NZS 4223:1985

Amendments No 1&2
Appended

New Zealand Standard

Code of practice for
GLAZING IN BUILDINGS

Part 1

The Selection and Installation of Glass in Buildings

Part 2

The Selection and Installation of Manufactured Sealed Insulation Glass Units.

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This Standard was prepared under the direction of the former Building and Civil Engineering Sectional Committee (38/-) and subsequently the Building and Civil Engineering Divisional Committee (30/-) for the Standards Council, established under the Standards Act 1965. The committee consisted of representatives of the following:

*Building Research Association of New Zealand
Department of Scientific and Industrial Research
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New Zealand Contractors Federation
New Zealand Counties Association
New Zealand Forest Service
*New Zealand Institute of Architects
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New Zealand Master Builders Federation
New Zealand Railways Corporation
New Zealand Sawmillers Federation
New Zealand Timber Importers Association
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The Glass and Glazing Committee (38/17) was responsible for the preparation of the Standard and consisted of representatives of the following organizations in addition to those marked with an asterisk (*) above:

Architectural Aluminium Association
Double Glazing Manufacturers Association of New Zealand
Glass Manufacturers
New Zealand Glass Merchants Federation
New Zealand Sealant Manufacturers

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AMENDMENTS

No.	*Date of issue*	*Description*	*Entered by, and date*

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RELATED DOCUMENTS

Reference is made in this document to the following:

NEW ZEALAND STANDARDS

NZS 1900:____	Model building bylaw
NZS 3504:1979	Aluminium windows
NZS 3619:1979	Timber windows
NZS 4203:1984	Code of practice for general structural design and design loadings for buildings

AMERICAN STANDARDS

ASTM E773-1983	Test method for seal durability of sealed insulating glass units
ASTM E774-1984	Specification for sealed insulating glass units

AUSTRALIAN STANDARDS

AS 1263:1972	Oil-based putty
AS 1288:____ Parts 1-3:1979	Rules for installation of glass in buildings (known as the SAA Glass Installation Code)
AS 2208:1978	Safety glazing materials for use in buildings (human impact considerations)

BRITISH STANDARDS

BS 544:1969	Linseed oil putty for use in wooden frames
BS 2750:	Methods of measurement of sound insulation in buildings and of building elements
Part 5:1980	Field measurements of airborne sound insulation of facade elements and facades
BS 4255:____	Preformed rubber gaskets for weather exclusion from buildings
Part 1:1967	Non-cellular gaskets
BS 5516:1977	Code of practice for patent glazing
BS 5713:1979	Specification for hermetically sealed flat double glazing units

OTHER PUBLICATIONS

Orr, Leighton. Practical analysis of fractures in glass windows, PPG TSR No. 104D and 130.

Turner D P. Window glass design guide, Architectural Press.

BRANZ ALF manual 1980.

CIBS Guide A3. Thermal Properties of Building Structures 1980.

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FOREWORD

This Standard, NZS 4223:1985, supersedes NZS 2258:1969 *Recommendations for glass and glazing.*

As with the earlier editions of the Standard, preparation of this revision was undertaken by a Standards Association committee representative of manufacturers, Government departments, research organizations and users.

Modern techniques, practices and recommendations have been incorporated which make the document suitable for use in New Zealand.

Considerable emphasis has been put on the need to minimize the risk of injury through the careless use of glass. The human impact section of this Standard received long and careful consideration by the committee which it is felt should now result in the reduction of glass-related injuries.

While this Standard was being prepared, a survey was conducted by the Accident Compensation Corporation and the New Zealand Glass, Paint and Wallpaper Merchants' Association, which recorded over a period of approximately six months, details of glass-related accidents. This information, for which the committee was very grateful, was gathered by those responsible for the repair of broken glass and served to emphasize the need to pay particular attention to this section of the document. It is acknowledged that the replies received probably represented only a small proportion of the total accidents for the period and that the problem is much greater than shown by the results of the survey.

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NEW ZEALAND STANDARD

Code of practice for GLAZING IN BUILDINGS

General

1
SCOPE

1.1
This Standard lays down requirements and recommendations for the selection of glass for buildings, paying particular attention to loading, thermal control, and human impact safety as well as general design principles. It also provides a method for the installation of glass in buildings. It is not intended to apply to non-inhabitable buildings for horticultural use.

Part 1 covers design and installation considerations for the general situation and deals with safety requirements. Part 2 relates specifically to sealed insulating glass units.

2
DEFINITIONS

2.1
For the purposes of this Standard the following definitions shall apply:

ANGLE OF INCIDENCE means the angle between the solar rays and a line perpendicular to the surface of the glass.

ANNEALING means the process whereby residual stresses are removed from glass by uniformly and slowly cooling the glass under controlled conditions. Sometimes called ordinary glass, annealed glass may be cut, drilled, or edge worked.

ANTI-BANDIT GLASS means laminated glass specially designed to resist deliberate physical attack.

ANTIQUE OR BLOWN GLASS means hand-made or machine-made glasses of uneven thickness with varying textured surfaces in a range of tints. They are similar in character to medieval glass.

ATTENUATION means the sound reduction process in which sound energy is absorbed or diminished in intensity as the result of energy conversion from sound to motion or heat.

BACK PUTTY means that portion of the compound remaining between the glass and the depth of the rebate after the glass has been pushed into position in the bedding putty.

BACK SEAL. See fig. 1.

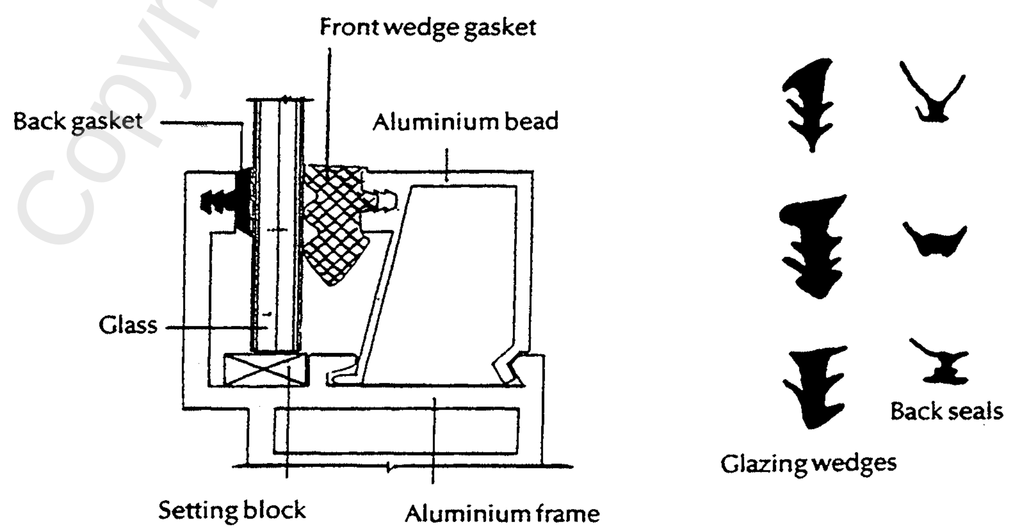

Fig. 1 GLAZING WEDGES AND BACK SEALS

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BACK-UP MATERIAL means a compressible material used in a joint to provide the proper shape factor in a sealant. It controls the depth of sealant and provides support or reinforcement for the sealant. Dependent on joint design, it may also provide a bond breaker, preventing the sealant bonding to the bottom of the joint.

BASE (OF SEALING COMPOUND) means the general composition of a compound, such as vegetable oil, polysulphide, and polybutene. In a 2-part compound, it means the major unit of a compound to which a curing agent or accelerator is added before use.

BEAD OR GLAZING BEAD means a strip of wood, metal, or other suitable material attached to the rebate to retain the glass.

BEDDING PUTTY OR COMPOUND means the compound placed in the rebate into which the glass is bedded.

BEVELLING means the process of edge finishing flat glass to a bevel angle.

BLEEDING means giving up a component, usually liquid.

BLIBE means a gas-filled cavity in glass, larger than seed.

BLISTER means a relatively large gas-filled cavity in glass.

BLOCKS means
(a) SETTING. Pieces of resilient material used between the bottom edge of glass and the surround. A non-absorbent, resilient material should be used with a non-setting compound. See figures 2 and 3.
(b) LOCATION. Pieces of resilient material used between the edges of the glass and frame, other than the bottom, for positioning the glass in the surround as required. In opening windows according to the design and method of opening. See fig. 3.
(c) SPACING. Pieces of resilient non-absorbent material used between glass and rebate and between glass and bead to prevent lateral movement of the glass. See figures 2 and 3.

BOND BREAKER means a release surface to which the sealant will not adhere.

BREWSTER'S FRINGES means the 'rainbow' effect occasionally seen on double glazing. This is not a physical deterioration of the surfaces of the glass, which can be proved by exerting finger pressure on the glass when the effect will be seen to move. The phenomenon is caused by the refraction of light from the four glass surfaces and occurs because of the parallelism of each pane of glass and the close similarity of their thickness. This phenomenon

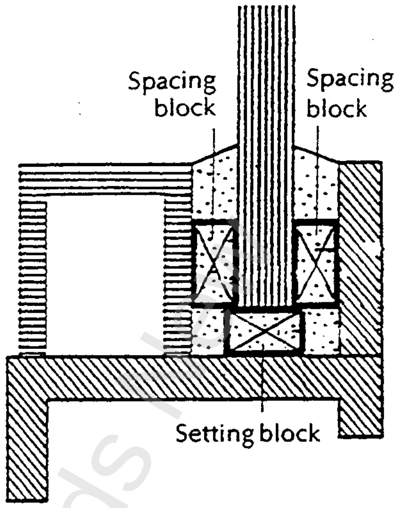
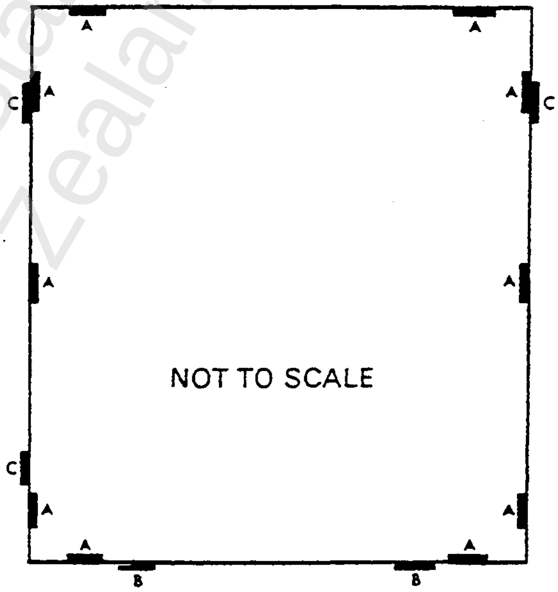


Fig. 2 **SETTING AND SPACING BLOCKS**



A. Spacing blocks (Front and back)
B. Setting blocks (Under bottom edge only)
C. Location blocks
(Side edges as required)

NOTE – This diagram indicates the relationship of the various blocks to the edge of the glass. It is not intended to illustrate recommended positions of the various blocks.

Fig. 3 **PLACEMENT OF BLOCKS**

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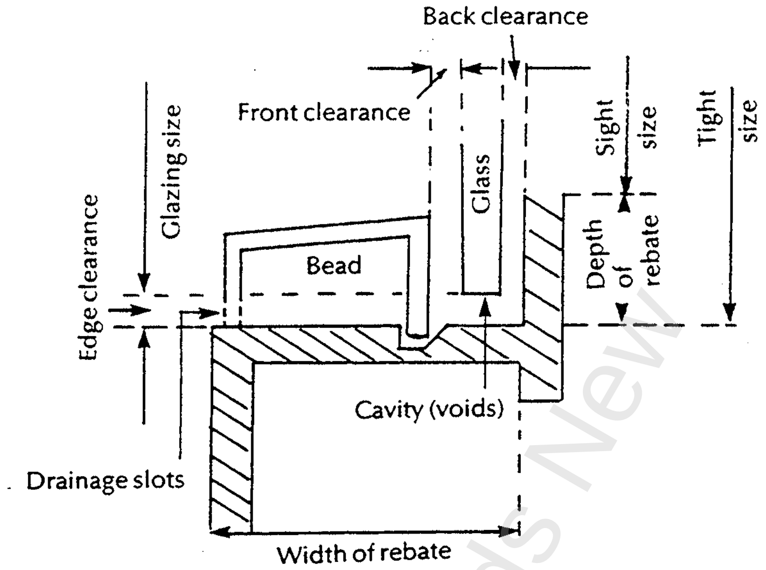

Fig. 4 MEASUREMENT OF CLEARANCES AND OTHER DIMENSIONS

can also occur with glass table tops protecting highly polished furniture.

BUTYL means a synthetic rubber formed by co-polymerization of isobutylene with a small amount of isoprene.

CAME means a lead or zinc strip of H, T, U, and Y sections which holds together the pieces of glass in leaded lights glazing.

CAULK means to fill a void with a sealant. Any oleoresinous sealant.

CAVITY (VOID). See fig. 4.

CLEARANCES. Back clearance. Edge clearance. Front clearances. See fig. 4.

CONDUCTION means the process by which heat flows through or along a material, or from one material to another in contact with it.

CONVECTION means the movement of air (or any gas or liquid) caused by differences in density due to variations in temperature.

CURING AGENT means one part of a 2-part compound that, when added to a base, will cause the compound to set by chemical action.

DOUBLE GLAZING means glazing which incorporates two panes separated by substantially stationary air for the purpose of sound or thermal insulation, or both.

DRAINAGE SLOTS. See fig. 4.

DRAWN GLASS means sheet glass made by a continuous mechanical drawing operation, and has a naturally fire polished surface.

E.P.D.M. means a durable, strong resilient synthetic rubber formulation used in glazing wedges, gaskets, and locking strips.

EDGE POLISHED is a term applied to flat glass, the edges of which have been polished after cutting.

EDGE-WORK means grinding, smoothing, or polishing the edge of flat or shaped glass.

ELASTOMER means an elastic, rubber-like substance.

FLOAT GLASS has two surfaces which are flat, parallel, and fire- finished so that they give clear undistorted vision and reflection, manufactured by floating molten glass in ribbon form upon a heated liquid with a density of greater density than that of glass.

FRONT PUTTY means a triangular fillet of compound formed between the surface of the glass and the front edge of the rebate.

GASKETS means a preformed section, generally of a durable strong and resilient synthetic rubber or plastic formulation, providing a continuous surround for the glass and a weathertight seal when compressed.

GLAZING means the securing of glass or plastics in prepared openings such as windows, door panels, screens, partitions, and skylights.

INSIDE GLAZING means external glazing in which the glass is inserted from inside the building.

OUTSIDE GLAZING means external glazing in which the glass is inserted from outside the building.

INTERNAL GLAZING (in contrast with inside glazing) means glazing, neither side

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of which is exposed outside the building.

EXTERNAL GLAZING (in contrast with outside glazing) means glazing, either side of which is exposed outside the building.

GLAZING CLEAT means a small non-corrosive metal component, usually right-angled in section, secured to the frame to hold the glass in position, in conjunction with distance pieces when necessary. Used with putty glazing.

GLAZING COMPOUND means a setting or non-setting material used in glazing, applied by hand, knife, or gun to provide a bedding for glass and a weather-tight joint between glass and surround.

GLAZING TAPE means a pre-shaped sealing material normally of butyl rubber base furnished in varying thicknesses and widths, in roll form. It may be plain or reinforced with scrim, fibreglass, or other materials, and often has one face or opposite faces pregummed for adhesion.

GLAZING WEDGE. Of a suitable synthetic polymer, for example PVC, E.D.P.M. or neoprene material. See fig. 1.

HEAT SOAKING means a supplementary process whereby toughened glass is exposed to heat treatment to expose product defects due to impurities for example nickel sulphide inclusions. This endeavours to prevent a spontaneous fracture of toughened glass.

HEAT STRENGTHENED GLASS means annealed glass made substantially stronger by a heat treatment process. When broken, cracks are few and shards result, similar to the sizes of shards produced by the breaking of annealed glass of similar thickness.

INCLUSIONS means impurities, such as nickel sulphide, which from time to time appear in the raw material batch for flat glass production. Such impurities cause no problem in annealed or heat strengthened glass, but when such glass is toughened these inclusions can cause spontaneous fracture.

INSULATING GLASS UNIT means a factory-made unit comprising two or more panes of glass, spaced apart and hermetically sealed.

K FACTOR (THERMAL CONDUCTIVITY) means the quantity of heat that will flow through a unit area in unit time when unit difference of temperature exists between the faces of unit thickness of the material.

K = Watts per square metre/hr/°C/m

K = B.t.u. in. per square foot per hour per degree Fahrenheit. (B.t.u. in./ft^2 h °F)

LAMINATED SAFETY GLASS means two or more sheets of normal glass firmly bonded with one or more sheets of plastic.

LOCATION BLOCKS. See BLOCKS.

MASTIC means any of a wide variety of materials including, but not limited to, sealants.

MULTIPLE GLAZED UNITS means a form of glazed unit based on the same principle as the double glazed unit but incorporating three or more panes of glass.

NECKING means the reduced area in cross-section of a sealant that has been elongated.

NEOPRENE means a material brand of a durable strong and resilient synthetic rubber formed by polymerization of chloroprene.

ORGANIC COATED GLASS means glass to which a polymeric sheet or film has been applied on one or both sides.

PANE means a piece of glass cut to size and shaped ready for glazing (often called a square or a light).

POINTING COMPOUND means a non-setting material, available in colour, with a workable consistency and used for filling joints.

POLYMER means a molecule derived by a combination of many smaller molecules, or by the condensation of many smaller molecules eliminating water, alcohol and so on.

POLYSULPHIDE means a synthetic elastomer produced by the reaction of ethylene dichloride and sodium tetrasulphide, and that can be compounded into a 1 or 2 component sealant.

POT LIFE means the time during which a 2-part sealant remains usable after being mixed with a catalyst.

POLYBUTENE covers the various polymers of isobutene, for example Butyl rubber.

PRIME means to condition a surface for subsequent applications.

PRIMER means a liquid compound of brushing consistency applied to a surface to prevent the absorption of oils from the glazing or fixing compounds, or to prevent attack by alkalis on these oils.

PROCESSED GLASS OR DERIVED PRODUCTS are products processed from flat glass.

PVC means polyvinyl chloride, a durable synthetic polymer.

RADIATION means the process by which heat is emitted from a body and transmitted through space as energy.

REBATE means the part of a surround, the cross-section of which forms an angle into which the edge of the glass is received.

SAFETY GLASS means a glass so treated or combined with other materials as to reduce the

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likelihood of injury to persons when it is cracked or broken.

SEALANT means a flexible material placed between two or more parts of a structure, with adhesion to the joining surfaces, to prevent the passage of certain elements such as air, moisture, water, dust, and other matter. They are often used as cappings on joints filled mainly with other materials.

SEALER means a material applied to the glass and frame surfaces, to create a constant contact condition and thereby improve adhesion of the sealant to the surface.

SEED means small gaseous inclusions in glass.

SHADING COEFFICIENT means a number used to compare the solar radiant heat admission properties of different glazing systems. It is calculated by dividing the appropriate transmittance by 0.87 which is the total transmittance of a notional clear single glazing between 3 mm and 4 mm thick.

SHEET means transparent flat glass made by drawing, which has clear naturally fire polished surfaces.

SHELF LIFE means the length of time that packaged materials can be stored under specified temperature conditions and still remain suitable for use.

SIDELIGHT means any glass in a fixed panel adjacent to a doorway which is so located that it may be mistaken for a doorway or for an unimpeded path of travel.

SILICONE means a semi-inorganic compound derived from quartzite.

SIZES:

GLAZING SIZE (glass size) means the actual size of a piece of glass.

SIGHT SIZE (daylight size) means the actual size of the opening which admits light.

TIGHT SIZE (full size, rebate size) means the actual size of the rebate opening.

SKIN means a dry film that forms on the surface of a compound.

SLOPED GLAZING means glazing tilted more than 15° from the vertical and including overhead glazing.

SPRIG means a small headless nail or triangular or diamond-shaped piece of metal, used for securing panes of glass in wooden surrounds, while the setting compound hardens.

SPRING CLIP means a small metal component used for securing panes of glass in metal frames while the setting compound hardens.

SQUARE OF GLASS. See PANE.

TEMPERED GLASS. See TOUGHENED GLASS.

NOTE – There are many other configurations of back seals, glazing wedges and "U" glazing channels. The illustrations are only diagrammatic.

Fig. 5 "U" GLAZING CHANNEL

THERMAL CONDUCTIVITY. See K FACTOR.

THERMAL TRANSMITTANCE. See U VALUE.

TOOL means to work a sealant compound or putty to improve the seal or smoothness or shape or both.

TOUGHENED GLASS (HEAT-TREATED; TEMPERED GLASS) means glass, the surface of which has been rapidly cooled from near the softening point, so that a residual internal compressive stress remains after complete cooling. This increases the thermal and mechanical shock strength of the glass and tends to make it shatter into small and less dangerous fragments than ordinary glass when it is broken.

TRANSLUCENT GLASS means glass which transmits light with varying degrees of diffusion, so that vision is not clear.

TRANSPARENT GLASS means glass in which the visible light transmittance for 6 mm thickness exceeds 85 % with corresponding transmittance for other thicknesses.

"U" CHANNEL GASKET means a suitable synthetic polymer, for example, PVC, E.D.P.M. or neoprene, used in glazing some types of aluminium joinery. See fig. 5.

U VALUE (THERMAL TRANSMITTANCE) means the quantity of heat that will flow through a unit area in unit time when a unit difference of temperature exists between the air on each side thus:

U = Watts per square metre degree Celsius (W/m^2 °C) U = B.t.u. per square foot per hour per degree Farenheit difference of air temperature (B.t.u./ft^2 h °F).

UNITED DIMENSION means the sum of the dimensions of one length and one width of a pane of glass.

VEHICLE means the liquid portion of a compound.

VOID. See CAVITY.

VENT means a crack or run at the edge of a piece of glass which seriously weakens the glass.

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Part 1
The selection and installation of glass in buildings

101 CLASSIFICATIONS

101.1 General

This Part of this New Zealand Standard classifies soda-lime-silica flat glasses into 4 major classifications:

(a) Transparent glass, as defined in 2.1.
(b) Translucent glass, as defined in 2.1.
(c) Processed glass or derived products, as defined in 2.1.
(d) Miscellaneous glass, which are products not accurately defined by the above three items.

101.2 Transparent glass

101.2.1 *Sheet glass*

101.2.1.1 *General*

Transparent sheet glass manufactured by the flat drawn process has natural fire finished surfaces, but as the two surfaces are not always flat and/or parallel, there can be some distortion of vision and reflection.

Table 1 RANGE OF THICKNESSES AND SIZES IN SHEET GLASS

Nominal thickness (*mm*)	*Thickness tolerance* (*mm*)	*Approximate weight* (kg/m^2)	*Maximum size* (*mm*)
2	1.8 to 2.2	5.0	1840 x 1220
3	2.7 to 3.1	7.5	2140 x 1220
4	3.7 to 4.3	10.0	2440 x 1380
5	4.6 to 5.2	12.5	2140 x 1840
5.5	5.2 to 5.8	14.0	or
6	5.7 to 6.3	15.0	2440 x 1380

NOTE –
(1) 2 mm, 3 mm and 4 mm are known as thin sheet glass. 5 mm, 5.5 mm and 6 mm are known as thick sheet glass.
(2) Although 2 mm sheet glass is available, it must not be used for window glazing.

101.2.1.2 *Quality*

Sheet glass is supplied in New Zealand in the following qualities:

(a) *Horticultural quality*. This is used when the admission of light is the major requirement and vision is not important. As its name implies it is only suitable for horticultural use.
(b) *Ordinary quality (O.Q.)*. A clear glass accepted as the standard glazing quality in New Zealand and is always used unless specified otherwise. Stocks of this quality are available. This is equivalent to G.B. of ISO TC/160 (ordinary glazing)
(c) *Selected glazing quality (S.Q.)*. This is selected as a better quality than O.Q., but is used for glazing purposes only when it is specifically required. This is equivalent to G.B. of ISO TC/160 (ordinary glazing)
(d) *Special selected quality (S.S.Q.)*. This is a high quality glass which has been specially selected for high grade work.

101.2.1.3 *Availability*

Table 1 indicates the range of thicknesses, tolerances, approximate weight (kg/m^2), and the maximum sizes normally available in New Zealand.

101.2.1.4 *Body tinted sheet glass*

This is glass in which the whole body of the glass is tinted, resulting from the addition of small quantities of various metallic oxides. Such glass reduces solar radiation transmittance by increased absorption. It is usually available in bronze, grey, and green tints.

101.2.1.5 *Surface coated sheet glass*

This is sheet glass which has a reflective surface layer applied to either a clear or a body tinted base glass. Transmittance of solar radiant energy is reduced mainly by an increase in reflection, as well as absorption.

101.2.1.6 *Coloured sheet glass*

This is a semi-transparent glass which is available in a variety of colours. The colour may be flashed in a thin layer on to the untinted glass, in which case it is called "flashed colour", or the whole substance of the sheet may be tinted, when it is called "pot colour" (such as "flashed blue", "pot blue"). This glass is supplied in one quality only, which is not comparable with the standard qualities of ordinary sheet glass.

101.2.2 *Float glass*

101.2.2.1 *General*

Float glass is manufactured by a process

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whereby molten glass in continuous ribbon form is floated upon liquid metal at controlled temperatures. The glass is transparent; the two surfaces are flat, parallel, and naturally fire polished giving clear and undistorted vision.

101.2.2.2
Quality
Clear float glass is generally supplied in two qualities:
(a) Glazing quality: (selection G) for general window glazing.
(b) Silvering quality: (selection S) for use in the manufacture of mirrors or when a high quality finish is required.
For types other than clear transparent, generally only glazing quality is available.

101.2.2.3
Availability
Table 2 indicates the range of thicknesses, tolerances, approximate weight and (kg/m^2) generally available. Maximum sizes vary from one manufacturer to another. For the availability of thicker glass, refer to individual manufacturers.

Table 2 RANGE OF THICKNESSES AVAILABLE IN FLOAT GLASS

Thickness (mm)	*Tolerance (mm)*	*Approximate weight (kg/m^2)*
2.5	±0.2	6.25
3	±0.2	7.5
4	±0.2	10.0
5	±0.2	12.5
6	±0.2	15.0
8	±0.2	20.0
10	±0.3	25.0
12	±0.3	30.0
15	±0.5	37.5
19	±1.0	48.0
25	±1.0	62.25

NOTE –
(1) 2.5 mm glass shall not be used for window glazing.
(2) Thickness tolerances may vary from manufacturer to manufacturer.

101.2.2.4
Body tinted float glass
This is glass in which the whole body of the glass is tinted, resulting from the addition of small quantities of various metallic oxides. Such glass reduces solar radiation transmittance by increased absorption.

101.2.2.5
Surface modified float glass
This is clear float glass which during manufacture has a coloured layer of metallic ions injected into the glass, to a controlled depth. Surface modified glass reduces solar radiation transmittance by increased absorption irrespective of thickness.

101.2.2.6
Surface coated float glass
This is float glass which has a reflective surface layer applied during manufacture to either a clear or a body tinted base glass. Transmittance of solar radiant energy is reduced mainly by an increase in reflection, as well as by absorption.

101.2.3
Polished plate glass
Polished plate resulted from the grinding, smoothing and polishing of rough textured rolled glass, which provided synthetically polished, flat and parallel surfaces. Polished plate has been superseded by the float glass method of manufacture.

101.2.4
Polished wired glass
This is a transparent glass with metal wires introduced into it during the rolling process and subsequently the surfaces are ground and polished to create flat and parallel surfaces.

101.3
Translucent glass

101.3.1
Patterned glass
This is a translucent glass manufactured by the rolling process, which creates a textured pattern to one or both surfaces. Light is transmitted with varying degrees of diffusion so that vision is not clear but is partially and in some instances almost completely, obscured.

101.3.2
Tinted patterned glass
This is patterned glass, but with the body of the glass tinted during manufacture. The tints are incorporated either for decorative purposes or to give solar control properties, and should be specified according to the property required.

101.3.3
Wired patterned glass
This is a translucent glass with metal wires introduced during the rolling process.

101.3.4
Tinted wired patterned glass
This is wired patterned glass but with the body of the glass tinted during manufacture, for decorative purposes only. It is not recommended for exterior use as there would be a risk of thermal fracture.

101.4
Processed glass

101.4.1
Insulating glass units
Factory-made insulating glass units consist of at

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least two panes of glass, assembled in a factory, and with various forms of edge sealing according to the process. The panes are separated by one or more hermetically sealed spaces containing dehydrated air or gas. The units provide both thermal and acoustic insulation.

