

Code of practice for

Glazing for buildings —

(Formerly CP 152)

UDC 698.3

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Brick Development Association	Institute of Quality Assurance
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Architectural Aluminium Association	Metal Window Federation of Great Britain
Chief and Assistant Chief Fire Officers' Association	National Association of Shopfitters
Child Accident Prevention Committee	National House-building Council
Department of the Environment (Building Research Establishment)	Patent Glazing Conference
Department of Trade (Metrology, Quality Assurance, Safety and Standards Division)	Sealant Manufacturers' Conference
	Union of Construction, Allied Trades and Technicians

This British Standard, having been prepared under the direction of the Elements and Components (of Diverse Materials) for Buildings Standards Committee, was published under the authority of the Board of BSI and comes into effect on 30 June 1982

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Foreword

This code of practice was first published, as BS 973, in 1941 and revised under the same number in 1945. A second revision was published in 1960 as CP 152 and this was subsequently revised in 1966, 1972 and 1982.

The 1982 edition of the code is currently being revised under the direction of Technical Committee B/520 and will be published in seven Parts covering the following areas:

- *Part 1: General;*
- *Part 2: Heat, light and sound;*
- *Part 3: Fire, security and wind loading;*
- *Part 4: Safety — Human impact;*
- *Part 5: Frame design considerations;*
- *Part 6: Special applications;*
- *Part 7: Provision of information.*

Part 4 which gives recommendations related to safety from human impact has now been published and supersedes subclauses 4.7, 5.7, 6.7, Table 11, appendix A and Figures 43 and 44 which are withdrawn.

The drawings contained in this code are diagrammatic, their purpose being only to complement the text and indicate design principles.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to vi, pages 1 to 84, an inside back cover and a back cover.

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1 Scope

This code of practice gives recommendations for the design, installation and maintenance of vertically glazed (see 3.40) glass and plastics glazing sheet materials for the external walls and interiors of buildings.

The recommendations in this code do not apply to:

- a) patent glazing (see BS 5516);
- b) glazing of furniture and fittings;
- c) glazing of barriers and balustrades (see BS 6180);
- d) glazing of commercial greenhouses (see BS 5502);
- e) glazing of domestic greenhouses;
- f) bent, profiled and corrugated glass;
- g) glass blocks;
- h) glass lens lights (precast and cast in situ);
- i) glass and plastics bullions;
- j) thermoformed plastics panels;
- k) corrugated plastics sheeting (reinforced and unreinforced).

NOTE 1 All dimensions given in this code for thickness are nominal. Tolerances on glass thicknesses should be in accordance with BS 952-1.

NOTE 2 It is not possible to state individual tolerances on all the installation dimensions contained in this code. These dimensions, which are based on considered good practice in the glazing industry and assume skilled workmanship, should be reasonably applied.

2 References

The titles of the publications referred to in this code are listed on the inside back cover.

3 Definitions

For the purposes of this code the following definitions apply.

3.1

aspect ratio

the ratio of the longer side of a pane to its shorter side

3.2

back bedding

that portion of the glazing material between the face of the glass or plastics and the rebate upstand after the glass or plastics has been pushed into position

NOTE See 3.4.

3.3

bead or glazing bead

a strip of wood, metal or other suitable rigid material attached to the surround to retain the glass or plastics

3.4

bedding

the glazing material placed in the rebate, into which the glass or plastics is bedded

3.5

blocks

a) **location blocks.** Pieces of resilient material used between the edges of the glass or plastics (other than the bottom edge) and the surround to prevent relative movement between the pane and the surround.

b) **setting blocks.** Pieces of resilient material used between the bottom edge of the glass or plastics and the surround to support and centralize the pane in the surround.

NOTE See also 3.11.

3.6

butt jointing

the positioning of the edges of panes close together and the filling of the space between them

3.7

capping

a sealant applied to fill the space remaining above a strip glazing material positioned between the glass or plastics and the rebate and/or bead

NOTE See 9.3.3.4.

3.8

clearance (see Figure 1)

a) **back clearance.** The distance between the face of the glass or plastics and the upstand face of a rebate or groove.

b) **edge clearance.** The distance between the edge of the glass or plastics and the rebate.

c) **front clearance.** The distance between the face of the glass or plastics and the upstand face of a bead or groove.

NOTE The back clearance and front clearance are sometimes called the "face clearance" or, collectively, the "face clearances".

3.9

cleat

a small, non-corrodible metal component, usually right-angled in section, secured to the surround to hold the glass or plastics in position, in conjunction with distance pieces when necessary

3.10

coupled windows

one single-glazed frame with another glazed frame hinged or fastened to it, so that both open together for ventilation and can be separated for cleaning purposes

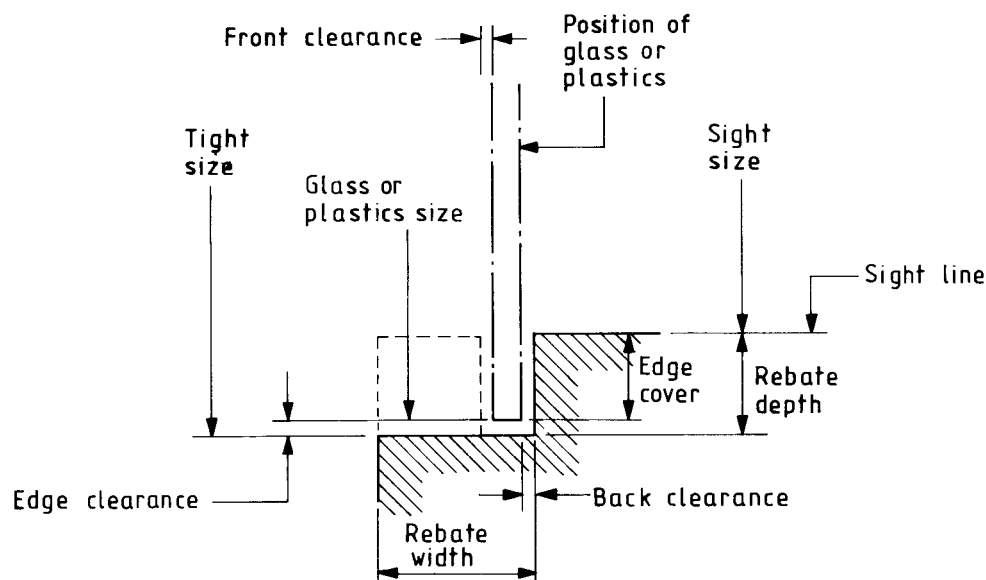


Figure 1 — Glass, plastics and rebate dimension definitions

3.11 distance pieces

pieces of resilient material used between the glass or plastics and rebate upstand and bead to constrain movement of the glass under wind load

3.12 double glazing

glazing that incorporates two panes, separated for the purposes of sound and/or thermal insulation

3.13 double-glazing unit

two panes of glass or plastics spaced apart and hermetically sealed in a factory

NOTE A double-glazing unit is often referred to as an insulating glazing unit, but this latter term also caters for any number of panes and spaces (see 3.24).

3.14 double windows

two separate glazed frames superimposed in the same wall opening

3.15 edge cover

the distance between the edge of the glass or plastics and the sight line (see Figure 1)

3.16 factory glazing

glazing into surrounds (usually in a factory) prior to the surround being installed in the building

3.17 fixing

the securing of glass or plastics to surfaces (e.g. walls)

3.18 fronting

a triangular fillet of glazing material on the rebate platform between the surface of the glass or plastics and the front edge of the rebate

3.19 gasket

a specially profiled material for bedding or securing the glass or plastics

3.20 glass assembly

a matrix of glass panels connected together by mechanical or adhesive means and supported against wind loading by the use of glass stiffeners (e.g. fins)

3.21 glazing

the securing of glass or plastics in prepared openings in, for example, windows, door panels, screens and partitions

a) **external glazing.** Glass or plastics where one or both faces are exposed outside the building.

1) **inside glazing.** External glazing in which the glass or plastics is inserted from inside the building.

2) **outside glazing.** External glazing in which the glass or plastics is inserted from the outside.

b) **internal glazing.** Glass or plastics where neither face is exposed outside the building.

3.22 glazing material

a material that provides a bedding for the glass or plastics and produces a joint between them and the surround

3.23 location blocks

see 3.5

3.24 multiple glazing

a form of glazing incorporating two or more panes spaced apart for the purposes of sound and/or thermal insulation

3.25 pane

a piece of glass or plastics glazing sheet material cut to size and shape ready for glazing

NOTE A less preferred term for this definition is "square".

