Introduction

Safety is often closely linked with security as a topic. The link is so close that the French and German languages use the same word for both aspects of protection. In order to make a differentiation, this publication – ‘Glass and Safety’ – relates to accidental actions, whereas the publication ‘Glass and Security’ concerns deliberate actions.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Glass and Safety</th>
<th>Glass and Security</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Impact (Glazing )</td>
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<tr>
<td>Human Impact (Furniture)</td>
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<td></td>
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<tr>
<td>Overhead Glazing</td>
<td>●</td>
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<tr>
<td>Protection from falling</td>
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<tr>
<td>Anti-Bandit Glass</td>
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<tr>
<td>Bullet Resistance</td>
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<tr>
<td>Explosion Resistance</td>
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<td>Data Protection</td>
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<td>One-Way Vision</td>
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<td></td>
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<tr>
<td>Manifestation</td>
<td>●</td>
<td></td>
</tr>
</tbody>
</table>

Photograph supplied courtesy of Laminated Glass Information Centre
Safety

Safety in relation to glass can be succinctly put as:

“Using appropriate products to reduce the possibility of severe cutting and piercing injuries.”

Safety Glass Classification in Relation to Accidents

When talking about Human Impact the loading considered is that which relates to a human being having accidental contact with the glass. As soon as the word ‘accidental’ is used, the loads cannot be quantified.

The variables that relate to this occurrence are as follows:

- Size and weight of person
- Part of the body that impacts the glass; hand, leg, head, trunk and their relative hardinesses
- Velocity (speed) of the body when impacting the glass
- Angle of impact; e.g. 90° (normal to) or 5° (glancing)

The only definite conclusions that can be made are that the impacts are from a semi-hard body acting over a relatively small, unspecified area. The duration of loading should be short though of indeterminate length.

Over the many years that the subject of Human Safety has been studied, a considerable amount of data has been collected on accidents. Analysis has given data on:

- The age and sex of those involved in accidents
- The type and position of glazing involved in accidents

and has allowed some quantification of the energy dissipated in an accident.

Classification Methods


BS 6206 requires that the glass does not break or breaks safely (as defined in BS 6206) when subjected to a pendulum impact from a lead-shot filled bag weighing 45 kg. This impact method is designed to represent accidental impact from a human body. Three classification levels are achievable – Class A, the highest, when the impactor is swung through a drop height of 1219mm, Class B, 457mm drop height, and Class C, 305mm drop height.
Class A safety glass is not required by any of the regulations or standards related to human impact safety, but is part of the requirement for some types of barriers in BS 6180 ‘Barriers in and about buildings’, where containment, guarding, or prevention from falling is required.

BS 6206 defines the term **breaks safely** by reference to the outcome of the impact test.

- Toughened glass breaks safely if the glass breaks into sufficiently small fragments after impact, i.e. if the weight of the 10 largest crack-free particles weigh less than the equivalent of 6500mm$^2$ of the original sample.

- Laminated glass, wired glass and filmed glass are deemed to have broken safely if, after the impact, any glass fragments which fall off are not too large (defined in BS 6206) and it is not possible to pass a 75mm diameter sphere through any opening formed in the glass.

Other glass products used for glazing, e.g. annealed (ordinary) glass, or heat strengthened glass, do not break safely, and can only pass the requirements if they do not break in the test.

The test requires either a standard size or the maximum size of pane available if this is smaller than the standard size. The test specimen size is 865 x 1930mm.

A safety glass only complies with BS 6206 if it is **marked** as doing so. The standard requires that all installed panels shall be marked to include the following:

- An identifiable name or trademark or other mark capable of identification through a suitable source
- The type of material
- The number of the British Standard, i.e. BS 6206
- The classification relating to impact test behaviour (Class A, B or C).