101.4.2
Toughened glass

101.4.2.1
Toughened glass is a safety glazing material produced by subjecting annealed glass to a process of heating followed by rapid cooling which induces high compression in the surface and a compensating tension in the centre. Because of this pre-stressing, toughened glass is less liable than annealed glass to break as a result of impact, mechanical load, or thermal stress. Its resistance to breakage is approximately 4 to 5 times that of annealed glass. If toughened glass should break, it will fragment into comparatively harmless pieces.

101.4.2.2
Pre-determined sizes are necessary because once the glass has been toughened it cannot be cut or worked.

The following types of toughened glass are available:
(a) Clear float or sheet
(b) Body tinted float or sheet
(c) Surface modified float
(d) Surface coated float or sheet
(e) Patterned glasses
(f) Cladding glass – this is normally clear float, sheet, or patterned glass which has a coloured ceramic enamel fired on to one surface during toughening. An extensive range of colours is available. Various types of materials can be fixed to cladding glass to improve its insulation properties.

101.4.3
Heat strengthened glass

101.4.3.1
Heat strengthened glass is obtained by a heat treatment process which results in a product approximately twice as strong as the annealed glass from which it was made. The process increases the ability of the glass to withstand thermal pressures and impact loads and although it is less likely to break than annealed glass, when the glass is broken it tends to remain in position since its break cracks are few in number and their interlocking pattern limits relative movement. Pre-determined sizes are necessary because once the glass has been heat strengthened it cannot be cut or worked.

101.4.3.2
All types of glass that can be toughened can also be heat strengthened.

101.4.4
Chemically toughened glass
Chemically toughened glass is becoming available particularly for incorporation as very thin, relatively strong leaves in laminated glass. Chemically toughened glass will not necessarily break into small harmless pieces, but the toughening process is essentially a means of increasing the mechanical strength.

101.4.5
Laminated glass

101.4.5.1
Laminated glass is a safety glazing material which normally consists of two or more panes of glass separated by a plastic interlayer (for example polyvinyl butyral). When the glass is broken the interlayer holds the fragments of glass preventing separation.

101.4.5.2
Because laminated glasses may be made up with a wide variety of glass types, interlayers, interlayer thickness, and treatments to perform a variety of functions, manufacturers should be consulted before specification.

101.4.5.3
Although all laminated glass can be said to be a safety glazing material, certain laminates afford protection against a specified level of attack (for example, security glazing materials) and can also provide solar control and acoustic properties.

101.4.6
Organic coated glass

101.4.6.1
It is possible to modify the properties of a glass pane by applying to one or both surfaces a polymeric coating, sheet, or film. Such treated glass can have enhanced performance in terms of solar control, thermal insulation, and safety.

101.4.6.2
Organic coatings are usually applied to glass after installation. Because of the wide range of properties conferred by the coatings, it is important to discuss with the manufacturer or his agent the correct coating and any restrictions which may apply to its application.

101.5
Miscellaneous glass

101.5.1
Diffuse reflection glass

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101.5.1.1
This glass has one or both surfaces lightly textured so as to produce slight diffusion without excessive obscuration, thus reducing the nuisance of reflection. Its main use is in picture frames and cover glasses for instruments.

101.5.1.2
It is essential that the glass be glazed close to the picture or dial. The distance must not be more than 20 mm, depending on type.

101.5.2
Glass blocks
These are glass units, transparent or translucent, produced by a pressing process in which two hollow "dishes" are formed and subsequently fused together to form a hollow hermetically sealed block. Because of the cavity, glass blocks give a very significant degree of heat and sound insulation.

101.5.3
Glass lenses
Glass lenses are translucent pressed glass units. They are manufactured in a variety of sizes and shapes and are used for pavement lights, roof lights, and vertical lights. They can be toughened.

101.5.4
Channel glass
Channel glass is formed by rolling glass into the form of a shallow U-section, the flanges of which impart sufficient strength to enable each length generally to be fixed at the ends only. It has a textured surface and is therefore translucent. It is also manufactured in wired and body tinted forms and can be toughened.

101.5.5
Antique glass
This glass is hand or machine made and is of uneven thickness with varying textured surfaces in white, streaky white, and a range of tints in character to medieval glass. It is used mainly for decorative purposes, lead lights, and stained glass windows.

101.5.6
Bullions
Bullions, or roundells, were originally the thick central portion obtained from spun Crown glass and are now also made as a simulation.

101.5.7
Lead or x-ray glass
This glass contains a large percentage of lead oxide and has a high degree of opacity to x-ray radiation.

101.5.8
Heat resistant glass
This glass is manufactured using a higher proportion of silica and introducing boric acid. It is also called borosilicate glass. It can be used at much higher temperatures and resists more severe thermal shock conditions than ordinary soda lime glass.

102
WORK ON GLASS

102.1
General
This Section sets out descriptions and illustrations of typical methods of working glass. The main processes, comprising cutting, obscuring, and the various decorating processes, are described.

102.2
Cutting processes

102.2.1
Edgework and bevelling
Details of edgework and bevelling are set out in table 3.

102.2.2
Brilliant cutting
Brilliant cutting is a decorative process employed for cutting designs on glass whereby various types of cuts (V cuts, edge cuts, panel cuts, round cuts, and decorative motifs such as punts and hollows) are made by bringing the glass to bear on a wheel of the required section; the cuts, unless otherwise specified, are then smoothed and polished. The different types of cuts are illustrated in fig. 6.

102.2.3
Finger slotting
This is a feature obtained on the surface of the glass by allowing the edge of a smooth stone wheel to penetrate the surface. The typical detail of a finger slot is shown in fig. 7. A finger slot (also known as a 'cut sunk finger grip') is a purely functional surface treatment in glass of virtually all types to facilitate easy sliding of glass doors. Since finger slots are made by the controlled grinding of a wheel into one side of the glass, they vary dimensionally according to the diameter and width of the wheel. However, a typical size is 65 mm x 20 mm x 3 mm. Finger slots are usually smooth ground, but can be polished.

102.2.4
Engraving
Engraving is a decorative process usually applied to hollow glassware, but sometimes also to flat glass, whereby the surface of the glass is cut by a small revolving wheel with or without an abrasive. The cut may or may not be polished.

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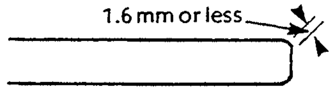
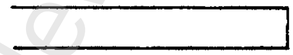
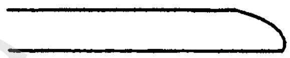
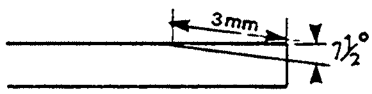
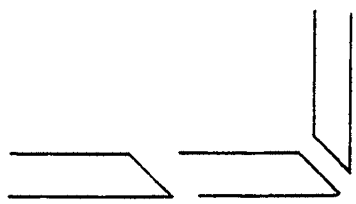
Table 3 EDGEWORK AND BEVELLING

Term	*Form*	*Finish*	*Illustration*
1. Arris edge	A small bevel of width not exceeding 1.6 mm at an angle of approximately 45° to the surface of the glass.	Ground, smoothed or polished	
2. Flat edge	The cut edge of the glass is flat and the surface edges are slightly arrised.	Ground, smoothed or polished	
3. Round edge	The cut edge of the glass is slightly curved to form an arc of a circle.	Ground, smoothed or polished	
4. Half round	Half of the cut edge of the glass is rounded approximately in the form of a quarter circle. The remaining surface edge is slightly rounded.	Ground, smoothed or polished	
5. Full round	The cut edge of the glass is rounded approximately in the form of a semi-circle.	Ground, smoothed or polished	
6. Thumb or bullnose	The surface edge of the glass is curved in a shape resembling the profile of a thumb.	Ground, smoothed or polished	
7. Bevel	The surface edge of the glass is bevelled to 3 mm or more in width as required. The angle formed by the intersection of the plane of the bevel with the face of the glass is about 7½°.	The bevel is polished unless otherwise specified. The nose of the bevel is left as cut	
8. Mitre bevel	The cut edge of the glass is bevelled to an angle of approximately 45° (unless otherwise specified): the extreme point is slightly arrised. If required the knife edge can be slightly radiused to form an arc of a circle when in contact with the corresponding edge of another plate.	Ground, smoothed or polished	

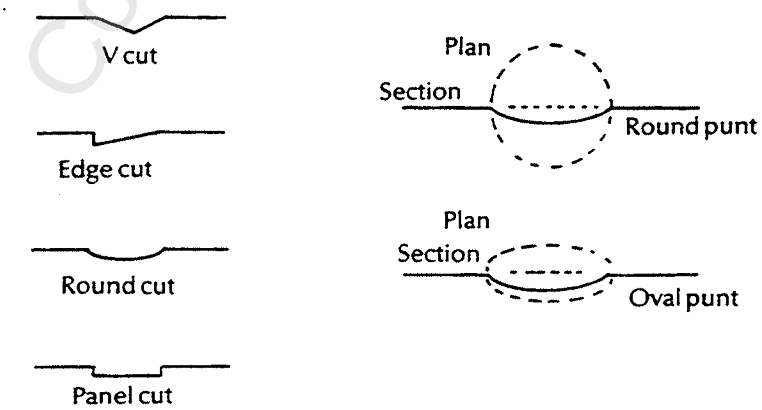


Fig. 6 TYPES OF BRILLIANT CUT (NOT TO SCALE)

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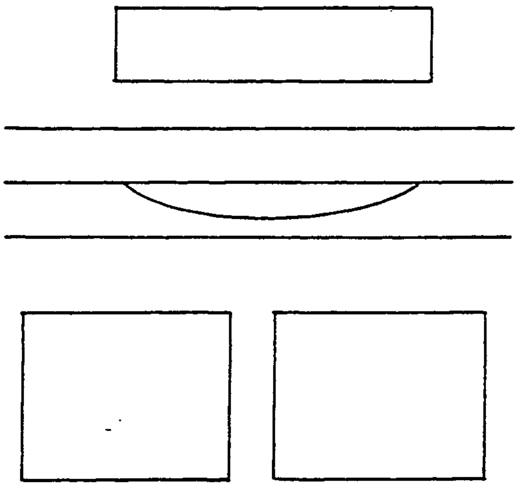

Fig. 7 FINGER SLOT (OR CUT SUNK FINGER GRIP) (NOT TO SCALE)

102.3
Obscuring processes

102.3.1
General
Obscuring processes involve treatment of the whole or part of the surface of glass after manufacture, whereby vision through the glass is obscured to varying degrees and the light diffusing properties of the glass are increased. Decorative effects are also obtained by these processes. Such treatments can reduce the strength of the glass.

102.3.2
Sandblasting
Sandblasting is a process whereby the surface of glass is obscured by means of a jet of abrasive propelled against it. The finish will be fine, medium, or coarse according to the pressure of the jet and the nature of the abrasive used.

Varieties are as follows:
(a) *Plain.* Surface obscuration only, either all over or with part left clear to produce designs.
(b) *Shaded.* A process producing delicate gradations of obscuration.
(c) *Grave or modelled.* A process producing a design of varying depth.

102.3.3
Grinding
Grinding is a process whereby the surface of glass is obscured by grinding with an abrasive. In general, grinding produces a finer surface than sandblasting; the fineness depends on the nature of the abrasive used.

102.3.4
Acid embossing
Acid embossing is a process whereby the surface of glass is obscured by treatment with hydrofluoric acid or its compounds. The degree of obscuration and the character of the surface produced depends upon the number of treatments with acid and the form of acid used.

NOTE – "Brights" are any portions of the glass which are not treated with acid and which form part of the design.

102.3.5
Acid stippling
Acid stippling is a process whereby the surface of glass is obscured by treatment with a mixture of acid and an inert substance. The depth of penetration of the acid accordingly varies over the surface of the glass, a stippled effect thus being produced.

102.4
Silvering

102.4.1
Silvering is a process whereby silver is deposited on the glass and covered or coated with a protective medium. The term "silvering" is also used to describe the deposition on glass of other metals, such as "gold silvering", "copper silvering", and the like.

102.4.2
Although protective coatings are applied to the depo sited silver during mirror production, such protection does have limitations and should not be regarded as fully protective for all situations. Extra protection should be provided where damp or highly humid conditions prevail, or where chemical attack from the fixing surface may occur. This protection can be provided by methods such as a metal foil or an extra coating of the mirror back. Mirror manufacturers should be consulted.

102.4.3
Striped silvering (venetian silvering)

102.4.3.1
Striped silvering is the process which produces alternate bands of silver and clear glass to form what is often referred to as "one-way vision glass".

102.4.3.2
One-way vision can also be achieved by the use of reflective glass. The governing factor is the

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light ratio between the two sides of the glass and it is essential that the side of the glass facing the subject of observation is more brightly lit, than the side from which observation takes place. To be effective, different types of reflective glass with differing light transmittance properties will require different lighting levels. The light ratio necessary may vary from between 12:1 to 2:1. The individual manufacturers should be consulted.

102.5
Gilding
Gilding is a process employed largely for lettering and decorative work, whereby leaf metal such as gold leaf is applied to the surface of glass and coated with a protective medium.

102.6
Staining or painting and firing
Staining or painting and firing is a process whereby glass is first coated with a fusible pigment, and subsequently fired so that the colour becomes permanent.

102.7
Shaped, drilled, and notched glass

102.7.1
Shape cutting

102.7.1.1
Glass may be cut to irregular shapes. Where the shape is relatively uncomplicated, such as raked panes, cutting can be carried out to given measurements. For more complicated shapes, involving corners to radius or irregular cut-outs, a template should be provided. For shape cutting of glass with a directional pattern or different surface finishes, it is necessary to identify the face of the template. It should also be stated whether a template is actual glass size or whether an allowance has been made for cutting around it.

102.7.1.2
It is desirable to avoid shapes with acute internal corners since these are points of weakness if the glass is put under stress. When such shapes are unavoidable, a radius in the corner should be made as large as possible.

102.7.2
Drilling

102.7.2.1
The drilling of holes in glass is generally carried out on the processor's premises.

102.7.2.2
As holes are a potential weakness in glass, they should not be drilled too close to the edges of the glass. As a general rule the edge of the hole should not be closer to the edge of the glass than the thickness of the glass.

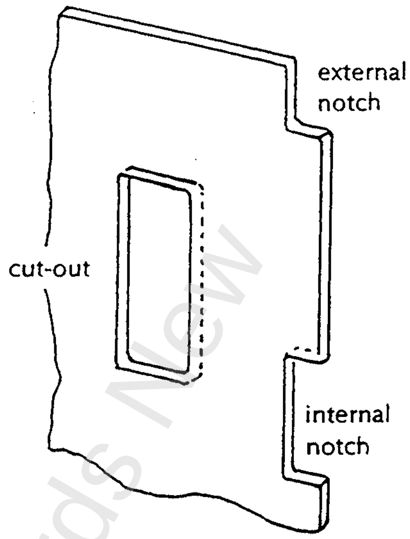

Fig. 8 RELATIVE POSITION OF NOTCHES AND CUT-OUT

102.7.2.3
Processors place certain limitations on the size, shape, number and positioning of holes. Processors' technical notes should be consulted.

102.7.3
Notches and cut-outs

102.7.3.1
Shapes cut at the edge of glass are known as 'notches'. Those involving one 90° corner are described as external, and those with two 90° corners as internal notches (see fig. 8).

The various shapes are achieved by:
(a) Cutting
(b) A combination of drilling and cutting
(c) A combination of sawing and cutting.

102.7.3.2
Shapes cut from the body of the glass are known as cut-outs and are illustrated in fig. 8.

102.7.3.3
Notches and cut-outs should be free from vents, otherwise breakage may occur in service. Exposed edges of cut-outs may be finished by smoothing or polishing. Cutting or drilling of solar control glasses is not advisable due to the risk of breakage.

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102.8
Bending
Bending is the formation during heating of a curved shape for all or part of a pane of glass. Most types of flat annealed glass can be bent. The glass is heated in a kiln until it softens sufficiently to allow formation over a mould. It is cooled slowly (re-annealed) to allow further cutting. Subject to certain limitations, toughened and laminated bent glass can be produced.

103
DESIGN CONSIDERATIONS

103.1
General

103.1.1
The specifications for windloading and design loadings for all glazing systems are the responsibility of the building designer. This clause provides a method by which the designer may arrive at an appropriate choice of glass and glazing systems.

103.1.2
The procedure detailed in fig. 9 may be useful in the selection of the glass and the glazing system. The following clauses are directly related to fig. 9. It has been assumed that:
(a) The glazing locations, their shapes, and preliminary sizes have been decided as part of the normal building process;
(b) The designer will have acquired information on glazing used in similar circumstances; and
(c) The designer is aware of the implications of any innovatory design.

103.1.3
Constraints

103.1.3.1
Before selecting glass types and glazing systems there are three basic constraints which the designer should have considered:
(a) *Design requirements.* These could include aesthetic considerations, psychological factors (for example, view, sunlight control, daylight admission), 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 glass.

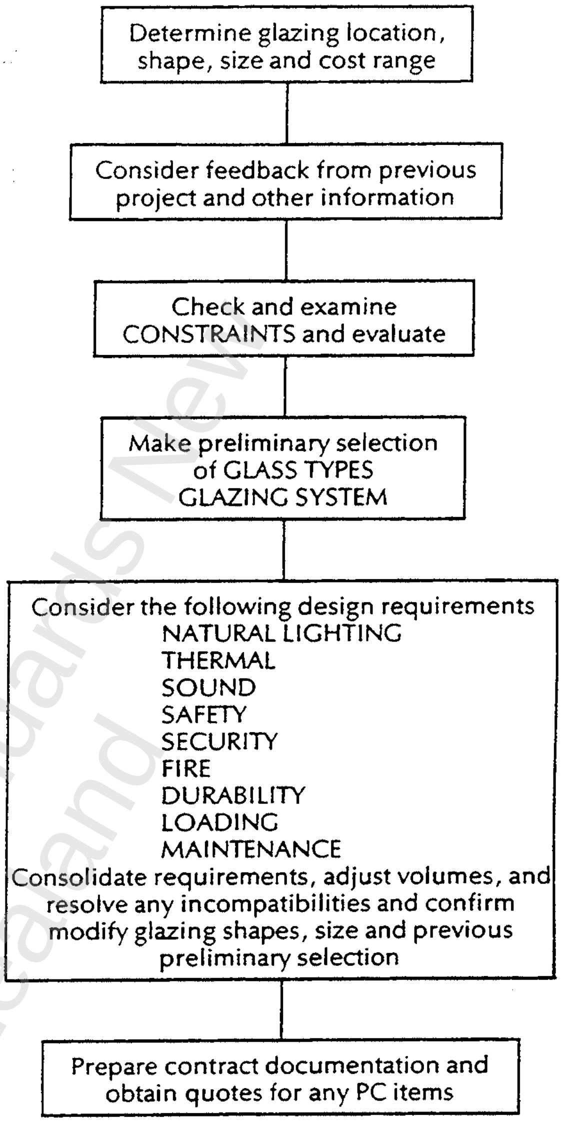

Fig. 9 DECISION PROCEDURE FOR GLASS DESIGN

(b) *Mandatory requirements.* The size and type of suitable glasses and in some cases of the glazing system and surrounds may be restricted by mandatory requirements contained within NZS 1900 or this Standard.
(c) *Cost.* This involves consideration of:
  (i) The capital cost of the glazing systems
  (ii) The effect of the glazing on the building capital and running costs related to heating, lighting, and ventilation
  (iii) The maintenance of the glazing system.

103.1.3.2
Factors affecting the initial glazing cost include:
(a) Type, size, and thickness of glass
(b) Method of glazing

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(c) Materials used to seal the system
(d) Access for initial glazing (glazing from inside or outside, need for scaffolding, etc,
(e) Whether continuity of work can be provided
(f) Whether glazing is done in the factory or on site
(g) Whether the system has to be protected by paint.

Of these factors the most likely to affect maintenance costs are:
(i) materials used to seal the system
(ii) access for reglazing
(iii) ease of reglazing, including whether or not the glazing materials have to be repainted.

103.1.3.3
The comparative costs of materials should be considered in conjunction with their life expectancy and probability of need for maintenance. The use of more expensive glasses such as solar control glass or insulating glass units or both, should take into account the possibility of lower running costs and fuel economy.

103.1.4
Selection of glazing
When the designer has evaluated the effect of these constraints a preliminary selection of glazing can be made. Details of design requirements are given in later clauses. These requirements should be considered in order to check the validity of the initial selection.

103.2
Natural light

103.2.1
General
There are well established methods of predicting the amount of natural light which will enter a building as well as established codes for natural and artificial lighting related to the building type and the tasks which are to be performed. The satisfactory balance, both qualitative and quantitative, of natural and artificial lighting can be found either by calculation or by measurement.

In considering natural light, it is usual to separate daylight and sunlight.

103.2.2
Light transmittance is the fraction of visible light at normal incidence that is transmitted through the glazing. Visible light has a special distribution corresponding to the CIE (Commission Internationale de l'Eclairage) Standard Illuminant C. This is approximately the same as daylight. If, for any glass, the light transmittance is required not for normal incidence but for a CIE standard overcast sky with vertical or horizontal glazing, or for a sky of uniform luminance distribution, it can be found by multiplying the tabulated light transmittance by the factors in the table below. Thus the transmittance of a vertical 6 mm proprietary surface modified float glass with a 51% visible light transmittance for a CIE sky is 0.51 x 0.91 = 0.46.

Diffuse source factor	*Glazing position* vertical	horizontal
CIE standard overcast sky	0.91	0.94
Uniform sky	0.92	0.92

103.2.3
Glare

103.2.3.1
Classification
Glare associated with windows can be conveniently regarded as appearing in three forms: direct glare, sky glare and reflected glare.

103.2.3.2
Direct glare
Direct glare is caused by a direct view of the sun or by viewing direct sunlight through a diffusing medium which itself becomes a bright source. It can be a serious problem and is best controlled by choice of the orientation of the facade or by mechanical shading, such as blinds or louvres.

103.2.3.3
Sky glare
Sky glare is caused by bright areas of sky in the field of view. It occurs under cloudy conditions and is usually controllable by correct choice of glass and in some cases by suitable shading.

103.2.3.4
Relected glare
Reflected glare is caused by the reflection of sunlight from light-coloured surfaces or water and this too can usually be controlled by choosing the correct glass or some form of shading.

103.2.4
Glass

103.2.4.1
Tinted glass
The glasses that can be used to control both sky and reflected glare are tinted, but for most normal situations the tint is not noticeable from within a building. It is important that tinted glasses should not be glazed alongside clear glass or glass with a different tint in the same area if unwanted visual effects are to be avoided. Normally, inside a building, the eye adapts very rapidly to the slightly modified light passing through tinted glasses and colour discrimination is virtually unaffected.

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104.2.4.2
Light transmission
Typical light transmission factors for different types of glasses are given in table 4.

Table 4 TYPICAL LIGHT TRANSMISSION PROPERTIES FOR DIFFERENT GLASS TYPES

Glass type	*Transmission*
Clear glasses – 4 mm	– 0.88
25 mm	– 0.72
Patterned glasses	0.74 – 0.85
Surface modified and body tinted glasses	0.14 – 0.78
Solar energy reflecting laminated glass	0.16 – 0.39
Solar energy reflecting insulating glass unit	0.12 – 0.47
Surface coated reflective glass	0.08 – 0.33

103.2.5
Fading
Clear monolithic glass rejects approximately half of the ultraviolet content of natural light. This proportion can be increased 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 that are not fade-resistant will have their life extended by the use of ultraviolet rejecting glasses.

103.3
Thermal considerations

103.3.1
Thermal control

103.3.1.1
Design information
The conflicting requirements of solar gain and heat loss must be considered in relation to the total heat balance of the building and glazing areas.

103.3.1.2
Solar transmission

103.3.1.2.1
The effects of solar transmission can be considered in two ways:
(a) Solar gains which occur during the summer months, November to April
(b) Solar gains which occur during normal heating season, April to November.

Unwanted summertime solar gains can be dealt with by means of window geometry and orientation, glazing systems, and various forms of shading. Solar radiation can be subjectively stimulating and economically useful; but it can cause discomfort by overheating and glare, with consequent reduction in human efficiency. Direct solar radiation can also adversely affect some industrial processes.

Solar gains which occur during the heating season can be used to advantage by considering 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 north of the east-west axis can be positive, that is the useful solar gains can more than equal the conduction losses due to the window.

103.3.1.2.2
Control of solar heat by choice of glazing
Solar heat may be controlled by the following types of glazing:
(a) Clear glass – depending on the percentage of glazing, orientation, and detail design
(b) Clear, double, or multiple glazing – these give slightly less transmission than (a) above due to the additional glass
(c) Solar control glasses – these are reflective and/or absorbent to different degrees. The types and properties of solar control glass which can be incorporated as single, double, and multiple glazing are summarized in table 5 as described later
(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
   (i) Internal shading devices, either between two panes or on the room side of glazing, are in general less efficient than external devices and allow different solar heat gains depending on their position in relation to the glass and their properties
   (ii) 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 radiant heat properties are given in table 5.

103.3.1.2.3
When radiation is incident on a piece of glass, some is reflected, some is absorbed, and some is transmitted directly. The relative amount of each component will depend upon the composition of the glass itself and also whether or not the glass is in the form of single or multiple glazing.
Fig. 10 shows examples of the mechanism of solar radiation transfer for:
(a) Clear single glass
(b) Clear insulating glass units
(c) A typical reflective insulating glass unit.

NOTE – BRANZ ALF manual gives data on the average winter seasonal heat and the balance of windows in various orientations.

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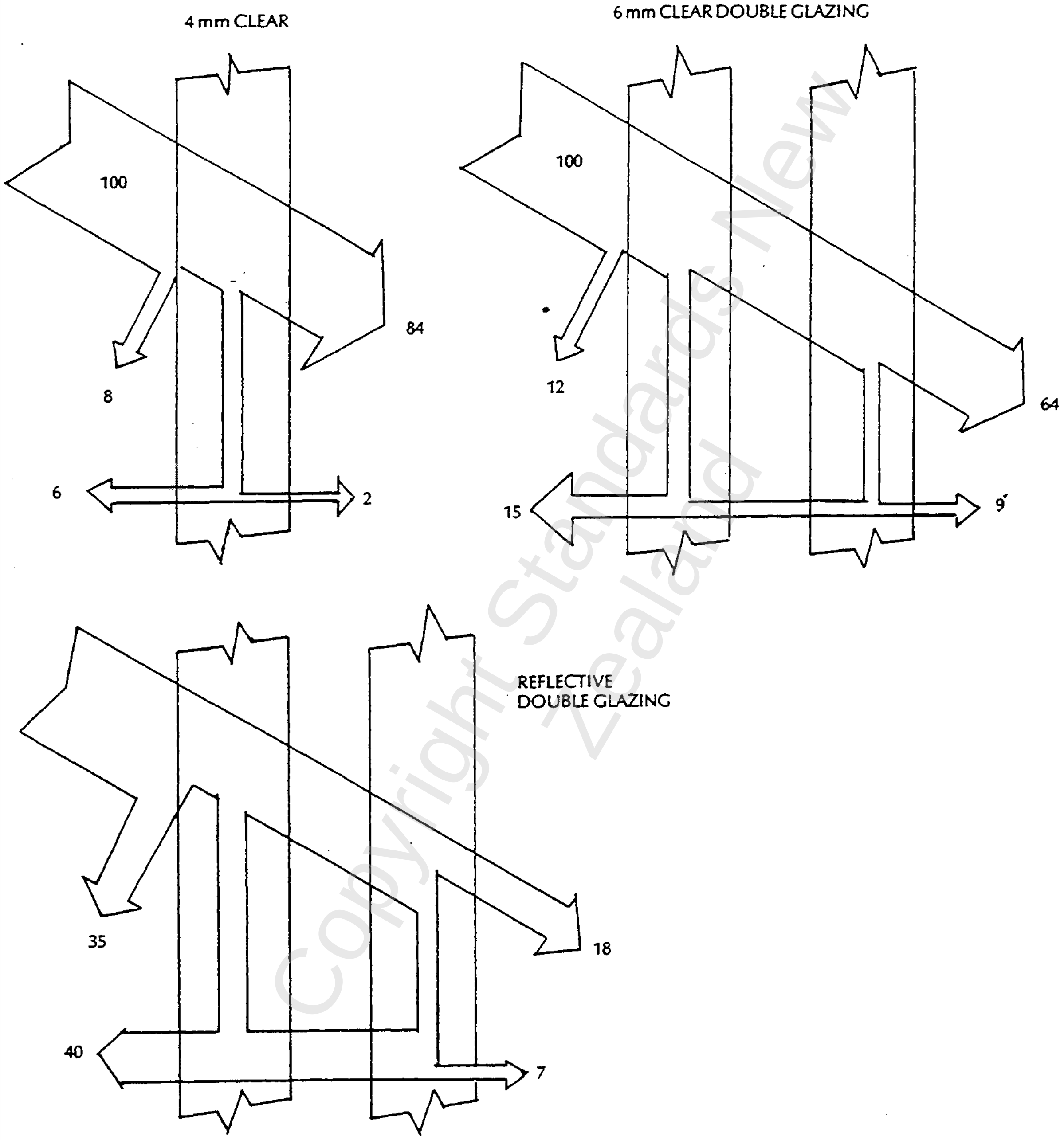

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Fig. 10 EXAMPLES OF TOTAL TRANSMISSION CHARACTERISTIC

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Table 5 TYPICAL SOLAR RADIANT HEAT PROPERTIES FOR GLASSES

Glass type	*Reflectance*	*Absorptance*	*Direct transmittance*	*Total transmittance*	*Shading coefficient*
4 mm clear monolithic glass	0.07	0.11	0.82	0.85	0.98
6 mm clear monolithic or laminated glass	0.07	0.15	0.78	0.83	0.95
6 mm body tinted monolithic glass	0.05 to 0.06	0.49 to 0.51	0.44 to 0.46	0.60 to 0.61	0.69 to 0.70
6.5 mm tinted interlayer laminated glass	0.04 to 0.07	0.19 to 0.82	0.13 to 0.74	0.46 to 0.80	0.52 to 0.92
6-10 mm surface modified monolithic glass	0.09 to 0.10	0.36 to 0.42	0.49 to 0.54	0.62 to 0.65	0.71 to 0.75
6 mm surface coated monolithic glass	0.06 to 0.33	0.44 to 0.82	0.05 to 0.37	0.20 to 0.53	0.23 to 0.61
6.5 mm inner surface coated laminated glass	0.12 to 0.57	0.34 to 0.75	0.04 to 0.45	0.19 to 0.54	0.21 to 0.62
6 mm + 6 mm clear glass double glazed unit	0.11	0.28	0.61	0.71	0.82
6 mm surface coated plus 6 mm clear glass double glazed unit	0.06 to 0.58	0.41 to 0.84	0.03 to 0.28	0.10 to 0.41	0.12 to 0.47
6mm clear glass with solar films applied	0.08 to 0.65	0.31 to 0.55	0.06 to 0.50	0.18 to 0.62	0.21 to 0.71

Shading coefficient is the ratio of the total transmission of the glass to 0.87.

