN 1628** Pedestrian doorsets, windows, curtain walling, grills and shutters – Burglar resistance – Test method for the determination of resistance under static loading

**BS EN 1629** Pedestrian doorsets, windows, curtain walling, grills and shutters – Burglar resistance – Test method for the determination of resistance under dynamic loading

**BS EN 1630** Pedestrian doorsets, windows, curtain walling, grills and shutters – Burglar resistance – Test method for the determination of resistance to manual burglary attempts

NOTE: These four Standards include a national annex.

**European Standards**

**EN 1522** Windows, doors, shutters and blinds – Bullet resistance – Requirements and classification

**EN 1523** Windows, doors, shutters and blinds – Bullet resistance – Test method

**EN 13123-1** Windows, doors and shutters – Explosion resistance – Requirements and classification – Part 1: Shock tube

**EN 13123-2** Windows, doors and shutters – Explosion resistance – Requirements and classification – Part 2: Range test

**EN 13124-1** Windows, doors and shutters – Explosion resistance – Test method – Part 1: Shock tube

**EN 13124-2** Windows, doors and shutters – Explosion resistance – Requirements and classification – Part 2: Range test

**EN 14351-1** Windows and doors – Product standard, performance characteristics – Part 1: Windows and external pedestrian doorsets without resistance to fire and/or smoke leakage characteristics

**EN 14351-2** Windows and doors – Product standard, performance characteristics – Part 2: Internal pedestrian doorsets without resistance to fire and/or smoke leakage characteristics

### 3.2 Reference documents

**LPS 1175** Loss Prevention Standard – Requirements and testing procedures for the LPCB approval and listing of intruder resistant building components, strongpoints, security enclosures and free-standing barriers

**GSA** US General Service Administration - Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loadings

**Paper ID 12892** International Standards for Blast Resistant Glazing – Nicholas F Johnson – Symposium on Building Security in an Age of Terrorism

## 4. Principles - Glazing, Framing And Support

The following has been reproduced verbatim from BS 5357: 2007 with the express permission of BSI.

### 4.1 General

The complete installation for the security glazing, including the framing and support, should provide at least the equivalent resistance to attack as the security glazing it is designed to hold in place.

Any method used to hold framed or unframed security glazing in place should be of sufficient strength to resist dislodgement by any anticipated means of manual attack.

NOTE: Glazing resistant to attack by firearms might not necessarily be resistant to manual attack.

Where security glazing is installed within 1 metre of a personnel workstation, the danger of spalling from the glazing material should be considered.

### 4.2 Framed security glazing

The frame should be of sufficient strength and stiffness to hold the glazing securely in place when either the frame or the glazing is subjected to the specified level of attack.

The depth of the rebate should be sufficient that, after allowance for edge clearance around the glazing, there is adequate edge cover to prevent the glazing being levered out of the frame when subjected to the specified level of attack.

NOTE: The depth required depends on the strength and stiffness of the rebate upstand and the glazing bead.

The bead should be fixed, preferably on the private side, in a manner which ensures that it cannot be removed or dislodged when subjected to the specified level of attack.

Glazing gaskets and sealants should be checked for compatibility with the security glazing. Where possible, chemically curing sealants with good adhesion to the glazing and the framing material should be used.

### 4.3 Fixing methods for explosion resistant glazing

#### 4.3.1 Fixings where the glass is intended to remain unbroken

Where the glass is intended to remain unbroken (except for any sacrificial layer), the support system should be designed so that it resists the forces of the explosion transmitted through the glass, i.e. the full blast overpressure, without significant distortion, maintaining the glass in position.

NOTE 1: The fixing method for this design is usually of a much heavier duty than those used to resist wind forces. This is particularly important with conventional glazing frames, where the frames themselves, the attachment of the frame to the building, and the attachment of beads to the frame, might need to be considerably stronger than normal.

The installation of such glazing also has consequences for the building structure, since the full force of the blast is transmitted to the structure, which should be designed to resist it.

NOTE 2: This might only be practical for new buildings.

#### 4.3.2 Fixings where the glass is allowed to fracture

Where the glass is allowed to fracture, glazing with deep rebates on all edges of the glass is recommended. The beads holding the glass in place should be of sufficient strength to remain intact and hold the glass in position.

NOTE: If the glass is allowed to fracture, the forces transferred to the frame and the structure is reduced and might result in a practical economical option.

It is recommended that a tested framing system and proven fixing method is adopted but, in general, increasing the edge cover to the glass and bolting the bead at frequent intervals is sufficient.

### 4.4 Unframed bullet resistant security glazing

Unframed bullet-resistant security glazing should have no gaps, except as described in 5.4, between the edges. Butt joints should not be used for bullet-resistant glazing.

NOTE: Guidance edge finishes of laminated glass can be found in EN ISO 12543-5 and defects on edges that will not be framed in EN ISO 12543-6.

### 4.5 Supports

All fixings to ceilings, walls, floors and junctions should be of sufficient strength to securely hold in place all components of the installation, when subjected to the specified level of attack. Vertical supports (mullions) should be securely fixed at ceiling and floor levels.

Alternatively, if a counter is provided and it is strong enough to provide satisfactory anchorage, fixings may be made at the counter level rather than at floor level. Vertical supports should generally be taken through suspended ceilings and raised floors in order to achieve satisfactory anchorage.

Horizontal supports (transoms) should be securely fixed at each junction with the vertical supports and walls where appropriate. Where a counter or other non-glazed component is provided as part of the glazed security screen, it should be securely supported and fixed to the walls and floors.

Where a counter or other non-glazed component is provided as part of the glazed security screen, it should be securely supported and fixed to the walls and floors.

NOTE: The reference in 4.4 to clause 5.4 is in BS 5357 and refers to speaking and transaction apertures.

## 5. Security Framing

### 5.1 General

For any framing/glazing system, e.g. window, door, curtain walling, etc.; to be approved as a security framing/glazing system it must be tested for the claimed performance in accordance with the appropriate standard.

### 5.2 Manual attack resistant

The Standards BS EN 1627, BS EN 1628, BS EN 1629 and BS EN 1630 detail a classification system and associated test methods.

NOTE: These four Standards include a national annex.

BS EN 1627 recommends classes of manual attack resistant glazing in accordance with EN 356, (see GGF Data Sheet 8.1.2 Security Glazing Part 2: Manual Attack Resistant Glazing) that relate to specific classifications of security framing.

NOTE: The applicability of these standards, certainly for domestic applications, in the United Kingdom is questionable.

### 5.3 Bullet resistant

The standard EN 1522 details the requirements and classification system for windows and doors. EN 1523 details the applicable test method.

The details of the test for classification of the windows, doors, etc. are the equivalent to those used for the classification of bullet resistant glass (see GGF Data Sheet 8.1.3 Security Glazing – Part 3: Bullet Resistant Glazing). The ballistic attack impact is directed at the framing, i.e. joints, beads, hinges, etc.

### 5.4 Explosion resistant

The classification and test standards cover both shock tube and open arena (range test).

The applicable standards are:

- Shock tube EN 13123-1 and EN 13124-1 respectively;
- Open arena EN 13123-2 and EN 13124-2 respectively.

## 6. Specification

### 6.1 General

The specification of security glazing should be the result of an appropriate risk assessment. It is recommended that professional advice, i.e. police, crime prevention, security services, etc., be obtained.

### 6.2 Specific factors for consideration

#### 6.2.1 Manual attack

The following is a non-exhaustive list:

- External or internal glazing
  - Prevention of ingress to a building
  - Prevention of access to protected space
  - Protection of objects
- Type of building
  - Private dwelling
    - Location
    - Value
  - Commercial premises
    - Location
    - Accessibility
    - Desirability of contents
- Type of attack
  - Implements available
  - Time available

#### 6.2.2 Bullet resistance

The following is a non-exhaustive list:

- Type of weapon
  - Single weapon
  - Single or multiple strikes
- Proximity to protected space
  - Distance between weapon and glazing
  - Angle between weapon and glazing
- Requirement in protected space
  - Personnel protection - acceptability of:
    - Splintering/spalling
    - No splintering/spalling
  - Objects

#### 6.2.3 Explosion resistance

The following is a non-exhaustive list:

- Type of explosion
  - Industrial
    - Gas
    - Petrochemical
    - Dust
  - Terrorist bomb
    - Size, e.g. satchel, car, lorry
    - Explosive material
- Building design
  - Structure
  - Surroundings
- Proximity to target of explosion

### 6.3 Other factors

The following should also be considered:

- Requirements of insurance industry
  - This will be influenced by previous history of criminal activity
- Change of use of premises
- Environment
  - Neighbourhood
  - Climatic conditions for external glazing
- Security glazing products – multi-functionality
  - Because a product has been classified for a particular type of security performance it does not necessarily mean that it will meet other standards
  - If multi-functionality is necessary, then the security glazing product manufacturer should be consulted

## 7. Installation of Security Glazing

### 7.1 General

All security framing, security glass products and associated adhesive sealants, etc. should be installed in accordance with the manufacturers' instructions.