These marks shall be permanent and applied before installation in a position to remain visible after installation. All suppliers of final cut sizes of safety glass should mark the glass in accordance with BS 6206.
Photography supplied courtesy of Laminated Glass Information Centre
Glass Performance

Annealed Glass

Annealed glass is glass which, immediately after it has solidified into the required form, while still at a high temperature, is slowly cooled in a carefully controlled temperature regime in order to reduce to a minimum the internal stresses in the glass. The resulting glass can be cut and worked. It is, in fact, “ordinary” glass as taken from the production line and stored in stock plates.

These plates will be subsequently cut to size, and the cut sizes may be subsequently treated where required, e.g. by toughening.

Annealed glass is not usually classifiable as a safety glass.

Toughened Safety Glass

Toughened safety glass (sometimes called tempered glass) is produced by heating annealed glass to approximately 620°C, at which point it begins to soften. The surfaces of this heated glass are then cooled rapidly. The technique creates a state of high compression in the outer surfaces of the glass and, as a result, although most other characteristics remain unchanged, the bending strength is increased by a factor of up to five times that of annealed glass.

When broken, the toughened glass fractures into small pieces (called dice). As these particles do not have the sharp edges and dagger points of broken annealed glass, it is generally regarded as a safety glass. While these dice may cause minor cuts, it is very difficult to cause a severe injury with them, provided the fragments are small enough.

Toughened safety glass must be cut to size and have any other processing, such as edge polishing or hole drilling, completed before toughening, because attempts to “work” the glass after toughening will cause it to shatter.

All Pilkington Toughened Safety Glass is Class A to BS 6206.
Heat Strengthened Glass

Heat strengthened glass is produced by a process similar to that used for toughened glass. However, the strength developed is about half that of toughened glass and distortion may be less. The product is mainly used where thermal stress may be a problem and where the safety characteristics of toughened glass are not required. It does not meet the safe break criteria for safety glass because its breakage pattern resembles that of annealed glass.
Wired Glass
This is a product which has been regarded as a safety glass for many, many years. The wires in wired glass tend to hold the glass together when it is cracked. They perform this function admirably when used in roof glazing and, most particularly, in providing fire resistance, but most of the wired glass products on the market are not classifiable as safety glass to BS 6206.

It may come as a surprise to many that wired glass is not stronger than float glass. This is probably by association with reinforced concrete, where the presence of the steel dramatically improves strength.

In Pilkington Pyroshield (wired glass), the wires shear through when the glass is broken in the BS 6206 test. After considerable research, Pilkington produced Pilkington Pyroshield Safety, by introducing new thicker and stronger wires, so that they do not break at the Class C drop height. Pilkington Pyroshield Safety combines both fire and impact safety in the one product.

Pilkington Pyroshield Safety, launched in 1992, obtains Class C to BS 6206.
Laminated Glass

Laminated glass consists of one or more panes of glass and/or plastics attached to and separated from each other by means of interlayer materials.

Laminated glass is usually made from annealed glass, although it can also be manufactured using toughened, heat strengthened or wired glass. It is no stronger than the glass it is made from and cracks as easily. However, when laminated glass breaks, the glass fragments tend to adhere to the interlayer material. Although the glass itself may be annealed glass, on breaking, any sharp cutting edges are not generally exposed.

The performance of the glass depends very much on the type of interlayer, and there are many different types.

The most common interlayer is PVB (polyvinylbutyral) sheet, which usually sticks to the glass very well and produces a uniform thickness, high energy absorbing interlayer. Pilkington Laminated Safety Glass (made with PVB interlayer) normally obtains at least Class B to BS 6206, depending on glass thickness and interlayer thickness.

Some glass products with uneven surfaces, for example some types of patterned glass, are not easy to laminate with PVB. For these types of glass, an alternative laminating material is cast-in-place (CIP) resin. This comes in many different varieties, but essentially requires the resin to be poured in between the pre-spaced panes of glass, to fill the whole of the void. The resin is then cured to form an energy absorbing interlayer. Adhesion to the glass is good but the interlayer thickness may not be uniform. CIP interlayers do not have as good energy absorbing properties as PVB. Pilkington Laminated Glass (made with CIP interlayer) normally obtains at least Class B to BS 6206, depending on glass thickness and interlayer thickness.