3.26 peg

a metal pin used to hold the glass or plastics in a metal surround

3.27 plastics 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

3.28 plastics film

any plastics material less than 1 mm in thickness

3.29 plastics glazing sheet material

plastics materials consisting of a single sheet or a combination of sheets laminated together or as profiled extruded double skin sheet

3.30 plastics sheet

any plastics material 1 mm or greater in thickness

3.31 primer

a coating applied to a surface to improve the adhesion of compounds or sealants subsequently applied to that surface

3.32 primer/sealer

a coating applied to a porous substrate to prevent migration from compounds or sealants subsequently applied to that surface and at the same time to improve the adhesion of compounds or sealants to the substrate

3.33 rebate

that part of a surround, the cross section of which forms an angle into which the edge of the glass or plastics is placed (see Figure 1)

3.34 sealer

a coating applied to a porous substrate to prevent migration from compounds or sealants subsequently applied to that surface

3.35 secondary sashes

the addition of a second glazed frame either to an existing window or fixed to the reveals

3.36 size (see Figure 1)

- a) **glass size or plastics size.** The actual size of a pane.
- b) **sight size or daylight size.** The actual size of the opening that admits light.
- c) **tight size or rebate size.** The actual size of the rebate opening.

NOTE Size dimensions should be given as width (measured horizontally as used) followed by height (measured vertically as used).

3.37 sprig

a small headless nail or triangular piece of metal used for securing panes in wood surrounds while the glazing material hardens

3.38 spring clip

a small metal component used for securing panes in metal frames while the glazing material hardens

3.39 surround

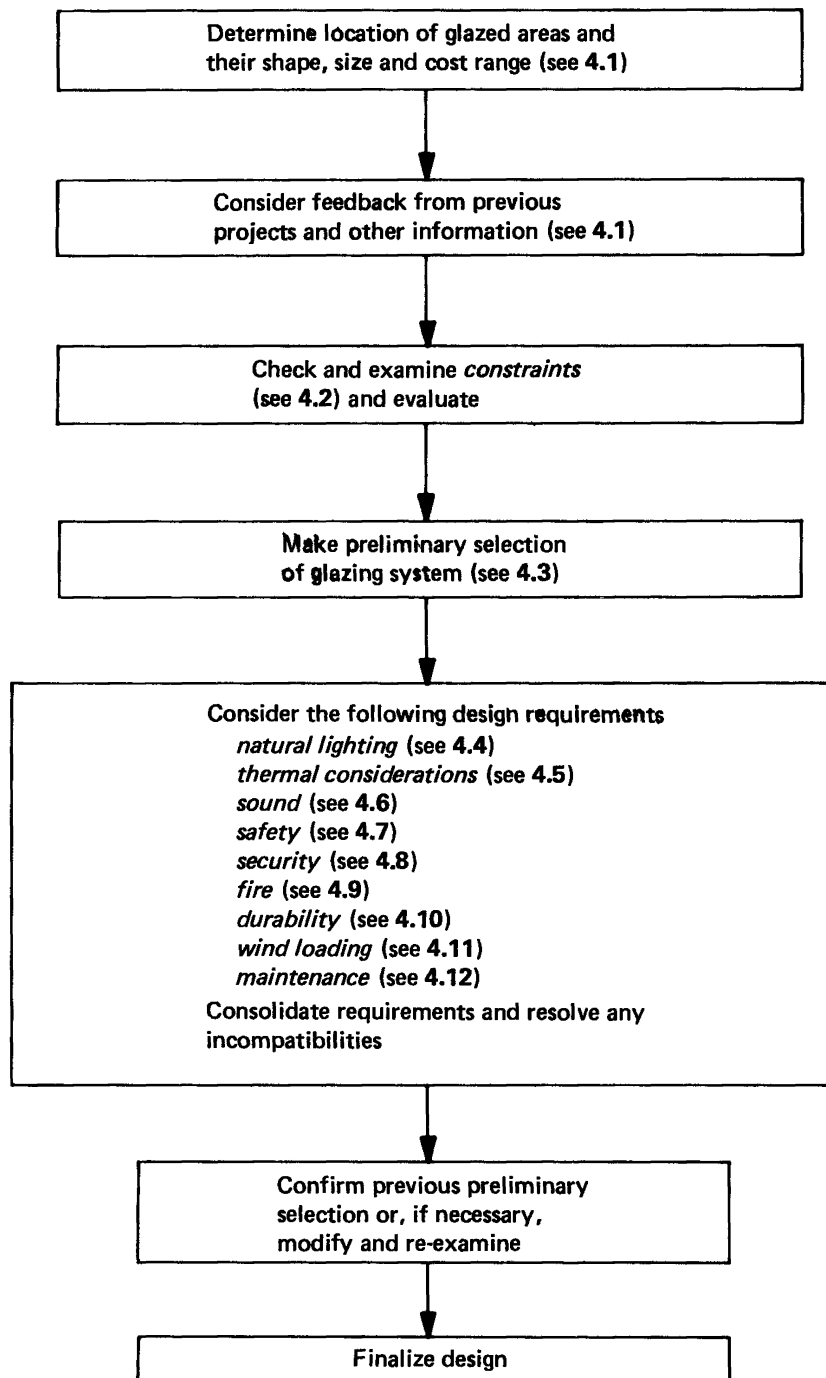
any frame or building element designed to be glazed

3.40 vertically glazed

glass or plastics glazing sheet material glazed either truly vertical or sloping at up to 15° either side of true vertical

4 Design and performance

4.1 Introduction. This clause provides a methodology to arrive at an appropriate choice of glass, plastics and methods of glazing (see Figure 2).



NOTE. Reference should be made to clause 5, which deals with the performance of glass and glazing systems, to clause 6 for plastics glazing sheet materials and systems to satisfy the evaluated design requirements, and to clause 15 which sets out essential information needed for installation.

Figure 2 — Sequence of design evaluation for glazed areas

In recent years the design and performance requirements for glass and plastics have become more demanding, particularly in terms of energy conservation. It is important at the initial project evaluation stage that sufficient note is taken of the implications of using glass and plastics that are adequate. 4.2 to 4.12 are directly related to the sequence shown in Figure 2. It has been assumed that:

- a) the locations of the glazed areas, their shapes and preliminary sizes have been decided as part of the normal building design process;
- b) the designer will have acquired information on glass and plastics used in similar circumstances;
- c) the designer is aware of the implications of any innovatory design.

4.2 Initial constraints

4.2.1 General. Before making any selection, the factors given in 4.2.2, 4.2.3 and 4.2.4 should be considered.

4.2.2 Design requirements. Design requirements include aesthetic considerations, psychological factors (e.g. view) and any specific client requirements, such as security and maintenance considerations.

The desire to provide a visual link from the inside of the building to the outside (and in some cases vice versa) may determine the size, proportion and type of windows and the positioning of intermediate frame members, all of which is beyond the scope of this code, but could determine the size and type of the glass or plastics glazing sheet material.

4.2.3 Legislative requirements. The size and type of the glass or plastics, and in some cases the surrounds, may be restricted by legislation.

4.2.4 Effect of design on cost. This involves consideration of:

- a) not only the initial cost of the glazing system but the effect of the glass and plastics on the capital and running costs related to the building and its heating, lighting and ventilation; factors affecting the initial glazing cost include:
 - 1) type, size and thickness of glass or plastics;
 - 2) method and materials for glazing;
 - 3) access for initial glazing;
 - 4) continuity of work schedule;
 - 5) possible need for protection during construction and its removal on hand-over;
- b) the maintenance of the glazed areas, the factors most likely to affect maintenance costs being:
 - 1) the glazing materials used;
 - 2) access for cleaning and reglazing;

3) ease of reglazing.

The use of more expensive glass and plastics should take into account the possibility of reduced fuel consumption and lower running costs.

The comparative costs of glazing materials should be considered in conjunction with their life expectancy and probability of need for maintenance. (For guidance, see Table 5.)

4.3 Glazing system. When the designer has evaluated the effect of the constraints given in 4.2, a preliminary selection of a system of glazing can be made. The design requirements in 4.4 to 4.12 can be considered in detail in order to check the validity of the initial selection.

4.4 Natural lighting

4.4.1 Design information. For design guidance relating to the assessment and provision of natural lighting, reference should be made to DD 67 for sunlight, and DD 73 for daylight. Further references will be found in the bibliographies included in these standards. Consideration of natural lighting should be related to the provision for artificial lighting. Recommendations for artificial lighting are given in CP 3:Chapter I-2.

4.4.2 Glare. The following four manifestations of glare from glass and plastics should be considered:

- a) direct glare from the sun;
- b) glare from the sky, excluding direct sunlight;
- c) glare resulting from diffracting or diffusing glass and plastics of high surface luminance;
- d) glare resulting from reflection of sunlight or skylight.