NOTE: Product combinations must be those that were tested and classified.

### 7.2 Specific advice

The following is a non-exhaustive list:

- Orientation of security glazing product.

NOTE: Most security glazing products have an attack face and a non-attack face. An installation with the non-attack face towards the attack will result in a non-quantifiable performance.

- The application of an approved edge retention system may be used to mechanically affix adhesive backed polymeric security film to the frame. This will enhance the level of protection and minimise the hazard level. This is especially true where broken glass may otherwise be propelled out of the framing structure. The combination of the film and edge retention system should meet the relevant levels of performance and classification for use in blast protection.

NOTE 1: Specific information on blast mitigation using adhesive backed polymeric filmed glass can be found in GGF Data Sheet 5.18.6 Recommendations for Blast Mitigation: Adhesive Backed Polymeric Films Applied to Glass.

NOTE 2: The manufacturer of the adhesive backed polymeric security film should be contacted for details on performance and application.

- Correct attachment of security framing to the building structure;
- Correct orientation of security framing;
- All glazing compounds/gaskets/etc. should be compatible with the security glazing product;
- Application of glazing compounds should be in accordance with the suppliers instructions;
- Substitution of approved components is NOT permitted

**8. Compliance with the Construction Products Regulation (CPR)**

Any window, door or curtain walling product which is covered by an official mandate under the CPR, when placed on the European market, should comply with the applicable harmonized European standard (hEN). Conformity relates not only to the performance of the product, i.e. Initial Type Testing, but also the Factory Production Control including on-going inspection and surveillance, i.e. Assessment and Verification of Constancy of Performance (AVCP).

The applicable hENs are EN 14351-1 and EN 14351-2.

# The Centre for Effective Dispute Resolution (CEDR) Services. Consumer Arbitration Scheme for the GGF

14.2 August 2014

## 1. Scope

This data sheet explains a scheme administered by the CEDR for the resolution of disputes between Members of the Glass and Glazing Federation and their customers.

### Explanatory notes

These explanatory notes do not form part of the Rules of the Scheme.

The Scheme provides for the settling of disputes or differences between Members of the Glass and Glazing Federation ('GGF') and their customers where the normal dispute procedure has failed to achieve an amicable settlement within a reasonable time.

The Scheme is designed to offer a simple and inexpensive method of resolving disputes by the appointment of an independent arbitrator to make a binding award soon after the parties complete their submissions to the arbitrator and with the minimum of formality. In normal circumstances proceedings can be completed within three months of the date of acceptance by the CEDR (The Centre) of an application. The Rules commit the customer to pay a modest registration fee, which may be reimbursed at the arbitrator's discretion. The balance of the costs of the Scheme is borne by the Member.

An application must be made on the prescribed form and the parties by doing so agree to be bound by the arbitrator's decision.

Informality is the essence of the Scheme. The arbitrator appointed by the Centre will decide disputes by reference to written submissions and documentary evidence supplied by the parties, with no oral hearing, although may the arbitrator may view the installation which is the subject of the dispute.

The Scheme is not designed to accommodate disputes in which compensation is an issue or where issues are unusually complicated or are likely to require a hearing with oral evidence for their proper resolution.

If the issues are such that this simplified scheme is inappropriate, the normal services of the Centre (particulars of which can be obtained on application to the Centre) are available to the parties to cover disputes, which are likely to require a hearing, or are otherwise excluded under Rule 2.2. The Centre will be prepared to accept arbitrations in such cases under its normal Rules if the parties agree and request it.

In such circumstances the special costs provisions of the GGF Arbitration Scheme will not apply and the arbitrator will determine which party shall pay the costs involved.

## 2 Introduction

**2.1** This Scheme applies to applications for arbitration made to the Centre for Effective Dispute Resolution (CEDR) in respect of disputes between members ('traders') of Glass & Glazing Federation ("GGF") and their customers. Prior to the institution of arbitration proceedings the Parties must attempt to settle the dispute through GGF's conciliation procedure for at least 56 calendar days. If the conciliation procedure fails to resolve the dispute the Parties may proceed to arbitration.

**2.2** The Scheme does not apply to disputes where:-

- One or either of the Parties has already initiated legal action, unless that legal action is cancelled by agreement;
- The claims concern physical injury, illness, nervous shock or their consequences;
- The claim is frivolous or vexatious;
- The claim is for compensation in respect of stress, inconvenience or consequential loss;
- The claim concerns an application for payment of an amount greater than £25,000.

**2.3** The rules apply to disputes between two parties but may be adapted for disputes involving three or more parties upon the agreement of CEDR and all parties to the dispute.

**2.4** The service is designed for use without the need for legal representation. However, any party may choose to be legally represented, but must do so at their own cost which may not be recovered within the service or any subsequent legal action.

**2.5** Any arbitration under the scheme will be conducted under the provisions of the United Kingdom Arbitration Act 1996 (the Act), the Laws of England & Wales and these rules. For the purposes of the Act, all arbitrations under these rules will be deemed to take place in London and will be conducted in English.
The New York Convention and the Scottish Arbitration Act 2010 will apply to the recognition and enforcement of Awards in Scotland and Northern Ireland.

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While every attempt is made to present up to date information, this data sheet, produced by the Glass and Glazing Federation, is issued for guidance but without responsibility for any advice given therein or omission therefrom or for the consequences of acting in reliance thereon and all liability on the part of the Glass and Glazing Federation however arising in connection therewith is expressly disclaimed.

**3 Commencement of arbitration proceedings**

**3.1** To commence arbitration proceedings, a joint application by the Parties must first be submitted to CEDR through the GGF. The application form must be accompanied by the appropriate registration fee from both Parties.

**3.2** On receipt of all forms, fees, evidential documents and / or materials from the parties, CEDR will appoint an arbitrator from the panel it maintains for these purposes and inform the parties of the arbitrator's name. The arbitration commences when CEDR writes to the parties telling them that their application has been accepted.

**3.3** If the arbitrator believes that the dispute is not capable of proper resolution under these rules, the parties will be so advised. In that case the arbitrator's appointment shall be cancelled, the application for arbitration treated as withdrawn and the registration fees shall be refunded. The parties will then be able to pursue the matter either through other appropriate arbitration rules provided by CEDR or through the courts.

**3.4** Once appointed, the arbitrator will communicate with or issue directions to the parties through CEDR. Correspondence with the arbitrator must be copied to all parties.

**4 Arbitration procedure**

**4.1** The arbitrator shall have the jurisdiction and power to direct the procedure of the arbitration including the amendment of any time limits and other procedural requirements. The arbitrator shall also have the power to:

- Allow submission of further evidence and the amendment of claim or defence;
- Order the parties to produce goods, documents or property for inspection;
- Conduct such enquiries as may appear to the arbitrator to be desirable;
- Receive and take in to account any oral or written evidence as the arbitrator shall decide to be relevant;
- Appoint an expert to report on specific issues or take legal advice;
- Award interest, whether or not claimed;
- Proceed with the arbitration if either party fails to comply with these rules or with the arbitrator's directions, or if either party fails to attend any meeting or inspection ordered by the arbitrator but only after giving that party written notice;
- Terminate the arbitration if the arbitrator considers the case to be incapable of resolution under the service, or if the parties settle their dispute prior to an award. If the case is settled the parties must immediately inform the administrator in writing of the terms of the settlement and the arbitrator shall record them in an agreed award enforceable under the Arbitration Act 1996, if requested.
- Order the customer to pay the trader any outstanding fees.

**4.2** In addition to the powers conferred by these rules, the arbitrator shall have the widest discretion permitted by law to resolve the dispute to a possible breach of the GGF Consumer Code of Good Practice in a just, speedy, economical and final manner and in accordance with natural justice.

**4.3** The arbitration will proceed on the basis of written argument and evidence, which must be submitted in accordance with the following procedure.

**4.4** A copy of the claim documents will be sent by CEDR to the trader, who then has 21 days in which to submit a written defence.

**4.5** CEDR will send a copy of the defence documents, including any counterclaim and supporting documents to the customer, who is entitled to submit written comments within a further 14 days. Such comments must be restricted to points arising from the trader's defence. The customer may not introduce any new matters or new points of claim.

**4.6** CEDR will send a copy of the customer's comments to the trader who may provide a response. No further comments can be made following the trader's response, without the arbitrator's express approval.

**4.7** The arbitrator may request further relevant information or other evidence from the parties.

**4.8** The arbitrator will make an award with reasons, normally within 28 calendar days of appointment, after considering all submissions and evidence.