Other interlayers, not specifically designed for human impact safety, are also used with glass. Interlayers specified purely for their decorative effect may not give impact safety properties, although most can be made to do so. Interlayers in some of the fire resisting glass products, for instance Pilkington Pyrostop, are primarily designed to give fire resistance, although all variants of the product also have a safety rating.

Because of the wide variety of these interlayers, it is not possible to give a blanket statement about their performance to BS 6206.
### Table 1 – Typical BS 6206 safety performance levels of Pilkington products

<table>
<thead>
<tr>
<th>Product</th>
<th>Variant</th>
<th>BS 6206 Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilkington <strong>Pyroshield</strong></td>
<td>●</td>
<td>none</td>
</tr>
<tr>
<td>Pilkington <strong>Pyroshield</strong></td>
<td>●</td>
<td>C</td>
</tr>
<tr>
<td>Pilkington Lam’ Safety Glass 0.38mm PVB interlayer</td>
<td></td>
<td>usually B</td>
</tr>
<tr>
<td>Pilkington Laminated Glass ≥0.76mm PVB interlayer</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Pilkington Laminated Glass CIP interlayer</td>
<td></td>
<td>at least B</td>
</tr>
<tr>
<td>Pilkington Toughened Glass all</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Pilkington <strong>Pyrostop</strong> all</td>
<td></td>
<td>at least B</td>
</tr>
<tr>
<td>Pilkington <strong>Pyrodur</strong></td>
<td>●</td>
<td>at least B</td>
</tr>
<tr>
<td>Pilkington <strong>Optifloat</strong> up to 8mm</td>
<td></td>
<td>none</td>
</tr>
<tr>
<td>Pilkington <strong>Texture Glass</strong> up to 8mm</td>
<td></td>
<td>none</td>
</tr>
<tr>
<td>Pilkington Acoustic Laminate all</td>
<td></td>
<td>at least C</td>
</tr>
<tr>
<td>Pilkington <strong>Anti-Fade</strong> all</td>
<td></td>
<td>at least B</td>
</tr>
</tbody>
</table>
Applied Plastic Films

Changes in the uses of glass have, in themselves, brought about the need for the development of new materials. The growth in mirror-fronted wardrobes, where the mirrors are unbacked (i.e. not mounted directly on to board), is one such instance. Before the development of applied plastic safety films, the only way of making such mirrors safe was to silver toughened or laminated glass.

Safety filmed mirrors are asymmetrical products which need to be tested both ways round. Depending on the type of film system, the product can have significantly different impact performance depending on which surface is impacted. BS 6206 has been modified to allow such products to be classified when impacted from only one side, where the use is such that human impact can only occur from one direction (e.g. wardrobe doors). There are now three new classes, i.e. Ao, Bo, and Co, which relate to classification for impact from the glass side only.

Because of the wide variety of these films, it is not possible to give a blanket statement about their performance to BS 6206.
Safety Considerations in Buildings

The Purpose of Safety Regulations and Standards
The regulations, standards and expert advice on safety glazing are concerned with reducing the possibility of severe cutting and piercing injuries.

Making anything completely safe is impossible, and the same applies to glazing. But it is possible to put appropriate glazing products in the most vulnerable positions, which are termed “critical locations” in the regulations and standards.

In none of the regulations or standards which make requirements for safety glass, does the type of glass receive major attention. The requirements are all couched in terms of conformity with BS 6206 classification levels. Only where glass can be used which is not required to be a safety glass, to BS 6206, do the regulations and standards refer to the type of glass.

Hazardous Areas
Over the years since 1966 several studies have been made, around the world, to gather data on accidents. From this and other research data it has been possible to produce a list of areas, where, if glass is used in buildings, there can exist an increased risk of accident and care should be taken on glass specification.

Hazardous areas:
- Doors and side panels to doors
- Low-level glazing
- Swimming pools and bathrooms
- Buildings with special activity, e.g. gymnasium

Various British Standards have, over the years, given advice on appropriate glass types to use in these various locations. Currently, the subject is covered by Building Regulations, Part N in England & Wales, Part P in Scotland and Part V in Northern Ireland, as well as by BS 6262: ‘Code of practice for glazing for buildings’: Part 4 ‘Safety related to human impact’.