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103.3.1.2.4
Table 6 gives a range of values of the components for selection of glass types. The use of shading devices either in the form of external canopies or internal blinds or blinds within the cavity will modify the performance of the glass. Table 7 gives an indication of the influence of different properties of blinds as detailed according to types.

103.3.2
Thermal insulation
Double and multiple glazing provide a greater degree of protection against heat loss than single glazing. Double and multiple glazing are the means of reducing heat loss through a glazed area where light transmission is also required. Glass can also be used in conjunction with other insulation materials to reduce heat loss through the opaque building fabric. A single pane of glass offers comparatively little resistance to the loss of heat by conduction. This can be improved by the use of double or multiple glazing. The insulation increases with cavity width to a spacing of about 20 mm beyond which there is no significant gain. Surrounds of high thermal conductivity will provide direct paths of heat flow and thus losses can be reduced by the use of thermal breaks.

103.3.2.1
Heat loss through glazing is dependent on the temperature difference on either side of the glass and whether or not multiple glazing in some form is in use. In multiple glazing a layer of still air will reduce the heat transfer across the cavity resulting from the separation of the panes of glass. The thermal transmittance (U value) is a convenient method of specifying the glass thermal insulation properties. To determine the total instantaneous heat loss for a particular glass configuration it is a simple matter of multiplying the U value (measure in W/m^2K) by the area of glazing and by the temperature difference related to each side of the glazing.

103.3.2.2
Tables 8 and 9 give typical U values for various glazing configurations that is, different air space widths and also for different degrees of site exposure. Site exposure is conventionally

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Table 6 SHADING COEFFICIENTS FOR A SELECTION OF 6 mm GLASSES WITH VARIOUS ARRANGEMENTS OF LOUVERED BLINDS

Window design	*Shading coefficient*				
	No blinds	*Opaque materials: medium performance blinds*		*Translucent materials: medium performance blinds*	
		Louvres at 45° to plane of glass	*Louvres closed*	*Louvres at 45° to plane of glass*	*Louvres closed*
Clear single glass	0.95	0.62	0.50	0.62	0.63
Heat absorbing glass	0.69	0.50	0.46	0.50	0.52
Insulating units, 12 mm air space, both panes clear glass	0.82	0.58	0.50	0.58	0.60
Insulating units, 12 mm air space, inner pane clear glass and outer panes heat-absorbing glass	0.54	0.40	0.37	0.40	0.42
Insulating units with 20 mm or greater air space, louvres between panes, both panes clear glass	–	0.29	0.21	0.41	0.45
Insulating units with 20 mm or greater air space, louvres between panes, inner pane clear glass, outer pane heat absorbing glass	–	0.25	0.21	0.31	0.34

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Table 7 SOLAR OPTICAL PROPERTIES OF GLASS AND BLINDS MATERIALS CONSIDERED IN TABLE 6

	Reflectance	*Absorbance*	*Direct transmittance*
Solar radiation at normal incidence			
Clear glass	0.07	0.15	0.78
Heat absorbing glass	0.05	0.51	0.44
Opaque material blind	0.55	0.45	0.00
Translucent material blind	0.40	0.20	0.40
Solar radiation at 45°			
Clear glass	0.09	0.15	0.76
Heat absorbing glass	0.07	0.53	0.40
Opaque material blind	0.40	0.53	0.07
Translucent material glass	0.40	0.27	0.33

divided into three categories: sheltered, normal, and exposed as specified in CIBS Guide Book A3 1980 *Thermal properties of building structures.*

103.3.3
Thermal balance

103.3.3.1
The final energy balance of glazing will be a

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Table 8 THERMAL TRANSMITTANCE OF SINGLE GLAZING – AGGREGATE "U" VALUES IN W/m²K

Percentage frame area	10			20			30		
Exposure	*Sheltered*	*Normal*	*Severe*	*Sheltered*	*Normal*	*Severe*	*Sheltered*	*Normal*	*Severe*
Wooden frame	4.6	5.2	6.2	4.3	4.8	5.7	3.9	4.4	5.2
Aluminium frame without thermal barrier	5.0	5.6	6.7	5.0	5.6	6.7	5.0	5.6	6.7
Aluminium frame with thermal barrier	4.8	5.3	6.4	4.6	5.1	6.0	4.3	4.8	5.6
Glass without frame	5.0	5.6	6.7						

Table 9 THERMAL TRANSMITTANCE OF INSULATING GLASS UNITS – AGGREGATE "U" VALUES IN W/m²K

Percentage frame area	10			20			30		
Exposure	*Sheltered*	*Normal*	*Severe*	*Sheltered*	*Normal*	*Severe*	*Sheltered*	*Normal*	*Severe*
Wooden frame									
6 mm air space	3.0	3.2	3.5	2.8	3.0	3.3	2.6	2.7	3.0
12 mm air space	2.6	2.8	3.1	2.5	2.6	2.9	2.3	2.5	2.7
Aluminium frame without thermal barrier									
6 mm air space	3.4	3.6	4.1	3.6	3.8	4.4	3.7	4.1	4.7
12 mm air space	3.0	3.3	3.6	3.3	3.5	4.0	3.5	3.8	4.3
Aluminium frame with thermal barrier									
6 mm air space	3.2	3.4	3.7	3.1	3.3	3.7	3.1	3.3	3.6
12 mm air space	2.8	3.0	3.3	2.8	3.0	3.3	2.8	3.0	3.3
Glass without frame									
6 mm air space	3.2	3.4	3.8						
12 mm air space	2.8	3.0	3.3						

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combination of the solar gains and the conduction losses and can be calculated but it requires close co-operation between the supplier, the glass manufacturer, and the building designer because many of the modes of heat transfer through windows are complex.

103.3.3.2
Establishing the thermal balance of a glazing system during the heating season. The thermal balance of the glazed walls will have to be established by taking into account the following factors which are specific to those walls:

(a) Thermal loss by transmission
(b) Usable solar energy entering through the glazing
(c) Reduction of thermal loss produced by internal or external closing devices (netting, curtains, shutters)
(d) Energy corresponding to the useful natural lighting available in the premises
(e) For single glazing, the additional energy expended with a view to obtaining comfortable thermal conditions.

For opaque walls, in general only the first item of the balance is taken into account that is the thermal loss by transmission.

103.3.4
Thermal stress

103.3.4.1
Whenever heat absorbing and reflecting

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glasses are used and are likely to be subjected to solar radiation, the effects of the window design on the creation of excessive thermal stresses in the glass should be considered during the design of the window details.

103.3.4.2
Clear annealed and float glasses which have been modified by the application of reflective plastic film, to either of the faces, must be considered as heat absorbing glasses.

103.3.4.3
Because the method of application will generally leave at least the edge cover dimension free of the film, the characteristic heat absorbing glass condition of "hot centre/cold edge" will be enhanced. This may increase the thermal service stress beyond the design stress of the parent clear glass and create the possibility of thermal fracture. The risk may be increased if the edge condition of the parent glass is not of the standard considered acceptable for heat absorbing glass.

103.3.4.4
It is important with double glazing and solar control glasses, to minimize stress. With such glasses it is essential that the edges of panes be cleanly cut. Glass with nipped or damaged edges should not be used because of the risk of cracks starting from edge flaws.

103.3.4.5
Assessment of thermal safety of glass

103.3.4.5.1
Although thermal stress in glass and the need for its assessment are discussed, thermally safe or unsafe applications related to particular circumstances are not considered, such detail is 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 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 blinds 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.

103.3.4.5.2
The resultant service stress is then 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 glazed glass are of sufficient quality.

103.3.4.5.3
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.

103.3.4.5.4
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.

103.3.4.5.5
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 re-radiate solar radiation.

103.3.4.5.6
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.

103.3.4.5.7
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.

103.3.5
Edge condition

103.3.5.1
Solar control glasses must not be nipped to size and any squares with shelled or vented edges should not be accepted for glazing on orientations subject to solar radiation. Although a wheel cut edge is the most satis-

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factory, laminated glasses may be supplied with worked edges. Where clean cut edges are not permissible, arrises should be created by a wet process, working parallel to the edge and not across the thickness and the design implications of such action should be examined.

103.3.5.2
Most solar control glasses can be toughened or heat strengthened 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.

103.3.5.3
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 must be taken to see that only glass with edges of an acceptable condition is glazed. The glass must 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.

103.3.6
Breakage evaluation

103.3.6.1
General

103.3.6.1.1
Frequently, the only clues to the cause of glass fracture are contained in the broken glass and by studying the form the fracture takes and the broken pieces, the most likely cause can be deduced and precautions can be taken to reduce the risk of recurrence.

103.3.6.1.2
Most of the evidence is contained in the type and pattern of markings that appear on the new surfaces created by the fracture, each of the two sides of the crack being a mirror image of the other. The remaining clues come from the pattern of cracks across the surface of the glass.

103.3.6.1.3
By an examination of the break origin, it is possible to estimate the stress that caused failure.

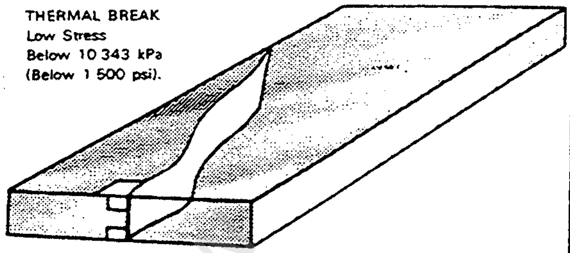

Fig. 11 THERMAL BREAK – LOW STRESS

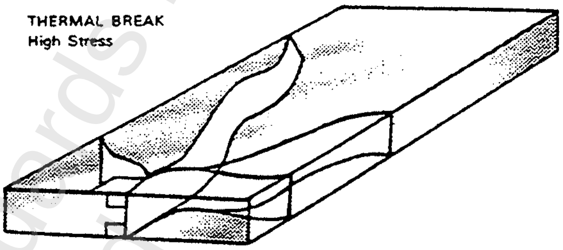

Fig. 12 THERMAL BREAK – HIGH STRESS

103.3.6.2
Fracture by solar radiation
Breaks in annealed glass can be identified by the following characteristics:

(a) A thermal break line always makes a right angle with the edge of the glass at or near the origin
(b) If the break line does not separate into two or more lines within 50 mm of the edge and the origin a low stress caused the failure. This indicates that the glass edge was damaged. See fig. 11.
(c) If the break line separates into two or more lines within 50 mm of the edge (more lines indicate higher breaking stress), it indicates that the surrounding conditions are causing a high temperature difference between the centre portion and the edge of glass. See fig. 12
(d) At the break origin is a mirror surface and the radius of the mirror surface increases as the stress causing failure decreases. If the mirror surface is so large that a radius cannot be measured (quite common with thermal breaks) it means that the stress which caused failure was less than 10 343 kPa. Failure at 10 343 kPa or less means that the edge was damaged, or was not originally clean cut. See figures 13 and 14.

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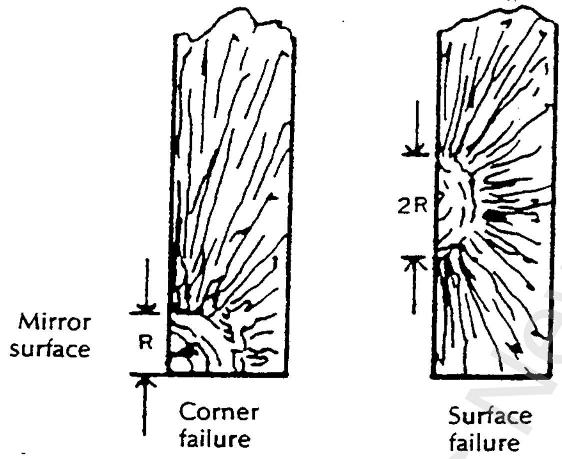

Fig. 13 EXAMPLES OF PURE TENSION FAILURES INCLUDING THERMAL BREAKS

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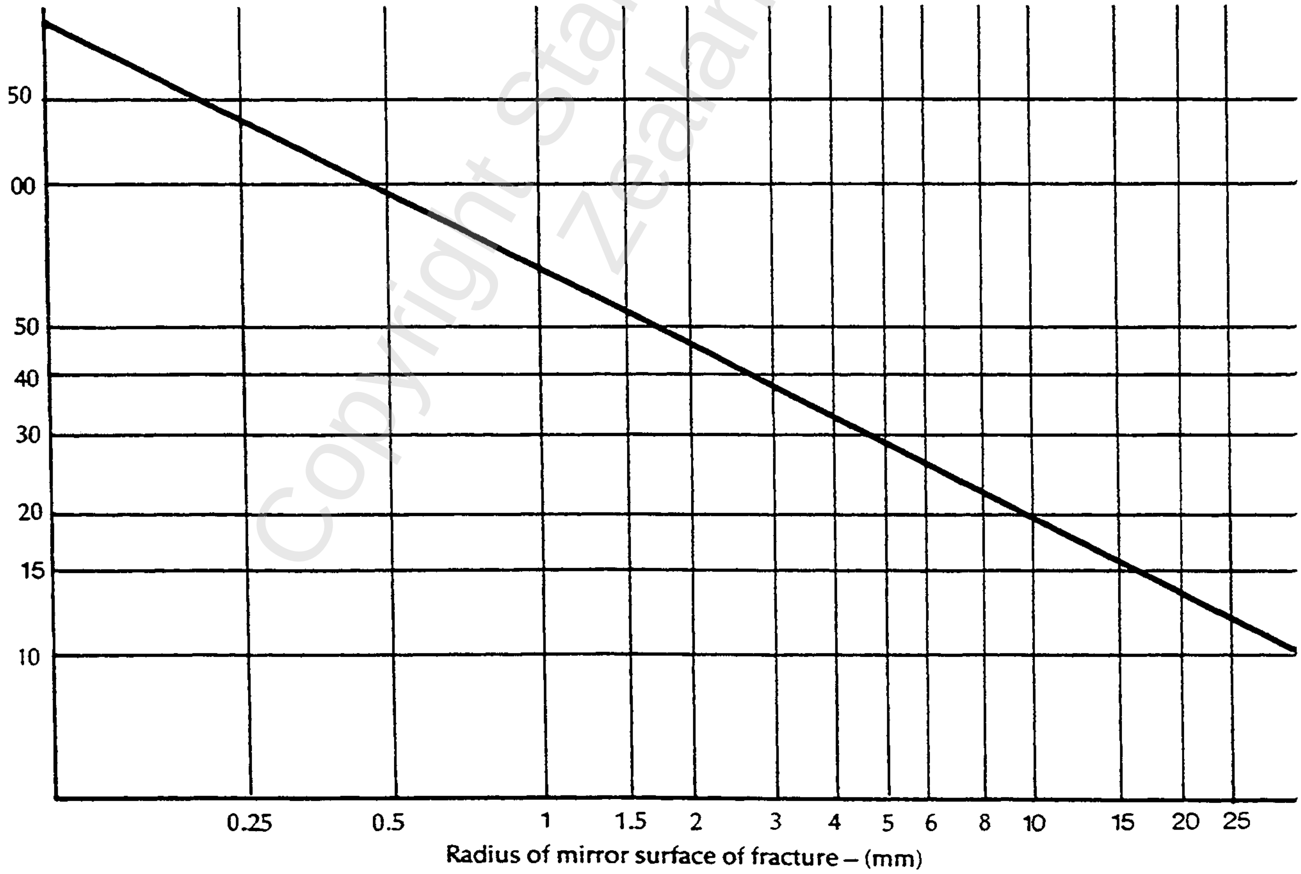

Fig. 14 RADIUS OF FRACTURE

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103.3.6.3
Fracture of mechanical loads
Mechanical breaks (such as bending, edge pressure) can be identified by the following characteristics:

(a) If the break line does not make a right angle with the edge of the glass at or near the origin, this indicates a low stress below 10 343 kPa tension break from bending. See figures 15 and 16

103.3.6.4
Fracture by impact

103.3.6.4.1
Impact damage either to the edge of the glass or to the face of the glass is very easy to determine, as the point of impact is normally clearly visible, from which cracks radiate in several directions. See figures 17 and 18.

103.3.6.4.2
For more detailed information refer to "Practical Analysis of Fractures in Glass Windows" by Leighton Orr PPG TSR No. 104D and 130.

103.4
Sound

103.4.1
General

103.4.1.1
In recent years there has been a significant increase in the levels of externally generated noise, particularly from traffic and aircraft. The successful reduction of transmitted noises requires an appraisal of three elements:

(a) The noise source and relative position
(b) The receptor
(c) The acoustic filter.

103.4.1.2
Each of these is frequency dependent, so that a careful analysis of the full spectrum of the offending noise relative to these is necessary for the successful resolution of noise problems.

103.4.1.3
The weakest point for sound transmission through an external wall is usually the window. This is due in part to air gaps and cracks which can occur round the frame and in part to the fact that conventional single glazing has relatively low sound insulation. In addition, windows are often opened to allow for natural ventilation and in this case sound insulation will be negligible, regardless of the glazing system employed.

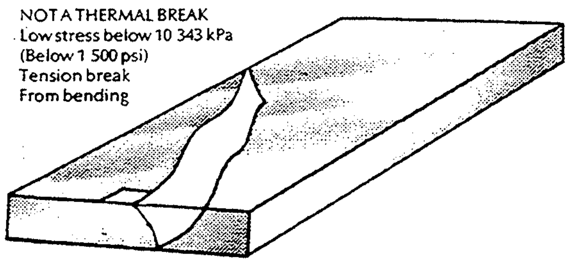

Fig. 15 NON-THERMAL BREAK

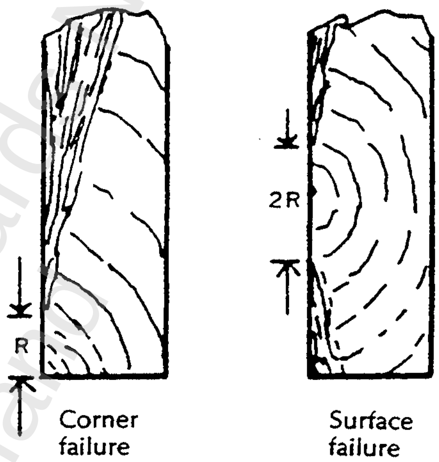

Fig. 16 EXAMPLES OF TENSION FAILURES FROM BENDING

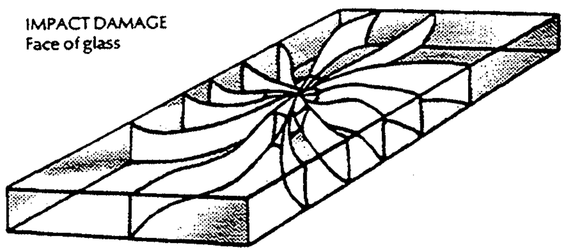

Fig. 17 IMPACT DAMAGE – FACE OF GLASS

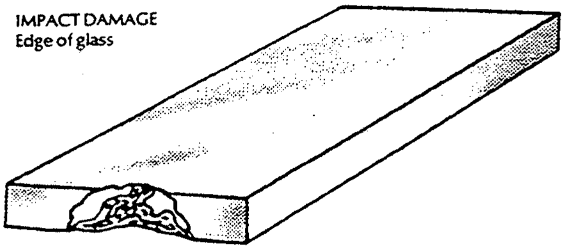

Fig. 18 IMPACT DAMAGE – EDGE OF GLASS

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103.4.2
Design considerations

103.4.2.1
There are a number of factors to be considered, all of which affect the characteristics of sound transmitted through a closed window.

103.4.2.1.1
Window size
Doubling the area of glass will mean that amount of energy admitted is doubled and this will increase the level of transmitted sound by 3 decibels (dB). Similarly, halving the area of window will reduce sound levels by 3 dB. 3 dB can be described subjectively as a just-noticeable difference only. Clearly a significant change in window area is necessary before noise levels are affected to any noticeable degree and therefore reducing the window area is not an important factor in improving sound insulation.

103.4.2.1.2
Glass
(a) *Thickness*. Three effects are dependent on thickness.
   (i) The 'MASS LAW' EFFECT. For a given frequency, doubling the mass and therefore the thickness of a piece of glass will theoretically increase its sound insulation by 6 dB.
   (ii) PANEL RESONANCES. A glass panel can resonate at certain frequencies depending on its size, stiffness, and mounting as well as its mass. The effect of resonance can be to impair sound insulation at low frequencies, such as traffic noise. The thinner the glass the lower will be the frequency at which fundamental resonance occurs.
   (iii) The COINCIDENCE EFFECT. At a certain frequency the wave length of sound will be the same as that of the natural oscillation of the glass and consequently the transmission loss through the glass is reduced. This gives a characteristic 'coincidence dip' in the insulation frequency range. The greater the thickness of the glass, the lower will be the frequency at which the coincidence dip occurs. Laminated glass will minimize the effect of coincidence. The overall sound insulation of laminated glass is marginally better than that of monolithic glass of similar thickness, most of this improvement occurring in the coincidence region.
(b) *Differences in pane thickness*. When two parallel glasses are of equal thickness, a drop in sound insulation will occur at the coincidence frequency of the individual panes. By employing glasses of different thicknesses, this loss will not occur at the same frequency and thus an improved sound insulation performance will result.
(c) *Non-parallel panes*. Theoretically, non-parallel panes ought to show better acoustic insulation than parallel panes. However, unless the angle of incidence of noise is well defined, this improvement is negligible. With moving or line sources (such as road traffic) there is no advantage in using non-parallel panes.

103.4.2.1.3
Mechanical separation
On a double window, the vibrations of the first pane can be transmitted to the second, not only across the air space but also via the frame. This may be reduced by flexible mounting of the surround of at least one of the panes.

103.4.2.1.4
Air space
In multiple glazing systems the width of the air space between panes is the most important factor. In general the wider the air space the better and a separation of 150 mm to 200 mm, with the glasses in separate frames, is usually required when insulating against severe noise sources. With wide air space double windows, additional benefit can be obtained by lining the reveals with an acoustic absorbent material. Care must be taken to ensure that this lining does not come into contact with the frames.

Tight fitting windows are essential; small gaps have a marked influence on the overall efficiency so, where possible, arrangements should be made to obtain the necessary ventilation of rooms by means other than opening windows. If ventilation has to be provided by the windows, some sound insulation can be achieved by using sliders and by opening the inner and outer windows at opposite ends. This provides a baffle and can give sound insulation similar to closed single glazing.

103.4.2.1.5
A single figure, in decibels, is often given when describing the sound insulation of a particular window. Such a figure is the arithmetic mean of the values of insulation measured in each of 16 third-octave bands (according to BS 2750). However, this means that different glass substances with different insulation spectra could be represented by the same single figure for insulation. A single figure should, therefore, be regarded as an approximate rather than as an exact indication of performance. A more satisfactory way of describing the noise reducing properties of glass is to list the complete insulation frequency range. In this way, and by knowing the spectrum of the noise source, a designer will be able to decide which

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Table 10 SOUND INSULATION (dB)

Centre frequency of third-octave band	*Glass thickness (mm)*					*Thickness of glass/air space/glass (mm)*						*Laminated glass*
						6/12/6 unit	*10/12/6 unit*	*10/100/6*	*10/200/6*	*6/200/6*	*6/200/6*	
						Sound absorbent in reveals						
(HZ)	*4*	*6*	*8*	*10*	*12*	*no*	*no*	*yes*	*yes*	*yes*	*no*	*3/0.76/3*
100	20	22	23	24	25	21	22	26	33	32	32	26
125	20	22	24	25	26	27	28	29	37	35	35	26
160	21	23	25	26	27	27	28	32	39	38	37	24
200	22	24	26	27	28	23	24	34	41	40	38	26
250	23	25	27	28	29	25	25	36	42	42	39	27
315	24	26	28	29	31	28	29	38	44	43	41	27
400	25	27	29	30	32	29	30	40	45	45	43	28
500	26	29	30	31	33	31	31	42	47	46	44	29
630	27	30	31	32	33	32	32	44	48	47	45	31
800	28	31	32	32	32	33	33	45	49	48	46	33
1000	29	31	32	31	29	34	34	47	50	49	46	36
1250	30	31	29	27	26	33	34	47	50	50	46	37
1600	31	28	26	27	30	31	33	48	50	49	44	37
2000	29	25	28	31	34	27	34	50	51	44	39	38
2500	26	27	32	35	37	29	35	52	52	47	41	37
3150	23	31	35	37	40	34	36	54	54	52	46	37
4000	28	34	38	40	42	36	38	56	56	55	49	39
Mean (100-3150 Hz)	25	27	29	30	31	29	31	42	46	44	41	31
STC RATING	27	29	30	32	30	31	33	42	47	46	44	

NOTE – Under laminated glass, the 0.76 is the interlayer thickness and the 3 mm is the glass thickness.

glass types will be most effective. In particular he can check that the coincidence dip does not occur at the same frequencies as the predominating frequencies of the noise source.

103.4.2.1.6
A selection of insulation frequencies for typical glasses is given in table 10. Because of the variation in results of sound insulation measurements from different laboratories these values represent averaged results derived from a range of published measurements.

103.4.2.1.7
It has been determined by the Building Research Establishment in the U.K. that the type of frame material, wood or metal, makes no significant difference to sound insulation; the important factors are that the frame should be of good quality and have means of providing adequate sealing.

NOTE – Laminated glass has certain sound insulation properties; special sound control laminated glass can be designed to minimize sound transmission. By choosing the appropriate combination of glass and interlayer thickness, insulation can be provided against traffic, aircraft, factory, and office noise. Because of the complexity of laminated glass design, the manufacturer should be consulted for particular applications.

103.4.3
Safety

103.4.3.1
General

103.4.3.1.1
Glass and plastics of suitable type, thickness, and size should be selected to provide an appropriate degree of safety, taking into account the intended use. In addition to considering the risks of accidental impact, or where activities generate a special risk, the following criteria should also be taken into account:
(a) Wind loading (see 103.10.5)
(b) Fire (see 103.7)
(c) Security (see 103.6).

103.4.3.1.2
For internal doors, the wind loading is negligible, but the possible risk of accidental human impact could be appreciable.

103.4.3.1.3
The recommendations in this subclause are based on the best informed opinion available. The main criteria are:
(a) The characteristics of the glass and plastics glazing sheet materials under impact and the mode of fracture. Dependent on the location, the glass and plastics need to have different properties. These are:
   (i) No break. The glass and plastics remain undamaged and serviceable.
   (ii) 'Break safe'. Fracture of the glass and plastics gives either relatively harmless pieces or insufficient penetration to allow serious injury.
   (iii) Containment. Fracture of the glass and plastics gives no significant penetration.

These three characteristics should be determined for single panes of glass or plastics or for the individual panes of double glazing, by testing in accordance with AS 2208. When it is required that the glass or plastics, on impact, should remain in position and be unbroken, the specifier should consult the manufacturer.
(b) The building and its use, particularly the number and likely behaviour pattern of the

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people expected to be in close proximity to the glazed area.