**4.9** CEDR will send a copy of the award to each party.

**4.10** Unless otherwise directed, any amount awarded shall be paid within 21 days of dispatch of the award to the parties. Such payments shall be made direct to the party entitled to receive it, which may include a payment from the customer to the trader for outstanding fees.

**4.11** Any award made under this scheme is final and legally binding on all parties, subject to either party's right under the provisions of the Act to seek leave to appeal in the courts. If either Party wishes to appeal against the Award, then they must seek leave to appeal in the High Court, and will have 28 days from the date of publication of the Award in which to do so. It should be noted that Parties cannot appeal on a point of fact. Neither CEDR nor the Arbitrator can advise the Parties on how to seek leave to appeal.

**4.12** Any party may request the return of its original documents but must do so within 4 weeks of the date of dispatch of the award, after which date CEDR will destroy them.

**5 Content of submissions for arbitration**

**5.1** The claim shall include:

- The nature and basis of the claim;
- The amount of payment claimed or other remedy sought;
- All supporting documents relied on as evidence, in duplicate.

**5.2** An award cannot be made for any amount that is more than the total amount claimed on the application form. Compensation for stress and inconvenience or consequential loss cannot be claimed under the scheme. The customer may make a claim for payment to cover the value of the work, and/or the cost of employing another trader carry out the work required.

**5.3** If the customer is unable to submit a copy of any original contract, order or evidence of such an arrangement the trader shall submit a copy of that document or evidence with their defence.

**5.4** The defence shall include:

- What matters in the opposing documents are accepted or agreed;
- What matters are disputed, with reasons why;
- Details of any outstanding amounts which remain unpaid by the customer, and any associated counterclaim for such amounts;

Any supporting documents relied on as evidence in support of their response.

**5.5** The response by the customer to any defence shall include:

- What matters in the opposing documents are accepted or agreed;
- What matters are disputed, with reasons why;
- Any supporting documents relied on as evidence in support of such response.

**5.6** Any counterclaim shall include:

- The basis of such counterclaim; and
- What is being claimed (and where a monetary claim, the amount claimed and upon what it is based);
- Any other relevant supporting documents.

**5.7** The Response by the customer to any counterclaim shall include:

- Notification of what matters in the opposing document(s) are accepted or agreed; and
- Notification of what matters are disputed, and reasons why; and
- Any other relevant supporting documents.

**5.8** If any party fails to deliver anything required by these rules and does not supply it within 7 days of a reminder by CEDR then:

- Where a claim is not delivered in accordance with Rule 4.1 it shall be deemed to be abandoned;
- Where a claim is abandoned the arbitration will not proceed and the customer's registration fee will be refunded;
- Where the failure concerns information requested by the arbitrator, the arbitration shall proceed as the arbitrator considers appropriate;
- Where the failure is the non-delivery of the defence, the arbitrator may make the award on the basis of documents already received.

### 6 Arbitration costs

**6.1** The cost of the registration fee for a "documents only" arbitration is £100 plus VAT for the customer and £395 plus VAT for the trader. CEDR will not accept applications made without payment.

**6.2** If the arbitrator decides that a site visit is required, the customer will pay 20% of the overall cost and the trader will pay 80% of the overall cost. The cost must be reasonable. If the customer is successful in their application, the arbitrator may, at their discretion, award all or part of the site visit cost back to the customer. The trader is not entitled to payment for any fees or site visit costs paid by the customer, except as specified in rule 5.5.

**6.3** Subject to Rules 5.4 and 5.5 below, each party shall bear its own costs of legal representation, preparing and submitting its case and of attending any hearing. No legal action may be brought to recover these costs.

**6.4** The arbitrator may award that the trader shall reimburse the customer their registration fee if the customer is successful in their application.

**6.5** The arbitrator may also order one party to pay all or part of the other's costs where the former has acted unreasonably and caused the opposing party unnecessary expense.

**6.6** These provisions for costs will not apply to any appeal to the courts of England & Wales.

### 7 Confidentiality

**7.1** No party involved in any dispute under the rules, or CEDR or the arbitrator, shall disclose details of the proceedings to any stranger to the proceedings unless it is necessary to do so in order to enforce a binding settlement or as may be required by law. Notwithstanding the foregoing, CEDR may collate and process data pertaining to the use of the service, compile, analyse and publish statistics therefrom and monitor and review the operation of the service provided always that (save with the express consent of the parties) no personal data, privileged or confidential information shall be published.

### 8 Miscellaneous

**8.1** CEDR reserves the right to appoint a substitute arbitrator if the originally appointed arbitrator dies, is incapacitated or is, for any reason, unable to deal expeditiously with the dispute. The parties shall be notified of any substitution.

**8.2** Subject to the right of either party to request CEDR to draw the arbitrator's attention to any accidental slip or omission which he / she has power to correct by law, neither CEDR nor the arbitrator can enter into correspondence regarding an award made under the service.

**8.3** Neither CEDR nor the arbitrator shall be liable to any party for any act or omission in connection with any arbitration conducted under these rules, save that the arbitrator (but not CEDR) shall be liable for any wrongdoing on his / her own part arising from bad faith.

**8.4** The language of the arbitration shall be English. If the parties request for the arbitration to be conducted in a language other than English, CEDR will endeavour to appoint an Arbitrator who can conduct the process in the requested language. However, in the event that CEDR is unable to appoint an Arbitrator who can conduct the process in the requested language, the cost of any interpretation to English required will be shared equally between the parties. The parties will pay the cost of translating their own documents to English.

**8.5** Where CEDR receives notification that a member has failed to comply with the arbitrator's award, CEDR will advise the GGF who will refer the matter to its Finance and Membership Committee.

**8.6** Where the Arbitrator determines that the member has failed to comply with the GGF Consumer Code of Good Practice, CEDR will advise the GGF who will refer the matter to its Finance and Membership Committee.

# GGF Deposit Indemnity Fund Rules

14.3 June 2015

**1. Scope**

This data sheet provides GGF Member companies with the rules of the Federation's Deposit Indemnity Fund.

**2. Definitions**

**Assistance:** At the option of GGF Fund Limited, either: to enable the work the subject of the relevant Contract to be carried out or completed (as the case may be) by another Member at a Fair Market Price to the Customer, less the amount of the relevant Deposit; or: in cases of hardship, as determined by GGF Fund Limited, payment of up to an amount equal to the Deposit.

**Application:** An application to GGF Fund Limited by any Customer, who is not in breach of Contract, and who has paid a deposit under a Contract to which a Defaulting Member is a party, to receive assistance from the Fund.

**Contract:** Any legally binding agreement between a Member and a Customer to supply, or to supply and install, home improvement products, or to effect repair and maintenance work to an existing installation in premises situated in the United Kingdom or the Isle of Man, the terms of which are clearly evidenced in writing, and subject to the laws of England, Scotland, Northern Ireland or the Isle of Man.

**Contract Price:**The price payable by reference to a Contract for its performance without variations or additions thereto, unless agreed in writing, and without deductions in respect of damages liquidated or otherwise.

**Customer:** Any private individual who has personally entered into a Contract with a Member.

**Default:** The circumstances in which a Contract cannot be completed by a Member, by reason of that Member being adjudged bankrupt, or, where a Member is incorporated, where an administration order or a winding-up order has been made by the Court, or a resolution has been adopted for a creditors' voluntary winding-up.

**Date of Default:** The date on which the circumstances of Default are deemed to have occurred.

**Defaulting Member:** A Member who is in Default in relation to a Contract, in the opinion of GGF Fund Limited.

**Deposit:**

(a) In respect of a Contract to supply and install: the sum paid by the Customer to the Member concerned as deposit and/or stage payments under the terms of the Contract, limited to 50% or £12,500 whichever is the lower. (less than the Fair Market Price of goods and services supplied by the defaulting Member).

(b) In respect of a Contract for repair and maintenance 100% of the Contract Price (less the Fair Market Price of goods and services supplied by the Defaulting Member) or £500, whichever is less.

**Fair Market Price:** Such price as shall, in the opinion of GGF Fund Limited, represent the open market value, at the time at which any Assistance is to be provided.

**The Fund:** The deposit indemnity fund operated by GGF Fund Limited in accordance with these Rules.

**Member:** A member of the Glass and Glazing Federation who, in respect of a Contract, takes a deposit.

**Members:** Members of the Glass and Glazing Federation who routinely take deposits and contribute to the Fund or, if the Glass and Glazing Federation shall be dissolved or if there shall be a payment of surplus assets of the Fund pursuant to these Rules, the persons who were Members of the Glass and Glazing Federation and whose Membership in respect of the Fund had not ceased or been terminated pursuant to these Rules at the time of such dissolution or payment (as the case may be), and Membership shall be construed accordingly.

**Premises:** Any private domestic premises covered by a contract, including a dwelling house, bungalow, flat or maisonette.