Knowing the areas in which safety glasses should be used and the appropriate class of safety glass to use are essential. With this knowledge the appropriate safety glass can be obtained from the glass manufacturer/processor. When installed, safety glass reduces the risks of serious injury in the event of accidental impact.
Building Regulations

Building Regulations Part N (England & Wales), Part P (Scotland), Part V (Northern Ireland) and BS 6262: Part 4 give very similar advice on the use of glass in the main critical locations of doors, side panels and low level glazing.

Glazing in Doors

Glazing in doors which is wholly or partially within 1500mm from floor level shall be:

Minimum Class C to BS 6206 and marked according to BS 6206. If the smaller dimension of the pane is greater than 900mm it shall be:

Minimum Class B to BS 6206 and marked according to BS 6206

Glazing Adjacent to Doors

Glazing which is wholly or partially within 300mm of the edge of a door and which is also wholly or partially within 1500mm from floor level shall be:

Minimum Class C to BS 6206 and marked according to BS 6206. If the smaller dimension of the pane is greater than 900mm it shall be:

Minimum Class B to BS 6206 and marked according to BS 6206

Low Level Glazing

(Excluding guarding) not covered by (1) or (2). Glazing which is wholly or partially within 800mm from floor level shall be:

Minimum Class C to BS 6206 and marked according to BS 6206

Note. Insulating units. Where an insulating unit can only be impacted from one side, then only the pane on that side needs to comply.

There are some exceptions to these requirements for safety glass, based on the robustness of annealed glass:

- Panes having the smaller dimension less than 250mm and of area less than 0.5m² may be minimum 6mm (nominal) thick glass not complying with BS 6206
- Panes forming parts of fronts (but not other locations) to shops, showrooms, offices, factories and public buildings, supported on all edges, may be of equivalent robustness in glass not complying with BS 6206

8mm < 1100 x 1100mm
10mm < 2250 x 2250mm
12mm < 3000 x 4500mm
15mm (and thicker) – no limit
Panes protected by a suitably designed barrier

Building Regulations apply only to buildings for which Building Regulations Approval is required, i.e. to new buildings or to major structural alterations to old buildings. Small (<30m² floor area) extensions, like conservatories, are excluded from the Building Regulations (England & Wales) requirements.

BS 6262: Part 4: 1994

The publication of BS 6262 ‘Glazing for Buildings’: Part 4 ‘Safety Related to Human Impact’ mirrors Building Regulations Part N (England & Wales), but extends the critical locations to cover bathing areas and gymnasium, where advice is to use minimum Class C safety glass. It also contains further explanation and guidance.

Consumer Protection Act 1987

Section 10 of the Consumer Protection Act 1987 provides (amongst other things) that it is an offence to supply goods which fail to comply with the general safety requirement. Goods fail to comply with the general safety requirement if they are not reasonably safe having regard to all the circumstances including any safety standards. This means that in deciding whether the goods complied with the general safety requirement, the court can have regard to standards, such as British Standards, and can do so irrespective of whether those standards have been incorporated in safety regulations.

Thus, in effect, it is wise to regard BS 6262: Part 4 for all practical purposes as a legal requirement for any glass sold directly to the general public for use in critical locations.
Edinburgh Sheriff Court

Figure 1. Critical Location in BS 6262: Part 4 1994.
Workplace Health & Safety Regulations 1992 – Regulation 14

Regulation 14 (windows, transparent or translucent doors, gates and walls) of the Workplace (Health, Safety and Welfare) Regulations 1992 states the following:

- Every window, or other transparent or translucent surface, in a wall or partition and every transparent or translucent surface in a door or gate shall, where necessary for reasons of health or safety –
  - Be of safety glazing material or be protected against breakage of the transparent or translucent material
  - Be appropriately marked or incorporate features so as, in either case, to make it apparent

The critical phrase in the Regulation is “... where necessary for reasons of health or safety...”.