It is generally accepted that direct glare from the sun can be controlled only by design to prevent the sun from entering the window aperture. In relation to glare from the sky, or reflected glare, it is possible to use special glass and plastics with reduced light transmissions in order to produce satisfactory lighting. Methods exist for the prediction of glare indices when direct sunlight is excluded, and these relate the size and shape of the glazed area, the luminance of the relevant part of the field of view and the light transmission characteristics of the glass and plastics. As a general rule it is more rewarding to maintain the size and reduce the light transmission of the glass or plastics material than it is to maintain a high light transmission and reduce the area. This is because the contrast between the glazed area and its surrounding opaque walls, etc., has to be minimized if glare is to be reduced to an acceptable level.

4.4.3 Fading. When sunlight or skylight is received by an object, fading can occur. The rate of fading depends on the nature of the object, the duration and intensity of the exposure and the type of radiation. Fading is generally associated with ultraviolet radiation, which comprises about 3 % of the sun's energy received at the earth's surface. It should, however, be borne in mind when assessing the performance of glass or plastics in reducing fading, that fading can result from exposure not only to ultraviolet radiation but also to some part of the visible radiation in sunlight and skylight.

4.4.4 Privacy. The required degree of obscuration should be considered in respect of the privacy needed, from either side of the glass or plastics and under the difference between internal and external lighting conditions.

4.5 Thermal considerations

4.5.1 General. The total annual energy implications of solar gain and heat loss should be considered in relation to the total heat balance of the building and the glazed areas should be chosen accordingly.

4.5.2 Solar transmission. The effects of solar transmission can be considered in two ways:

- a) solar gains that occur during the summer months;
- b) solar gains that occur during the normal heating season of September to May.

Unwanted summertime solar gains can be dealt with by means of window design and orientation, and various forms of shading.

Solar gains that occur during the heating season can be used to advantage by the consideration of window geometry and orientation and the use of suitable controls on the heating and lighting systems. Effective use can mean that the net energy balance of windows facing south of the east/west axis can be positive, i.e. the useful solar gains can more than equal the conduction losses due to the glazed area.

4.5.3 Thermal insulation. The thermal insulation of a building material such as glass or plastics is conveniently expressed by its thermal transmittance (U -value). To determine the total heat loss for a particular type of glass or plastics, single or multiple, it is simply a matter of multiplying the U -value [expressed in $W/(m^2 K)$] by the area of the glass or plastics and by the temperature difference between the environments, usually indoors and outdoors, on each side of the glazed area.

Glazed areas enable daylight to be admitted to a building, but at the expense of a comparatively high heat loss. Multiple glazing has a reduced heat loss (lower U -value) compared with single glazing because of the additional thermal insulation provided by the cavity(ies) separating the individual panes. Glass and plastics can also be used in conjunction with insulating materials to reduce the heat loss through an opaque building element.

The risk of condensation on the indoor surface of glass or plastics is reduced by using multiple glazing. The risk of condensation in the cavities of such glazing systems is minimized by sealing and dehydrating these (see 5.3.1.3.3) or by venting them to the outside air.

4.5.4 Heat absorption. The effects of the window design on the creation of excessive thermal stresses resulting from the heat absorbed by the glass and plastics should be considered.

4.6 Sound. The reduction of transmitted noise requires an appraisal of the following three elements, each of which is frequency dependent.

- a) *The noise source.* Most noises are complex in that they include sounds of different frequencies and amplitudes. The method of sound determination described in BS 2750 is the one normally used in the UK construction industry, but it is necessary for the designers to be aware that other methods of determination (e.g. ISO) are widely used in the USA and Europe. Further information on external noise climates is given in CP 153-3.
- b) *The human response.* The range of sound energy to which the ear responds is very large. A logarithmic scale is more in accord with the ear's response and is therefore used to measure sound levels (decibels).
- c) *The glass or plastics and its surround*
 - 1) *Sound insulation of windows: effects of mass.* The mean sound insulation value of glazing may be predicted with reasonable accuracy from its mass. However, it is not this mean sound insulation value that is important in practice but the sound insulation at the dominant frequencies of the relevant noise spectrum. High insulation values at other frequencies in no way compensate for a deficiency in these bands.

2) *Differences in pane thickness.* Where two parallel panes are of equal thickness, a drop in sound insulation will occur at the coincidence frequency of the individual panes. By employing panes of different thicknesses, this loss will not occur at the same frequency and thus an improved sound insulation performance will result.

3) *Physical separation of panes.* Glass and plastics separated by an air space or a plastics interlayer can provide increased sound insulation. However, the vibrations of the first pane can be transmitted to the second pane and also via the surround.

4) *Non-parallel panes.* Theoretically, non-parallel panes should provide better acoustic insulation than parallel panes. However, unless the angle of incidence of the noise is well defined, this improvement is negligible in practice.

For further design guidance reference should also be made to CP 3:Chapter III and CP 153-3.

4.7 Text deleted

4.8 Security. Security glazing is used in situations where a high degree of protection either to persons or property is required. The basic considerations are:

- a) protection against violent, malicious manual attack;
- b) protection against the use of firearms;
- c) protection against the effect of explosions.

For design guidance relating to security glazing reference should be made to BS 5051-1 and BS 5051-2, BS 5357 and BS 5544.

4.9 Fire

4.9.1 Regulations and test standards. Structural fire precautions, in which the performance of glass and plastics may need to be considered, are controlled by Building Regulations and bye-laws for new building work and by the Fire Precautions Act 1971 and other legislation for occupied premises.

For new buildings, control is exercised separately in England (excluding Inner London) and Wales, Inner London, Scotland and Northern Ireland. The extent of control, depends on the type of glass or plastics and the method of specification, the particular location and the regulations applicable thereto.

In determining the appropriate fire properties of materials, the following tests apply.

a) *BS 476-4:1970.* This test determines whether building materials are non-combustible within the meaning of the definition. Determination of combustibility is made by reference to the duration of any flaming or the increase in the temperature of the sample or furnace above a defined limit.

b) *BS 476-6:1968.* This test provides a means of comparing the contribution of building materials to the growth of a fire by measuring the rate of heat evolution. The performance is expressed as a numerical index from 0 to 100 or more, low values indicating a low rate of heat release.

c) *BS 476-7:1971.* The standard is used to determine the tendency of materials to support the spread of flame across their surfaces and specifies a method of classification appropriate for wall and ceiling linings.

The performances are expressed as four classes, class 1 representing the best performance.

NOTE For class 0 see the appropriate Building Regulations.

d) *BS 476-8:1972.* These tests determine whether elements of construction retain their stability, resistance to the passage of flame and hot gases and provide, where necessary, resistance to heat transmission. Performances are expressed in minutes to failure by the appropriate criteria.

e) *BS 2782:1970:Method 102C.* Test to determine softening point of thermoplastics. Used for categorization of materials for certain regulations.

f) *BS 2782:1970:Method 508A.* Laboratory test method to determine the rate of burning of a plastics or duration of flame or after-glow.

Generally, regulations are written in terms of performance under the standard fire tests but CP 3:Chapter IV¹⁾ and other codes of practice dealing with means of escape in case of fire make specific mention in connection with the use of glass when fire resistance is required.

Glass and plastics installed vertically may need to satisfy requirements in connection with the control of:

- 1) surface spread of flame over room linings; and
- 2) the fire performance of external cladding.

Where glass and plastics are to be incorporated within doors, walls or partitions forming elements of construction or enclosures forming protected escape routes, etc., the glazed installation should satisfy the necessary period of fire resistance in terms of BS 476-8:1972.

¹⁾ At present under revision. To be superseded by BS 5588.

The ability of elements to comply with fire resistance requirements will depend on the type of material, its thickness, size, height to width ratio of pane, type of frame, method of fixing, the form of construction surrounding the glazed area, and whether or not the element consists of a single pane.

Only certain types of glazed installations are able to satisfy fire resistance ratings specified in terms of BS 476-8:1972. Although periods in excess of 1 h are obtainable for stability and integrity, as most glazed elements transmit radiant heat, the insulation criterion cannot normally be met for more than a few minutes. However, in such circumstances, waivers or relaxations may need to be obtained. No restrictions are made on the use of glazed systems meeting the full fire resistance performance in terms of stability, integrity and insulation, but those systems not providing adequate insulation will be limited under codes of practice dealing with the protection of escape routes, etc.

There may be situations in which a designer needs to take account of both legislative fire requirements and the safety considerations in 4.7.

4.9.2 Information. Information on the fire performance of glass and plastics and on glazed systems (e.g. fire-resisting doors and partitions) should be obtained from the manufacturers of the material, component or system. Further information will be found in CP 153-4.

4.10 Durability. The designer should consider the durability of the glass, plastics and the glazing materials and should consult the system manufacturer and the relevant codes of practice, e.g. CP 153-2.

The expected performance of glazing materials is described in 5.3.

It is important to consider the possibility of interactions between adjacent materials both in the glazing system and between it and the surround.