**Rules:** The regulations contained herein, and any further regulations approved by GGF Fund Limited.

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## 3. General

The Fund has been established, and will be administered by GGF Fund Limited as a mutual fund for the purpose of protecting Customers' Deposits against the Defaults of Members.
The accounting period of the Fund shall be co-terminous

with that of the Glass and Glazing Federation.

Headings of paragraphs are for ease of reference only, and shall not affect the interpretation of these Rules.

## 4. Applications

**(a)** Any Application shall be made in writing, addressed to the Secretary of GGF Fund Limited, provided that no Application shall be considered by GGF Fund Limited if received more than ten months after the date of Default of the relevant Defaulting Member.

**(b)** For the purposes of its consideration of an Application, GGF Fund Limited may require the Customer to supply such documents and correspondence constituting the relevant Contract as GGF Fund Limited may request. Should a Customer fail, in whole or in part, to comply within a reasonable time with any such request, his Application shall not be entertained by the Fund any further.

## 5. Assistance

**(a)** If GGF Fund Limited is satisfied that a deposit was paid to a Member and that such Member will be unable to carry out the work the subject of the relevant Contract by reason of the relevant Member's Default, then GGF Fund Limited will consider, in its absolute discretion (i) whether assistance will be provided to the relevant Customer from the Fund and (ii) if assistance is to be provided, what form it will take.

**(b)** If assistance is provided, GGF Fund Limited may, at its absolute discretion:

**(i)** enable the work the subject of the relevant Contract to be carried out or completed (as the case may be) by another Member at a Fair Market Price to the Customer, less the amount of the relevant Deposit; or

**(ii)** make a payment to the Customer from the Fund up to an amount equal to the Deposit.

**(c)** If GGF Fund Limited exercises its discretion as described in paragraphs (a) and (b)(i) above, the Customer will be issued with a voucher redeemable with a Member, to be used against the cost of the successor contract, providing it is of similar monetary value. Vouchers shall be valid for one year from the date of issue.

**(d)** GGF Fund Limited may require the Customer, as a condition of receiving Assistance, to legally assign (in such form as GGF Fund Limited may require) to GGF Fund Limited, as custodian for the Members for the time being whose membership in respect of the Fund has not ceased or been terminated pursuant to these Rules, all rights he may have against the Defaulting Member in respect of the relevant Deposit.

**(e)** GGF Fund Limited shall not consider a request for Assistance where the Customer making the request may be entitled to recover the deposit or otherwise claim compensation in respect of non-performance of the relevant Contract from any person other than the relevant Member, unless the Customer can show to the satisfaction of GGF Fund Limited that he has exhausted (or taken all reasonable steps to exhaust) such other possible remedies.

## 6. The Fund

The Fund is financed by Members' subscriptions (as further provided in Clauses 8 and 9 of these Rules). Any surpluses accruing to the Fund belong to the Members as provided in Clauses 12 and 19 of these Rules.

GGF Fund Limited is empowered (i) to accumulate and set aside monies which form part of the Fund and to allocate and expend any such monies to any purpose connected with the maintenance, operation and any winding up of the Fund, including contributing to advertising or promotional expenditure by the Glass and Glazing Federation for the benefit of Members, promoting public awareness of the Fund, purchasing insurance to protect the Fund and meeting all costs, charges, outgoings and expenses of GGF Fund Limited in connection with the maintenance, operation and any winding-up of the Fund and (ii) to invest such monies or borrow for the purposes of the Fund.

## 7. Contributions on Winding-up

Every Member undertakes to contribute the full amount of the year's subscription to the Fund in the event of its being wound up during the time he is a Member, which he would otherwise have been liable to pay if the Fund had not so been wound up.

## 8. Successions

Where, in the opinion of GGF Fund Limited, there is a continuity of business following the incorporation of a Member, reconstitution of a partnership or transfer of ownership, any rights or obligations of the proprietor as last constituted may be succeeded to by the new proprietor.

## 9. Funding

All Members will pay quarterly subscriptions to the Fund on or by 30 April, 31 July, 31 October and 31 January in each year, being one month after close of the relevant quarter, calculated by reference to deposits received in that quarter.

## 10. Rate of Subscription

The rate of subscription will be fixed from time to time by GGF Fund Limited, and shall be uniformly applied in the calculation of the amount due from each Member. Each Member shall pay his subscription within fourteen days of it falling due. In the case of a Member being admitted to Membership after the first subscription date of the year, the Member shall pay such sum by way of subscription to the Fund as GGF Fund Limited shall decide.

## 11. Certificates of Membership

Each of the Members is entitled to a certificate of Membership in respect of the Fund.

**12. Surpluses**

GGF Fund Limited may return to Members the whole or any part of any surplus not considered by GGF Fund Limited to be required for the purposes of the Fund, by relief of subscriptions, cash refund or by whatever other method GGF Fund Limited may deem appropriate.

Any amount so returned to Members shall be allocated in proportion to their aggregate subscriptions paid during their respective periods of Membership.

**13. Termination of Membership**

GGF Fund Limited may terminate Membership at any time upon breach of or failure by a Member to observe any requirement upon the Member under these Rules (including but not limited to failure by a Member to pay subscriptions within fourteen days of their falling due). Such termination shall be without prejudice to the Member's liability to perform all his obligations in respect to events occurring before such termination. In such a case, the Member shall have no right to participate in any return or distribution of assets of the Fund.

Upon a Member ceasing to be a member of the Glass and Glazing Federation, his Membership will automatically cease.

**14. Publication**

If Membership is terminated or ceases as referred to in Clause 13 above, GGF Fund Limited may publish that fact, and the fact that applications for assistance from persons contracting after such termination or cessation with the Member concerned shall not be entertained, in such form and manner as it may determine.

**15. Alteration of these Rules**

Alterations of these Rules shall require the authority of a resolution of the board of directors of GGF Fund Limited. Unless stated, alterations shall not apply in respect of Contracts made prior to the date of the alteration.

**16. Notices**

A notice from GGF Fund Limited to a Member for any purpose connected with these Rules shall be deemed to have been delivered on the third clear day after being put in the post to the address last notified by the Member to the Glass and Glazing Federation or on the day on which the notice is delivered personally to such address (as the case may be).

**17. Expenditure of GGF Fund Limited**

GGF Fund Limited may recover from the Fund all its expenditure incurred in the administration of the Fund.

**18. Indemnity**

GGF Fund Limited shall be entitled to be indemnified from the assets of the Fund against all costs, charges, losses, expenses, claims and liabilities incurred by GGF Fund Limited in relation to its acts, omissions and decisions as administrator of the Fund except to the extent that the same arise out of its fraud or wilful misconduct or that of any of its directors or other officers or its agents, and GGF Fund Limited shall be entitled to treat the costs of any such indemnification payment as part of the management expenses of the Fund.

**19. Termination of the Fund**

GGF Fund Limited may terminate the Fund at any time.

If the Fund shall be terminated in connection with any establishment of a new fund providing similar benefits, GGF Fund Limited may direct the vesting of all or any part of the assets of the Fund in the persons authorised to administer such successor fund.

Upon termination, otherwise than by investing the assets in a successor fund, the surplus assets attributable to Members shall be ascertained after all applications made by Customers for assistance from the Fund prior to commencement of the winding-up have been determined and fully provided for and after full provision has been made for all outgoings of the Fund (including costs and expenses incurred by GGF Fund Limited) which may be incurred in connection with the winding-up and otherwise under these Rules (including the provisions of Clauses 17 and 18 hereof).

The distribution of such surplus shall be made to Members [whose subscriptions are fully paid up to the date of the termination], in proportion to their aggregate subscriptions paid during their respective periods of Membership.

**20. Law of England**

The law of England shall govern the provisions of these Rules. Rules of the Deposit Indemnity Fund

# GGF Deposit Indemnity Fund Guidance Notes for Members

14.3.1 March 2015

**1. Scope**

This data sheet gives guidance to Members on the operation of the Federation's deposit indemnity scheme.

**2. Introduction**

Established in 1980, in consultation withthe OFT, the Deposit Indemnity Fund has proved to be a most important innovation by the GGF in safeguarding deposits paid by householders to GGF Members.The purpose of the Fund is to provide assistance to private individuals who have placed a deposit with a GGF Member, in the event of that Member failing to commence a contract because they have, in certain circumstances, ceased to trade. Requests by customers to receive assistance from the Fund are considered by GGF Fund Limited and granted in its absolute discretion.

The Fund is managed by GGF Fund Limited.The Rules of the Fund are set out in GGF Data Sheet 14.3.The scheme is voucher based. When a request for assistance is granted, the voucher issued to the customer contains abridged guidance on the procedure to follow, and how to avoid action that might deprive the customer of assistance which otherwise would be provided. It is not a 'cash-back' scheme, although GGF Fund Limited may in its absolute discretion make cash payments in cases of hardship. Guarantee work is not within the scope of the Fund.