To determine whether glazing in a workplace complies with the requirements of the Regulation, an assessment should be made of the risks associated with the presence of the glazing, taking into account the activities on the premises and previous accident experience. The occupier of the premises is in the best position to determine if and where there might be a risk. Glazing which conforms to Part N of the Building Regulations 1991, or to BS 6262: Part 4: 1994, is likely to satisfy Regulation 14. Where there is a history of no accidents involving the glazing, or few very minor incidents, and no particular special hazard can be foreseen, then the risk would be low.

If it is decided to make changes to the glazing, the changes should result in the glazing conforming to BS 6262: Part 4: 1994.

Care should be taken to ensure that any changes made also result in the glazing complying with other regulations or standards, such as fire safety (e.g. Part B of the Building Regulations (England & Wales) 1991, or BS 5588) and protection against falling (e.g. Part K of the Building Regulations (England & Wales) 1991, or BS 6180), and take any special hazards into account.

Specific care should be taken when considering the use of applied films on fire resisting glass. While suitable films applied in accordance with the manufacturer’s instructions can upgrade annealed (ordinary) glass to safety glass, their presence may have an adverse effect on the fire performance of existing fire safety glazing.
Risk Assessment
A risk assessment takes into account both the risk of there being an accident with a particular pane of glass and the likely consequences of serious cutting and piercing injuries if there was an accident. In order to perform a risk assessment, it is necessary to know the activities and nature of the occupants or users of that part of the building, in relation to the position of the glass, and also to be able to identify the glass to determine the likely consequences of an accident.

This process requires documentation for each pane of glass. The risk assessment should make a judgement, related to the phrase “where necessary for reasons of health or safety”, based on the risk of accidental impact and knowledge of the likely performance of the glass under impact.

Identifying Glass on Site
Using measuring tapes, glass thickness gauges, “toughened glass identifiers”, “laminated glass identifiers” and visual inspection, it is possible to identify the following in situ:

- Glass which does not fall into a critical location (as defined by Part N of the Building Regulations 1991, or by BS 6262: Part 4: 1994). Glass outside these critical locations is not normally a hazard:
- Glass which is marked correctly according to BS 6206
- Annealed clear or tinted (and possibly coated) float glass. This can be identified as definitely not complying with BS 6262: Part 4, if in critical locations and outside the appropriate size/thickness limits
- Heat treated float glass, but not whether it is fully toughened or heat strengthened, and certainly not whether it complies with BS 6206 and to which class
- Laminated glass, but not whether the interlayer is PVB or cast-in-place, nor, in general, how thick the interlayer is, and certainly not whether it complies with BS 6206 and to which class
- Polished wired glass, with Pilkington Pyroshield Safety is Class C to BS 6206. All other types are not currently classifiable to BS 6206 and can be identified as definitely not complying with BS 6262: Part 4, if in critical locations and outside the appropriate size/thickness limits

Patterned glass may be difficult to determine as to thickness, and whether it is annealed or heat treated or laminated.

In conclusion, only glass which is not in a critical location, glass which is marked correctly, annealed float glass and wired glass can be identified adequately. There are difficulties with any other types.
Manifestation

Manifestation is another aspect of safety of glass in use. Irrespective of the type of clear or tinted float glass used, under certain conditions it can be very difficult to see. In this state it is vulnerable to persons trying to walk or run through what they perceive as openings, being unaware of the presence of glass. In such situations, where there is no obvious indication of the presence of glass, then there should be some form of manifestation such as a design on the glass.

A particular risk area is the use of extensive areas of uninterrupted, transparent, door height glazing in non-domestic buildings, where the glazing may not be immediately apparent and is not separating obviously different levels.

Indications could take many different forms. Transom rails are fairly obvious, as are mullions provided they are not too far apart. Stall risers (small upstands at the base of the glass) may also be effective as indicators, but would have to be sufficiently high to create the effect of a step. Simple differentiation of the environment may be sufficient. A flower bed immediately outside the glass is obviously not a normal path, but if there is a paved area or lawn, the glass may be mistaken for an open door.