4.11 Wind loading

4.11.1 General method of determination. The design wind pressure should be determined by the method described in CP 3:Chapter V-2. If the complexities are obviously beyond the scope of that code, the Building Research Establishment²⁾ or the National Maritime Institute³⁾ should be consulted.

4.11.2 Abbreviated method of determination for low rise buildings. For low rise buildings (i.e. up to 10 m high) an abbreviated method of determining the design wind pressure may be used, employing Figure 3 and Table 1 and Table 2. Although the wind loading so determined may not be identical with a loading derived from CP 3:Chapter V-2 it should be sufficiently accurate to be used for most low rise buildings.

This abbreviated method assumes a combined pressure coefficient of 1.4, which takes into account that the glazed area may be exposed to pressure on one side and suction on the other. There may be instances when a coefficient higher than 1.4 should be used, e.g.:

- a) near to the corners of some buildings;
- b) where eddies or downdraughts are likely to occur;
- c) in areas of particular local topography and/or building configuration.

It is therefore recommended that if, having found the required glass and plastics thickness for a wind load using this abbreviated method, the required glazed area is close to the maximum area suitable for the exposure, then the exposure should be reassessed using CP 3:Chapter V-2.

This abbreviated method is not suitable for any buildings higher than 10 m from ground level or where the basic wind speed is higher than 52 m/s nor should it be used for buildings on cliff tops. In all such cases the method described in CP 3:Chapter V-2 should be used.

To find the design wind pressure, select

- 1) the basic wind speed (3 s gust) from Figure 3,
 - 2) the ground roughness category from Table 1,
- then use these to obtain the design wind pressure from Table 2.

Table 1 — Ground roughness categories

Ground description	Category
Long fetches of open, level or nearly level country and all coastal situations	1
Open country with scattered windbreaks	2
Country with many windbreaks; small towns; outskirts of large cities	3
Surfaces with large and frequent obstructions, e.g. city centres	4

²⁾ Building Research Establishment, Building Research Station, Garston, Watford, WD2 7JR.

³⁾ National Maritime Institute, Faggs Road, Feltham, Middlesex.

4.12 Maintenance (including reglazing after occupation)

4.12.1 Design. Adequate provision for cleaning, care and replacement should be incorporated in the design of the building.

Table 2 — Design wind pressures

Basic wind speed (from Figure 3)	Height to eaves	Design wind pressure for a ground roughness category (see Table 1) of:			
		cat. 1	cat. 2	cat. 3	cat. 4
m/s	m	N/m ²	N/m ²	N/m ²	N/m ²
52	3	1 600	1 200	950	750
	5	1 800	1 450	1 150	850
	10	2 350	2 000	1 450	1 050
50	3	1 500	1 150	900	700
	5	1 700	1 350	1 050	800
	10	2 150	1 850	1 300	1 000
48	3	1 400	1 050	850	650
	5	1 550	1 250	1 000	750
	10	2 000	1 750	1 200	900
46	3	1 250	950	750	600
	5	1 400	1 150	900	650
	10	1 850	1 600	1 100	850
44	3	1 150	900	700	550 ^a
	5	1 300	1 050	850	600
	10	1 650	1 450	1 050	750
42	3	1 050	800	650	500 ^a
	5	1 200	950	750	550 ^a
	10	1 550	1 350	950	700
40	3	950	750	600	450 ^a
	5	1 100	850	700	500 ^a
	10	1 400	1 200	850	650
38	3	850	650	550 ^a	400 ^a
	5	1 000	800	600	450 ^a
	10	1 250	1 100	750	550 ^a

NOTE 1 The values have been rounded.

NOTE 2 1 N/m² = 1 Pa.

NOTE 3 This table is based on CP 3:Chapter V-2 using the following:

- a) topography factor (i.e. the natural shape of the ground) $S_1 = 1.0$;
- b) building life factor equivalent to a wind exposure of 50 years, i.e. $S_3 = 1.0$;
- c) total pressure coefficient (difference between external pressure coefficient, C_{pe} , and internal pressure coefficient, C_{pi}), $C_p = 1.4$.

^a In order to avoid excessive deflection, it is recommended that a minimum design wind pressure of 600 N/m² is used in these cases (see 5.11.2).

The selection of glazing systems (including materials and surrounds) should be influenced by:

- a) the provision of suitable and safe access for cleaning and maintenance, including consideration of any possible inconvenience to the building occupants;
- b) the ease and cost of replacement of materials;
- c) the cleaning costs.

4.12.2 Instructions. The requirements for maintenance should be handed over on completion of the glazing, thus ensuring awareness of the need to comply with the maintenance procedure for the satisfactory performance of the glazing system in the years to follow.

5 Performance of glass and sealing materials

5.1 Introduction. The properties of the glass are described in this clause for each of the performance requirements listed in clause 4. Sophisticated techniques to predict the performance of glass are also available. The appropriate manufacturers should be consulted.

5.2 Constraints. Not every manufacturer offers every glass type described in BS 952-1. Where British Standard test methods are available it is recommended that, where appropriate, glass known to pass BS test methods should be specified. Table 3 gives availability of glass types and processes.

5.3 Descriptions of materials and systems

5.3.1 Glass

5.3.1.1 General. 5.3.1.2 and 5.3.1.3 list those types of annealed and processed flat glasses it is technically feasible to manufacture. However, the designer is recommended to check the availability/viability of some of the types of processed flat glasses listed in 5.3.1.3 as indicated in Table 3.

For a description of the various glass types see BS 952-1.

5.3.1.2 Annealed flat glass

5.3.1.2.1 Transparent glass. Transparent glass comprises the following types:

- a) float glass:
 - 1) clear;
 - 2) body tinted (e.g. for solar control);
 - 3) surface modified tinted (e.g. for solar control);
 - 4) surface coated (e.g. for solar control);
- b) polished wired glass;
- c) sheet glass:
 - 1) clear;

- 2) body tinted (e.g. for solar control);
- 3) flashed or pot coloured.

5.3.1.2.2 Translucent glass. Translucent glass comprises the following rolled and cast types:

- a) patterned;
- b) tinted patterned;
- c) wired patterned;
- d) rough cast;
- e) tinted rough cast;
- f) rough cast wired.

5.3.1.3 Processed flat glasses

5.3.1.3.1 Toughened (tempered) glass

5.3.1.3.1.1 Transparent glass. Transparent glass comprises the following types:

- a) float glass:
 - 1) clear;
 - 2) body tinted (e.g. for solar control);
 - 3) surface modified tinted (e.g. for solar control);
 - 4) surface coated (e.g. for solar control);
- b) sheet glass:
 - 1) clear;
 - 2) body tinted (e.g. for solar control).

5.3.1.3.1.2 Translucent glass. Translucent glass comprises the following rolled and cast types:

- a) patterned;
- b) tinted patterned (e.g. for solar control);
- c) rough cast;
- d) tinted rough cast (e.g. for solar control).

5.3.1.3.1.3 Opaque glass. Opaque glass comprises the following types:

- a) enamelled glass;
- b) insulating infill panels.

5.3.1.3.2 Laminated glass. Laminated glass is a manufactured product consisting of any of the annealed and/or toughened flat glasses incorporating interlayer(s) appropriate to the design function (i.e. ultraviolet absorption, colour, penetration resistance, decoration, solar and/or sound control) and, where required, wire (e.g. for alarm circuits, decoration, security).

5.3.1.3.3 Multiple glass units. Multiple glass units are manufactured products consisting of any of the annealed, toughened or laminated flat glass (or any combination thereof), the panes of glass being separated by one or more hermetically sealed spaces of dehydrated air or special gas mixture appropriate to the design function (e.g. thermal or acoustic insulation).