Explanatory leaflets, which may be overprinted with a Member's name, are available in pad form.

**3. Key roles**

It is worth noting that the Deposit Indemnity Fund was set up to serve two purposes.The first objective was to safeguard customers' deposits. A customer of a GGF Member needs to be able to place his deposit with confidence. Providing a scheme for the protection of customers' deposits enhances the credibility and responsibility of the industry, and presents Membership with an excellent marketing tool, when compared with non-members. The second role developed as soon as the Fund was established, when the right of the industry to take deposits was being questioned in European and UK government circles.The original draft of the EC Directive 'Contracts Negotiated Away from Business Premises' would only have permitted taking a deposit after a 'cooling-off ' period. Everyone in the industry appreciated the time and cost involved in making a return call, and that the best time to take a deposit was when an order was taken. Costs could be kept down and cash flow protected.

These remain the key roles of the Fund today. They are the reasons why Member companies are prepared to support the Fund.

**4. Background**

At the time of its inception, the Fund had no reserves, and no income apart from Members' subscriptions.When a company failed, other Member companies had to be prepared to complete the job, and absorb the cost of the customer's lost deposit. Over the years, as the balance sheet strengthened, the percentage of the deposit borne by the Fund on completion of a voucher job has increased. In 1991, 10% of the original contract value was borne by the customer.This was subsequently reduced to 5% and from 1999 to nil. More recently since 2012, the Fund safeguards stage payments as well as deposits, in particular where the product is a conservatory.

**5. Future developments**

GGF Fund Limited has the right to vary the operation of the Fund according to circumstances (and in order to comply with Government legislation on consumer protection.)

**6. Definition of Fair Market Price**

The price at which a Member undertakes a successor contract does not have to be the price quoted by the failed company. There may be cases where the failed company seriously under quoted in the mistaken belief that volume alone would alleviate its trouble. It must be the Fair Market Price for the work as defined in the Rules of the Fund.

**7. Purchase of order books from a Receiver**

Where a Member purchases the order book of a failed company from a Receiver, no benefit shall accrue to that Member from the

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Fund. Customers shall not receive vouchers unless they wish to have their contracts completed by another Member.

**8. Procedure**

**(a)** Where GGF Fund Limited exercises its discretion to issue vouchers to householders who have lost deposits in consequence of the insolvency of a Member, vouchers will be issued after GGF Fund Limited has received confirmation from the liquidator that they are listed as unsecured creditors.

**(b)** Vouchers are limited to 50% of contract value, limited to £12,500.

**(c)** Where a deposit has been paid by credit card, or where a finance agreement has been signed, it is normally in the house holder's interest to approach those organisations for a refund under the Consumer Credit Act of 1974.

**(d)** The householder is under no obligation to accept completion of his contract by the Receiver, or the assignment of this contract, should he not so wish.

**(e)** In order to be valid, the successor contracts must not pre-date the issuance of vouchers by the Fund.

**(f)** The successor contract should be for the same work or value as the householder originally contracted for.

**(g)** In order to redeem the voucher, the Member must submit the voucher, a satisfaction note signed by the customer, and a copy of his contract to GGF Fund Limited.

The householder must bear in mind that the Fund is supported by Members' contributions and that the provision of assistance from the Fund is entirely at the discretion of GGF Fund Limited.

Not all Members of the Federation are entitled to accept vouchers. Acceptance is restricted to Members who routinely take deposits and contribute to the Fund.

**9. Conclusion**

The support Members give the Fund through their contributions and willingness to carry out successor contracts is greatly appreciated.The Fund achieves a great deal for the industry as is evident from the relieved, appreciative letters received from many customers who have benefited from its provisions.

# Basic Guidance Notes on Construction Contracts (Commercial)

15.1 May 2012

**Introduction**

This data sheet deals with a Construction Contract as defined below between the specialist contractor, i.e. glazier and the building owner/main contractor. A contract comes into existence when one party makes an offer, which the other party unconditionally accepts. Contracts may be made verbally or in writing. If it is made subject to contract, no contract will come into existence until the necessary terms are agreed. In the construction industry it is held that an estimate is usually an offer, capable of acceptance.

If the offer is made subject to the specialist contractor's terms, then a contract can only come into being if the acceptance is unconditional. If the building owner/main contractor accepts the specialist contractor's offer, but includes his own terms and conditions, it becomes a counter offer, which is then subject to acceptance by the specialist contractor: However, the specialist contractor is under no obligation to accept that counter offer and may wish to renegotiate the terms and conditions which apply to the contract.

If a specialist contractor commences work or does not refute the counter offer, either within a reasonable time or within any time imposed by a counter offer, or in any case before the commencement of work, then the specialist contractor may be deemed to have accepted the building owner's/contractor's terms. It is, therefore essential that the specialist contractor understands clearly what he has offered to unconditionally accept.

It is not unusual for a building owner/main contractor to issue a letter of intent instructing the specialist contractor to commence work. A simple letter of intent is not binding upon either party and does not usually amount to a contract. If a specialist contractor is instructed to commence works or part thereof on a letter of intent, it is essential that there is wording in the letter of intent that the specialist contractor will be entitled to be paid on a quantum meruit basis, i.e. a reasonable remuneration for the work carried out to the date the instruction is cancelled or a contract is not entered into. The letter of intent should also make clear who is liable for payment to the specialist contractor.

Many of the widely used sub-contract agreement forms for buildingowner/main contractors and architects are drafted and produced by the following bodies:-

- Joint Contracts Tribunal Limited (JCT)
- Construction Confederation (CC)
- National Specialist Contractors Council (NSCC)
- Institution of Civil Engineers (NEC)

**Contractual Forms and Housing Grants, Construction and Regeneration Act 1996 (as amended by the Local Democracy, Economic Development and Construction Act 2009)**

**1** This Act came into force on 1 May 1998 and was amended by the subsequent Act in 2011. In order for a contract to fall within the remit of the Act, and therefore afford the specialist contractor the protection given by the Act, the contract must be a "Construction Contract", as defined by Section 104 of the Act. The contract may be in writing or may be wholly or partly oral.

Every building contract or sub-contract other than those excluded by Section 105 (2) must comply by statute with conditions set out in the Act.

**2** The following is an outline of the exclusions referred to above which apply to the glazing industry:-

**a** The manufacture or supply only to site of building or engineering components, except under a contract which provides for their installation.

**b** A contract made directly with a residential occupier (a contract is with a residential occupier if it principally relates to work carried out on a dwelling house or flat, which one of the parties to the contract occupies or intends to occupy as his residence). However, where the specialist contractor is in contract with a main contractor, who in turn is in contract with a residential occupier, the sub-contract is afforded the protection given by the Act. The Act will also apply if the work is carried out to a building containing a dwelling house or flat(s) but the contract is not with the residents.

**3** Every "Construction Contract" must provide a mechanism which gives protection for the specialist contractor in respect of payment terms, set off and the right to adjudication.

**Payment**

It must be possible to determine what payments become due, when they become due, and the basis of the calculation of that payment.

It must also be possible to determine a final date for payment for any payment due (interim and final).

Every contract or subcontract shall provide for the payer (or such other person specified in the contract e.g. a certifying officer or employer's agent), or the payee, to give notice of the amount to be paid (with the basis of calculation) no later than five days from the

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date when payment becomes due. A notice must be sent even if the amount to be paid is zero (which is important to bear in mind if you are in the rectification period of the contract).

If the contract states that the payer is to give the notice of the amount to be paid and he fails to do so, the Act provides that the payee can send the notice instead. The payer must pay the amount specified in such notice by the final date for payment (unless a pay-less notice is sent – see below).

Payment may not be withheld after the final date for payment for any sum due, unless the payer gives notice of his intention to pay less than the amount in the notice of payment within the period prescribed by the contract; such notice must specify the amount the payer considers due and the basis on which that sum is calculated. Pay-less notices have replaced withholding notices under the amendments to the Act.

Except in the event of the insolvency of the ultimate client "pay-when-paid" clauses are rendered ineffective by the Act and are not permitted. "Pay-when-certified" clauses are also now excluded by the Act so that a main contractor cannot make payments to his sub-contractors conditional upon his own payment being certified by the employer.

Where the duration of the work exceeds 45 days (including preparation or works off-site) the specialist contractor shall be entitled to payment by instalments. Specialist contractors should be aware that while instalments are usually on a monthly basis, this may not necessarily be the case. Specialist contractors should check proposed contract conditions and resist elongated periods.

As a matter of law when payment is made by cheque, payment is deemed to be made when posted if sent by post or when received if delivered by hand. However, this is conditional on the cheque being honoured.