Manifestation has more to do with avoiding the accidents than dealing with the consequences. It is an active attempt to reduce accidents, rather than the passive role of using appropriate glass products to reduce the consequences.

Dormy Hotel Leisure Centre, Dorset
Barriers

Containment or Guarding

When the nature of loading was initially discussed, it was implied that it was not possible to design for accidental human impact. This is certainly the case when the ‘reduction of cutting and piercing injuries’ is the criterion. However, when the glass is being used to prevent people ‘falling through’ then engineering design can be applied together with knowledge of the impact performance of the glasses.

Barriers (balustrades), whether of glass or any other material, will be expected to carry a number of applied loads, e.g. line load, point load, uniform load. Knowledge of the mechanical properties of glass ensures that an appropriate type and thickness of glass can be designed and specified.

The use of barriers and the loads they may be subjected to are covered by Part K of the Building Regulations (England & Wales), Part S in Scotland and Part H in Northern Ireland. All these documents refer to BS 6180: 1982 ‘Code of practice for barriers in and about buildings’, which has recently been updated with the 1995 version of this standard.

The design of barriers incorporating glass is very effectively covered in BS 6180: 1995 and summary tables of appropriate glass products for the common types of barrier can be found in the Pilkington Technical Bulletin ‘Glass and Mechanical Strength’.

However, there is one specific area that requires further explanation.

Glazing to Comply with Part K of the Building Regulations 1991 – Containment

Table 11 of Part K of the Building Regulations (England & Wales) 1991 specifies that glazing in external walls should give “containment” up to a height of 800mm above finished floor level when it is providing “guarding”, i.e. protection against falling. The document does not give any guidance as to how “containment” is achieved.
Glazing can be considered as giving “containment” when the glass is wholly or partly within 800mm from the floor level, if it fulfills all the following criteria:

- The glass is a safety glass according to BS 6206 and complies with either Part N of the Building Regulations 1991 or BS 6262: Part 4. If the glass is in an insulating unit, only the glass on the accessible side needs to comply.

- The glass is designed not to break when subjected to the loads, in Table 11 of Part K, appropriate to the building use. Where the design height indicated in Table 11 suggests that the horizontal line load would be applied directly to the glass, then the glass must resist this without breaking. Any part of the glass below the design height is designed to resist the infill loads, from BS 6180, which are associated with the line load from Table 11 of Part K.

- The method of fixing the glass is capable of retaining the glass when it is subjected to the appropriate loads. Glazing according to BS 6262 will suffice, but methods not covered in BS 6262 may also be appropriate.

- The framing, or other method of supporting the glass, is capable of resisting the loads transferred to it from the glass without permanent damage or distortion.
Table 2 – Fully framed, single glass pane sizes which comply with the containment criteria of Building Regulations Part K. (when used in glazing wholly or partly below 800mm from floor level)

<table>
<thead>
<tr>
<th>Building use</th>
<th>Nominal Glass Thickness (mm)</th>
<th>Area in m² for glass type</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pilkington Laminated Glass</td>
<td>Pilkington Toughened Glass</td>
</tr>
<tr>
<td>Domestic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>3.6</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>5.8</td>
<td>6.0</td>
</tr>
<tr>
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<td>10</td>
<td>8.4</td>
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<tr>
<td></td>
<td>12</td>
<td>11.6</td>
<td>11.7</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>no limit</td>
<td>no limit</td>
</tr>
<tr>
<td>Commercial, but excluding retail</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>premises or places of assembly</td>
<td>6</td>
<td>2.2</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>4.2</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>5.8</td>
<td>6.0</td>
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<td></td>
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<td>Retail premises</td>
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<td>24</td>
<td>no limit</td>
<td>no limit</td>
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</tbody>
</table>

Notes.
(1). Glass panes within these sizes will satisfy the design criteria irrespective of shape, for glazing methods which support the glass pane on all edges.
(2). Panes not supported on all edges may need thicker glass or smaller areas, please contact Pilkington for advice.
(3). 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.