103.4.3.1.4
The assessment of these criteria, and the subsequent glass and plastics specification, is the responsibility of the designer or other specifier. Clause 103.5.4 gives guidance on the minimum standards that should be accepted. It is for the specifier to consider whether, in a particular case, these standards are sufficient.

103.4.3.2
Risk areas

103.4.3.2.1
General
The situations in which risks can exist, being dependent on the criteria described in 103.4.3.1, can be described in general terms only.

103.4.3.2.2
Not every accident is avoidable but many injuries are due to failure to provide protection of the glazed area at vulnerable points. Standards of safety assume reasonable standards of human behaviour for appropriate age groups. In most buildings glass and plastics in areas not defined in 103.5.4 do not usually give a significant risk, neither are these recommendations intended to apply to internal display fitments or display windows.

103.4.3.3
Fracture characteristics of glasses

103.4.3.3.1
General
The energy requirement to cause fracture and penetration will vary with the type and particular composition of the glass.
The safety characteristics of glasses can be identified using the classiciation in AS 2208.

103.4.3.3.2
Annealed glass
(Such as float glass, sheet glass, patterned glass, tinted float glass). If annealed glass is broken and penetrated and pieces are dislodged, the resulting glass edges will be sharp. The risk of breakage under human impact is reduced where annealed glass is used in accordance with table 12.

103.4.3.3.3
Wired glass
Wired glass, if broken after impact, will be held together by the wires and penetration is unlikely except under higher impacts, where the wires are broken. If penetrated, the characteristics of the edges are similar to those of annealed glass.

103.4.3.3.4
Laminated glass
The fracture characteristics will be similar to those of the basic types of glass used but the pieces will remain substantially adhered to the plastics interlayer. The broken glass, when containing an interlayer, such as 0.38 mm thick PVB, is unlikely to be penetrated. Much greater penetration resistance is given with thicker PVB interlayers.

103.4.3.3.5
Toughened (tempered) glass
Thermally toughened soda-lime glass is difficult to penetrate, but if broken it fragments into small, relatively harmless pieces.

103.5
Safety (Human impact safety requirements)

103.5.1
General
The locations where glass is likely to be subjected to human impact are as defined by 103.5.4. In these locations glass shall comply with the human impact safety requirements of this Section as well as with the requirements of 103 and 104 where appropriate. Glass installed at greater than 15° from the vertical is not covered by this Section (see NOTE (4)).

103.5.2
Provision is made for the use of a Grade A* safety glazing material, a Grade B* safety glazing material, and ordinary annealed glass. Grade B safety glazing materials may be used in lieu of ordinary annealed glass in the circumstances where ordinary annealed glass is permitted, and with the same area and thickness limitations, but ordinary annealed glass shall not be used where Grade B safety glazing materials are specified.

Glazing materials which do not comply with AS 2208 shall not be considered as safety glazing materials.

NOTES –
(1) *Risk of breakage.* The application of the requirements of this Section will reduce the risk of glass breakage and subsequent injury caused by human impact. If the glass should be broken, the likelihood of cutting and piercing injuries will be minimized by the limited size of the glass or by the fracture characteristics of the glass.
(2) *Manifestation of glass.* When transparent glass is used in doors and adjacent side panels it is recommended that it be marked by a motif or other decorative treatment to indicate its presence. Such marking is not a substitute for other requirements in this Section.
(3) *Repairs.* Where it is not practicable to replace damaged panels that do not comply with this Part of this Standard, with glazing materials in accordance with this Section, the owner may specify the type of material that was previously used if currently permitted by the local authority.

* As specified in AS 2208.

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(4) *Glass at an angle greater than 15° from the vertical.* The manufacturer of the glass should be consulted for design data when glass is used at greater than 15° from the vertical and may be subject to human impact.
(5) Safety plastics materials may be used where they comply with the requirements of AS 2208.

103.5.3
Identification of safety glazing materials

103.5.3.1
Each original panel of safety glazing material shall be legibly marked in accordance with AS 2208.

103.5.4
Glass selection for minimizing injury

103.5.4.1
Framed glass doors
Framed glass doors shall be glazed with Grade A or Grade B safety glazing materials in accordance with table 11 except that ordinary annealed glass in accordance with table 12 may be used in any one of the following cases:
(a) The clear opening width of the glass is not wider than 500 mm at any part, or
(b) The lowest part of the glass is 200 mm or more above the highest finished floor level abutting it, or
(c) The clear opening height of the glass does not exceed 1000 mm, or
(d) The door is provided with a horizontal rail or bar located with its upper edge not less than 700 mm, or its bottom edge not more than 1000 mm above the finished floor level abutting it. The horizontal rail or bar shall have a face width of at least 40 mm and shall take the form of a fixed glazing bar or a rigid push-bar firmly attached to the stiles to protect each face of the glass.

103.5.4.2
Framed glass side panels
Framed glass side panels shall be glazed with Grade A or Grade B safety glazing materials in accordance with table 11 except that ordinary annealed glass in accordance with table 12 may be used in any one of the following cases:
(a) The clear opening width of the glass is not wider than 500 mm at any part, or
(b) The lowest part of the glass is 200 mm or more above the highest finished floor level abutting it, or
(c) The clear opening height of the glass does not exceed 1000 mm, or
(d) The side panel is provided with a horizontal rail and bar as specified in 103.5.4.1(d); except that glass used above the horizontal rail or bar may be selected in accordance with the wind loading requirements in 103 of this Standard.

Table 11 MAXIMUM AREA OF CLEAR OR PATTERNED SAFETY GLAZING MATERIAL FOR FRAMED GLASS DOORS AND FRAMED GLASS SIDE PANELS

Type of glass	*Nominal thickness (mm)*	*Maximum area (m^2)*
Toughened safety glass	3	2.0
	4	2.0
	5	3.0
	5.5	3.5
	6	4.0
	8	6.0
	10	8.0*
	12	10.0*
Laminated safety glass†	5.0	2.0
	6.0	3.0
	8.0	5.0*
	10.0	7.0*
	12.0	9.0*
Wired glass	6 and over	2.5
Safety organic-coated glass	3	1.0
	4	1.5
	5	2.0
	5.5	2.5
	6 and over	3.0

* These areas of glass may not be readily available.
† The nominal thickness of laminated glass does not include the interlayer thickness

NOTE – The safety glazing materials listed in this table may not be available in both Grade A and Grade B. However, the area and thickness requirements are applicable to both grades.

Table 12 MAXIMUM AREA OF CLEAR OR PATTERNED ORDINARY ANNEALED GLASS FOR FRAMED GLASS DOORS AND FRAMED GLASS SIDE PANELS

Nominal thickness of glass (mm)	*Maximum area (m^2)*
3	0.1
4	0.3
5	1.6
5.5	1.9
6	2.2
8	3.7
10	5.6
12	7.7
15	10.0

NOTE – Diagrams illustrating the allowable use of ordinary annealed glass in framed glass doors and framed glass side panels are given in fig. 19.

103.5.4.3
Low level glass
For the situation, not covered specifically elsewhere in this Part, where the lowest part of the glass is within 200 mm of the finished floor level abutting it, annealed glass of not less than 5 mm thickness is permitted in accordance with

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the maximum areas shown in table 12, except that where the glass protects a difference in level exceeding 1000 mm, and the glass exceeds 500 mm in width, Grade A safety glazing material shall be used in accordance with table 11.

103.5.4.4
Unframed or partly framed glass doors and side panels
Unframed or partly framed glass doors and side panels shall be glazed with toughened safety glass not less than 10 mm nominal thickness, except that nothing in this clause shall apply to framed or unframed glass used in cabinets or furniture components.

103.5.4.5
Shower doors, shower screens, and bath enclosures
Panels or doors enclosing or partially enclosing a shower or bath shall be glazed with Grade A or Grade B safety glazing material in accordance with table 11.

except that:
(a) for panels or doors with any edges exposed, toughened safety glass not less than 5 mm thick, shall be used in accordance with table 11.

NOTE –
(1) The slippery surfaces of shower bases and baths are considered a contributory factor to potential glass injury. Accordingly, attention is drawn to the need to provide non-skid surfaces.
(2) Glass, other than toughened, is liable to damage from thermal shock. This can result from hot water from the shower fitting impinging upon the glass.

103.5.4.6
Framed internal partitions
Framed internal partitions that are not defined as doors or side panels shall be glazed with ordinary annealed glass in accordance with table 13, except that where the lowest part of the glass is less than 700 mm above the highest finished floor level abutting it, annealed glass of not less than 5 mm thick shall be allowed in accordance with the maximum areas shown in table 13.

103.5.4.7
Partly framed internal partitions
Partly framed internal partitions shall be glazed with ordinary annealed glass in accordance with table 13 except that where the lowest part of the glass is less than 700 mm above the highest finished floor level abutting it, annealed glass of not less than 10 mm thick shall be used, in accordance with table 13.

NOTE – Where any glass edges are exposed some form of edge working shall be used to remove the sharp edges.

Table 13 MAXIMUM AREA OF ORDINARY ANNEALED GLASS FOR INTERNAL PARTITIONS

Nominal thickness of glass (mm)	*Maximum area (m^2)*	
	Fully framed	*Partly framed*
3	0.8	0.1
4	1.4	0.3
5	2.2	0.5
5.5	2.8	0.7
6	3.3	0.9
8	4.5	1.8
10	6.0	2.7
12	8.0	4.5
15	10.0	6.3

103.5.4.8
Fully framed balustrades
For fully framed balustrades Grade A or Grade B safety glazing materials in accordance with the maximum areas shown in table 11 shall be used, except that ordinary annealed glass not less than 4 mm thick may be used, to a maximum area of 0.3 m^2.

103.5.4.9
Unframed or partly framed balustrades
For unframed or partly framed balustrades Grade A or Grade B safety glazing materials in accordance with the maximum areas shown in table 11 shall be used, except that where the lowest part of the glass is 300 mm or more above the highest finished floor level abutting it, ordinary annealed glass not less than 4 mm thick may be used, to a maximum area of 0.3 m^2.

103.5.4.10
Free standing glass
Where glass is used as a structural member to support hand rail loads, only Grade A safety glazing material shall be used, and the design and installation of such members shall be approved by the Engineer.

103.5.4.11
Shopfronts

103.5.4.11.1
The glazing of doors and side panels incorporated in shopfronts shall be in accordance with 103.5.4 All other glass in shopfronts shall be selected in accordance with the wind-loading requirements in Part 1.

103.5.4.11.2
Shopfronts in enclosed malls or arcades shall use the same wind loading criteria as external glazing.

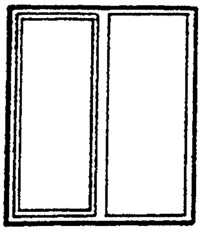
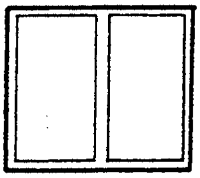
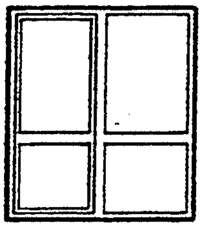
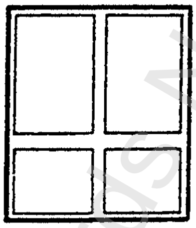
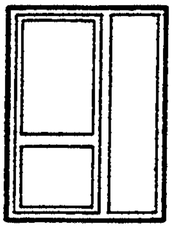
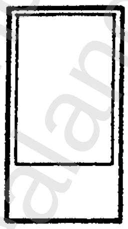
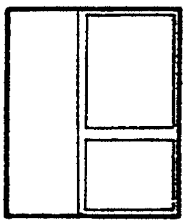
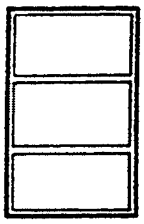
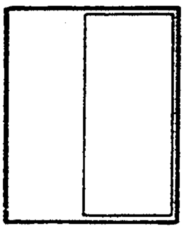
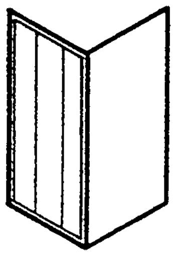
	*Door and side panel* Door: Clause 103.5.4.1 Toughened, laminated or wired. Side panel: Clause 103.5.4.2 Toughened, laminated or wired. All areas to table 11.		*Window not within 200 mm of floor* Glass selected to wind loading requirements.
	*Door and side panel with vision rail* Door: Clause 103.5.4.1(d) Annealed to table 12. Side panel: Clause 103.5.4.2(d) Bottom panel annealed to table 12. Upper panel to wind load requirements.		*Window, bottom panels within 200 mm of floor* Bottom panels: Clause 103.5.4.3 annealed to 5 mm minimum thickness to table 12, except where glass protects a level difference of 1000 mm, toughened or laminated to table 11.
	*Door with vision rail side panel under 500 mm wide* Door: Clause 103.5.4.1(d) Annealed to table 12. Side panel: Clause 103.5.4.2(a) Annealed to table 12.		*Door or side panel bottom edge not within 200 mm of floor* Clause 103.5.4.1(b) or 103.5.4.2(b) Annealed to table 12. Window: Glass to wind loading requirements.
	*Side panel with vision rail, width over 500 mm* Clause 103.5.4.2(d) Bottom panel annealed to table 12. Upper panel to wind loading requirements.		*Door or side panel less than 500 mm wide* Door: Clause 103.5.4.1(c) Annealed to table 12. Side panel: Clause 103.5.4.2(c) Annealed to table 12. Window: Glass to wind-loading requirements except bottom panel to clause 103.5.4.3.
	*Side panel over 500 mm wide* Clause 103.5.4.2 Toughened, laminated or wired to table 11.		*Shower door and bath enclosures* Clause 103.5.4.5 Toughened, laminated or wired to table 11.

Fig. 19 HUMAN IMPACT SAFETY REQUIREMENTS

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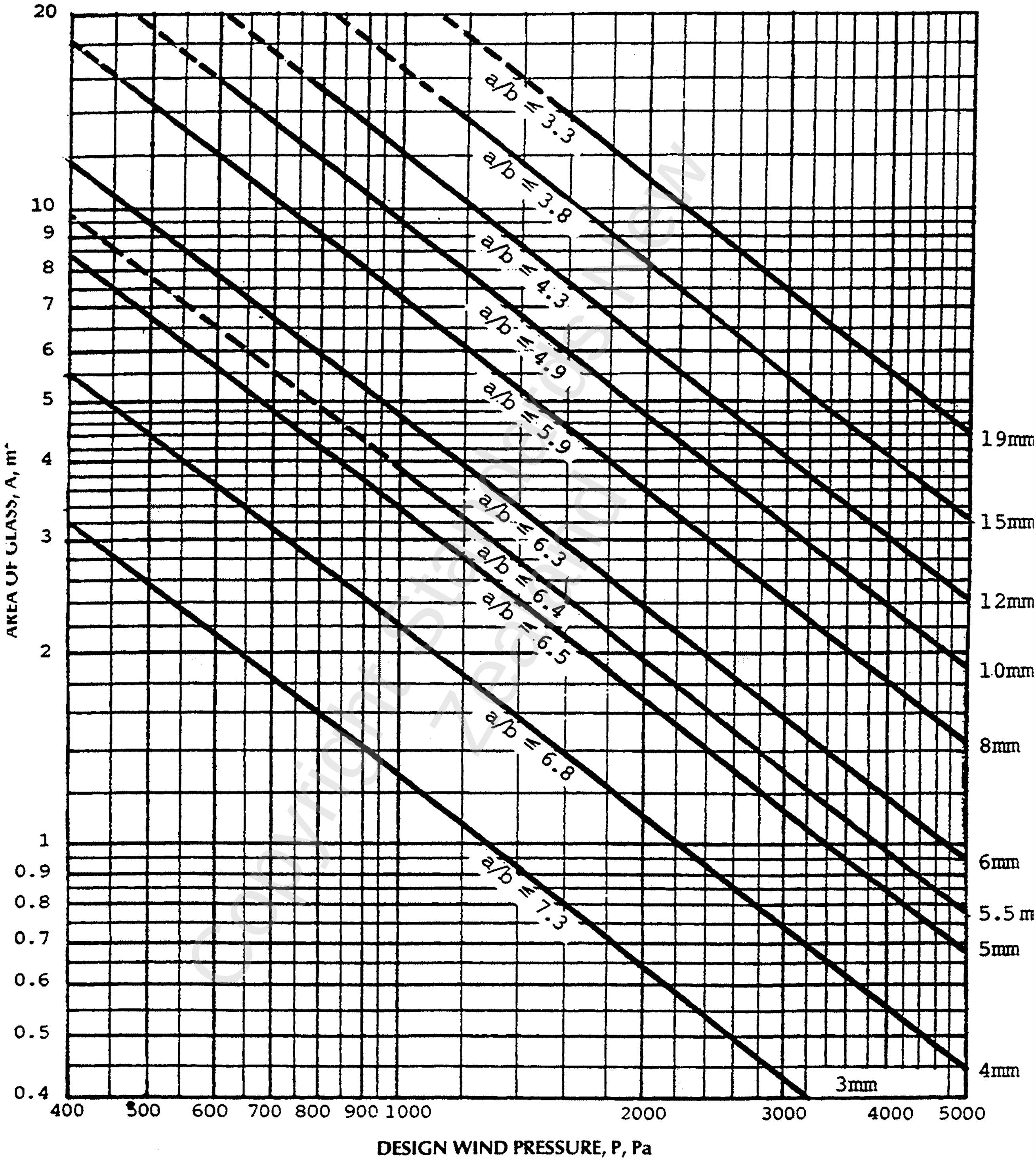

NOTE –
(1) Dotted lines indicate sizes outside normal manufacturing capabilities.
(2) For aspect ratios greater than those shown use the two edge support charts.

Fig. 20 ANNEALED GLASS. FOUR EDGE SUPPORT

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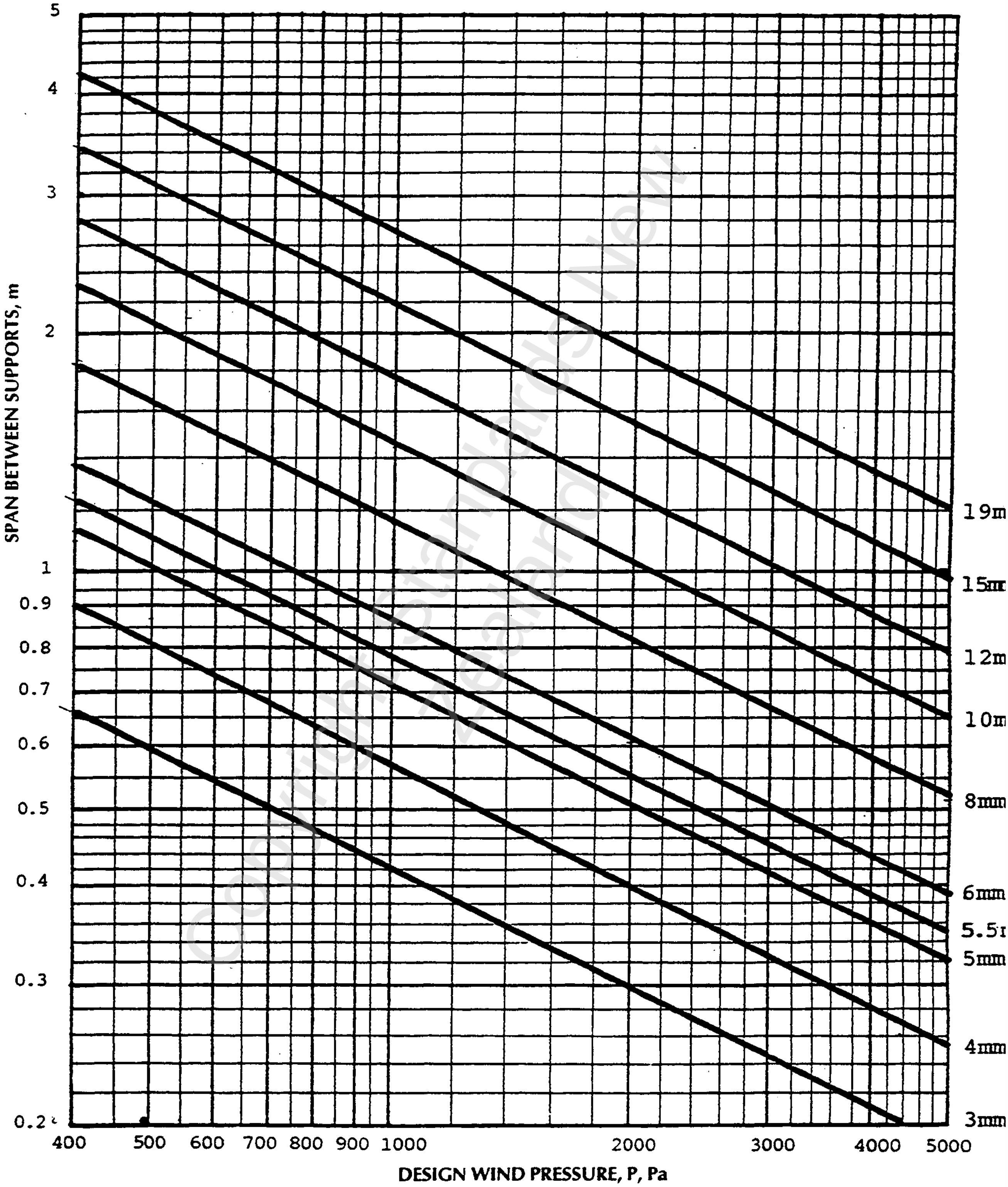

Fig. 21 ANNEALED GLASS. TWO EDGE SUPPORT

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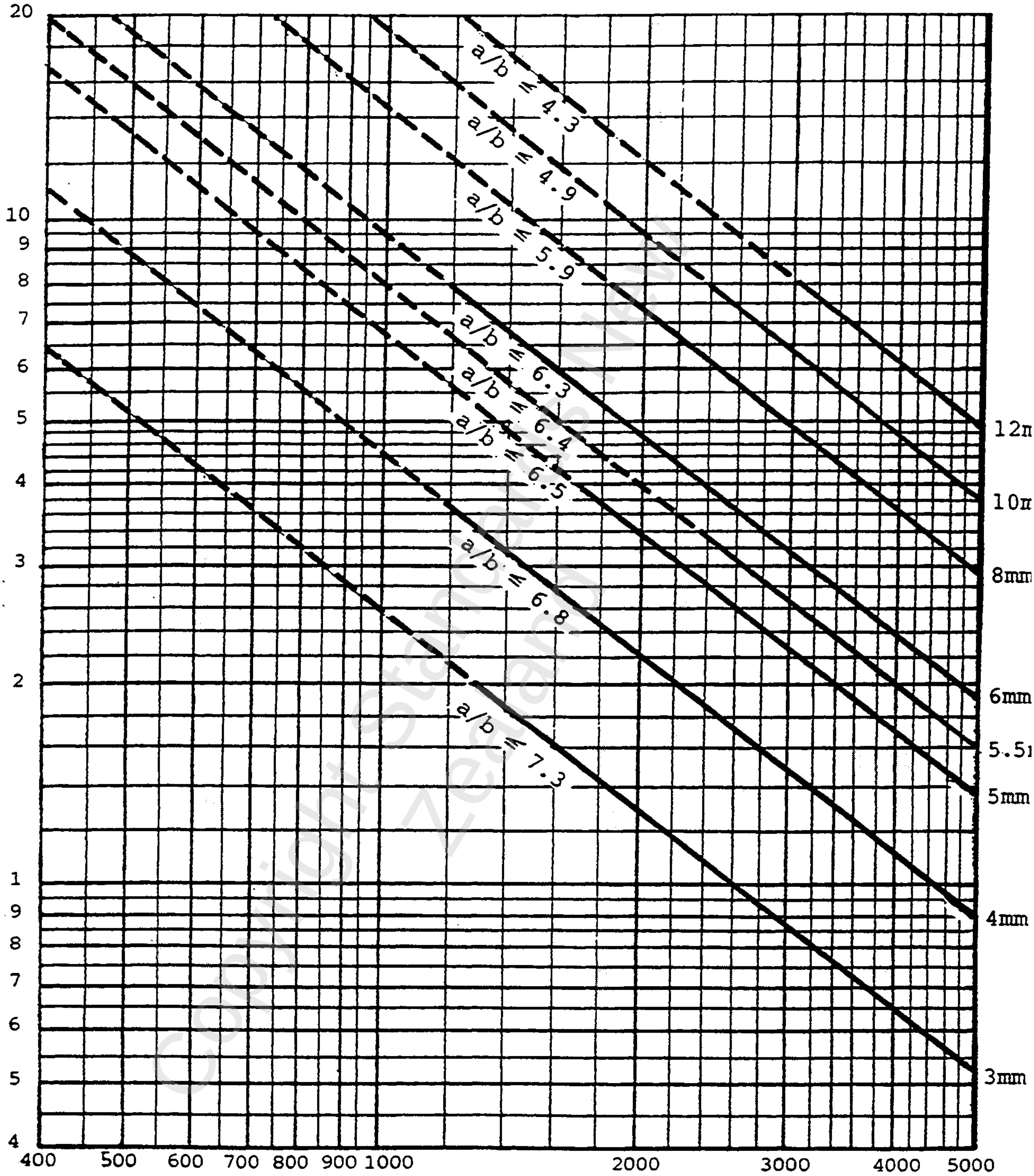

NOTE –

(1) The maximum area of toughened glass of a given thickness has been restricted to an acceptable deflection limit. Areas above those shown may lead to glazing which, although mechanically safe, has large and possibly visually disturbing deflections under load.

(2) Dotted lines indicate sizes outside normal manufacturing capabilities.

(3) For aspect ratios greater than those shown use the two edge support charts.

Fig. 22 TOUGHENED GLASS. FOUR EDGE SUPPORT

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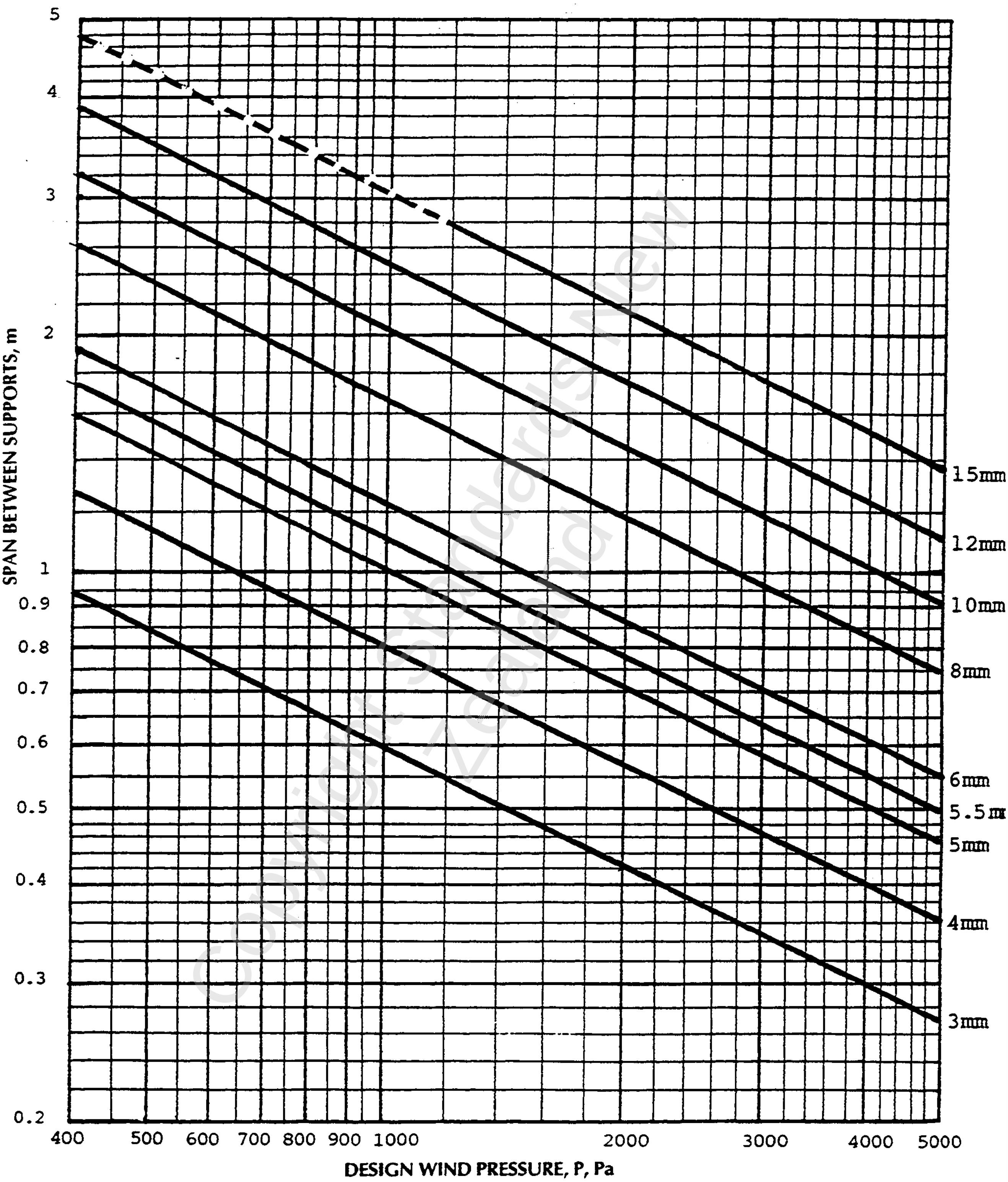

NOTE –
The maximum span of toughened glass of a given thickness has been restricted to an acceptable deflection limit. Spans above those shown may lead to glazing which, although mechanically safe, has large and possibly visually disturbing deflections under load.