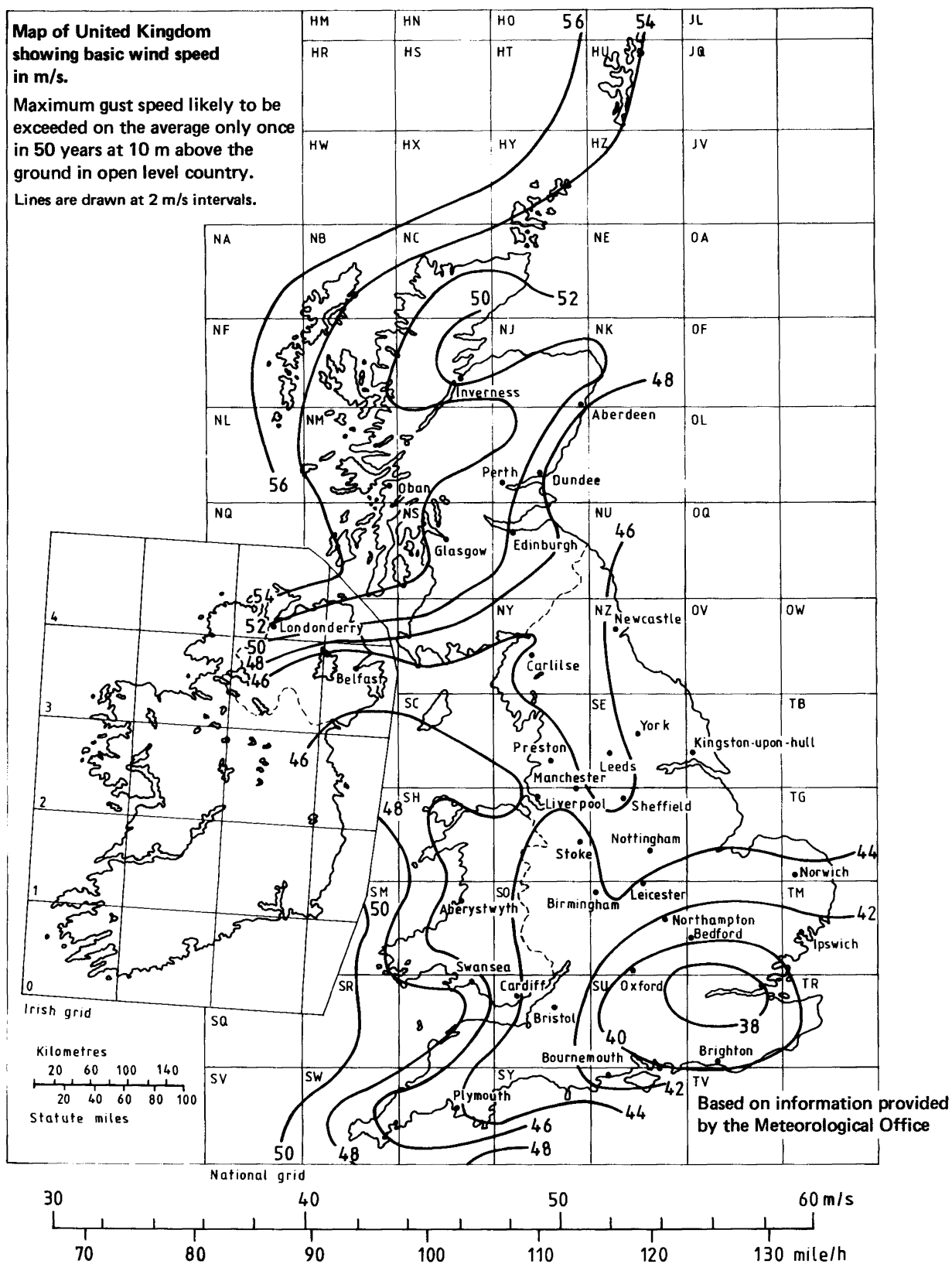


Figure 3 — Distribution of basic wind speed over the United Kingdom

Table 3 — Summary of availability of glass types and processes

Processes	Glass types (see BS 952-1)												
	Clear float	Body tinted float	Surface modified float	Surface coated float	Clear sheet	Body tinted sheet	Clear rough cast	Body tinted rough cast	Clear patterned	Body tinted patterned	Clear rough cast wired	Clear patterned wired	Clear polished wired
Toughened (tempered)	X	X	X*	X*	X	X	X	X	X	X	—	—	—
Laminated safety	X	X	X	X	X	X	X*	X*	X*	X*	X*	X*	X
Multiple glass units	X	X	X	X	X	X	X	X	X	X	X	X	X
Surface treatment	X	X	X*	X*	X	X	X	X	X	X	X	X	X
Edge treatment	X	X	X*	X*	X	X	X	X	X	X	X	X	X
NOTE X denotes technically feasible; X* denotes technically feasible but check viability; — denotes not technically feasible.													

NOTE Surface coatings not suitable for single glazing can be incorporated on the internal surfaces of multiple glass units.

5.3.1.3.4 Surface treated glass. For decorative and/or functional effect, different methods of surface treatments are available as follows (see also BS 952-2):

- a) obscuring (sandblasting, grinding and acid embossing);
- b) brilliant cutting;
- c) engraving;
- d) enamelling, staining or painting and firing;
- e) stoving;
- f) gilding;
- g) silvering;
- h) striped silvering;
- i) metallic coating.

For further details manufacturers and processors should be consulted.

5.3.1.3.5 Edge treated glass. Edge treatments may be divided into three categories:

- a) arrissing;
- b) grinding, smoothing and polishing;
- c) mitreing and bevelling.

These various types of edge finishing are described in BS 952-2.

5.3.1.3.6 Holes and notches. Most glasses can be drilled and/or notched but in all cases specialist advice should be sought. In the case of toughened glass and insulating glass units, such work has to be executed as part of the manufacturing process.

5.3.1.4 Plastics covered annealed glass. In order to meet certain needs for thermal properties, safety and security, a plastic film may be applied to one or both surfaces of glass already glazed in buildings, or prior to glazing for glass intended for glazing in new buildings.

Where the plastic film or organic coating is applied to the glass prior to glazing, a margin of untreated glass may be left at the perimeter of the glass so that the plastic film or coating does not extend into the rebate when the glass is glazed. Where the plastic film or organic coating extends to the edge of the glass before glazing, advice should be sought from the manufacturer on the glazing method and materials to be used.

5.3.2 Glazing materials and components

5.3.2.1 Putties

5.3.2.1.1 Linseed oil putty. Linseed oil putty is a glazing putty traditionally manufactured from linseed oil and fillers and complying with BS 544. It is used for glazing into softwood and absorbent hardwood frames. Linseed oil putty should not be used on dense, non-absorbent hardwood, such as teak, because initial setting of linseed oil putty is controlled by the absorption of some of the oil into the frame, which is facilitated by primers complying with BS 2521 & BS 2523, or primers having equivalent properties. Varnish, gloss paint and some acrylic primers are not suitable for use as primers because they seal the timber surface. Some combinations of preservative and decorative treatments, primers and timber may reduce the porosity of the frame to an unacceptable level and so prevent setting of linseed oil putty. In most cases, the keg life is in the order of three months, after which there may be some separation of oil. The oil should be mixed back into the putty before use to restore the original characteristics.

When it has firmed off sufficiently, normally within 7 days to 21 days, linseed oil putty needs to be protected by paint, full protection being given only by the finishing coats, which should be applied within 28 days of glazing. Failure to provide this protection will lead to early deterioration of the putty, i.e. loss of adhesion and cracking.

5.3.2.1.2 Metal casement putty. Metal casement putty is formulated to set hard and adhere to non-porous surfaces. The putty needs to be painted as soon as it has hardened (normally within 7 days to 14 days) and the finishing coat should be applied within 28 days of glazing. If painting is not carried out or maintained within the specified time, loss of adhesion or cracking can occur.

5.3.2.2 Flexible compounds

5.3.2.2.1 Non-setting glazing compounds.

Non-setting glazing compounds are manufactured for use in conjunction with beads or in grooves where glass is subject to structural or thermal movement that cannot be accommodated by putties. Solar control glasses, insulating glass units and glass faced infill panels can be glazed using such compounds. They form a dust-resistant skin on the surface in 5 days to 7 days, yet remain flexible underneath. The protective skin does not require further protection by painting.

The maintenance of the non-setting property of these compounds is dependent on the volume of compound employed. A thin layer of these compounds will harden quickly. A minimum thickness of 3 mm, and generally a maximum of 5 mm, is therefore recommended for both sides of the glass, and the compound should be continuous around the edge of the glass, forming a solid bedding from sight line to sight line without voids. Owing to the non-setting properties of these compounds, it is important that distance pieces are used to prevent displacement under wind loading;

5.3.2.2.2 Two-part rubberizing compounds. These are hand- or gun-applied flexible glazing compounds, comprising two parts that, when mixed, cure to form a rubbery material. Suitable for glazing with beads in exposed situations and for frames subject to movement or distortion, they can be used with glass types as listed in summary Table 4. They can also be used for presite glazing since, when fully cured, they are not subject to displacement in transit.

Two-part rubberizing compounds are normally used with primers on both glass and frame. They are capable of withstanding high wind loads or other pressures when cured.

Two-part rubberizing compounds are normally used in a similar fashion to non-setting compounds (see 5.3.2.2.1), using a minimum 3 mm thickness of compound, and incorporating distance pieces and setting blocks in order to withstand wind loading until the compound has cured.

These materials cannot be painted except with the use of special primers.

5.3.2.3 Sealants

5.3.2.3.1 General. Sealants are gun-applied materials generally used for capping and bedding applications. Such sealants, together with their primers and cleaning fluids, often contain hazardous or toxic materials and in this connection, manufacturers' handling recommendations should be strictly observed.