*Larger areas or thinner glass may be used depending on the position of the pane in the wall and if the pane is in a Pilkington Insulating Unit, please contact Pilkington for advice.
Overhead Glazing

In most types of buildings, in sloping or overhead glazing situations, it is generally regarded as appropriate to install glass which will either tend to stay in place if it is cracked (Pilkington Pyroshield and Pilkington Laminated Safety Glass come into this category) or to fracture into relatively harmless pieces (Pilkington Toughened Safety Glass comes into this category) which are less likely to cause serious injury, if they fall, than sharp shards of annealed glass.

BS 5516: 1991 ‘Code of practice for vertical and sloping patent glazing’ is the only regulation or standard which gives any recommendations about the type of glass to use in roofs. For single glazing, either wired, laminated or toughened glass is recommended by BS 5516, while insulating units should have one of the three types as the lower pane. With regard to toughened glass, BS 5516 suggests that, if the lower pane of an insulating unit is toughened, then the upper pane should also be one of the three recommended types of glass.

While BS 5516 is concerned only with patent glazing, the advice on glass selection for roofs is equally applicable to all non-agricultural roof glazing or canopies.

Two further notes are given by BS 5516 in relation to toughened glass, one being that it should not be used over swimming pools and the other being that, to reduce the risk of “spontaneous fracture”, the use of heat soaked toughened safety glass should be considered. Heat soaked toughened glass has a much lower risk of fracture than ordinary toughened glass from an impurity known as nickel sulphide.
Overhead Glazing

**Recommendations for the possible types of glass suitable for use in sloping or horizontal overhead glazing in or around non-agricultural buildings are as follows:**

**Glazing at a height less than 5m above floor level**  
(this covers single storey buildings – conservatories etc.)

**Single glazing:** Pilkington Toughened Safety Glass, Pilkington Laminated Safety Glass, or Pilkington Pyroshield.

**Insulating units:** The lower pane should be one of the above types of glass. If the lower pane is Pilkington Toughened Safety Glass, then the upper pane should also be one of the above types of glass. **Glazing at a height over 5m but less than 13m above floor level**  
(this covers intermediate height atria, larger conservatories, etc.)

**Single glazing:** Ideally Pilkington Laminated Safety Glass or Pilkington Pyroshield. Pilkington Toughened Safety Glass may be considered with the following restrictions; not more than 6mm thick and not more than 3m² area.

**Insulating units:** Ideally the lower pane should be Pilkington Laminated Safety Glass or Pilkington Pyroshield. Pilkington Toughened Safety Glass may be considered with the following restrictions; not more than 6mm thick and not more than 3m² area. If the lower pane is Pilkington Toughened Safety Glass, then the upper pane should also be one of the above types of glass.

**Glazing at a height over 13m above floor level**

**Single glazing:** Pilkington Laminated Safety Glass, or Pilkington Pyroshield.

**Insulating units:** The lower panes should be Pilkington Laminated Safety Glass or Pilkington Pyroshield.

**Note.**
- This general advice is not applicable to specialist systems such as Pilkington Planar.
- Where Pilkington Toughened Safety Glass is used in single glazing or the lower pane of Pilkington Insulight Units, consideration should be given to using Pilkington Heat Soaked Toughened Safety Glass.
- Pilkington Toughened Safety Glass should not be used as single glazing or the lower pane of insulating units over swimming pools, where fragments of broken glass can get into the pool pumps and cause major damage.
Furniture

Consideration also needs to be given to the type of glass used in furniture. Table tops and open shelves are particularly vulnerable and the impact force is often quite high.

The purpose of standards for the safer use of glass in furniture is the reduction of cutting and piercing injuries. This can be addressed with two approaches, first to ensure the furniture is inherently stable and strong enough, and secondly to ensure appropriate glass is used for the purpose.