Fig. 23 TOUGHENED GLASS. TWO EDGE SUPPORT

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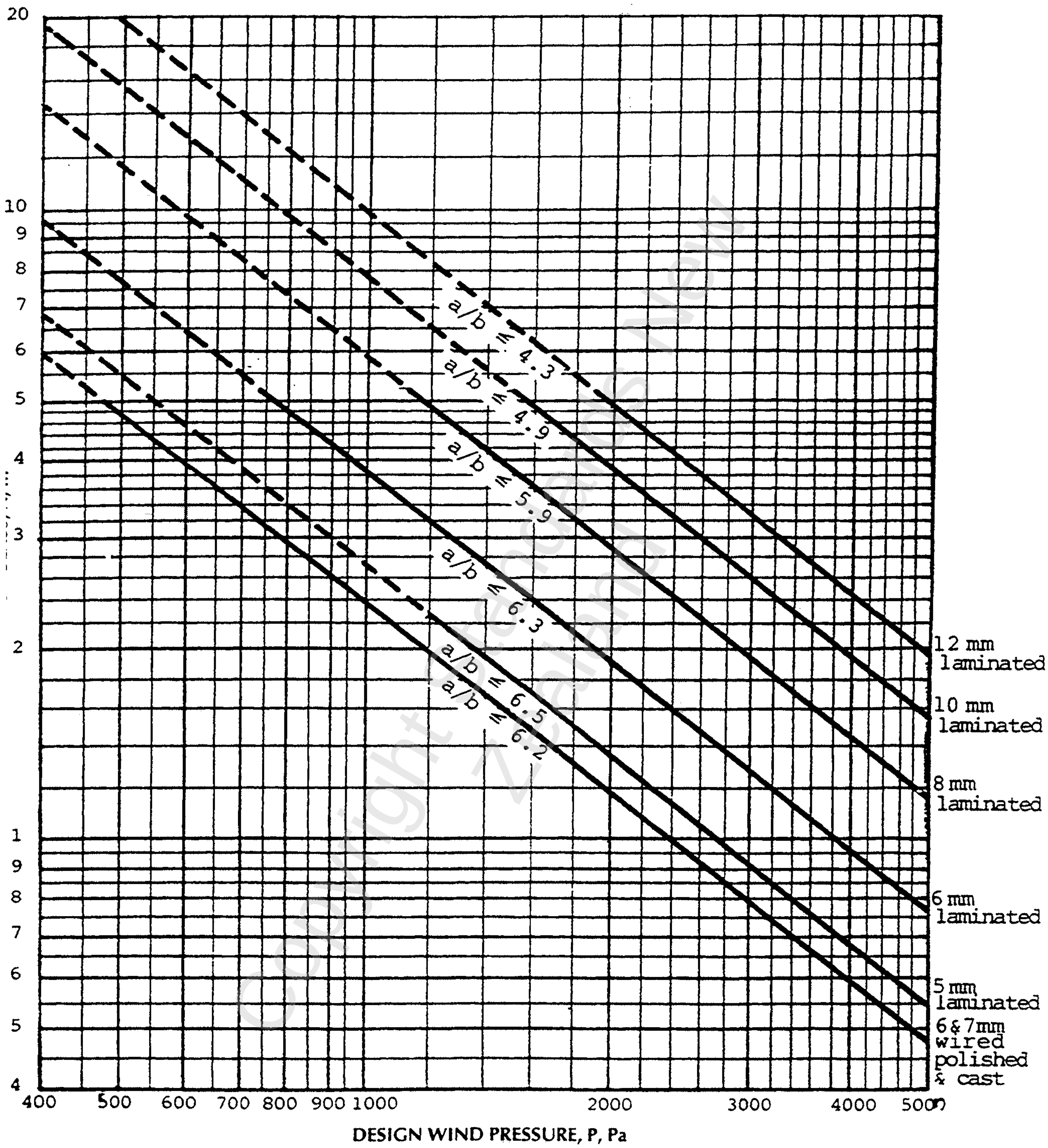

NOTE –

(1) Thicknesses shown are based on glass only and symmetrical construction.
(2) Interlayer thickness is not shown and should be added to obtain the nominal thickness.
(3) For non-symmetrical constructions consult the manufacturer.
(4) Dotted lines indicate sizes outside normal manufacturing capabilities.
(5) For aspect ratios greater than those shown use the two edge support charts.

Fig. 24 LAMINATED AND WIRED GLASS. FOUR EDGE SUPPORT

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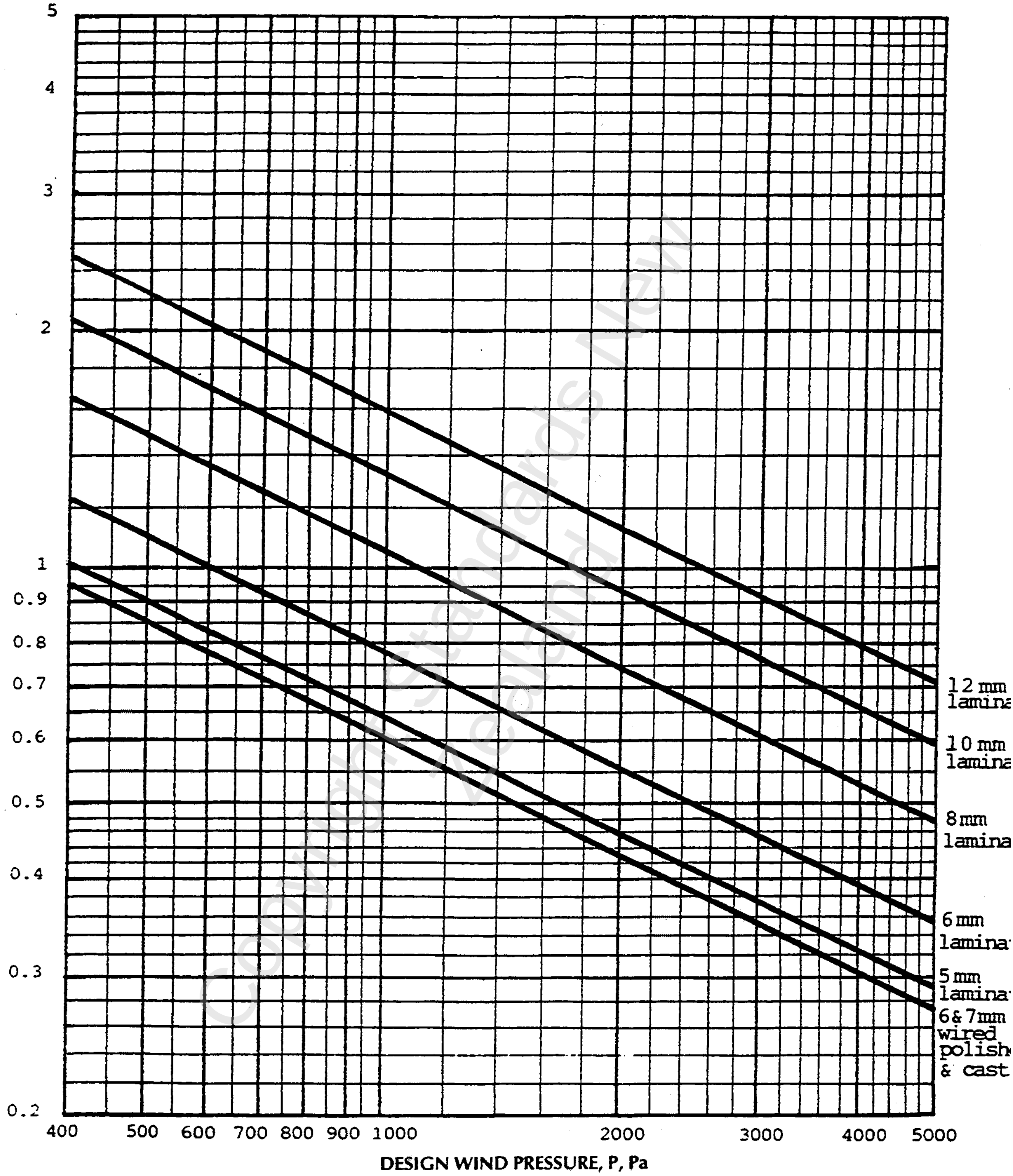

NOTE –
(1) Thicknesses shown are based on glass only and symmetrical construction.
(2) Interlayer thickness is not shown and should be added to obtain the nominal thickness.
(3) For non-symmetrical constructions consult the manufacturer.

Fig. 25 LAMINATED AND WIRED GLASS. TWO EDGE SUPPORT

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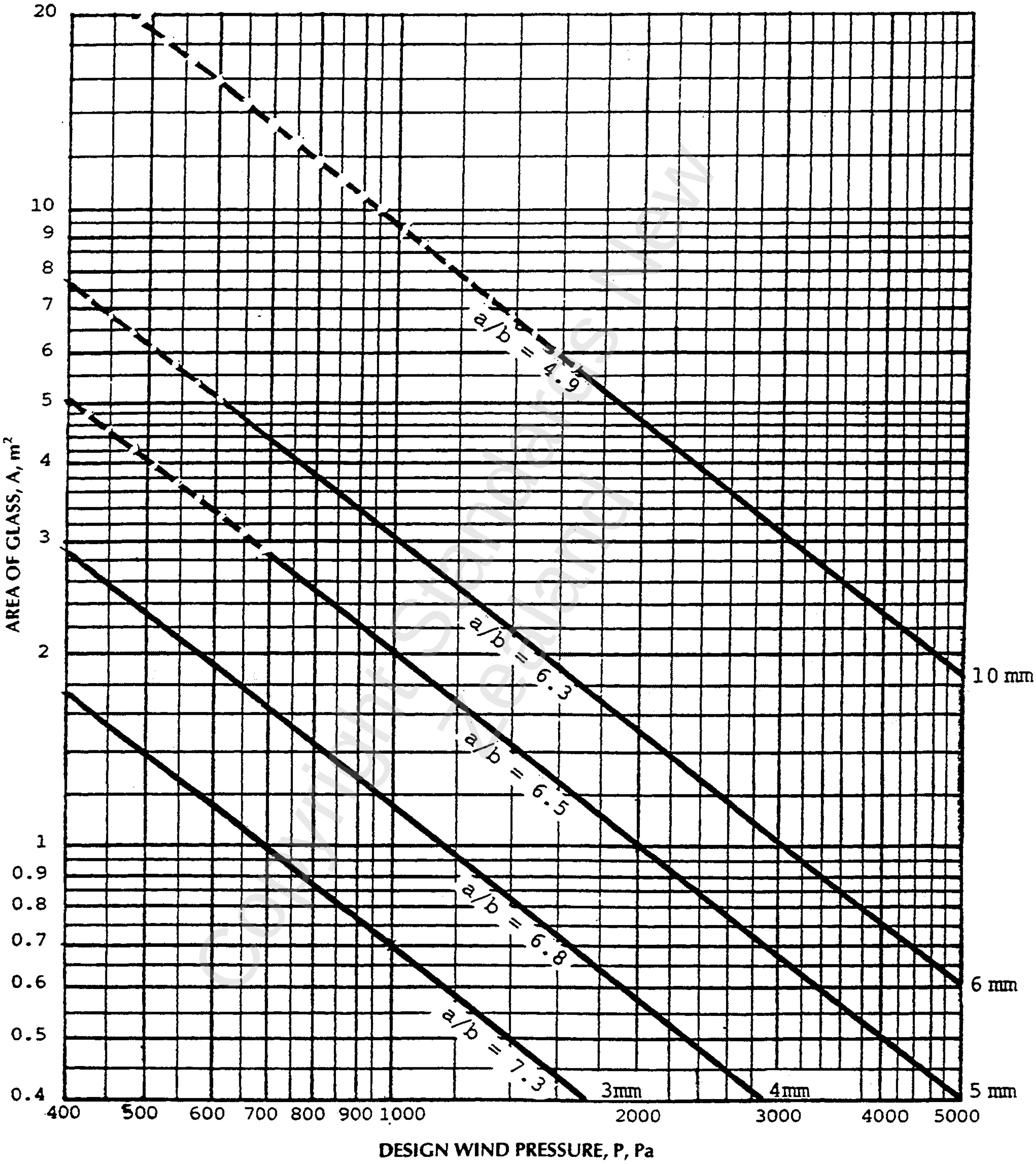

NOTE –
(1) Dotted lines indicate sizes outside normal manufacturing capabilities.
(2) For aspect ratios greater than those shown use the two edge support charts.

Fig. 26 PATTERNED GLASS. FOUR EDGE SUPPORT

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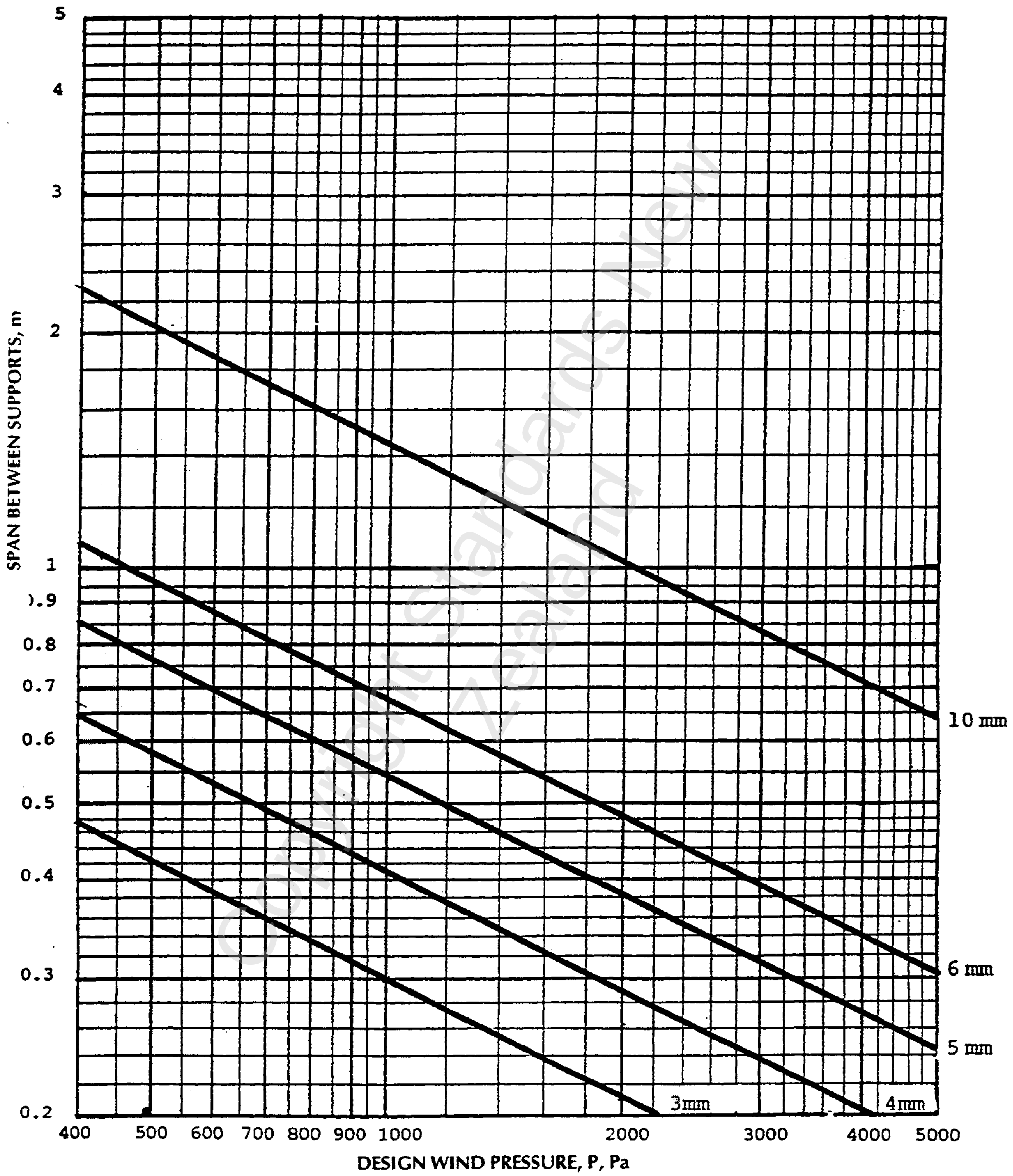

Fig. 27 PATTERNED GLASS. TWO EDGE SUPPORT

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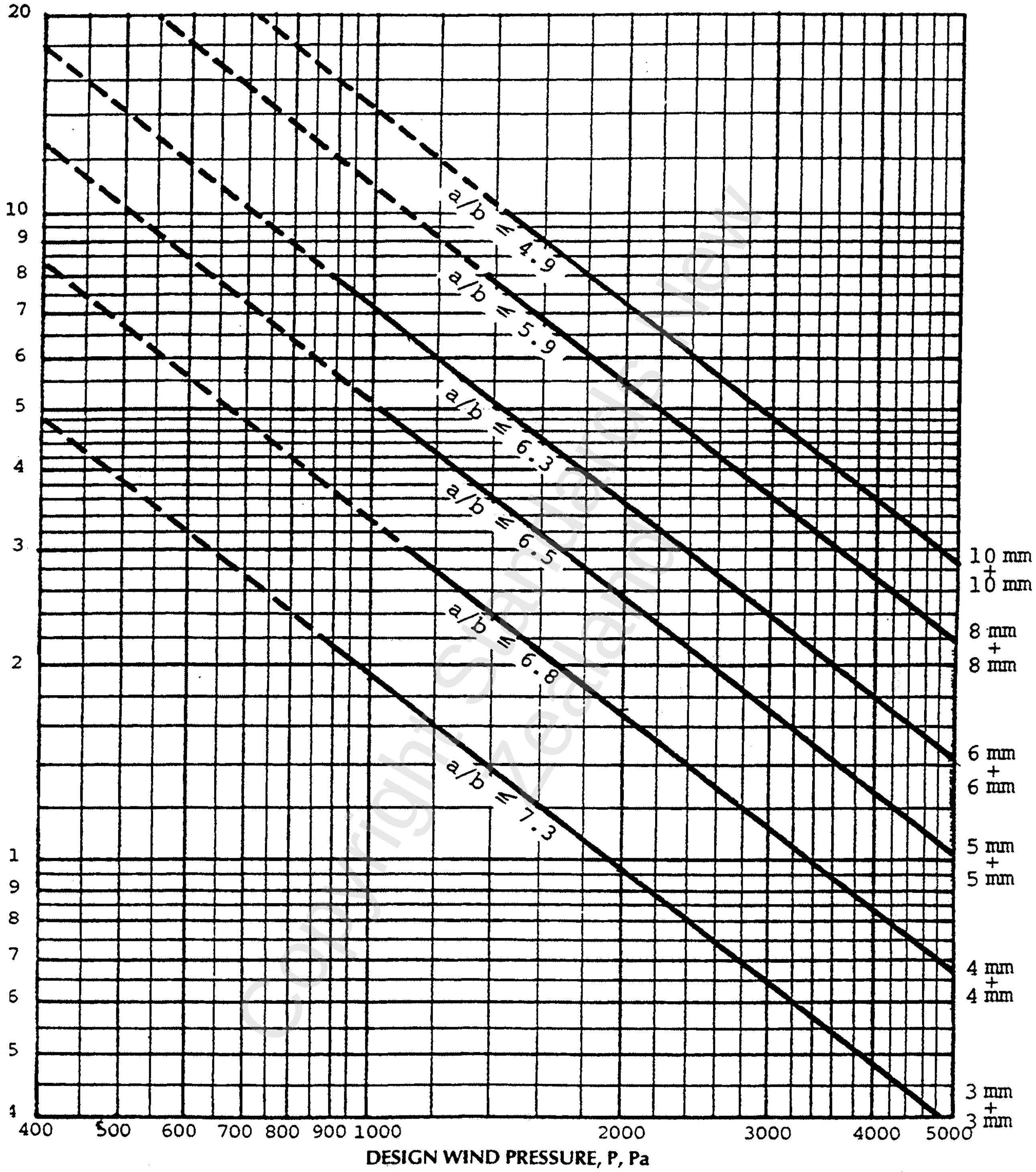

NOTE –
(1) The charts are for units using annealed glass. For other combinations consult the manufacturer.
(2) For non-symmetrical units use the thickness of the thinner of the two panes.
(3) For stepped edge units, treat as single glass.
(4) Dotted lines indicate sizes outside normal manufacturing capabilities.
(5) For aspect ratios greater than those shown use the two edge support charts.

Fig. 28 DOUBLE GLAZING UNITS. FOUR EDGE SUPPORT

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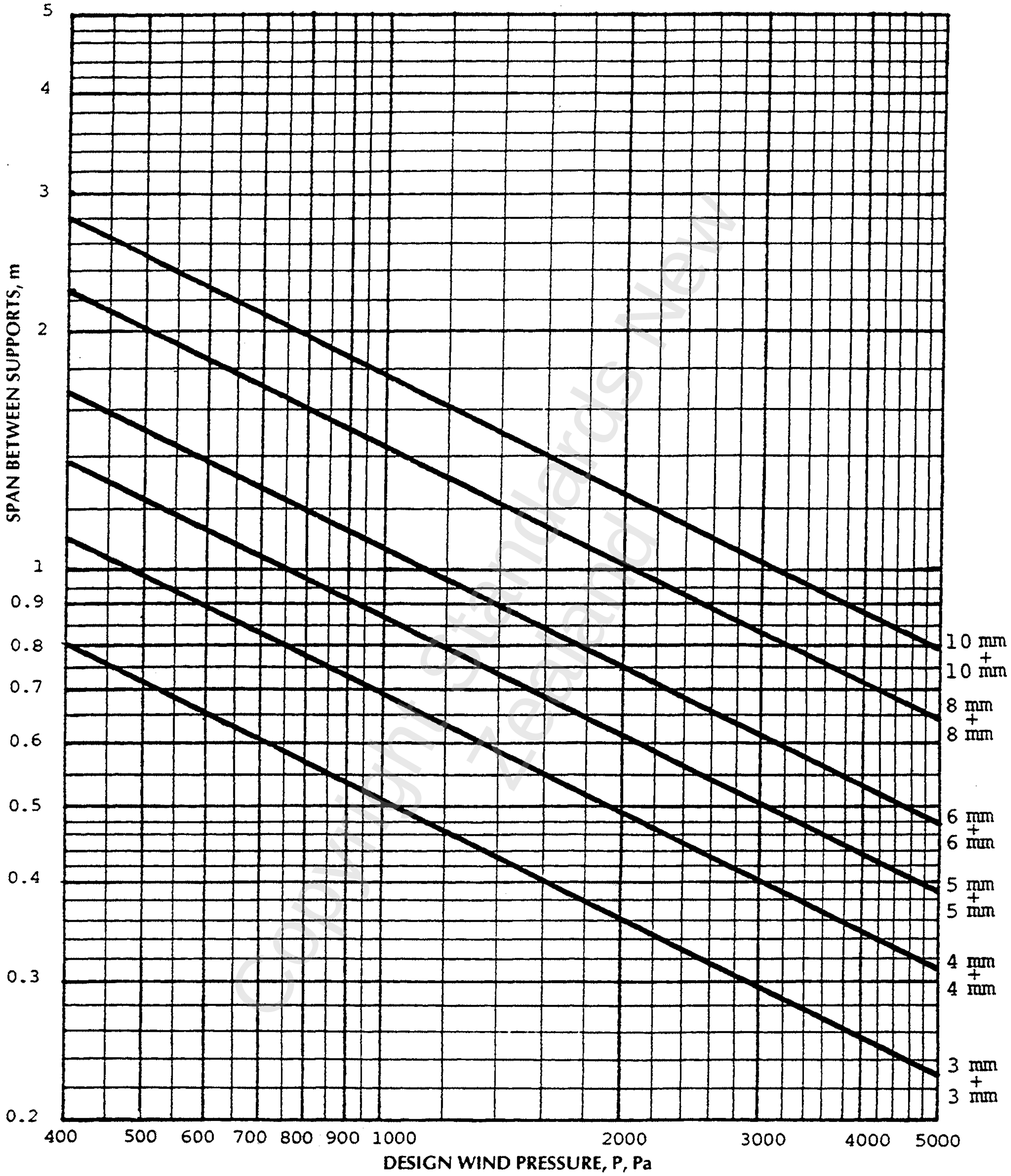

NOTE –
(1) The charts are for units using annealed glass. For other combinations consult the manufacturer.
(2) For non-symmetrical units use the thickness of the thinner of the two panes.
(3) For stepped edge units, treat as single glass.

Fig. 29 DOUBLE GLAZING UNITS. TWO EDGE SUPPORT

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103.5.4.12
Glass for buildings designed for special activities
Where there is a risk of breakage, as determined by the local authority, to glass fixed at all levels other than roof light glazing as in gymnasiums and other similar non-domestic buildings designed for special activities, Grade A safety glazing materials shall be used and shall be selected according to table 11.

103.5.4.13
Leadlights
Provided that the individual squares of annealed glass in a leadlight do not exceed 0.10 m^2 in area, leadlights are excluded from the above requirements, and may be glazed in any size and any location except balustrades and overhead glazing.

103.6
Security

103.6.1
General
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 violence, malicious manual attack
(b) Protection against the use of firearms
(c) Protection against the effects of explosions. Laminated glasses can be designed to provide any specified degree of resistance of penetration. The precise constituents of the laminated glass will depend on the particular purpose and the specification will require detailed discussion with the supplier who should also be able to advise on the correct manner of glazing.

103.6.2
Manual attack: laminated anti-bandit glass
This is glass with a high penetration resistance and is used to protect valuables and property from the smash-and-grab raid and violent attack. Anti-bandit glass generally has thicker interlayers than standard laminated glass and can be effective as protection against bomb blast. Fine wires may be incorporated within the interlayer and arranged such that if a wire is broken an alarm is activated. Laminated glass is also available with a heavy wire mesh screen buried in the plastic interlayer which acts as a visual deterrent to any potential bandit.

103.6.3
Firearm attack: laminated bullet resistant glass
Bullet resistant glass is multi-ply laminated glass. Thicknesses are fabricated to provide protection from different levels of attack and weapon categories.

103.6.4
Explosion resistance
Special glass types and fixing systems are available and specialist advice should be obtained.

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

103.7
Fire

103.7.1
Attention shall be given to the design of glazing where fire resistance is required and reference shall be made to relevant building codes, particularly NZS 1900: Chapter 5.

COMMENT – Glass is a non-combustible material and therefore will not contribute to fire nor directly help a fire to spread. However, because ordinary annealed glass will crack and fall away from frames when exposed to high temperatures only certain types of glass and glazing are accepted where a degree of fire resistance is required and even then the total area is restricted. The ability of glazing to withstand excessive heat depends on the type of glazing, the nature of the frames and beads, and the sizes of panes.

103.7.2
Because glazing can normally satisfy the test performance criteria of integrity and stability only, and not the criterion of insulation, the extent of glazing permitted within doors and screens forming parts of escape routes is also restricted.

103.8
Durability

103.8.1
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.

103.8.2
It is important to consider the possibility of interactions between adjacent materials both in the glazing system and between it and the surround.

103.8.3
Glass should be adequately protected on site to ensure that no damage occurs before installation. Glass may require special protection both externally and internally, from the effects of plastering, welding spatter, special adhesives, alkaline paint removers, stone-cleaning chemicals, and so on. It is recommended that anything deposited on unprotected glass be removed immediately to avoid damage. (See 103.12).

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103.8.4
Although the durability of glass used in buildings today is excellent under ordinary conditions, all glasses are subject to chemical deterioration by the action of water-borne or deposited materials or permanent condensation with unventilated spaces behind glass cladding. Where rain water is allowed to collect alkalis from surrounding construction and to run down the surface of the glass, the glass can be subject to chemical attack or staining.

103.8.5
Air and water penetration between glass and glazing may affect the durability of the glazing system, except in a specially designed drained system. Water penetration may occur and glass may break if neglected metalwork corrodes, if timber warps, or if the glazing deteriorates.

103.8.6
Where glass treated with a transparent organic material, such as adhesive-coated plastic film, is used, the durability of the system will depend on the durability of the organic material applied to the glass and advice should be sought from the manufacturer.

103.9
Strength of vertical glass to withstand uniform wind loading

103.9.1
General

103.9.1.1
The following procedure is for vertical windows for two alternate support conditions:
(a) Supported on 4 edges, and
(b) Supported on 2 opposite edges only.