**4 Suspension of Work**

Where the sum due to a specialist contractor has not been paid in full by the date for final payment and no valid notice of intention to pay less or set off has been given, provided the specialist contractor has given seven days notice of his intentions he will be entitled to suspend the execution of all or part of his work until payment of the sum due is received in full; such periods of suspension will not give rise to claims by the main contractor: The specialist contractor will also be entitled to his reasonable costs and expenses incurred in respect of exercising the right of suspension. However, before a specialist contractor suspends his work, it is suggested that he seeks expert advice, to ensure that his proposed action is correct. Unlawful suspension will put the specialist contractor in breach of contract.

**5 Adjudication**

This is a quick and relatively cheap method of dispute resolution. Every construction contract must provide for adjudication on any matter of dispute or difference arising from the contract. The specialist contractor is entitled to refer any dispute or difference arising under the contract at any time to the adjudicator named in the sub-contract or alternatively nominated by an adjudicator nominating body named in the contract. In the event that the contract document neither names an adjudicator nor an adjudicator nominating body, the specialist has the right to select an adjudicator nominating body to nominate the adjudicator: The GGF suggest that members select the Association of Independent Construction Adjudicators as the appropriate nominating body. No party has the right unilaterally to select their own adjudicator but the specialist contractor can seek the opposing party's agreement to a particular individual. An appointment will be made within seven days of referral and matters in dispute must be determined within 28 days unless this is extended by agreement i.e. the referrer (specialist contractor) grants an extension to the adjudicator (such extension is limited to 14 days). Once again, before a specialist contractor refers a dispute to adjudication, it is suggested he seeks expert advice.

If the parties do not have a construction contract which automatically falls under the protection of the Act, the parties can still agree in their contract that adjudication will apply to the resolution of disputes.

**6 Scheme for construction contracts**

Where a construction contract does not conform to the requirements of the Act in relation to adjudication and payment provisions, the Government Scheme for Construction Contracts shall apply. The Scheme has also been revised as part of the 2011 changes to the Act. The Scheme sets out standard terms that comply with the provisions of the Act. 2011 versions of the JCT sub-contracts are being issued which have been updated to take account of the changes to the Act introduced on 1st October 2011. After that date, only the new forms should be used. Specialist contractors should beware amendments to the Standard Forms.

**7 Conclusion**

Members are strongly advised to insist upon the exclusive use of standard forms or their own standard terms and conditions and to resist the use of non–standard forms or amendments to standard forms which, without exception, incorporate onerous conditions and as a direct consequence, increase the liabilities which members are forced to accept.

These notes are for guidance only. It is suggested that members seek advice on specific circumstances and problems. For your information GGF Members are entitled to one hour's free advice on the Wedlake Bell Helpline, telephone 020 7395 3000

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# The Construction Act - How to make it work for you

15.2 August 2012

## Introduction

Members should be aware of the provisions of The Housing Grants, Construction & Regeneration Act 1996 ('The Act') which came into force on 1 May 1998 (as amended by the Local Democracy, Economic Development and Construction Act 2009). Information on the relevant provisions contained within the Act is included in the GGF Data Sheet 15.1 May 2012 entitled 'Basic Guidance Notes on Construction Contracts'. The whole purpose of the Act was to provide a framework within which the various factions of the construction industry should be enabled to work in closer harmony with one another, and to attempt to promote the tendency for parties to construction contracts to become less reliant upon arbitration and court action.

The Act however, recognised that not all building contracts and sub-contracts would include the clauses required of them by the Act or might seek to alter the content or impact of the Act upon the construction scene. With this in mind therefore, government included in the Act, Supplementary Provisions at Section 114, ('The Scheme').

## The purpose of 'The Scheme'

The Scheme deals only with two items namely; adjudication and payment.

## Adjudication

It is intended that where a construction contract, - within the meaning of the Act, including construction sub-contracts - fails to comply with Section 108(1) to (4) of the Act, (the section relating to Adjudication), then the provisions of the Scheme shall apply. There are some exclusions, most notably the Act does not apply to domestic contracts, or supply only contracts.

All such construction contracts must contain a procedure in writing (even if the rest of the contract was made verbally) which complies with the following list of requirements;

> the right for any party to refer any dispute or difference arising under that contract to adjudication,
>
> provision for an adjudicator to be appointed and the dispute referred within 7 days of the notice of intention to refer being given,
>
> provision for the adjudicator to reach a decision within 28 days of the dispute being referred to him,
>
> provision allowing the adjudicator to extend the 28 day period by a further 14 days, if and only if the referring party consents.

Further written clauses must be included requiring;

> the adjudicator to act impartially and allowing him to take the initiative in any way he considers appropriate in order to ascertain the true facts and the law relating to the matters in dispute.

Additionally, the contract shall provide that any decision of the adjudicator shall be binding upon the parties unless and until the dispute is ultimately resolved by court action, arbitration or alternatively by agreement between the parties. The contract shall ensure that the adjudicator and those working with him will be exempt from liability unless he has acted in bad faith.

**In the event that a contract or sub-contract fails to include the items, the Scheme for Construction Contracts will apply.**

In practice this means that if your contract is deficient in any or all of the foregoing items you will be able to rely on the clauses relating to adjudication included within the Scheme as if they had been written into your contract.

Many members may feel that adjudication is the single most influential factor within the Act. Indeed, already there is evidence that notice to a contractor that you intend to refer a dispute to adjudication is often sufficient to concentrate minds to find an acceptable solution.

If you are proceeding with works under a letter of intent, ensure that it contains or refers to conditions which you have seen, read, understood and accept. If in doubt seek legal advice.

## Upon what can you adjudicate?

You should be aware that the Act permits parties to a construction contract to refer a dispute or difference of whatever nature arising under the contract to resolution by adjudication at any time. The Scheme is provided for the protection of contracting parties whose contract conditions fail to comply with the Act.

Remember, adjudication will not always be about money. In practice you can adjudicate about matters relating to interpretation of contractual terms, bills of quantities, specification (including quality matters), delays and extension of time, re-imbursement in respect of delay or acceleration, under-valuation, non-payment of sums due,

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deduction of sums relating to alleged right of set-off (L and AD's or other delay charges) and matters where contractual documents fail to include the statutory requirements of the Act. This list is not exhaustive.

The right of a party to have access to adjudication is one provided by Statute and it cannot be waived or excluded by any clause either inserted or implied within a contract.

It is important to ensure that you abide strictly by the requirements of the Act when instituting adjudication proceedings.

### How to embark on adjudication

Take specialist advice; adjudication is not a 'cure all' for your own shortcomings. Contact GGF regarding specialist advice — High Street solicitors are not usually experienced in adjudication matters.

### Step One

The first requirement under both the Act and the Scheme is to give notice to the other party that it is your intention to refer a dispute or difference to adjudication. The notice from the referring party (which must be sent to all other parties to the referrer's contract) should set out briefly:

> the nature and a brief description of the matters in dispute, details of where and when the dispute arose, an
>
> outline of the redress which is sought, the names and addresses of the parties and in particular the address of the referring party to which notices should be given.

A specimen letter of notice of intention to refer is given at Appendix A.

### Step Two

Where there is a person named in the contract as the adjudicator, the referring party must use that adjudicator and in such instances may move directly to Step Three of the process.

However, having checked that no individual adjudicator is named in the contract, the referrer should now select one of the Adjudication Nominating Bodies from any list in the contract. (A specimen letter of such referral is given at Appendix C). Where no such list exists he should select an Adjudicator Nominating Body (lists available from the GGF) and should write to that Body, formally requesting them to select an adjudicator (A specimen letter of such referral is given at Appendix D). It would be wise to include within such request, in addition to the general information included in the Notice of Intent to Refer, such additional information as might assist the appointing body in selecting a suitable and appropriate adjudicator, having regard to the nature of the matters in dispute. Also where he should be based i.e. the geographical location of the contract and the parties to it. Give an indication of what discipline you think the adjudicator should be chosen from e.g. quantity surveyor, lawyer, etc.

The Adjudicator Nominating Body is required to nominate an adjudicator within seven days of referral. Where an Adjudicator Nominating Body fails to nominate an adjudicator within seven days (five days if the Scheme applies) from a request to nominate, the referring party has the right to request a different Adjudicating Nominating Body to make a nomination.

### Step Three

### The Notice of Referral

The referrer has only seven days from the notice of intent to refer to adjudication in which to refer the dispute and provide full details of it to the selected adjudicator. **The referrer will see therefore the importance of having his case properly prepared before embarking on the process by issuing his Notice of Intent to adjudicate.**

The Notice of Referral is a document of immense importance. Such referral should be accompanied by all the necessary documentation to support the referrer's submission. It should set out details of his case but should be prepared with it in mind that the adjudicator has initially only 28 days to reach his decision. It would therefore be futile to make the documentation over complex or to run to several ring binders of information, which the adjudicator will be obliged to study. Concise facts and evidence are what is required, together with a clear statement of exactly what redress you seek (as opposed to that which you anticipate the other party may seek) — including a detailed build up of the sum claimed as payment, where applicable.