5.3.2.3.2 One-part sealant: curing types. One-part sealants, of polysulphide, silicone or urethane base, undergo, at normal temperatures, a chemical reaction to form a firm resilient seal. They are capable of tolerating much greater movement over all climatic temperature variations, but vary considerably in their rate and degree of cure. It is important that selection should therefore be made to ensure that a slow curing type does not have to withstand excessive movement during the early stages of the cure. Generally speaking, the silicones and urethanes cure quickly, while one-part polysulphides have a slow curing action that is accelerated by high temperatures and high relative humidity.

To obtain optimum adhesion these materials may require the use of primers or similar surface conditioners. They generally provide flexibility, elongation, resilience and similar rubber-like characteristics.

a) Polysulphides exhibit good resilience to direct sunlight, water and many organic salt solutions, mild acids and alkalis, solvents and oil-based fuels. Fresh sealant will bond to existing sealant, thus facilitating repair or remedial work. Curing time is approximately 14 days to 21 days under normal site conditions, but it can be as long as 4 months.

b) Silicones exhibit rubber-like properties and can have various degrees of stiffness. Water resistance is good and the sealant may be used in joints subject to permanent immersion in water. Resistance is also good to salt solutions, mild acids and alkalis, and to directly transmitted or reflected sunlight.

Surface primers are not usually necessary on glass, ceramics, aluminium and stainless steel. Porous surfaces should be primed. Other surfaces, e.g. plastics, glass-fibre reinforced plastics (GRP) and some metals, may require special primers. Fresh sealant does not readily bond to aged sealant. Curing time is normally of the order of 5 days to 7 days under normal site conditions. Paint will not adhere to silicone sealant.

c) Polyurethane sealants have excellent abrasion, adhesion and long-term weathering resistance coupled with good chemical resistance. Primers may be required to ensure optimum adhesion to both glass and surround. Flexibility is maintained at temperatures from -40°C to 80°C . Curing time is of the order of 5 days to 10 days under normal site conditions.

5.3.2.3.3 One-part sealant: solvent release types. Sealants of the solvent release type have butyl or acrylic bases, and are essentially non-curing in the sense that no extensive chemical change takes place. They should remain soft and pliable but are subject to a degree of solvent loss that may cause some shrinkage.

a) Butyl-based sealants set to form a rubbery compound, adhering readily to most surfaces without the need for primers. Some grades may be degraded by ultraviolet light, producing a tacky surface that collects dirt progressively. These grades are best suited to concealed positions, such as bedding beads to frames or filling perimeter voids around glass.

Grades susceptible to ultraviolet light are not suitable for use in exposed situations.

b) Acrylic-based sealants set to a tough plastic material that adheres well to most surfaces without the use of primers and is not affected by ultraviolet light. Some, however, are not recommended for use in permanently wet conditions or where they are liable to attack by alkaline water.

5.3.2.3.4 Two-part sealant: curing types. Sealants of the curing type are supplied as two component materials that, when mixed, react to form a rubbery material. Excessive mixing speed or mixing time can reduce the working life of the sealant. The working life and curing time may also be affected by temperature and humidity.

a) Two-part polysulphide sealants (see BS 4254) cure to form a tough rubbery material, remaining flexible in service. They exhibit good resistance to direct sunlight, water and many inorganic salts, mild acids and alkali solutions, and oil-based fuels. Adhesion is good to most surfaces, including aluminium, stainless steel, galvanized steel and ceramic materials. Bricks, concrete and other porous surfaces normally require primers. Primers are required on glass, especially where the bond is subject to transmitted or reflected sunlight.

Fresh sealant bonds readily to clean existing sealant. Curing times vary with individual products, normally taking between 10 days and 14 days under normal site conditions.

b) Two-part polyurethane based sealants cure to form a tough, rubbery material. Water resistance of the cured sealant is good and sealants may be used in joints subject to permanent immersion in water. The resistance of these sealants to ultraviolet light varies and some surface degradation or discoloration may occur. Primers are usually required to ensure optimum adhesive strength to glass and other surfaces. Fresh sealant does not bond readily to existing sealant without special preparation.

Curing time is normally of the order of 7 days to 14 days under normal site conditions.

5.3.2.4 Preformed strip materials. Various forms of preformed tape materials and extruded sections may be used in certain glazing applications. Specific types are as follows.

a) *Preformed mastic tapes.* These are usually based on butyl or polyisobutene polymers, most grades being available in various widths and thicknesses. Where softer, non-load bearing types are used, distance pieces are required but some grades are load bearing and may be used without distance pieces.

b) *Extruded solid sections.* These are of PVC or synthetic rubbers. They may be used under compression on both sides of the glass, or as insert wedges in conjunction with strip sealant or compound, either as an internal trim or as part of external weather protection in a drained system. Such insert sections usually have a means of locating on the bead or surround, and provide a water-shedding cap to the glazing line. Other extruded solid sections of PVC or synthetic rubber may be used as a continuous distance piece and be capped with a sealant. Extruded sections may also be used for internal glazing (doors, partitions, etc.) without sealant or compound.

c) *Cellular strips.* Generally these are made of self-adhesive synthetic rubber that may be used on either side of the glass, alone or in conjunction with sealants, and that need to be compressed sufficiently to ensure adequate load bearing ability to withstand wind pressures.

When used externally it is normally necessary to cap the strip with sealant, except in very sheltered situations, or where the strip forms part of a drained glazing system.

If a capping sealant is to be used, care should be taken to ensure that the materials are compatible.

5.3.2.5 Preformed compression type gaskets. Gaskets have several advantages over conventional glazing materials. They are easy to install, involve no waste and in general need no maintenance.

Gaskets should remain flexible under load and have dimensional stability (see BS 4255-1).

The successful application of gasket glazing depends on careful cooperation between gasket manufacturer, window frame designer and the glazing contractor.

There are two types.

a) *Structural gaskets.* These products are usually made from vulcanized polychloroprene-based rubber compounds, but other synthetic rubbers may be used. They should comply with BS 4255-1. Good weather resistance and resistance to permanent deformation are essential. Integral locking strips or “zipper” type insertions produce a compression grip on the frame structure and the glass. The dimensions of opening, glass and gasket are critical and manufacturers should be consulted for guidance regarding allowable tolerances.

Corners of gaskets should be factory moulded and where possible should incorporate a secondary pressure seal to ensure weather-tightness between frame and gasket.

Standard H and Y sections are available for most glass thicknesses but special purpose-made gaskets can be provided when necessary.

Ladder gaskets are structural gaskets designed to receive two or more pieces of glass in one structural opening.

b) *Non-structural gaskets.* These products may be of synthetic rubber or plastics and are supplied in solid, tubular or dense sponge form. They should comply with BS 4255-2. They are extruded into many shapes, mainly channel and wedge. They may be used as primary seals where they can be maintained under positive and specified compression. If compression is not provided the gaskets should be mechanically retained in the rebate and top sealed with one- or two-part sealant.

5.3.2.6 Glazing materials for internal glazing. In addition to the materials described for external glazing (see **5.3.2.1**, **5.3.2.2**, **5.3.2.3**, **5.3.2.4** and **5.3.2.5**), the following are suitable for internal glazing only.

a) *Self-adhesive glazing tapes.* These comprise treated cotton-based tapes and black velvet ribbons treated with an adhesive coating on one side.

b) *Simulated washleather and black velvet tapes*

c) *Extruded mastic tapes.* These can also be satisfactory for external glazing of small panes of glass, up to 600 mm major dimension, in sheltered locations.

5.3.2.7 Asbestos-based materials. Woven asbestos fabric tape or channels of soft asbestos material can be used in fire resistant glazing. They should never be used externally unless capped. In addition, a fire resistant adhesive can be used. Any health hazard of these materials should be considered.

5.3.2.8 Non-asbestos based fire-protecting materials. Intumescent glazing materials are available for incorporation in glass surrounds. Such materials, when subjected to fire, expand and fill adjacent gaps and voids. The manufacturers should be consulted.

5.3.3 Selection of glazing materials. General guidance on the selection of suitable glazing materials for any particular glass type is given in Table 4. To assist the designer in further narrowing the choice of glazing materials, information on their properties and use is given in Table 5.

Of necessity, Table 4 and Table 5 can only give general guidance. Therefore, in addition to these specific uses where consultation with the manufacturer is advised, such action is also recommended in those cases where the use of the tables results in the selection of a material with which the designer is unfamiliar in that application.

5.4 Natural lighting

5.4.1 Light transmission. The admission of daylight into buildings is affected by a number of factors, one of which is the light transmittance of the window glass and its variation with the angle of the incident light. Daylighting calculation aids generally include a detailed allowance for this variation for clear transparent glass.

For some purposes, it is sufficient to assume a single value for the light transmittance, corresponding to that due to a diffuse source representing the sky. The light transmittance of multiple glazing is similarly given by the product of the diffuse light transmittances of the individual panes of glass. The diffuse light transmittance frequently forms the basis for corrections to the calculation aids for other types of glass.