It covers transparent and translucent glass as described in 1.3 of this Standard. This procedure applies to single glazing using float, plate, and sheet glass, patterned glass, wired glass, and laminated and toughened safety glass. It also applies to factory-made sealed double-glazing units and to all other forms of double window systems whether sealed, openable, or permanently ventilated. For other types of glass and for panes that are not supported on 4 edges nor supported on 2 opposite edges reference should be made to the glass manufacturer.

103.9.1.2
Throughout this Section the term 'wind loading' has been used to indicate the maximum effects of wind that glazing has to withstand. This takes account of the fact that in the worst circumstances the glass will be exposed simultaneously to pressure on one side and suction on the other.

103.9.1.3
The procedure for assessing the wind loading is based on the methods described in NZS 4203, but has been simplified and generalized in order to avoid the need to treat each window as a separate problem. It covers the most common condition in practice but where the conditions exceed the parameters given, recourse must be made to NZS 4203 to determine wind loading to be applied to glazing.

103.9.1.4
It should be noted that this abbreviated method is not suitable for any building higher than 10 m from ground level or where the basic wind speed is higher than 50 m/s and should not be used for buildings on cliff tops. In all such cases the method described in NZS 4203 should be used.

103.9.2
Determination of minimum thickness of glass

103.9.2.1
Three stages are necessary to determine the minimum thickness of glass.
(a) Determination of maximum wind loading
(b) Calculation of glass area, aspect ratio, or span between supports
(c) Determination of thickness of glass.

103.9.2.2
Determination of maximum wind loading

103.9.2.2.1
The basic wind speed has first to be determined for the geographical location of the building. This is the 3 – second gust speed, at a height of 10 m above ground level, which is likely to be exceeded on the average only once in 50 years, and the site is assumed to be unobstructed by buildings. The distribution of basic wind speeds over New Zealand is shown in NZS 4203 and the values for a number of cities and towns are given in table 15 below. Where there is any doubt about the basic wind speed, the Meteorological Service should be consulted.

For low rise buildings (that is up to 10 m high) an abbreviated method of determining the design wind pressure may be used, employing tables 14 and 15.

103.9.2.2.2
This abbreviated method assumes a combined pressure coefficient of 1.5 which takes into account that the glazed areas may be exposed to

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pressures on one side and suction on the other. It also assumes a Topography factor (S_l in NZ 4203) of 1.0.

To find the design wind pressure select the:
(a) Ground roughness category from table 14
(b) Basic wind speed in table 15 to obtain the design wind pressure.

Table 14 GROUND ROUGHNESS CATEGORIES

CATEGORY
1 Open stretches of level or nearly level country with no shelter. Examples: flat coastal fringes, airfield, and swamps.
2 Flat or undulating country with obstructions such as hedges or walls around fields, scattered windbreaks, occasional buildings. Examples: wasteland and most agricultural land that is not well wooded.
3 Surface covered with numerous large obstructions. Examples: well wooded farmland and forest areas, towns, and cities.

NOTE – It is expected that ground roughness 3 will apply to most buildings.

103.9.2.3
Calculation of glass area, aspect ratio, or span between supports
(a) For glasses supported on 4 edges:
Calculate the glass area and aspect ratio thus:
Glass area (m²) = length (m) x width (m).

$$\text{Aspect ratio} = \frac{\text{length}}{\text{width}} \text{ (longer dimension)}$$

(b) For glass supported on 2 opposite edges only (other edges unsupported): Determine only the span (metres) between the two supports (parallel glazing members)

Where the aspect ratio for glasses supported on 4 edges exceeds that given in figures 20 to 29 for the appropriate glass thickness, determine the width (minimum dimension) in metres of the glass and use this value as the span and consider the glass as supported on 2 opposite edges.

103.9.2.4
Determination of thickness of glass
(a) For glasses supported on 4 edges. Select the glass type to be used and using the appropriate figure from figures 20 to 29 read up from the line of wind loading obtained in 103.9.2.2, until the point where the vertical line for the required wind loading intersects the horizontal line for the required area. If the point of intersection is between the lines, the next thicker glass is required.
Check that the aspect ratio obtained in 103.9.2.3(a) does not exceed the value given on the figure. If the aspect ratio exceeds this value consider the glass as supported on 2 opposite edges with the minimum dimension used as the span.
(b) For glass supported on 2 opposite edges only. Select the glass type to be used and using the appropriate graph, read up from the line of wind loading obtained in 103.9.2.2 until the point where the vertical line for the required wind loading intersects the horizontal line for the required span. If the point of intersection is between the lines, the next thicker glass is required.

103.9.2.5
The following notes relate to the wind loading graphs, figures 20 to 29.
(a) These figures are applicable to ordinary single windows. Coupled and doubled windows and secondary sashes should be designed on the basis that each glass is required to carry the full wind loading. This will be the case if the cavity between the glasses is ventilated, or if either of the two windows can be opened
(b) The designer should check the availability of glass before proceeding with the design, particularly for the larger areas or sizes
(c) For other glass thicknesses and for other glass combinations in insulation glazing, recourse should be made to the glass manufacturer for recommendations
(d) In preparing the graphs, the minimum tolerance on the glass thickness specified in 101 of this Standard has been used
(e) The design stress has been based on experience, experimental knowledge, and statistical methods of analysis
(f) The design stress used for figures 22 and 23 is based on fully toughened glass
(g) The area reterred to in this clause is the area of the clear unsupported opening after glazing
(h) Glass that has to withstand only low wind loading, that is under 600 Pa, or glass used internally, may need to be increased in thickness to keep its deflection within acceptable limits.
(j) Compliance of a glass design with the wind loading graphs does not imply suitability of use. Other requirements of this Standard also need to be fulfilled
(k) Although some glasses (particularly toughened glass) may be adequately designed from a structural point of view by the methods used in this clause, glasses of high strength may be so flexible that they are unsatisfactory from an appearance point of view (toughening does not increase stiffness). Edge movements associated with extremely flexible glasses can result in excessive strains on the sealant leading to seal failure and water leakage. These considerations are not necessarily satisfied by a safety factor, nor adequate with respect to

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Table 15 BASIC WIND SPEED FOR VERTICAL GLAZING

Basic wind speed (m/s) (use for locations)	*Height to eaves (m)*	*Ground roughness* 1	2	3
32 (Tauranga)	3 5 10	549 729 942	488 588 814	386 461 573
33 (Auckland, Blenheim)	3 5 10	690 775 1001	519 625 866	410 491 609
34 (Rotorua)	3 5 10	732 823 1063	551 663 919	435 521 647
35 (Gisborne)	3 5 10	776 872 1126	584 703 974	461 552 685
36 (Westport, Palmerston North)	3 5 10	821 923 1192	618 744 1031	488 584 725
37 (Hokitika, Napier, Nelson)	3 5 10	867 975 1259	653 786 1089	516 607 766
38 (Dunedin)	3 5 10	915 1028 1328	688 829 1148	544 660 808
39 (Timaru)	3 5 10	963 1083 1399	725 873 1210	573 685 851
40 (Christchurch)	3 5 10	1014 1139 1471	763 918 1272	603 721 895
41 (New Plymouth)	3 5 10	1065 1197 1546	801 965 1337	633 757 940
42 (Invercargill)	3 5 10	1117 1256 1622	841 1012 1403	664 795 987
44 (Whangarei)	3 5 10	1226 1379 1780	923 1111 1540	729 872 1083
46 (Wanganui)	3 5 10	1340 1507 1946	1009 1214 1683	797 953 1184
48 (Kaitaia)	3 5 10	1459 1641 2119	1098 1322 1832	868 1038 1289
50 (Wellington)	3 5 10	1584 1780 2299	1192 1402 1988	941 1126 1399

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risk of breakage (see 103.1.2). For flexible high strength glasses, deflection limitations must always be considered as part of the overall design. Should knowledge of actual deflection in a given case be required, the building designer should seek assistance from the glass manufacturer

(m) Where satisfactory experimental evidence is presented and approved by the Engineer, more favourable pressure factors than those in table A1 of Appendix A may be used.

103.9.2.5.1

EXAMPLE 1

Consider annealed glass, size 1.8 m x 1.2 m, in a rectangular plan building 10 m high in the residential area of Dunedin.

(a) *Determination of maximum wind loading*

From table 14 the ground roughness category 3 is obtained (surface covered with numerous large obstructions. Examples are towns and cities).

From table 15, for a basic wind speed of 38 m/s (Dunedin) a building height of 10 m and a ground roughness of 3, the design wind pressure is 808 Pa.

(b) *Calculations of glass area and aspect ratio*

For glass supported on 4 edges.

Area = 1.8 x 1.2 = 2.16 m^2

Aspect ratio $= \frac{1.8}{1.2} = 1.5$

(c) *Determination of thickness of glass*

For glasses supported on 4 edges.

From the appropriate graph for annealed glass with 4 edged support (fig. 20), the line of design wind pressure is taken as 808 Pa as determined in (a) above.

Reading up from this pressure and across from the area of 2.16, as determined in (b), we find that a glass thickness of 4 mm is required. The aspect ratio for this thickness is given on the graph as 6.8. The calculated aspect ratio of 1.5, as determined in (b), does not exceed the value of 6.8.

The minimum thickness of annealed glass to use in this case is therefore 4 mm.

103.9.2.5.2

EXAMPLE 2

Consider a rectangular plan building 5 m high in the city area of Auckland, with a glazed shop front 2.2 m high x 9 m long, made up of 6 panels 1.5 m long without vertical mullions but with silicone butt joints between panels and hence supported at top and bottom only.

(a) *Determination of maximum wind loading*

From table 14, the ground roughness category 3 is obtained. From table 15, for a basic wind speed of 33 m/s (Auckland), a building height of 5 m and a ground roughness of 3, the design wind pressure is 491 Pa.

(b) *Calculation of span between supports*

For glass supported on 2 opposite edges only (other edges unsupported). The span between supports is the height of the window, that is 2.2 m.

(c) *Determination of thickness of glass*

For glass supported on 2 opposite edges only. From the appropriate graph for annealed glass with 2 edged support (fig. 21) the line of design wind pressure is taken as 491 Pa as determined in (a) above.

Reading up from this pressure and across from a span of 2.2 m, as determined in (b) above, we find that a glass thickness of 12 mm is required.

The minimum thickness of annealed glass to use in this case is therefore 12 mm.

103.9.3

Probability of failure

103.9.3.1

Figures 20 to 29 are based on a coefficient of variation of glass strength of 25% and a probability of glass failure of 0.8% at a wind pressure liable to occur once in 50 years. The design stress for glass for these conditions is equal to the mean breaking stress divided by 2.5, this latter figure sometimes being referred to as a 'safety factor'.

103.9.3.2

The probability of failure of 0.8% shall be the maximum allowable for general glazing exposed to normal wind conditions. Should lower probabilities of failure be required, the safety factor derived from table 16 can be used to modify the design wind pressure p_z. If the building designer wishes to use higher probabilities of failure in special circumstances, approval of the relevant building authority shall be obtained before using table 16.

The design wind pressure for use with figures 20 to 29 is equal to:

$$p_z \times \frac{\text{(chosen safety factor)}}{2.5}$$

NOTE – Stress calculations using large deflection theory, which takes into account membrane stresses, show that for the same area and design wind pressure in panels designed using figures 20 to 29 the maximum tensile stresses at the centre of a square panel are lower than at the centre of a rectangular panel. Thus for these figures the probability of failure varies from 0.2% for a square panel (aspect ratio = 1) to approximately 0.8% for rectangular panels of high aspect ratio. However, this latter percentage is taken to generally represent the probability of failure of rectangular panels of all aspect ratios. This in effect helps to limit very high deflection in panels with low aspect ratio.

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Table 16 SAFETY FACTORS

Probability of failure (%)	*Safety factor*
50	1
2.3	2
0.8	2.5
0.4	3
0.2	3.5
0.13	4
0.07	5
0.02	8
0.015	10

103.9.3.3
EXAMPLE 3
A designer elects to use a probability of 2 in 1000 (0.2 %) rather than 8 in 1000 (0.8 %) corresponding to safety factors of 3.5 and 2.5 respectively.

Glass dimensions are 1.70 m x 1.10 m giving an area of 1.87 m^2. The design wind pressure is 1500 Pa. The thickness of glass is calculated from figures 20 to 29 using a design wind pressure of

$$1500 \times \frac{3.5}{2.5} = 2100 \text{ Pa}$$

Using fig. 20 for annealed glass this will give a thickness of 6 mm. If the usual probability of 8 in 1000 was used then the thickness would be calculated using a design wind pressure of 1500 Pa giving a thickness of 5 mm.

103.10
Strength of sloped overhead glazing to withstand loadings

103.10.1
General
Unlike vertical glazing which is normally only subjected to one pressure loading (wind), sloped and overhead glazing is subjected to various loadings.

103.10.2
Design loads
The loads on the glass can be described as combinations of momentary (3 seconds) and sustained loads as follows:

(a) *Weight of bars and glass.* This is usually expressed as a pressure acting inward ($+p_d$). Loads due to bars and glass weights are shown in table 17. Although in this subclause, the symbol p_d refers only to glass, it is based on the combined weights of the bars and glass, on the argument that the weight of the bars acts indirectly on the glass, in that the glass has to follow any curvature of the bars

(b) *Wind loads.* This, expressed as pressure, may act either inward ($+p_w$) or outward ($-p_w$) and may not necessarily be equal in magnitude. The procedures for determining wind loading should be based on NZS 4203 or some agreed simplification of these procedures as detailed in 103

(c) *Snow loads.* This is expressed as a pressure, acting inwards ($+p_s$). The component of the snow loading perpendicular to the plane of the glazing should be calculated from the requirements for snow loading measured on plan as stated in NZS 4203

(d) *Maintenance loads.* When appropriate these should be taken as acting inwards ($+p_m$) on ordinary roof slopes, but may act inwards ($+p_m$) or outwards ($-p_m$) on vertical glazing or high pitches approaching the vertical (slope 75°).
When maintenance loads may have to be carried by glazing, suitable provision should be made in the initial design in accordance with NZS 4203.

103.10.3
Combined design loads

103.10.3.1
All components of the design loads discussed can be finally expressed conveniently as pressure, p_d, p_w, p_s, p_m, with positive or negative signs according to whether the loads are acting inwards or outwards. Before proceeding further it is necessary to introduce an adjustment for the effect of sustained loading on glass. Under short-term loading, glass is considerably stronger than it is under long-term loading, and the strength factor between the 3-second loading of wind gust and the sustained loading caused by snow and the weight of glazing is approximately 2.6. In adding these sustained loads to wind loads, therefore, it is reasonable to recognize their more damaging effect by multiplying them by 2.6 but not where the weight merely serves to diminish the effect of a wind suction.

103.10.3.2
For maintenance loading the periods involved are probably not more than a few hours and a smaller strength factor 2.0 can be assumed.

Using these adjustments for sustained loading, the combined design loads to be considered for glass on sloping roofs are either:

$+2.6\,(p_d + p_s) + p_w$ .... (1)
$+p_d - p_w$ .... (2)
or, if necessary,
$+2.6p_d + 2.0p_m$ .... (3)
($-p_w$ being used for suction conditions).

Whichever of these three values is numerically the greatest is taken as the operative design working pressure.

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103.10.3.3
Where the glass is to be 2-edge supported, the maximum allowable unsupported span, and where the glass is to be 4-edge supported, the maximum allowable glass area, shall be determined from the appropriate glass design graphs in Section 103.10 using the maximum numerical value of the combined working pressures and the graph for the appropriate glass type.

103.10.3.4
Double (dual) window systems, other than factory-made and sealed double-glazing units, should be so designed that each glass can withstand the design working pressure on its own.

103.10.3.5
For vertical glazing the procedure is simpler, as the dead weight and snow loads can be ignored and only the wind loads have to be considered. For wind, the pressure coefficients assumed are ±1.5. The working pressures for vertical glazing are included in table 21 and tables B1 and B2.

103.10.4
Calculation of glass thickness for sloped glazing

103.10.4.1
Loads due to weights of bars and glass

103.10.4.1.1
The following loads due to bars and glass have been used in this Standard. These loads were taken from BS 5516 for aluminium bars as these are the most commonly used systems.

Wooden framing can be assumed at the same design loads as aluminium.

Table 17 LOADS ON SLOPED GLAZING DUE TO WEIGHTS OF GLAZING BARS AND GLASS

	Glazing bars N/m²
6 mm single glazing	180
6 mm + 6 mm double glazing	340

The load due to the 6 mm glass alone has been taken as 150 N/m^2. Where thinner glass is used the weight of the glass assumed in the computations can, be reduced proportionally if desired.

103.10.4.1.2
For the derivation of design loads the component of the weight perpendicular to the plane of the glazing is required. This is weight x cos A and figures for a range of angles are given in table 19. The values underlined, at the angles 15°, 45°, and 60°, are those used in compiling tables B1 and B2 of this Standard. Even when considering the design loads for the glass alone, the weight taken is that of the glass and bars together, as the curvature of the bars caused by their own weight is communicated to the glass and this effect can be regarded as an indirect load on the glass.

103.10.5
Wind loading

103.10.5.1
The procedure for assessing the wind loading is based on 103 of this Standard. It covers the most common conditions in practice but where the conditions exceed the parameters given, recourse must be made to NZS 4203 to determine wind loading to be applied to glazing.

103.10.5.2
It should be noted that this abbreviated method is not suitable for any building higher than 10 m from ground level and should not be used for buildings on cliff tops. In all cases the method described in NZS 4203 should be used.

103.10.5.3
The basic wind speed for the appropriate geographical location must first be found. Table 20 shows the basic wind speed for various towns and cities. It corrects the basic wind speed (m/s) into the corrected wind pressure (Pa). It assumes a topography factor (S_1 in NZS 4203) of 1.0. Ground roughness categories are as defined in Section 103 of this Standard.

103.10.5.4
From table 21 the corrected wind pressure (dynamic pressure) is multiplied by a pressure coefficient to take account of the building shape and of any possible reinforcing effects from internal pressure or suction, resulting from air leakages through the outer envelope and particularly from the effects of possible apertures. The final figure is the working pressure for wind for the roof type of the building and is given in table 21.

103.10.5.5
For many buildings without undue complications of location and shape it is reasonable to assume average wind loading effects and to use overall safe values for the pressure coefficients without the need for giving detailed consideration to each building.

103.10.5.6
For general use in this Standard, Cpe and Cpi

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can be condensed to a relatively small number of coefficients (Cp).

The results are given in table 18.

Table 18 COMBINED PRESSURE COEFFICIENTS FOR ROOFS (Cp)

Roof angle degrees	*Pitched roofs *h < 1.5*	*Monopitch roofs *h < 2*
0 to 30	−1.2 + 0.65	−1.3
45	−1.1 + 0.75	−1.3
60	−1.1 + 0.9	−1.3

*h = the height of the building to the eaves

For vertical glazing the combined pressure coefficients (Cpe − Cpi) have been taken as ±1.5. The design wind pressures derived from this analysis are set out in table 21.

103.10.5.7
If more detailed analysis is required on pressure coefficients, then NZS 4203 should be consulted.

103.10.5.8
On more complex problems, particularly those involving consideration of the excess pressures near ground level that can, in some circumstances, be generated by downdraught from tall buildings, and the special behaviour of buildings with curved walls or roofs, specialist advice should be sought.

103.10.6
Snow loadings
Snow loads in New Zealand vary from area to area to such a degree that it is not possible to apply a general snow load for New Zealand as a whole. Snow loads should be taken from NZS 4203 and apply to the formulas to give the total working pressure on the glass.

103.10.7
Maintenance loads
When maintenance loads may have to be carried by glazing, suitable provision should be made in the initial design.

Table 19 LOADS ON PATENT GLAZING DUE TO WEIGHTS OF BARS AND GLASS

Angle of glazing to horizontal (A)	*Load perpendicular to the glass*		
	Glass alone	*Aluminium bars and glass*	
	*Single glazing**	*Single glazing*	*Double glazing**
°	N/m²	N/m²	N/m²
0	150	180	340
5	149	179	339
10	148	177	335
15	145	174	328
20	141	169	319
25	136	163	308
30	130	156	294
35	123	147	279
40	115	138	260
45	106	127	240
50	96	116	219
55	86	103	195
60	75	90	170
65	63	76	144
70	51	62	116
75	39	47	88

* Single glazing based on 6 mm glass, double glazing on 6 mm + 6 mm glass.

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Table 20 BASIC WIND SPEED FOR SLOPED GLAZING

Basic wind speed (m/s) (use for locations)	*Maximum glazing height (m)*	*Ground roughness* 1	2	3
32 (Tauranga)	3 5 10	433 486 628	325 392 543	257 307 382
33 (Auckland, Blenheim)	3 5 10	460 517 667	346 417 577	273 327 406
34 (Rotorua)	3 5 10	488 549 709	367 442 613	290 347 431
35 (Gisborne)	3 5 10	517 581 751	389 469 649	307 368 457
36 (Westport, Palmerston North)	3 5 10	547 615 795	412 496 687	325 389 483
37 (Hokitika, Napier, Nelson)	3 5 10	578 650 839	435 524 726	344 405 511
38 (Dunedin)	3 5 10	610 685 885	459 553 765	363 440 539
39 (Timaru)	3 5 10	642 722 933	483 582 807	382 457 567
40 (Christchurch)	3 5 10	676 759 981	509 612 848	402 481 597
41 (New Plymouth)	3 5 10	710 798 1031	534 643 891	422 505 627
42 (Invercargill)	3 5 10	745 837 1081	561 675 935	443 530 658
44 (Whangarei)	3 5 10	817 919 1187	615 741 1027	486 581 722
46 (Wanganui)	3 5 10	893 1005 1297	673 809 1122	531 635 789
48 (Kaitaia)	3 5 10	973 1094 1413	732 881 1221	579 692 859
50 (Wellington)	3 5 10	1056 1187 1533	795 935 1325	627 751 933

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Table 21 DESIGN WIND PRESSURES (Pa)

Glazing angle	*0° to 30°*				*45°*				*60°*				*90° Vertical*
Roof type	*Pitched*		*Monopitch*		*Pitched*		*Monopitch*		*Pitched*		*Monopitch*		
Corrected wind pressure													
Pa	+	−	+	−	+	−	+	−	+	−	+	−	+ and −
245	159	294	0	319	184	270	0	319	221	270	0	319	368
383	249	460	0	498	287	421	0	498	345	421	0	498	575
552	359	662	0	718	414	607	0	718	497	607	0	718	828
751	488	901	0	976	563	826	0	976	676	826	0	976	1126
981	638	1177	0	1275	736	1079	0	1275	883	1079	0	1275	1471
1240	806	1488	0	1612	930	1364	0	1612	1116	1364	0	1612	1862
1530	995	1836	0	1989	1148	1683	0	1989	1377	1683	0	1989	2299
1850	1203	2220	0	2405	1388	2035	0	2405	1665	2035	0	2405	2781
2210	1437	2652	0	2873	1658	2431	0	2873	1989	2431	0	2873	3310
2590	1684	3108	0	3367	1943	2849	0	3367	2331	2849	0	3367	3885
3000	1950	3600	0	3900	2250	3300	0	3900	2700	3300	0	3900	4506

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103.11
Sloped glazing

103.11.1
General
Sloped glazing is a term applied to glazing that is sloped more than 15 degrees from the vertical. Overhead glazing is a term applied to all glazing above populated areas and thus those areas require special considerations because of human safety. Where human safety is of concern, Grade A safety glazing shall be used on all sloped and overhead glazing.

103.11.1.1
Generally the glass can be almost horizontal although sufficient slope for water drainage must be provided to compensate for deflection of the glass plates under both their own weight and other applied loads. Annealed glass shall not be installed in overhead glazing over populated areas.

103.11.1.2
Any glass glazed at a slope greater than 75 degrees from the horizontal (within 15 degrees or vertical) can be considered as vertical glazing.

103.11.1.3
Examples of calculations for sloped glazing are given in Appendix B.

103.11.1.4
Simplified methods of calculations and examples are also given in Appendix B.

103.11.2
Design considerations

103.11.2.1
The following are design considerations:
(a) Wind loads
(b) Mechanical loads due to gravity, snow, and maintenance
(c) Thermal stress due to the high solar radiation intensity
(d) Human safety in case of fallout
(e) Adequate glazing bar edge cover to prevent fallout from glass deflection and structural movement
(f) Weather resistance after breakage
(g) Maximum opening sizes relative to glass size and strength
(h) Solar control
(j) Falling objects from the sky or adjacent buildings
(k) Glass handling and installation methods
(m) Vandalism
(n) Fire safety.

103.11.2.2
When overhead glass is broken it is likely that all or some of the glass will fall to the floor. This is particularly so with toughened monolithic glass for although it will fracture into small crystals which in themselves may be harmless, these crystals tend to interlock and some very large pieces of these interlocked crystals can fall. Toughened glass is *not* subject to the risk of thermal stress breakage. An additional precaution is heat soaking which reduces the risk of spontaneous fracture.

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103.11.2.3
Two products on the market today that do not usually fall when broken are wired glass and laminated glass. Wired glass is still commonly and correctly used in factory skylights, fire restricted areas, and in general glazing where openings are not desirable after a breakage.

103.11.2.4
The rusting of the wire protruding from the edge of wired glass can cause breakage where the glass edge sits in water; attention must be given in the framing system to provide adequate drainage.

103.11.2.5
Laminated glass offers the best properties for controlling glass fallout and by increasing the interlayer thickness it can resist penetration from various falling objects or vandals. Even when broken, the resilient PVB interlayer remains intact maintaining weather protection until the pane can be replaced.

103.11.2.6
Laminated glass can be constructed using two panes of thicker glass to meet the required strength and can have one or both panes toughened or heat strengthened for greater thermal and mechanical strength. It can also be constructed using wired glass for fire safety.

103.11.2.7
Insulating glass units require a special mention as they are being used more and more in overhead glazing applications. Hermetically sealed insulating glass reduces heat loss and minimizes condensation during cold weather, and by the use of tinted and reflective glass, heat gain can also be minimized. Because of the higher solar radiation on sloped glazing and the fact that glass in a roof is not cooled by convection currents to the same extent as that in vertical windows, temperature and pressure build-up in the units must be considered.

103.12
Care of glass

103.12.1
Storage

103.12.1.1
The storage area should be clean, dry, level, firm, and able to support the weight of the stacked glass – each cubic metre of glass weighs 2.5 tonnes. The glass should be stored on its edge, the choice of long or short edge depends upon the size and thickness of the glass and the availability of space. The glass should not touch anything harder than itself and is best stacked on timber racks which, for extensive use, should be covered with felt, rubber, or soft plastics material. All nails and screws must be countersunk below the surfaces likely to touch the glass. If the glass is to be interleaved in the stacks, only approved interleaving materials should be used.

103.12.1.2
The glass should be supported as evenly as possible. It is usually better for the base support to be of separate timbers running across the edge of the glass than to be a single flat surface – there is less chance of broken glass or other hard objects fouling the supporting surface and applying excessive local pressure to the glass and it also makes handling simpler. At the back of the rack the glass should lean against vertical timber supports at least 50 mm wide and preferably not more than 250 mm apart. If site conditions are such that this minimum requirement cannot be achieved, the amount of glass in each stack must be reduced. The greatest acceptable spacing is 700 mm and the stack should be limited to 10 pieces of single glass or 5 double glazing units.

103.12.1.3
The slope of the glass in the racks should be between 3° and 6° from the vertical, that is, for each metre of height of the glass the foot of the back glass in the stack should be 50 mm – 100 mm from the vertical support. For double glazed units the angle at the base of the stack must be 90°. If the unit is stacked leaning on one edge the outer glass will tend to shear away from the organic seal.

103.12.1.4
Water must not be allowed to reach the edges of stacked glass as it could be drawn between the sheets by capillary attraction. Unless it could be dried out quite soon it would leach alkaline substances from the glass and damage the surfaces. So the glass must be dry when put into store and the store must keep the glass dry, protecting it not only from rain and driven snow but also from water on the ground. Adequate ventilation to the open air is needed to keep the storage space dry, and if some heating can be provided to stop the glass from getting too cold it will help prevent condensation.

103.12.1.5
The glass must also be shielded from direct sunshine to avoid the possibility of build-up of heat within the stack that could cause enough thermal stress to break the glass. This is especially important for solar control glasses. The close covering of stacks with tarpaulin is not adequate protection because there must be free ventilation to keep the glass cool.

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103.12.1.6
The store must offer adequate protection from mechanical damage. The edges of the glass should not be accessible to knocks and abrasions, for example by workers unaware of the presence of glass. The stacks of glass should not offer a tempting shelf or be sited where other things may drop onto them.

103.12.2
Edge conditions
Because solar control glasses and double glazing units containing solar control glasses absorb more solar energy and may therefore be subjected to greater thermal stress than other glasses, it is especially important that their edges are not damaged. They should be examined just before glazing, and set aside if damage is discovered. The same precaution should be used with those double glazing units that have edge-sealing tapes; the edges of the glasses cannot be seen but damage to the sealing tape may indicate damage to the underlying glass. Toughened glasses should be treated in the same way.