It is essential to ensure that a complete copy of the Notice of Referral and supporting documentation is sent to all other parties to the contract at the same time as the Notice of Referral is despatched to the adjudicator. A specimen letter of referral is given at Appendix B. Upon receipt of the Notice of Referral the Scheme provides that the adjudicator must inform every party to the dispute of the date that he received it.

Objection by the opposing party to the appointment of a particular adjudicator will not invalidate either the adjudicator's appointment or any decision he may make under paragraph 20 of the Scheme. He may therefore proceed despite the objection, although if his jurisdiction is challenged because, for example, it is argued that the works do not come within the Act, he may await a court ruling if he is unable or unwilling to determine the issue himself.

It is incumbent upon any party to the adjudication to comply with any request or direction of the adjudicator. Failure to do so will not prevent the adjudication from continuing but the adjudicator may draw such inference from the failure as he considers justified and may make his decision on the basis of the information that is before him.

### Adjudicator's decision

The adjudicator is provided with a very wide discretion as to how to make his decision. He may, with the agreement of the parties, take into account any other matters which he considers are connected with the dispute. He can open up and review, unless otherwise stated in the contract conditions, any decision taken by any other person referred to in the contract as well as reviewing certificates.

His decision will be binding upon the parties and they must comply with his decision immediately even though either party may subsequently decide to refer the dispute to arbitration or to the Courts. The Courts have made it clear that an adjudication award must be complied with immediately. If it is not, the Courts will enforce the award speedily. Compliance with an award cannot be delayed pending a later decision by either an arbitrator or a judge.

If you are confronted by an argument that the adjudication award can be challenged (e.g. because the adjudicator has exceeded his jurisdiction) you should seek specialist advice.

If there has been a clerical or typographical error in the decision, the adjudicator can correct this within five days of the delivery of the decision.

**Adjudicator's Fees**

The parties will be jointly and severally liable for the adjudicator's reasonable fees and expenses although the adjudicator has the power to determine how such amounts may be apportioned. It is important to ascertain the adjudicator's terms and conditions of payment at the time of appointment as terms and charges vary. Unless the adjudication provisions provide to the contrary or the parties so agree, the adjudicator may not award a party its own legal costs. If he does not the successful party will remain responsible for the costs he has incurred. Clauses that provide that the party bringing the adjudication claim will be liable to pay all costs of the adjudication (a "Tolent clause") are intended under the 2009 Act to be outlawed unless agreed by both parties at the time of the adjudication. The relevant legislation wording is ambiguous however and the Courts may need to interpret the wording in the Act before it can be said with certainty that these clauses are illegal.

**Generally**

Remember the following and beware of:

- contract conditions, which state that a dispute shall not exist until all other forms of dispute resolution have been exhausted, - avoid such a clause, wherever possible.
- do not be fooled by what has become known as a 'period of notice of dissatisfaction'. This is a ruse to put off adjudication by anything up to a month, - avoid such a clause, wherever possible,
- a clause which extends the period between notice and referral. Periods of 60 days have appeared in some sub-contracts, - avoid such a clause, wherever possible.

**Payment**

Part II of the Scheme deals exclusively with payment terms, and individual sections of Part II can be invoked in situations where the terms of a contract or sub-contract fail to comply with the requirements of the Act.

**Interim or stage payments**

In the event that in a relevant construction contract (one where the duration of the works is or is stated to be not less than 45 days) there is failure to agree;

> the amount of interim stage payments or periodic payment, or the intervals at which such payment becomes due, the relevant provisions of paragraphs 2 to 4 of Part II of the Scheme shall apply.

The paragraphs referred to define the method to be adopted in order to establish the time and the amount of the sum due. Broadly speaking they conform to the general principle which has normally been applied for ascertaining interim and final valuations and payment within the construction industry for many years.

**Using the Scheme to Overcome Non-compliant clauses in a contract**

Where a contract fails to provide a mechanism to determine what payments become due and when, the provisions of Part II come into play and will be used to determine both of the foregoing factors.

**Dates for Payment**

In the event of a payment period in a relevant contract not being agreed, the relevant period will be considered as 28 days and the due date for payment will be 7 days after the expiry of that period.

The final date for payment in relation to any sum which becomes due under a construction contract will be 17 days after the due date.

**Amount of payment**

The Scheme provides that no later than 5 days after the date upon which a payment becomes due or would have become due if the other party had carried out his obligations under the contract, one party shall give to the other a notice specifying the amount (if any) of the payment he has made or proposes to make, stating the amount that is to be paid, the basis of the calculation of such amount and the date for final payment. The notice must still be sent even if the amount to be paid is zero.

**Notice to pay less**

The Act provides that a party to the contract may withhold payment after the final date of interim payments only if he has given effective notice of his intention to pay less. To be effective a notice must:

Give notice that the payer intends to pay less than the notified sum, the sum that the payer considers to be due and the basis on which that sum is calculated,

and must be given not later than seven days before the date for final payment if the scheme applies.

**Final Payment under 'The Scheme'**

Where the referrer is seeking to rely upon the Scheme because specific contractual terms do not comply with the Act there are particular payment periods laid down for final payments as opposed to instalment payment periods.

In respect of 'relevant construction contracts', (i.e. contracts with a duration of more than 45 days), final payment will be due at the end of 30 days after completion of the works or alternatively 30 days after the making of a claim for payment, whichever is later. In the case of contracts where there is no contractual entitlement to payments by instalment (i.e. less than 45 days duration), payment for the contract is due at the end of a 30 day period following the completion of the works or alternatively 30 days after the contractor makes a claim for payment.

The last day by which payment must be paid in either of the foregoing instances will be 17 days after the due date.

**Remember**

The Act and therefore the Scheme applies generally to construction contracts, except where specific exclusions within the Act apply. The most important exclusion is that the foregoing does not apply to direct domestic contracts. It will apply to contracts for work at a domestic dwelling if the contract is with another contractor as opposed to the owner or occupier.

Matters relating to both interim and final payments can be referred to an adjudicator in the event of dispute, again with the exception of excluded items.

**Specimen letters**

## Appendix A

### Notice of intention to refer a dispute to adjudication.

*Name and address of the other party or parties to the contract*

Dear Sir

Contract identification

Notice of intention to refer a dispute to adjudication

In accordance with the contract between our companies for the above named works, we hereby give formal notice that, there being a dispute or difference having arisen between us namely:

*(List all the various matters of dispute and the redress sought),*

it is our intention to refer these disputes or differences to adjudication within 7 days of the date of this notice.

The address at the head of this letter is the appropriate address for receipt of all notices, letters and correspondence in connection with this matter. Would you please confirm by return the address of the appropriate office for receipt of such notices, letters or correspondence, so far as your company is concerned.

Yours faithfully

*(Name and position in company)*

## Appendix B

### Letter of referral to an adjudicator where named in the contract

*Name and address*

Dear Sir

Referral to adjudication of a dispute between *(insert your name)* and *(insert the name of the other party to the dispute).*

In accordance with the contract between the above named parties and more particularly with clause *(insert number)* or alternatively the Scheme for Construction Contracts we hereby give notice that we wish formally to refer the said dispute(s) to you for resolution by adjudication.

We confirm that we have advised *(insert name of other party or parties)* of our intention to refer these disputes to adjudication by our letter to them dated *(insert date)*

Attached hereto are the following documents:

*(Enclose all relevant documents including as appropriate.)*

notice of intention to refer this dispute to adjudication

a copy of the order to us

a copy of our quotation dated *(insert date)*

a copy of the contract documents

a copy of the pre-tender meeting dated *(insert date)*

copies of relevant site meeting minutes copies of relevant correspondence comprehensive and detailed statement of our case

our application/claim for financial reimbursement (where applicable)

*(any other documents, photographs, reports, signed daywork sheets, valuations, applications for payment etc. which you feel relevant to your case)*

We confirm that a copy of this letter together with a complete set of attached documentation has been forwarded to *(insert name of other party or parties).*

Yours faithfully

*(Name and position in company)*

## Appendix C

### Letter of referral to an adjudicator, where one or more nominating bodies are listed in the contract.

Where only one nominating body is named, that body must be approached for nomination. In the event of a list of nominating bodies appearing in the contract the choice of body to be approached for nomination rests with the referring party.

*(NB. We suggest that you telephone the Adjudicator Nominating Body first to ascertain the fee payable and obtain an application form if appropriate.)*

*Name and address*

Dear Sir

Letter to the Adjudicator Nominating Body specified in the contract between *(insert your name)* and *(insert the name of the other party to the dispute).*

You being the nominating body listed in the contract (or you being one of the nominating bodies listed in the contract) between the above named, we would ask that you select an appropriately qualified individual to adjudicate in a dispute, which has arisen on the above named contract. We enclose your application fee of £.