The manufacturer should be consulted on appropriate values of light transmittance for specific glasses.

Dirt on the glazing reduces the light transmittance, often by an appreciable extent before becoming noticeable to a building's occupants. Nonetheless, to ensure daylighting levels are adequate for the visual tasks being performed, an allowance for the reduced light transmittance is usually made in daylighting calculations. The glass should also be cleaned regularly (see **5.12.1**).

In most instances the tinted appearance of solar control glasses, whilst reducing the light transmission, has little or no effect on colour discrimination or on the colour appearance of the interior of buildings. It is, however, desirable to take precautions in situations where critical colour judgement will occur.

Attention is drawn to the variation in appearance from both inside and outside that may occur if glasses of different types or thickness are used in a single facade.

5.4.2 Glare. The light transmission of the glass is usually required to be at least as low as 50 % before a perceptible degree of control for sky or reflected glare is achieved.

5.4.3 Obscuration and diffusion. Obscuration and diffusion are controlled mainly by surface treatment of the glass or by the incorporation of a diffusing layer (insulating glazing and laminated glass only).

If the window is outside the normal field of view, diffusing glazing can be used to ease the problems of glare from bright sunlight. However, for glazing installations within the normal field of view, diffusing glazing should be used with extreme caution. Instead of one shaft of bright sunlight entering via, say, one corner of a window, the whole window becomes an extremely uniform bright light source and in many circumstances is totally unacceptable. Samples of glass and manufacturers' literature should be consulted before specifying obscuring and diffusing glasses.

5.4.4 Fading. Clear monolithic window glass rejects approximately half of the ultraviolet content of natural light. This proportion can be increased to about 99 % by using an appropriate interlayer in the construction of laminated glasses. Some tinted solar control glasses have greater rejection properties in the ultraviolet region than clear glass.

The degree of protection afforded by any type of glass will depend on the type of material receiving the radiation. Materials claimed to be fade-resistant will have their life extended by the use of ultraviolet rejecting glasses, whilst those materials not generally regarded as fade-resistant will benefit simply because of the overall reduction in radiation falling upon them whatever its spectral composition.

5.5 Thermal considerations

5.5.1 Solar transmission. When solar radiation is received on a piece of glass, some is reflected, some is absorbed and some is transmitted. The absorbed component is re-emitted, partly inwards and partly outwards, by the process of radiation and convection. The relative magnitudes of each component will depend on the composition of the glass, its surface treatment and whether the glazing is single or multiple, as follows.

- a) *Clear glass.* Gives high solar transmittance together with low solar absorptance⁴⁾ and reflectance. As the angle of the radiation increases to glazing incidence, reflectance increases and transmittance progressively decreases to zero (a feature not specific to clear glass).
- b) *Clear multiple glazing.* Gives slightly lower solar transmittance than a), owing to the additional pane(s) of glass.

c) *Solar control glasses.* Used singly or as the outer pane of multiple glazing. Solar absorptance and/or reflectance is higher than for clear glass, with consequent lower solar transmittance.

d) *Shading devices.* These are generally used in situations where direct or reflected glare or the thermal discomfort of direct sunshine are likely to be a problem.

- 1) Internal shading devices either between two panes or on the room side of the glass are in general less efficient than external devices, and allow different solar heat gains dependent on their position in relation to the glass and their properties.

- 2) External shading devices give more efficient reduction of solar heat gain. They will reduce instantaneous heat gain by ensuring that heat is dissipated externally. When external shading devices are to be used they will need to be considered as a major element in the aesthetic design of the building facade.

e) *Solar control plastic films.* These are normally coloured and/or reflective and may be applied to glass to produce reflecting/absorbing surfaces, the exact performance depending on the construction of the film.

Figure 4 shows examples of the mechanism of solar radiation transfer for:

- 1) 6 mm clear single glass;
- 2) 6 mm body tinted glass, 75/61 (green);
- 3) 6 mm clear double-glazing unit;
- 4) reflective double-glazing unit, 34/25.

The total solar transmittance for a particular glazing configuration comprises the transmitted component together with those parts of the absorbed components re-emitted inwards, for example:

$$(61 + 10)/100 = 0.71$$

in the case of Figure 4(c).

⁴⁾ **absorptance.** The ratio of the solar radiation absorbed by a surface to that falling on the surface.

Table 4 — Summary of usage of glazing materials for various glass types

Clause	Glass type	Clause	Glazing material	5.3.2.1.1	5.3.2.1.2	5.3.2.2.1	5.3.2.2.2	5.3.2.3.2	5.3.2.3.3	5.3.2.3.4	5.3.2.4 a)	b)	c)	5.3.2.5 a)	b)
				Linseed oil putty	Metal casement putty	Non-setting glazing compounds	Two-part rubberizing compounds	One-part sealant: curing types	One-part sealant: solvent release types	Two-part sealant: curing types	Preformed mastic tapes	Extruded solid sections	Cellular strips	Structural gaskets	Non-structural gaskets
5.3.1.2.1	<i>Transparent glass</i>														
	a) Float glass														
	1) Clear			X	X	X	X	X	X	X	X	X	X	X	X
	2) Body tinted			C	C	X	X	X	X	X	X	X	X	X	X
	3) Surface modified tinted			—	—	X	X	X	X	X	X	X	X	X	X
	4) Surface coated			—	—	X	X	X	X	X	X	X	X	X	X
	b) Polished wired glass			X	X	X	X	X	X	X	X	X	X	X	X
	c) Sheet glass														
	1) Clear			X	X	X	X	X	X	X	X	X	X	X	X
	2) Body tinted			C	C	X	X	X	X	X	X	X	X	X	X
	3) Flashed or pot coloured			C	C	X	X	X	X	X	X	X	X	X	X
5.3.1.2.2	<i>Translucent rolled and cast glass</i>														
	a) Patterned			X	X	X	X	X	X	X	X	X	X	X	X
	b) Tinted patterned			C	C	X	X	X	X	X	X	X	X	X	X
	c) Wired patterned			X	X	X	X	X	X	X	X	X	X	X	X
	d) Rough cast			X	X	X	X	X	X	X	X	X	X	X	X
	e) Tinted rough cast			C	C	X	X	X	X	X	X	X	X	X	X
	f) Rough cast wired			X	X	X	X	X	X	X	X	X	X	X	X
5.3.1.3.1	<i>Toughened (tempered) glass</i>														
	Clear rolled, cast			X	X	X	X	X	X	X	X	X	X	X	X
	Enamelled, tinted			—	—	X	X	X	X	X	X	X	X	X	X
	Insulating infill panels			—	—	X	X	X	X	X	X	X	X	X	X
5.3.1.3.2	<i>Laminated glass (all types)</i>			—	—	C	C	C	C	X	C	C	X	X	X
5.3.1.3.3	<i>Multiple glass units</i>														
	Hermetically sealed units			—	C	C	C	C	C	C	C	C	X	X	X
	Stepped hermetically sealed units			C	C	C	C	C	C	C	C	C	X	X	X
Key X denotes suitable; — denotes not suitable; C denotes consider, but dependent on precise details of compound constituents; consult the manufacturers involved.															