103.12.3
After installation

103.12.3.1
Glazing is completed by the removal of all excess putty or sealant smears from the glass and surround and it is usual to indicate the presence of glass by adding a white patch or a stencilled emblem. This does no harm to ordinary clear glass as long as whiting is used. On no account must materials containing lime be used because they can attack the surface of the glass. If advertising labels are attached, they should be of light colour, the adhesive must not attack the glass, and the labels must be easy to remove without scraping.

103.12.3.2
On solar control glasses and double glazed units no indicators or advertisements should be allowed because the local heating they cause would increase the risk of thermal fracture.

103.12.4
Splashing

103.12.4.1
If the glass is splashed with plaster, mortar, or concrete it should be cleaned before the splashes harden because afterwards it is almost impossible to remove them without damaging the glass. Although surface modified glasses are abrasion resistant it must be realised that deep scratches will be more noticeable than similar scratches on untreated glass. For this reason it is generally advisable to protect the coated surface with clear plastic sheeting. Where this is done the sheeting must not be allowed to touch the glass and the air space between it and the glass must be ventilated to prevent heat build up.

103.12.4.2
Where glass is endangered by nearby welding, sandblasting, or spraying operations or by wind blown sand or grit, it is essential to protect the glass with sheeting.

103.12.5
Design for maintenance and care of glass

103.12.5.1
Water run-off from new concrete, brickwork or other surrounding materials can stain or discolour glass by chemical attack. It is preferable to design the facade so that water sheds clear of the glass. The glass should be cleaned at frequent intervals to prevent the formation of deposits causing permanent damage, particularly during the early life of the building. Building design can reduce the amount of water discharged to the glass.

103.12.5.2
Concrete frames with horizontal soffits or surfaces splayed down and back towards windows should always be designed with some form of drip detail. These drips prevent water from travelling across concrete surfaces and running slowly over the window glass taking harmful substances in suspension with it.

103.12.6
Cleaning

103.12.6.1
If glazing in sunny situations is allowed to become very dirty either internally or externally, the dirt will absorb the solar heat. This may result in glass breakage, particularly where wired glass is used; the accumulation of dirt should therefore be avoided by regular cleaning. Toughened glass is not subject to the same risk as it can withstand large temperature differentials.

103.12.6.2
In normal cleaning a soft, clean cloth should be used with water and a mild soap or mild liquid detergent. This should be followed by rinsing with clean water and removal of excess water with a piece of clean leather or chamois. In exceptional circumstances, grease, glazing materials, and the like can be removed by commercial solvents such as toluene or methylated spirits, followed by a normal wash and rinse. Care must be taken to avoid damage to glazing compounds or the seals of double glazing units, for example by the use of strong sol-

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vents. Powdered pumice, cerium oxide, or rouge is sometimes used under supervision for the removal of persistent stains or light scratches on clear or body tinted glasses. Such abrasive cleaning materials must never be used on surface modified glasses or organic coated glasses. Care should be taken not to scratch the surface of such glasses.

103.13
Condensation

103.13.1
Condensation will occur on any surface, the temperature of which is less than the 'dew point' of the atmosphere near the surface. Thus, when the climatic conditions cause the temperature of the inner surface of glass to fall low enough, or the interior specific humidity is increased sufficiently, condensation will occur. This is likely to be most severe during periods of ground frost, cold rain, and low temperature with high wind. Ventilation can minimize condensation.

103.13.2
Where the pitch of the glazing exceeds 30° and the condensation is not severe, the condensate will generally run down the glazing without dripping, though with dirty patterned glass the condensation may sometimes drip at much steeper angles. Provision should be made for water running down the glass to be released to the exterior at the draught fillet. Where the glazing is at a low pitch the possibility of falling droplets may be minimized by the use of double glazing.

103.13.3
The less the depth of glazing, the less the tendency for droplets of condensate to fall. Consequently, where the daylighting requirements indicate considerable depths of glazing, it should be provided in two or more tiers or in separated runs.

103.13.4
Condensation on frames can be appreciably reduced by use of framing members with small areas exposed to the outdoors. It will also be affected by use of thermal breaks. Techniques for condensation predication are given by most manufacturers.

103.14
Louvres

103.14.1
Where either fixed or openable louvre windows are installed, the blade length for ordinary annealed glass shall not exceed the maximum values given in table 22. Where other types of glass are used for louvres, the blade length shall be determined in accordance with the requirements for wind loading for rectangles of glass supported on two opposite sides only as described in 203 of this Code.

Table 22 MAXIMUM LENGTHS FOR LOUVRE BLADES OF CLEAR AND PATTERNED GLASS

Nominal thickness of glass (mm)	*Maximum blade length (mm)*		
	Less than 100 wide	*100 to 155 wide*	*155 to 225 wide*
3	400	500	*
4	500	600	*
5	600	750	750
5.5	650	900	900
6	750	900	900

* Not to be used in this thickness

103.15
Frameless glass assemblies

103.15.1
General
Traditionally window glass is held in a frame and it is generally supported on four sides. For aesthetic reasons it may be desirable to remove parts of the frame, for example mullions, to allow an unobstructed view. Such systems are termed frameless assemblies.

103.15.2
Joining glass
Adhesive sealant materials may be used for non-structural butt joins. Silicone sealants are suitable for this. Mechanical methods must be used for structural joins.

103.15.3
Glass stiffening fins
Glass can be supported against bowing by introducing glass fins at the pane joints. Glass fins should be at least 12 mm thick, secured to the building structure and fixed with structural silicone sealant at right angles to the glazing to act as stabilizing beams against positive and negative design loads. The silicone sealant must have a tensile adhesive strength of not less than 1 MN/m^2. Design charts are available and manufacturers should be consulted.

103.15.4
Suspended assemblies

103.15.4.1
In conventional glazing systems glass must support its own weight. For long lengths of glass in frameless assemblies significant distortion can occur and this may upset design expectations. Also, dangerous stresses may develop. To overcome these effects glass may be suspended. Annealed glass must not be

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weakened by drilling holes. Toughened glass systems may have holes drilled before toughening. Various proprietary suspending systems are offered and full discussions with suppliers of these should be carried out at the design stage.

103.15.4.2
There are limitations in height due to the topmost glass piece having to support the total weight.

103.15.5
The following design information required to be provided to a manufacturer is:
(a) Opening size
(b) Relevant building design code
(c) Design wind pressure
(d) Deflection restrictions if any.

103.16
Building design, and maintenance

103.16.1
While the vulnerability of other glasses will vary from this figure, plain glass is vulnerable to alkaline attack from material with pH values of about 8 and greater. Fresh concrete, cement plaster and the like will have a pH of about 12-13.

103.16.2
Hence cementitious material such as fresh mortar, plaster, concrete etc, should be removed immediately to avoid serious risk of permanent etching or staining.

103.16.3
While glass is abrasion resistant, the effect of scratches on surface modified glasses can be greater than is the case with transparent glass. It is therefore advisable either to protect the coated surface or to adopt suitable safeguarding procedures to avoid possible problems of contact with deleterious materials. Deleterious materials also include contaminated water run-off.

103.16.4
It is essential to protect glass when welding, spraying or sandblasting operations are being carried out nearby, or from wind blown sand or grit.

103.16.5
To reduce the hazard of water run-off from fresh cementitious products external building features should be so designed that water will be shed naturally away from glass.

103.16.6
Concrete components with horizontal soffits or surfaces splayed down and back towards glass should always incorporate drips or similar features to break up the water flow travelling across the surface.

103.16.7
Particularly early in the life of concrete structures and in those locations where the glass will not get the benefit of unimpeded rain-washing, glass should be washed at frequent intervals to prevent early and irreparable damage.

104
GLAZING MATERIALS

104.1
General
This part of the Standard sets out the materials commonly available for glazing. Selection of these materials depends on the design of the glazing system, the glazing techniques, exposure conditions, maintenance schedules and type of glass. Table 23 gives a guide to various glazing materials and their properties.

104.2
Function
Glazing materials must fulfil two major functions:
(a) To *space* the glass to prevent edge contact between the glass and the frame
(b) To *seal* against the ingress of water.
Whilst any one material may achieve both the above functions, in developing a successful glazing system, the functions must be considered separately, to ensure that each function is fulfilled.

104.3
Glazing putties – hard setting

104.3.1
General
These are not suited to large glass areas or high exposure conditions. They have a limited life if not maintained.

104.3.2
Linseed oil putty

104.3.2.1
This should comply with BS 544 or AS 1263. Suitable for use only on absorbent hard wood or soft wood, suitably primed. Temporary protective dips cannot be considered as primers.

104.3.2.2
Sprigs or pins are essential for face glazing. Painting of the putty surface is essential within a period of fourteen to twenty eight days.

104.3.3
Metal casement putty
This is based on vegetable oils. It is suitable for

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;teel frames, but it is not suitable for aluminium, ;tainless steel, bronze or plastic coated or pre-inished frames. Retaining clips and painting of he putty surface are essential.

04.4
lexible glazing compounds

04.4.1
Von-setting glazing compounds

04.4.1.1
'hese are manufactured for use in bead systems vhere structural or thermal movement is slight.

04.4.1.2
pacers are essential. A slight wrinkled skin may orm and painting is not essential. A minimum nickness of 3 mm and a maximum of 6 mm is equired. This is suitable for use with heat bsorbing glass but caution must be used for election with large glass areas and dark metal ames.

OTE – Compatibility with laminated glasses and insulating azing units must be verified with glass manufacturers.

04.5
ealants

04.5.1
ieneral
hese are usually gun-applied pastes which nange to form rubber-like products after istallation by means of chemical change or oss of certain components. Primers (adhesion romoters) are often required. Manufacturer's ecommendations on primers and installation f these materials should be sought. Glazing nould not be carried out when the temp-rature is below 5°C.

OTE – Compatibility with laminated glasses and insulating azing units must be verified with glass manufacturers.

04.5.2
Ine part – curing type
or example polysulphide, silicone, olyurethane. These materials can be used in iany glazing systems. They do not tolerate oor design or preparation of surfaces. epending on formulation they may exhibit irt retention. Some types will not accept aint. They cure to rubber-like products. oacers are essential.

04.5.3
wo part – curing type
or example polysulphide, silicone, olyurethane. These are generally faster curing ian one part curing types and form rubber-ke materials. Spacers are essential. The mat-rials have a definite working life once mixed. lean surfaces are essential and priming is ften necessary.

104.6
Preformed strip materials

104.6.1
These are supplied in various forms with a wide range of uses and applications. They must be compressed to be effective.

104.6.2
Preformed mastic tape, compressible and resilient
These are usually based on butyl or polyisobutylene polymers with some tackiness for adhesion. Spacing pieces are required to prevent extrusion due to wind loads. Generally they are not suitable for exposed parts of glazing. Where used in this system a protective capping seal is recommended. Dirt retention is possible.

104.6.3
Extruded solid sections
For example PVC, neoprene, EP rubbers, and various other synthetic polymers. These do not adhere but rely on compression for their effectiveness. They can be used alone or in conjunction with sealants. Care in placing as well as in determining the cut length of these sections is essential to avoid gaps opening up after installation. Compliance with BS 4255: Part 1 is recommended.

104.7
Preformed compressive gaskets

104.7.1
General
Design and construction tolerances of building and gaskets are critical for successful performance.

104.7.2
Structural gaskets
Structural gaskets are usually made from vulcanized synthetic rubber to BS 4255: Part 1. Joints are invariably factory vulcanized. Compression is attained through locking strips.

104.7.3
Non-structural gaskets
These may be made of synthetic rubber or plastics and may be self adhesive. They are supplied in solid, tubular, or sponge form and are available in a variety of shapes.

104.8
Miscellaneous glazing materials
Special materials are manufactured for such purposes as glazing fire doors and embossed or decorative glasses.

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Table 23 GUIDES FOR THE SELECTION OF GLAZING MATERIALS

Materials and composition	*Uses*	*Suitable glass types*	*Exposure limits wind pressure*	*Comments*
Linseed oil putty, linseed oil and filler.	Bedding and fronting	1, 4a	1500 Pa	Paint protection essential. Life dependent on paint maintenance.
Metal casement putty, drying oils and fillers.	Bedding fronting	1, 4a 1	1500 Pa 1500 Pa	Paint protection essential. Life dependent on paint maintenance.
Non-setting compound: drying and non-drying oils: plasticizers, polymers and fillers.	Bedding glass and beads	1, 2, 3, 5a	1500 Pa	Paint protection not needed but prolongs life. Sealer required for porous surrounds.
Preformed non resilient tape (non-load bearing) synthetic polymer	Bedding	1, 2, 3	500 Pa	Limited load-bearing capability. Can be used with distance pieces for more severe exposures.
Gun grade sealant, solvent release type: butyl, neoprene, or acrylic polymers, fillers and plasticizers.	Heel bead bedding beads	1, 2, 3 All	1500 Pa 1500 Pa	Not normally exposed to direct weather.
Preformed resilient tape (load-bearing): butyl rubber and similar with fillers and plasticizers.	Bedding glass	All	Exceeding 1500 Pa	No exposure limit with adequate pressure glazing system, otherwise as appropriate to capping system.
Extruded solid section: synthetic rubber or pvc.	Bedding glass	All	Varies according to design and materials	Drainage is essential for insulating glass units and laminated glass.
Expanded plastics or rubber section: synthetic rubber or pvc	Bedding glass	All	1500 Pa	Drainage should be provided for insulating glass units and laminated glass. Exposure suitability improved by capping or beading with sealant.
Curing gun grade sealant, one-part: polysulphide, silicone, acrylic and some butyl sealants.	Heel bead, bedding and capping	1, 2, 3, 4	Exceeding 1500 Pa	Cure may be slow due to concealed position of sealant. Cure may be slow when using polysulphide sealant. Silicone sealant gives most rapid cure.
Curing gun grade sealant, two-part: polysulphide and polyurethane sealants.	Heel bead, bedding and capping	All	Exceeding 1500 Pa	Cure is even in concealed position.
Extruded sections, structural gaskets: synthetic rubber.	Bedding glass	All	Exceeding 1500 Pa	Drainage is essential for insulating glass units.
Extruded sections, non-structural gaskets: synthetic rubber or pvc.	Bedding glass	All	Exceeding 1500 Pa	Drainage is essential for insulating glass units.
Self-adhesive fabric tape: cotton or other fibres.	Bedding glass	1, 2, 3, 5	Internal use only	Used in glazing internal doors, partitions, etc.
Asbestos tape: asbestos fibre.	Bedding	Normally wired	Normally internal only	Used in glazing of fire doors and partitions usually incorporating a suitable mastic sealant.
Asbestos channel: asbestos fibres and other materials.	Bedding	Normally wired	Normally internal only	Used in glazing of fire doors and partitions usually incorporating a suitable mastic sealant.

Glass type suitability

1. All other glass, wired rough cast, and patterned glasses, both annealed and toughened
2. Enamelled glasses (annealed or toughened)
3. Solar control glasses, other than laminated
4. Insulating glass units all types

4a. Insulating glass units, stepped only

5. Laminated glass, all types

5a. Some types of laminated glass only

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105 PROCEDURES FOR GLAZING

105.1 General

This Section sets out procedures for glazing systems that are normally encountered. It does not include unframed assemblies or systems, which are partly dealt with in 103.15, nor does it deal with proprietary gasket glazing systems. Detailed information on these systems should be sought from the system manufacturer.

105.2 References

A comprehensive glossary of terms is included in 2.2, (Definitions). Reference should also be made to 104 (Glazing materials).

105.3 Rebate dimensions

105.3.1
General

Rebate size is a product of several factors (glass type, thickness and area, wind loading and exposure) as well as the glazing system to be used.

This Section covers normal situations within the limitations stated. Where unusual or abnormal conditions prevail, further advice should be sought from either the glass or window manufacturer.

105.3.2
Rebate width

The minimum width of rebate is governed by glass thickness, the glazing system, and the glazing materials used.

105.3.2.1

For glazing without beads, it is the sum of:
(a) Width of back clearance
(b) Nominal glass thickness
(c) Width of the front putty.

105.3.2.2

For glazing with beads, it is the sum of:
(a) Width of the front and back clearances
(b) Nominal glass thickness
(c) Width required to provide a platform and fixing for the bead (except where the bead is fixed to the face of the surround).

NOTE – Tolerances in the plane of bead fixing should not allow the bead to encroach into the glazing space.

105.3.2.3

For glazing into grooves, it is the sum of:
(a) Width of front and back clearances
(b) Nominal glass thickness

NOTE – Where the glass has to be inserted into the groove diagonally to the plane of the groove (for example, as in shuffle or joggle-set glazing) the groove width may need to be wider than indicated, to allow room to manoeuvre the glass into the groove. Clearances, both edge and cover, as indicated below, should not be reduced in these cases.

105.3.2.4

For large panes (as in some shopfronts) allowances should be made for the wider tolerances in total thickness and flatness.

105.3.3
Front and back clearances

The minimum width of materials for the front and back clearances will vary with the type of material used. Manufacturer's requirements should be conformed with and the following is given as a general guide.

105.3.3.1

Linseed oil and steel sash putty. Experience has shown that when bedding glass into these putties, they offer substantial resistance to displacement when pressed back to a thickness of approximately 1 to 2 mm. Used in this way, spacers are not needed. Where a thicker bedding is used, it will not be load bearing and spacers will be required to resist wind loading during the setting period of the putty.

The minimum width of faced putty without beads should be 8 mm. The face putty should be a triangular fillet angled at approximately 45°.

105.3.3.2

Hand-grade, non-setting compounds, plastic compounds, 2 part rubberizing compounds, sealants, and preformed strip material (3 mm). Generally these materials are not load bearing and spacers are required to ensure there is no displacement due to wind loading.

NOTE – Some materials are specially designed for use in a thickness of less than 3 mm, in which case manufacturers should be consulted.

105.3.3.3
Preformed compression-type gaskets and non-structural gaskets (2 mm)

The back and front clearances depend on the design of the gasket. Generally 2 mm should be allowed for the minimum clearance that will ensure that under wind loading there will not be glass-to-metal contact.

105.3.4
Rebate depth

105.3.4.1

The minimum depth of rebate or groove is governed by the depth of edge clearance and the edge cover necessary according to the type, size and thickness, the glazing system, and the materials used. Edge cover is also determined by the severity of the exposure conditions.

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105.3.4.2
The minimum rebate of groove depths for different glass sizes and types to suit various wind loadings are given in table 24.

105.4
Edge cover

105.4.1
General
The edge cover should be of sufficient depth to provide support for the glass wind loading. Where this support is by means of spacing blocks, the edge cover should be of a depth to allow the spacers to be covered by a suitable volume of compound or sealant. Refer to tables 25 and 26.

105.4.2
Special conditions
For certain glass the edge cover may need to be varied from the tables shown, for the following reasons:
(a) To give adequate protection to the edge seal of insulating glass units
(b) For visual or aesthetic reasons
(c) For safety
(d) For security
(e) To prevent thermal stresses building up in the edge perimeter of heat-absorbing and reflective glass.
In these cases, it may be necessary to make reference to manufacturers' recommendations.

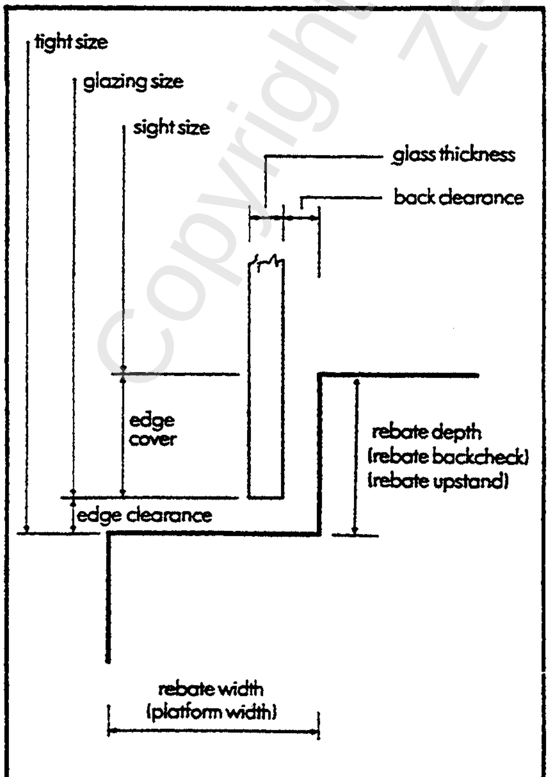

Fig. 30 THE GLAZING REBATE

Table 24 MINIMUM REBATE DEPTHS (PUTTY FRONTING)

Maximum wind loading	*Nominal glass thickness*	*Maximum glass area*	*Minimum rebate depth*
N/m^2	mm	m^2	mm
Up to 1000	3	0.1	6
	3	1.0	8
	4	2.0	8
1000 to 1500	3	0.1	6
	3	0.7	8
	4	1.25	8
Greater than 1500	Bead glazing required for all sizes of glass (see table 26)		

Table 25 MINIMUM EDGE COVER FOR SINGLE GLASS EXCEEDING 6 mm THICKNESS

Glass thickness	*Edge cover*
mm	mm
10	8
12	9
15	10
19	12
25	15

Table 26 BEAD GLAZING

Maximum wind loading	*Nominal glass thickness*	*Maximum glass area*	*Minimum rebate depth*
N/m^2	mm	m^2	mm
1000	3	1.0	9
	4	2.0	9
	5	3.2	11
	6	4.6	11
	10	9.0	13
	12	12.0	14
1500	3	0.7	9
	4	1.2	9
	5	2.1	11
	6	3.0	11
	10	6.1	13
	12	8.7	14
2000	3	0.5	10
	4	1.0	10
	5	1.5	12
	6	2.3	12
	10	4.4	15
	12	6.5	15
2500	3	0.4	10
	4	0.75	10
	5	1.2	12
	6	1.8	15
	10	3.6	18
	12	5.3	18
3000	6	1.5	15
	10	3.0	18
	12	4.4	18

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Table 27 MINIMUM EDGE COVER FOR SINGLE GLASS UP TO AND INCLUDING 6 mm THICKNESS

Glazing material	*Frame or surround*	*Glass area*	*Edge cover*			
			Internal glazing	*External glazing with a wind loading of:*		
				Up to 1000 N/m²	*Up to 1500 N/m²*	*Over 1500 N/m²*
		m²	mm	mm	mm	mm
Putty	Timber, galvanized steel	Up to 0.1	4	4	6	–
		Up to 0.4	4	6	6	–
		Over 0.4	6	6	6	–
Non-setting compound	Timber, metal, plastics	Up to 1.2	6	6	6	7
		Up to 2.0	6	6	6	7
		Up to 3.0	6	7	7	7
		Up to 4.6	6	7	–	–
	Stone, concrete	Up to 1.2	8	8	8	9
		Up to 2.0	8	8	9	9
		Up to 3.0	8	8	9	9
		Up to 4.6	8	9	–	–

105.5
Edge clearance

105.5.1
General
The minimum design edge clearances (that is based on the nominal glass cutting size) to allow glazing and to prevent contact between the edge of the glass and the surround should be as given in tables 25, 27 and 28.

105.5.2
Special conditions
The special conditions described in 105.4.2 also affect edge clearance, although it is desirable that the minimum specified in tables 24 and 26 should not be reduced. There will be situations where edge clearance will differ from table 27, for example, to conform with some types of gasket glazing, drained glazing, small size glass where the rebate depth is specified in table 24 is not considered necessary.

105.6
Blocks

105.6.1
General
Setting, location, and spacer blocks must collectively achieve the function of centralizing the glass in the rebate opening, preventing movement of the glass in the rebate and cushioning the effect of wind loading on the sealing system. Blocks must also prevent glass-to-frame contact.

105.6.2
Setting blocks

105.6.2.1
Setting blocks are used between the bottom edge of the glass and the surround, to support and centralize the glass in the opening. They should be rot-proof , non-absorbent, and load-bearing, capable of maintaining the requisite edge clearance without presenting local areas of stress to the glass through being non-compressible or non- resilient.

105.6.2.2
Suitable lengths and clearances are given in tables 28 and 29.

105.6.3
Position of setting blocks

105.6.3.1
The position of setting blocks (two only) should be generally as near as possible to the quarter points of the sill rebate.

105.6.3.2
The type of window may affect the position of setting block (for example, side hung sashes or doors). Reference must be made to fig. 31.

105.6.3.3
Where undue deflection of the frame must be avoided the window manufacturer should specify the position of the setting blocks as being either:
(a) Not less than 30 mm from the corners of the glass; or

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Table 28 MINIMUM EDGE CLEARANCE FOR GLASS

Glass type	*Edge clearance for a length or breadth (see notes 1 and 2) of:*	
	Up to and including 2 m	*Over 2 m*
	mm	mm
Float, sheet, cast, patterned and wired glass up to and including 12 mm nominal thickness Toughened glass up to and including 12 mm nominal thickness Laminated glass up to and including 12 mm overall thickness Insulating glass units up to and including 18 mm overall thickness	3	5
Float, sheet, cast, patterned and wired glass over 12 mm nominal thickness Toughened glass over 12 mm nominal thickness Laminated glass exceeding 12 mm but not exceeding 30 mm overall thickness Insulating glass units exceeding 18 mm overall thickness	5	5
Laminated glass exceeding 30 mm overall thickness	10	10

NOTE –
(1) Based on nominal glass cutting size.
(2) Edge clearance may need to be greater for some glazing systems, e.g. some gaskets, drained glazing.

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

105.6.4
Location blocks

105.6.4.1
Location blocks are used between the edges of the glass, other than the bottom edge, to prevent movement of the glass within the frame as the window or door is opened or closed, and to prevent the weight of glass causing the frame to become out-of-square.

Table 29 DETERMINATION OF SETTING BLOCK LENGTH

	Area (m^2)	*Setting block length (mm) (minimum)*
3 mm + 3 mm glass units	0.1 – 1.0	40
4 mm + 4 mm glass units	1.0 – 2.0	50
5 mm + 5 mm glass units	0.1 – 1.0	50
	1.0 – 3.5	65
6 mm + 6 mm glass units	0.1 – 1.0	50
	1.0 – 4.0	75
	4.0 – 7.0	100

NOTE – For stepped insulating glazed units the above lengths should be doubled

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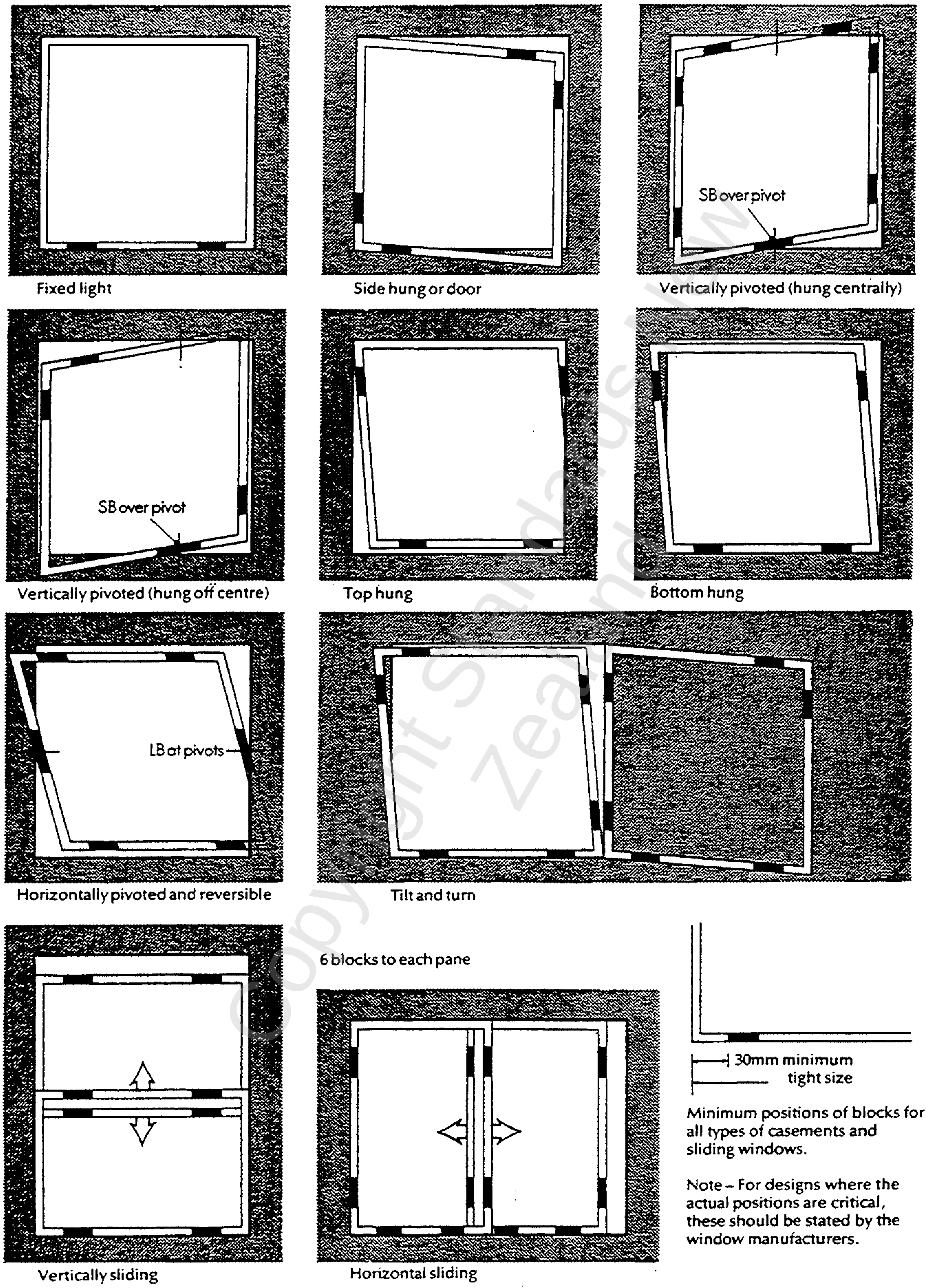

Fig. 31 RECOMMENDED POSITIONS OF SETTING AND LOCATION BLOCKS

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105.6.4.2
Location blocks should be of a resilient, non-absorbent material and should be at least 25 mm long for all opening windows and doors. For reversible, horizontally pivoted windows location blocks on the top edge should be treated as setting blocks.