The matters in dispute are:

*(Insert a list of matters in dispute and redress sought)*

The terms of the contract are:

*(Insert brief description of the nature or form of contract)*

the location of the works is *(insert address of the works).*

We would confirm that a Notice of our intention to refer this dispute to resolution by an adjudicator has been given to the other party or parties by our letter dated *(insert date of letter)*, a copy of which is attached hereto.

Yours faithfully

*(Name and position in company)*

## Appendix D

### Letter to an adjudicator nominating body. For use where no list of nominating bodies appears in contract documents.

NB: Telephone Adjudicator Nominating Body first to ascertain fee and ask for application form.

*Name and address*

Appointment of an adjudicator

Dear Sir

*Contract Identification*

There being no named adjudicator or alternatively no list of Adjudicator Nominating Bodies contained in the contract documentation for the above works, we would ask that you select an appropriately qualified individual to adjudicate on a dispute which has arisen on the above named contract.

The contract is between this company and *(enter name of other party to the dispute).*

The matters in dispute are

*(insert a list of matters in dispute)*

The terms of the contract are:

*(insert brief description of the nature or form of contract)*

the location of the works is *(insert address of the works).*

We would confirm that a notice of our intention to refer this dispute to resolution by an adjudicator has been given to the other party or parties by our letter dated *(insert date of l*, a copy of which is attached hereto.

Yours faithfully

*(Name and position in company)*

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# JCT 2011 Standard Building Sub-Contract: The Main Changes from JCT Standard Form of Domestic Sub-Contract ("DSC") A Short Guide for Sub-Contractors

15.4 February 2013

In 2011, JCT published a suite of main contracts and subcontracts in order to reflect the updated Housing Grants, Construction and Regeneration 1996 ("the Construction Act") made by the Local Democracy, Economic Development and Construction Act 2009 (which came into force 1 October 2011). These replaced the 2005 edition of JCT main contracts and subcontracts. The key amendments reflect the changes that have been made to payment terms and payment-related notices. These should be used for all contracts entered into after 1 October 2011 as the JCT contracts and sub-contracts which preceded them do not comply with the current legislation.

There is a non-design and a design form. The Agreement (SBCSub/A) forms the contract and incorporates the separate Conditions (SBCSub/C).
In the design version the Agreement is SBCSub/D/A and the Conditions are SBCSub/D/C.

**The main changes to the conditions are as follows:**

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| **Payment Notices** | All JCT Contracts now require Payment Notices to specify the total amount due for each interim payment and the basis on which that sum has been calculated. An optional Payment Application by the Sub-Contractor has been added to Sub-Contracts under the 2011 edition. The Contractor has to serve a Payment Notice within 5 days of the payment due date irrespective of whether a Payment Application has been submitted by the Sub-Contractor.<br>If a Payment Notice is not served by the Contractor until 5 days after the due date, the amount stated in the Sub-Contractor's Payment Application will automatically become due, subject to any Pay Less Notice served by the Contractor. The Pay Less Notice is required to be served by the Contractor if he wants to withhold monies from the Sub-Contractor. It must be served no later than 5 days before the final date for payment and must specify the sum which the Contractor considers to be due to the payee and the basis on which the sum was calculated. |
| **Final Payment Notice** | Unless adjudication proceedings are commenced within 10 days of the issue of the final payment notice, that notice shall have effect as conclusive evidence that effect has been given to the terms of the Sub-Contract and that all adjustments to the contract sum and time for completion have been made. In the DSC it was payment itself that was conclusive evidence that all adjustments had been made.<br>In the 2011 Sub-Contracts, the issue of the Final Payment Notice is not linked to the issuing of the Final Certificate under the Main Contract as it was before. It now has to be issued 2 months after either the Retention Release Date (a concept added in the 2011 Sub-Contract), or the date of issue of the Contractor's statement of the calculation of the Final Sub-Contract Sum; whichever is later. Final payment has to be made 17 days from the due date. |
| **Design** | The Sub-Contractor shall not be responsible for the contents of the Contractor's Requirements or for verifying the adequacy of the design contained within them. |
| **Third Party Rights** | The Sub-Contractor is required to provide collateral warranties in favour of the Employer/Purchaser/Tenant/Funder as required by the Main Contract or Sub-Contract documents. Unlike the JCT 2011 Main Contracts the Sub-Contract does not currently offer the option of a schedule of third party rights. (Although this might change.) |

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| **Delay Relevant Events** | The list of relevant events has been rationalised. The sweep up clause dealing with Employer's risk events includes any 'impediment, prevention, or default' of the Employer or Contractor. Therefore late instructions from the architect, works instructed directly by the Employer, changes in access and the Employer's failure to secure compliance by the Planning Supervisor and Contractor with the CDM Regulations which all come within the sweep up provision have been deleted. Failure to secure labour, goods or materials is also no longer a relevant event. |
| **CIS and VAT** | Clauses 5A, 5B and 5C of DSC 2002 are replaced with clauses 4.7 and 4.8 which deal with CIS and VAT in a much more concise way. |
| **Performance Specified Work** | Section 8 of DSC dealing with performance specified work has been deleted. Therefore if using the 2011 Sub-Contract the conditions will have to be amended if any works are to be performance specified. |
| **PI Insurance** | This is now required if specified in the Agreement. Terrorism cover provisions have now been incorporated into the body of the insurance provisions. |
| **Contract Documents** | Whereas under the DCS any document appended to the Agreement is a Contract Document, the 2011 sub-contract requires that any Contract Documents are listed in Article 5 and annexed to the Agreement. |
| **Termination** | Section 7 entitled 'Determination' under DSC 2002 is now renamed 'Termination'. The provisions have been streamlined. In the 2011 edition, the Insolvency definition has been revised. |
| **Practical completion** | Sectional completion is an option that can be selected in the Schedule of Information to be found in the Agreement. The Conditions define the Completion Date as completion of the Main Contract works or of a section as stated in the Main Contract. |
| **Fluctuations** | Fluctuation options have been moved to a schedule at the end of the conditions and the relevant option can be selected in the contract particulars (much as in the old Appendix) in the Agreement or all three can be deleted if none apply. |
| **Adjudication** | The Scheme for Construction Contracts is now the procedure for adjudication in all JCT contracts. The Scheme is amended so that in any dispute relating to the reasonableness of opening up or testing the Adjudicator must be a specialist in the relevant area or appoint an independent expert with appropriate experience.<br>The Sub-Contract also amends the provisions of the Scheme dealing with nomination of the Adjudicator. The adjudicator nominating body is RIBA, RICS, CIA constructionadjudicators.com or the AICA (agent of NSCC), (whichever is selected in the Agreement).Where a nominating body is not selected in the Agreement the party requiring reference to adjudication can select one of the bodies listed. |
| **Disputes** | There is a statutory right to refer disputes to adjudication. The default position is that arbitration does not apply and therefore 'shall not apply' must be deleted in the Contract Particulars if it is intended that disputes can be referred to arbitration. |

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| **Warranties** | Provision for the giving of such warranties as are provided for in the Main Contract. |
| **Retention** | The default retention percentage will be 3% if no figure is inserted at clause 8 of the contract particulars whereas under the DSC 2002 if the equivalent section was left blank no retention would be deducted.<br>To reflect the changes to the Construction Act, in the 2011 JCT Sub-Contract the release of retention can now no longer be linked to an act or event occurring under an upstream contract, e.g. the issuing of the Certificate of Making Good Defects under the Main Contract.<br>The release of the first half of the retention, as before, is triggered by practical completion of the Sub-Contract Works. The second half of retention will now be triggered for release on the "Retention Release Date" which has to be specified in the Sub-Contract Particulars.<br>A "Minimum Retention Amount" has also been introduced in the 2011 JCT Sub-Contracts. This is an amount agreed by the parties and specified in the Sub-Contract Particulars. If the total amount of retention that would be deducted is less than the Minimum Retention Amount (default is £250 if none is specified) then no retention can be deducted. Once the first half of retention is released, if the balance being withheld falls below the Minimum Retention Amount, then the balance must also be released to the Sub-Contractor. |
| **Right of Suspension** | The amendments to the Construction Act also give Sub-Contractors an express statutory right to recover costs and expenses incurred through exercise of their existing statutory right of suspension for non-payment , providing the exercise of that right is lawful i.e. a payment is properly due to the subcontractor and the statutory notice of suspension has been given as prescribed by the subcontract (7 days' notice in the JCT Sub-Contracts). |

Please note that this note is intended as a brief summary of the new provisions only. If you require specific advice, please contact the Construction Team at Wedlake Bell on **020 7395 3000.**