Table 5 — Glazing materials

Type	Basic components	Typical life expectancy ^a	Form	Uses	Wind pressure resistance ^b	Comments
0. Linseed oil putty	Linseed oil	See comments column	Bulk	Bedding and fronting	Up to 900 N/m ²	Paint protection essential. Life dependent on paint maintenance. Inspect annually.
1. Metal casement putty	Drying oils	See comments column	Bulk	Bedding and fronting	Up to 900 N/m ²	Paint protection essentials. Life dependent on paint maintenance. Inspect annually.
2a. Non-setting compound	Oils, plasticizers, polymers	See comments column	Bulk	Bedding glass and beads	Up to 1 500 N/m ²	Paint protection not essential, but painting prolongs life. Inspect every year and maintain as necessary. Sealer required for porous surround.
2b. Preformed mastic tape (non-load bearing)	Oils, plasticizers, polymers	Over 15 years	Reels	Bedding	Up to 1 500 N/m ²	Limited load-bearing capability. Use with distance pieces.
3. Gun grade sealant, solvent release type	Synthetic rubber or acrylic polymers and plasticizers	Over 15 years	Bulk or gun packs	Heel bead or bedding beads	Up to 1 500 N/m ²	
4a. Preformed mastic tape, load bearing	Synthetic rubber and plasticizers	See comments column	Reels	Bedding glass	Exceeding 1 500 N/m ²	Drainage is essential.
4b. Solid sections	Vulcanized synthetic rubber or PVC	See comments column	Coils	Bedding glass	Varies according to design and materials	Drainage is essential.
4c. Expanded sections	Cross-linked synthetic polymer or PVC	Over 10 years	Rolls	Bedding glass	Up to 1 000 N/m ²	Drainage should be provided. Resistance to wind pressure can be improved by capping or heel beading with sealant.
5a. Curing gun grade sealant, one-part	Solvent release acrylic sealants, polysulphide, silicone, polyurethane	Over 20 years	Gun packs or bulk	Heel bead and capping	Exceeding 1 500 N/m ²	Cure may be slow owing to concealed position of sealant.
5b. Curing gun grade sealant, two-part	Polyurethane, polysulphide, flexibilized epoxide	Over 20 years	Proportioned packs for on-site mixing	Heel bead and capping	Exceeding 1 500 N/m ²	Cure is unaffected by being in concealed positions.
6. Two-part rubberizing compound	Synthetic rubber, plasticizers	Over 20 years	Bulk	Bedding glass and beads	Exceeding 1 500 N/m ²	Compound is load bearing when cured.
7. Reinforced mastic tape	Foil or fabric, coated or impregnated with mastic compound	2 years to 10 years	Rolls	Covering joints	Up to 1 000 N/m ²	Generally used as a repair system, lapped over glass and frame.
8a. Extruded sections structural gaskets	Vulcanized synthetic rubber	Over 20 years	Factory moulded	Bedding glass	Exceeding 1 500 N/m ²	Drainage essential.
8b. Extruded sections, non-structural gaskets	Vulcanized synthetic rubber or PVC	Over 20 years	Rolls or factory moulded	Bedding glass	Exceeding 1 500 N/m ²	Drainage essential. Joints should be sealed.

^a Typical life expectancy is defined as the number of years during which the compound or sealant can be expected to perform its intended function satisfactorily under normal conditions of weather and exposure when used in accordance with the manufacturer's instructions.

^b These figures should be taken as a comparative guide only, and may be exceeded or attained according to the pane size, the particular material or the glazing system used.

Table 5 — Glazing materials

Type	Basic components	Typical life expectancy ^a	Form	Uses	Wind pressure resistance ^b	Comments
9a. Self-adhesive fabric tape	Cotton or other fibre	Over 20 years	Rolls	Bedding glass	Internal use only	
9b. Self-adhesive velvet tape	Velvet	Over 20 years	Rolls	Bedding glass	Internal use only	
9c. Extruded mastic tape	Vegetable oils	Over 20 years	Reels	Bedding glass	Internal use only	
9d. Asbestos tape	Asbestos fibre	Over 20 years	Rolls	Bedding	Normally internal use only	Used in glazing of fire doors and partitions usually incorporating a suitable mastic sealant.
10. Asbestos channel	Asbestos fibre	Over 20 years	Strip	Bedding	Normally internal use only	Used in glazing of fire doors and partitions usually incorporating a suitable mastic sealant.

^a Typical life expectancy is defined as the number of years during which the compound or sealant can be expected to perform its intended function satisfactorily under normal conditions of weather and exposure when used in accordance with the manufacturer's instructions.

^b These figures should be taken as a comparative guide only, and may be exceeded or attained according to the pane size, the particular material or the glazing system used.

For convenience in calculating the solar loads to a building, the solar performance characteristics of particular glazing configurations are identified by one or other of the following concepts, depending on the method of calculation being used:

- i) **shading coefficient.** The ratio of the total solar transmittance of the glazing configuration to 0.87, 0.87 being the total solar transmittance of a notional 3 mm to 4 mm thick clear glass⁵⁾.

Example. The shading coefficient of the clear double-glazing unit Figure 4(c) is given by:

$$0.71/0.87 = 0.82$$

- ii) **solar gain factor**⁶⁾

solar gain factor. The quotient of the daily mean solar cooling load due to the glazing configuration and the daily mean solar irradiance received on the glazing.

alternating solar gain factor. The quotient of the instantaneous cyclic cooling load due to the glazing configuration and the instantaneous cyclic solar irradiance received on the glazing.

The manufacturer should be consulted on appropriate values of shading coefficient or solar gain factor for specific glasses. Shading coefficients for a selection of clear and solar control glasses used singly are given in Table 5 of DD 67:1980. Solar gain factors for a similar selection of glasses used either singly, as the outer pane of double glazing or in conjunction with internal, mid-pane or external shading devices are given in Tables A5.3 and A5.4 of the CIBS Guide, Section A5 (see footnote⁶⁾).

However, for convenience, typical transmittance characteristics for a selection of glass types are given in Table 6. Similarly, Table 7 and Table 8 give an indication of the influence of different arrangements of louvred blinds used in conjunction with various types of glass.

5.5.2 Thermal insulation. Table 9 gives typical *U*-values for various glazing configurations and different degrees of site exposure. Site exposure is conventionally divided into three categories: sheltered, normal, and severe, as specified in CIBS Guide, Section A3 (Thermal properties of building structures), 1980.

⁵⁾ Definition taken from American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Handbook, *Fundamentals*, 1981.

⁶⁾ Definitions taken from Chartered Institution of Building Services (CIBS) Guide, Section A5, *Thermal Response of buildings*, 1979.

5.5.3 Energy balance of windows. The final energy balance of the glazed area will be a combination of the solar gains and the losses due to conduction, convection and radiation, and these can be calculated, but close cooperation between the supplier, the glass manufacturer and the building designer is required because many of the modes of heat transfer through windows are complex.

5.5.4 Assessment of thermal safety of glass.

Although thermal stress in glass and the need for its assessment is described below, the question of thermal safety related to particular circumstances is not considered, such detail being the subject of glass manufacturers' literature.

Knowledge of the radiation to which the glass is to be subjected and the thermal capabilities of the glass are necessary for the assessment of the thermal safety of glass. One method of assessment is by determining the solar radiation intensity on the glass surface and the air temperature range applicable to the location of the building. These, together with the heat transfer coefficients and the glass absorption allow determination of the appropriate basic temperature difference between the central area of the glass and its edge. This difference is related to the thermal stress and then modified for the type of glazing system, taking account of extraneous effects resulting from curtains, blinds, back-up walls, close proximity to heaters and the like, to derive a stress for actual service conditions. High air temperatures, low rates of air movement, and the insulation provided by curtains, blinds, back-up walls and multiple glazing tend to reduce the loss of heat and uphold the centre temperature. Low temperatures at the edges are maintained by conduction from the glass through the frame to a cold building structure with a large thermal capacity.

The resultant service stress should then be compared with the design stress for the glass. If on comparison the service stress is less than or equal to the design stress, the glass and glazing system can be accepted as thermally safe provided that the edges of the glass are of sufficient quality.

Insulating glass systems have different temperature distribution patterns from those of single glazing because each glass, having absorbed its share of solar energy, transfers some of its heat to other glasses in the system.

Where the application of a solar control film is being considered to a glass already glazed in a building, advice should be sought from the manufacturer on the effect of any additional thermal stress likely to be induced in the glass.

The materials used in framing the glass vary widely in their thermal properties and the details of the frame design are therefore important in determining the temperature gradients near the edges of the glass.

If the frame is in good thermal contact with a heavy masonry structure it will lose heat rapidly to the masonry and stay relatively cool. Blinds and other shading devices interfere with the free movement of air over the glass and they reflect, absorb and reradiate solar radiation. Edge cover is instrumental in causing stress in the edge of sunlit glass but, within the practicable limits consistent with the safe retention of the glass in conventional glazing, changes in the width of edge cover alter the edge stress so little that their effect on the thermal safety of the glass is negligible.

Because the normal mode of thermal breakage of glass is by the action of tensile stress located in and parallel to an edge, the breaking stress of the glass is mainly dependent on the extent and position of flaws in the edges. The condition of the glass edge is therefore extremely important.

Solar control glasses should not be nipped to size and any squares with shelled or vented edges should not be accepted for glazing in orientations subject to direct sunlight. Although a wheel-cut edge is the most satisfactory, laminated glasses may be supplied with worked edges. Where clean cut edges are not permitted, arrises should be created by a wet process, working parallel to the edge and not across the thickness, and the design implications of such an action should be examined.

Some solar control glasses can be toughened and this gives a means of raising the design stress and ensuring safety from thermal fracture. Where solar control glasses are to be used in sliding doors and windows there is always the possibility that, when opened during sunny periods, the overlapping will function as double glazing with little ventilation in the air space, and it is this condition that should be assumed in assessing the thermal safety of glass.

It is important to remember that the thermal safety assessment is based on the behaviour of glass in good condition and properly glazed. Even if the glass is shown to be thermally safe, that safety depends on close adherence to the recommended glazing procedures. All necessary precautions should be taken to see that only glass with edges of an acceptable condition is glazed. The glass should be stored and handled so that no contact with hard bodies can damage the edges and each square should be carefully examined immediately before glazing.