The provision of appropriate glass for use in furniture is covered by two British Standards – BS 7376: 1990 ‘Specification for the inclusion of glass in the construction of tables or trolleys’ and BS 7449: 1991 ‘Specification for the inclusion of glass in the construction of furniture other than tables or trolleys, including cabinets, shelving systems and wall-hung or free standing mirrors’.

BS 7449 excludes glass panes less than 0.06m² area (approximately 250mm²) since these are not considered large enough to be a serious risk.

Pilkington Optifloat and Pilkington Texture Glass, incorporating Pilkington Optifloat and Pilkington Texture Glass, are available to meet the requirements for laminated safety glass and toughened safety glass in furniture.

Tables and Trolleys

When the glass is not supported over its entire area, the types suggested by BS 7376 are toughened glass, laminated glass and thick annealed glass, according to Table 3.

If toughened glass is used where the edges are unprotected, the effects of breakage of toughened glass, in terms of the explosive nature of the fracture, should be considered. The built-in stresses of toughened glass can eject edge fragments with some considerable force if the edges are not restrained. While this is a very uncommon source of serious injury, the occurrence can cause some distress to those witnessing it. Laminated glass edges can never be machined as neatly as monolithic glass edges, so thick annealed glass may be a better option for tables where the glass overhangs the structure. Unfortunately, this option may not comply with other requirements in BS 7376 for the support conditions of annealed glass.
Fully Supported Glass

If the glass is laid on top of the upper surface of tables or other furniture, so that it is supported over its whole area, then thinner glass (see Table 4) is allowed by BS 7376 and BS 7449.

Shelves

Glass shelves which are not enclosed within cabinets or cupboards are required by BS 7449 to conform to Class C of BS 6206. This effectively requires them to be of toughened glass, laminated glass. For shelves within cabinets or cupboards, BS 7449 gives tables for load carrying capacity, but makes no safety requirements of the glass.

Other External Glass Surfaces in Furniture

BS 7449 suggests the requirements listed for all other exposed surfaces in furniture (see Table 5). There is no height limitation, so these requirements listed for furniture are considerably more onerous than the requirements for glass in the building structure, where there are few safety requirements for glass more than 800mm from floor level, except in and around doors.
Table 3 – Suggested thicknesses of different glass types when glazed horizontally and supported around its entire perimeter (other than for shelves)

<table>
<thead>
<tr>
<th>Area of Glass (m²)</th>
<th>Minimum BS 6206 Classification</th>
<th>Nominal Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Toughened Glass</td>
</tr>
<tr>
<td>≤0.25</td>
<td>C</td>
<td>≥4</td>
</tr>
<tr>
<td>&gt;0.25 to ≤0.5</td>
<td>C</td>
<td>≥5</td>
</tr>
<tr>
<td>&gt;0.5 to ≤0.75</td>
<td>C</td>
<td>≥6</td>
</tr>
<tr>
<td>&gt;0.75 to ≤1.5</td>
<td>B</td>
<td>≥8</td>
</tr>
<tr>
<td>&gt;1.5</td>
<td>A</td>
<td>≥10</td>
</tr>
</tbody>
</table>
### Table 4 – Allowable thicknesses of fully Horizontal glass fully supported over its entire area

<table>
<thead>
<tr>
<th>Area of Glass (m²)</th>
<th>Nominal Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Toughened Glass</td>
</tr>
<tr>
<td>≤0.5</td>
<td>≥4</td>
</tr>
<tr>
<td>&gt;0.5 to ≤1.0</td>
<td>≥4</td>
</tr>
<tr>
<td>&gt;1.0 to ≤1.5</td>
<td>≥4</td>
</tr>
<tr>
<td>&gt;1.5</td>
<td>≥4</td>
</tr>
</tbody>
</table>
Table 5 – Minimum thicknesses of exposed glass surfaces in furniture (excluding horizontal glass supported over its entire area)

<table>
<thead>
<tr>
<th>Minor dimension of glass (mm)</th>
<th>BS 6206 Classification</th>
<th>Minimum thickness fully framed (mm)</th>
<th>Minimum thickness partly framed (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥900</td>
<td>B</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>&lt;900</td>
<td>C</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
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