105.6.4.3
Location blocks should be of a thickness to match the edge clearance and should be at least as wide as the glass thickness.

105.6.5
Position of location blocks
The position of location blocks shall be as shown in fig. 31.

105.6.6
Spacer blocks (Distance pieces)

105.6.6.1
Spacer blocks are used to locate the glass in the glazing rebate. They are necessary with non-setting glazing compounds to prevent displacement of the compound under wind-loading, and with curing-type sealants to prevent displacement during the curing process. They should be of a resilient, non-absorbing material.

105.6.6.2
Spacer blocks should be approximately 25 mm long, and of a height to suit the depth of rebate and glazing system. It is important to use the correct height of spacer so that the spacers can be covered by approximately 3 mm of compound. Their thickness should be equal to the front and back clearances, thus retaining the glass firmly in the frame so that it cannot be displaced in service conditions.

105.6.7
Position of spacer blocks

105.6.7.1
Spacer blocks should be used on both sides of the glass, opposite each other, except for front putty glazing or flush edged glazing, where they should be used only between the glass and the back of the rebate.

105.6.7.2
Where beads are fixed by screws or over studs, spacers should coincide with the bead fixing points.

105.6.7.3
Where beads fix into continuous grooves, the first spacer should be approximately 50 mm from the corner and the remainder should be positioned at approximately 300 mm centres.

105.6.7.4
A spacer should never coincide with a setting or location block position.

105.7
Rebate preparation

105.7.1
General

105.7.1.1
The nature of the frame has a considerable influence on the choice of glazing system and materials and the preparation of the frame has a substantial effect on the success or failure of the glazing system.

105.7.1.2
Any specific recommendations or requirements of the glass manufacturer or the glazing materials manufacturer should be followed, and the chemical compatibility of all glazing materials, glass, and frame with each other should be established.

105.7.1.3
Ensure that all rebates and grooves are rigid, true, square, and free from distortion. Corner joints should be checked for weather tightness and the complete rebate, and beads where applicable, should be clean, grease-free, uncontaminated, and obstruction-free.

105.7.1.4
All rebates should be dry and moisture-free both immediately before and during glazing; the possible exceptions are metal or plastic frames glazed solely with gaskets and where a drainage system is provided.

105.7.2
Timber frames
Where linseed oil putty is to be used, the glazing rebates of windows manufactured to NZS 3619 require no further preparation. For timber frames other than those manufactured to NZS 3619, the porosity of the timber surface should be reduced by applying one coat of primer to prevent excessive absorption of the oil from the putty. Where hardwoods are used in the manufacture of windows, where proprietary brands of timber stains are used, and where other compounds or sealants are incorporated in the glazing system, the glazing material manufacturer should be consulted regarding requirements for sealing the rebates.

105.7.3
Steel frames

105.7.3.1
Where steel frames have been primed with zinc, no further preparation is required other than to ensure the priming coat has sufficiently hardened and is in good order and condition.

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105.7.3.2
As long as galvanized steel has been passivated or weathered naturally, further preparation is unnecessary.

105.7.3.3
Bare steel must be primed before glazing.

105.7.4
Aluminium and stainless steel

105.7.4.1
Anodized or baked enamel finishes on aluminium frames are often protected by wax or tape. Where the surface has been treated with wax or tape it must be completely removed to ensure satisfactory adhesion of glazing compounds. Solvents as recommended by the frame manufacturer should be used.

105.7.4.2
Where special sealants are used, manufacturers should be consulted for any special priming requirements.

105.7.4.3
Stainless steel rebates should be wiped clean and the sealant manufacturers' recommendations followed.

105.7.5
Plastics frames
Where sealants are used to glaze frames, the rebate should be cleaned and primed according to the frame manufacturers' requirements.

105.7.6
Concrete or similar surrounds
In general, all such surrounds should be carefully examined to ensure there are no excessive blow holes, chips, or other serious defects in the glazing rebate. Surfaces should be clean and free from dust and should be brushed before applying the primers or sealers appropriate to the system of glazing.

105.8
Glazing without beads

105.8.1
General

105.8.1.1
The glass is bedded and faced in putty and secured. Putty is suitable for glazing certain types of glass (see table 24) into rebates of timber and steel surrounds, for panes within the size and wind loading limits given in 103.

105.8.1.2
All putties should be finished with a light brushing in order to seal the putty to the glass. The putty should be allowed to firm for not less than 7 days before being painted. The paint type should be as recommended by the putty manufacturer and the painting (by other trades) including undercoat and finishing coat should be carried out within the required time to provide the protection necessary to ensure satisfactory weathering. Paint should be lapped approximately 2 mm on to the face of the glass above the sight line to provide a seal between putty and glass.

105.8.1.3
A duster brush should be used to apply a light coating of whiting on to the face putty and the glass, including the back putty, to assist with the initial surface set of the putty and to absorb excessive oil on the glass.

105.8.2
Linseed oil putty

105.8.2.1
When this is used with timber surrounds, sufficient putty should be applied to the rebate so that when the glass has been pressed back into the rebate, a bedding of putty not less than 1 to 2 mm thick will remain between the glass and the back rebate.

105.8.2.2
No voids in the putty shall occur and the surplus putty squeezed out above the rebate should be stripped off at an angle, see fig. 33. It should not be undercut. The glass should be secured by diamond points, sprigs, or beads, spaced not more than 460 mm apart. Further putty should be applied to the face rebate, forming a triangular fillet, stopping approximately 2 mm short of the sight line.

105.8.3
Steel sash putty
This is generally as for 105.6.2 except that the glass should be secured with the appropriate steel sash spring clips or pins in holes provided by the window manufacturer.

NOTE – Where deep well rebates are used, problems may arise due to the excessive amount of compound required to fill the rebate. It is recommended that the excessive bulk of compound be reduced by inserting fillets into the rebate.

105.9
Glazing with beads

105.9.1
General

105.9.1.1
Glazing beads may be of timber, metal, or other suitable materials used to retain the glass in the frame, as an alternative to front putty, where conditions are more severe than can be accom-

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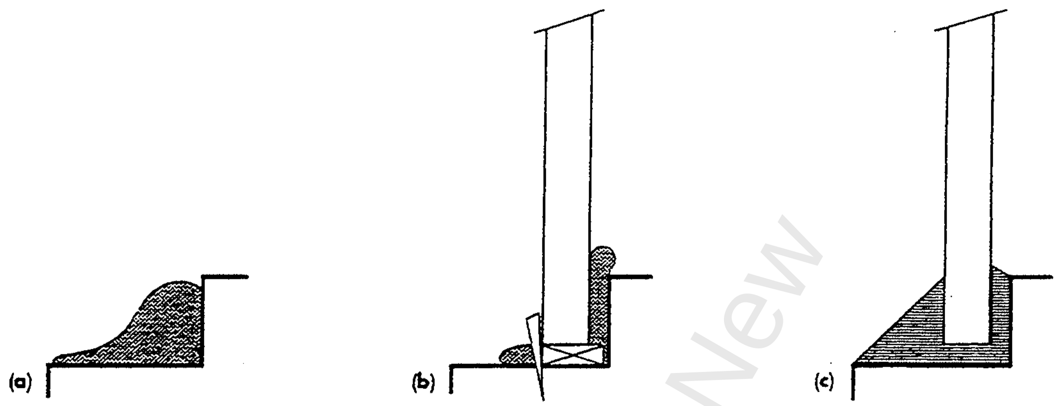

Fig. 32 GLAZING WITH PUTTY FRONTING

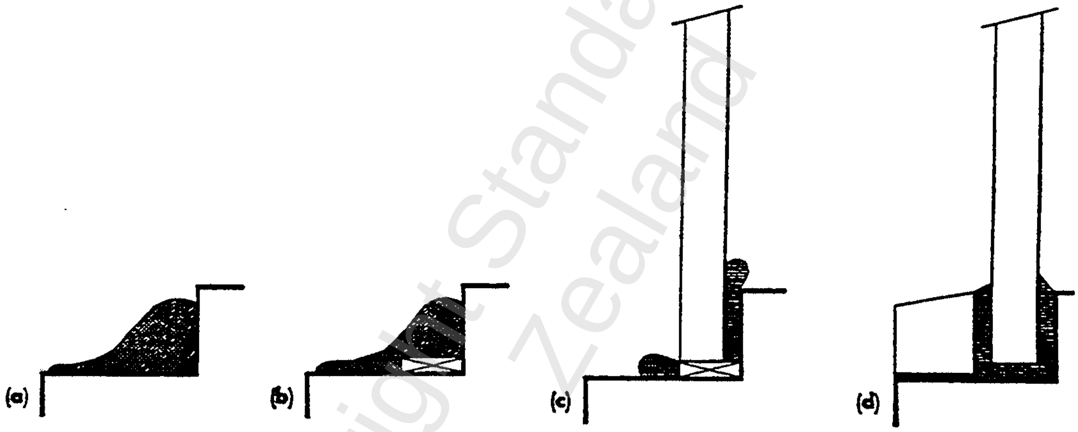

Fig. 33 GLAZING WITH PUTTY AND BEADS

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modated by front putty, or where the glazing method being used is not conducive to front putty.

105.9.1.2
The beads are attached to the frame by various means including screws and clips. Beads should be sufficiently rigid to prevent flexing under load in service.

105.9.1.3
In many instances, the type of bead affects the glazing procedure and method which can be used. Material and method of attachment may also affect the need for beading the bead to the surround when beads are used externally. Frame manufacturers' recommendations should be followed.

105.9.1.4
Adequate fixings must be used to retain the bead in positions; screws generally should be approximately 225 mm apart, starting 75 mm from each corner; nails should be at 150 mm centres starting 50 mm from corners.

105.9.2
Linseed oil putty
This is generally as for 105.6.2 except that beads shall replace faced putty. Beads shall be bedded with putty against the glass and to the rebate platform and fixed as detailed in 104.7.1 (see fig. 34).

105.9.3
Steel sash putty
This is generally as for 105.6.3 except that beads

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shall replace faced putty. Bed the beads with putty to the glass, and rebate platform where necessary, securing with an adequate number of pins, screws, or clips to prevent flexing or movement.

105.9.4
Hand grade, non-setting or plastic compounds

105.9.4.1
This method of glazing with non-setting compounds is normally restricted to moderately exposed situations as it is entirely dependent on the presence of correctly placed distance pieces to withstand wind pressure. With large areas of glass used in exposed situations, if glazed in this way, there is a danger of pumping between distance pieces due to flexing of the glass and so closeness in spacings of distance pieces becomes extremely critical.

105.9.4.2
The method is suitable for glazing into timber and metal frames and is also suitable for glazing into certain types of plastics frames with minimal movement characteristics. Sufficient compound should be applied to the rebate (fig. 34) so that, when the glass is pressed into the rebate, a bed of compound not less than 3 mm thick will remain between glass and rebate.

105.9.4.3
Before actually offering the glass to the surround, setting blocks should be pushed into position on the rebate, or, in the case of opening lights, in the position as shown in fig. 31. Distance pieces should then be pressed into the compound against the rebate upstand. Distance pieces should be of PVC or similar material approximately 25 mm long 3 mm less in depth than the height of the rebate, to permit subsequent cover to compound, and to a thickness equal to the face clearance between frame and glass (generally not less than 3 mm). They should be used opposite each other at both glass surfaces, approximately 75 mm from each corner with approximately 300 mm spacings. Distance pieces are required on all four sides of the frame and, where possible, they should be located at the fixing points of the beads.

105.9.4.4
When the distance pieces are in position on the rebate upstand, the glass should be offered to the surround, placed on setting blocks, centralized in the opening and pushed back into the glazing compound. Care should be taken to ensure that no voids or spaces are left. This action squeezes the surplus glazing compound out of the rebate and should leave a back bedding of not less than 3 mm thickness or equal to the thickness of the distance pieces, which should be held firmly between the glass and rebate. A duster may be used to prevent finger marks on the glass.

105.9.4.5
Ensure that the void around the perimeter of the glass is filled with compound and then make a further application of compound to the glass or glazing face of the bead using sufficient compound to form the bedding between bead and glass.

Distance pieces should be located in the compound opposite to those against the rebate upstand.

105.9.4.6
Where the bead is outside, it should be bedded with compound against the glass and with either the same or a compatible compound against the rebate platform. A gun-grade compound is usually recommended for bedding of solid rectangular or angle beads. A substantial bedding of hand-grade compound is normally recommended for bedding channel beads to the rebate. With channel or hollow rectangular beads, care should be taken to ensure that the ends of the beads are filled with compound to prevent the passage of water through the bead section.

Where the bead is inside, it should be bedded against the glass but it is not normally necessary to bed it to the surround.

105.9.4.7
Bed the beads to the glass, and rebate where necessary, ensuring that the distance pieces are firmly held between the glass and bead. Then fix the bead in position, securing with an adequate number of pins, screws, or clips to prevent flexing or movement.

When the beads are in position, the compound should be finished at an angle of both sides of the glass to prevent water lodgement.

105.9.5
Two part rubberizing compound

105.9.5.1
This method is similar to that used when glazing with beads with handgrade non-setting glazing compounds (see 105.9.4), except that it is necessary to prime all the contact surfaces of the frame, bead, and glass with a suitable primer (and allow it to dry) before glazing, in order to obtain satisfactory adhesion to these surfaces.

105.9.5.2
Two-part compounds should be thoroughly mixed before application. The compounds should be applied in a similar manner to non-

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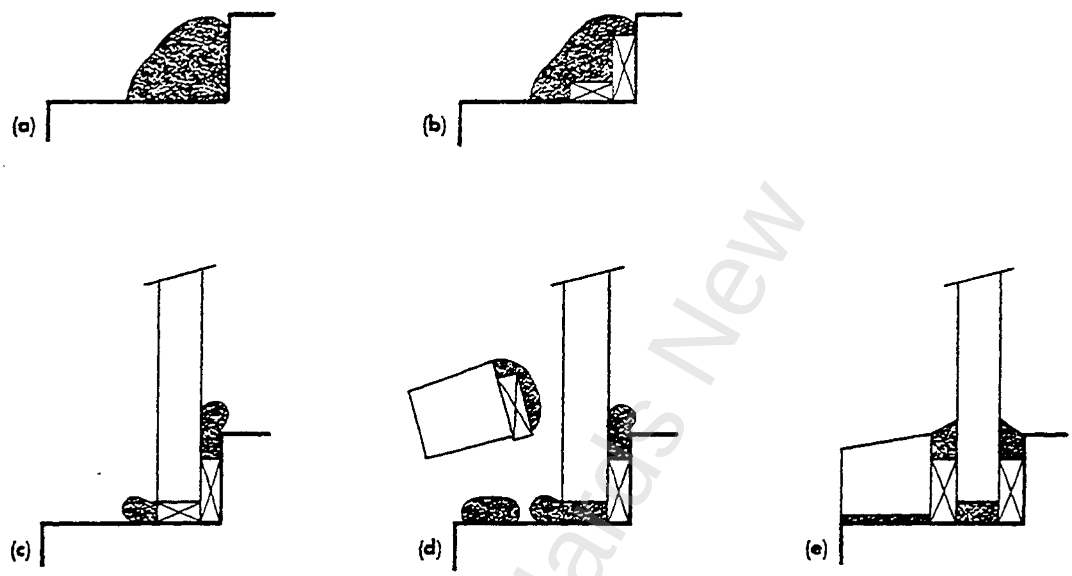

Fig. 34 GLAZING WITH HAND GRADE NON-SETTING COMPOUND AND BEADS

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setting compounds, incorporating distance pieces, setting and location blocks at the normal spacings to ensure an adequate bed of compound around perimeter of the glass. The compounds require 7 to 14 days to cure. It is advisable to trim off the majority of the compound at the time of glazing, but to leave final cleaning until compound has cured.

105.9.6
Preformed strips and sealant cappings

105.9.6.1

Apply the preformed load-bearing mastic strip to the rebate upstand. The strip should be of such a section that after compression it will be 3 mm thick and will finish flush with the sight line of the window. It should be applied on all four sides of the frame. Care should be taken to ensure that the butt joints at the corners are securely formed to avoid overlapping or leaving a gap.
Place setting blocks in appropriate positions on the rebate platform.

105.9.6.2
Offer the glass centrally into the surround, placing it on the setting and pressing it back into position against the preformed mastic strip, compressing the strip as required.

Apply the second preformed mastic tape to finish approximately 6 mm below the sight line, for silicone capping, not less than 3 mm.

105.9.6.3
Press the beads against the strips, compressing them and bedding the bead to the glass. Trim back the excess preformed mastic to provide a smooth chamfer to shed water.

Clean and prime the glass surface where it is to receive the sealant capping, and allow it to dry.

105.9.6.4
Apply the sealant capping, filling the void between the bead and the glass, finishing to a smooth chamfer to shed water.

Where clip-on beads are used for inside glazing, it is possible to use a combination method, using strip and capping sealant for the exterior with a non-setting compound for the interior. Similarly, where the rebate is of a complex profile and a suitable bead is used, it is possible to glaze with an external bead using strip and capping with a bedding of non-setting compound. Distance pieces should be used with non-setting compounds. These variations are normally used where the bead is unsuitable for mating with a strip form mastic, or where the bead is uneven or has a grooved surface and cannot therefore completely receive the strip form mastic.

105.9.7
Drained glazing systems

105.9.7.1
This method of glazing is designed such that any water that penetrates the glazing rebate is

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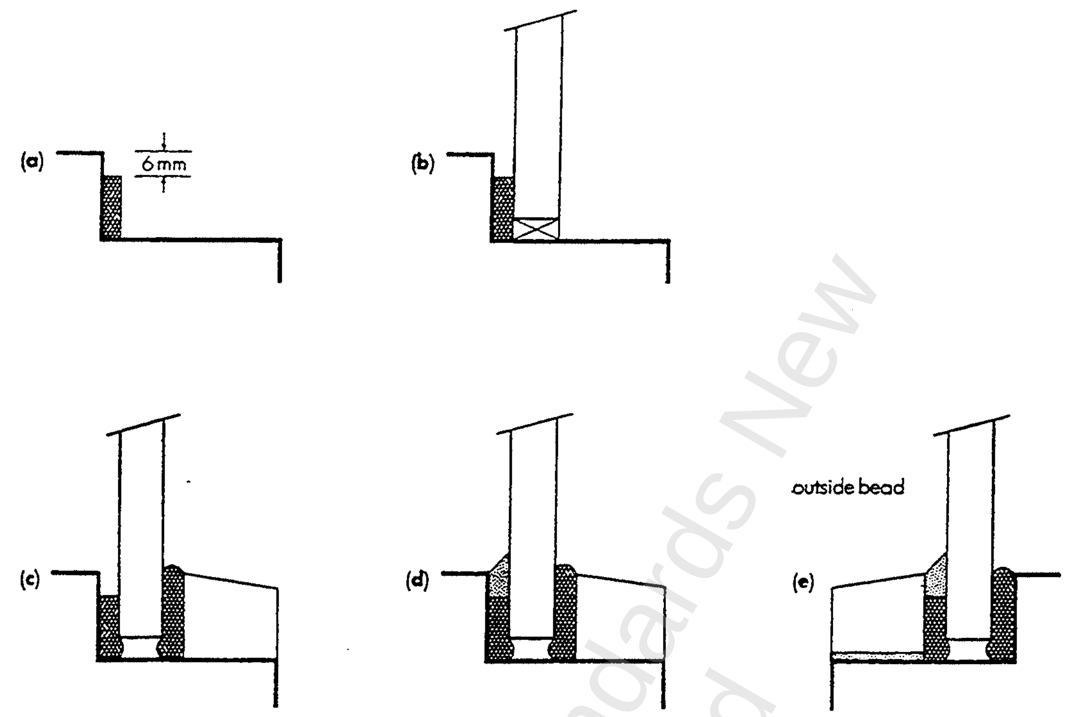

Fig. 35 GLAZING WITH STRIP SEALANTS AND CAPPING

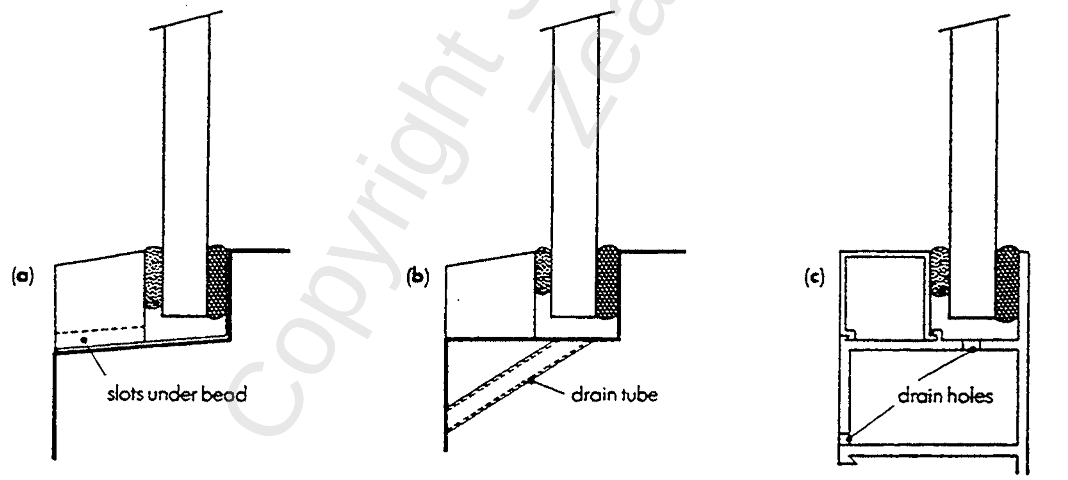

Fig. 36 DRAINED GLAZING SYSTEMS

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drained from that area to the outside of the building. Care must be taken to ensure that the internal sealing of the glass and frame is complete. The external treatment need only act as a means of retaining the glass in position and as protection to the edge of the glass. In some cases the external system may be required to compress the internal seal and in most cases it is also required to limit the amount of water penetrating the glazing area. This technique is particularly suited to some types of plastics window frames where the thermal movement of the frame and the frame components is considerable, making it extremely difficult to provide a completely weather-tight exterior seal. In all cases it is essential to ensure that the frame itself is completely weather-tight and that a suitable seal is used between the inside

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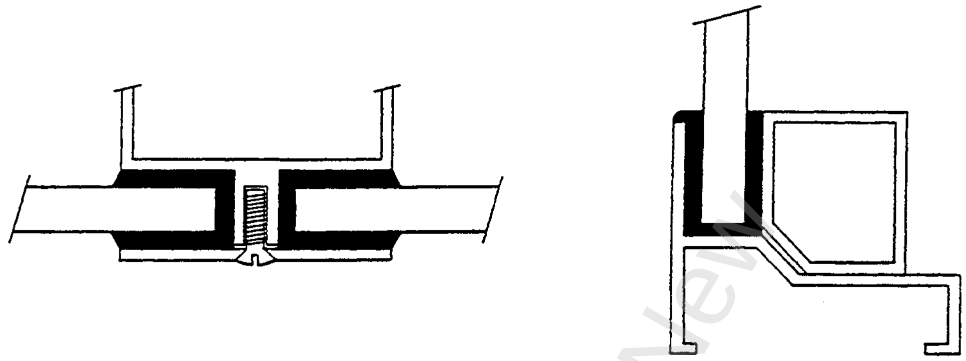

Fig. 37 COMPRESSION GLAZING

face of the glass and the frame to ensure that wind pressure does not force water through to the interior of the buiding.

This method can be applied to most types of frame provided that the temporary trapping of water for short periods is not likely to cause damage to the frame itself or the glass used.

105.9.7.2
Where laminated glasses are considered, the manufacturer should be consulted as to its use in this type of application. Similarly the frames used should also be suitable for use in environments where they are liable to have water trapped in the glazing area for short periods and where this area is also liable to be subject to high humidity conditions for prolonged periods.

The frames must therefore be made of non-corrodible materials and timber frames shall have been thoroughly impregnated with a suitable water-repellent preservative treatment to minimize the risk of water absorption should water become trapped in the glazing rebate for any length of time.

105.9.7.3
Drained glazing systems must provide three conditions:

(a) *Rain screen.* This is the first line of defence and is designed to shed most of the water running over the glass away from the rebate. It will not be 100 % effective, nor need it be, so it is probable that some water will get past it, particularly at the bottom corners of the window frame

(b) *Air-seal.* This is the last line of defence and as its name implies it should be air-tight. It is desirable that the air-seal be kept dry and protected from the effects of weathering

(c) *Drainage cavity.* Provision of a drained cavity between the rain screen and the air-seal is imperative. Weep or drainage holes at the sill are essential to equalize pressure in the cavity and to drain out water getting past the rain screen. Weep holes should not be less than 10 mm diameter and ideally three holes per sill should be provided, one in the centre width and one near each corner.

In certain walls, the system should be drained to the exterior at every floor. To a very large extent the success of this system rests with the effectiveness of the air-seal. However, air seals do not have to be totally air-tight. Some air leakage can be tolerated. The system should still perform satisfactory even though there are gaps in the air seals equal to 10 % of their associated drainage and vent openings. Thus, quite extensive failures in the air seals are not critical if the outside openings are not sealed up and the air seal remains dry.

105.9.8
Compression glazing

105.9.8.1
Where compression is provided by beads designed to apply pressure mechanically to the glazing system, methods similar to those described in 105.9 can be used, but the external capping and sealant may be omitted, depending on the exposure conditions and the nature of the external face seal. In such cases the external face seal should be taken to the full height of the bead of rebate.

105.9.8.2
The glazing procedure is similar to that given in 105.9 except that the mastic strips should be extended to the full height of the rebate, because capping is unnecessary. It is essential

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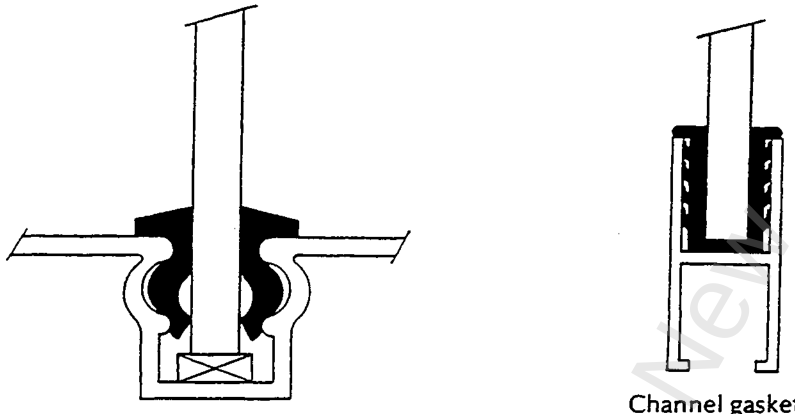

Fig. 38 GLAZING INTO GROOVES

when glazing by this method that sufficient pressure is applied to the glazing strip to ensure complete bedding of the glass but to prevent exudation of the strip under wind pressure.

105.9.8.3
Alternatively, gaskets may be used in conjunction with compression beads. If the gaskets have moulded corners, they should be si:ply fitted around the glass. Otherwise they should first be cut to size and fitted in accordance with the gasket designer's instructions. The beads should be tightened to the recommended torque.

Compression bead systems can be designed for inside or outside glazing either in pre-glazing or on site. The systems are generally for metal surrounds.

105.10
Glazing in grooves

105.10.1
General

105.10.1.1
The surround usually has a groove at the head and jambs and a bead at the sill. Extruded seals are provided on either side of the glass. The glazing grooves need to be of sufficient depth (at least on one side) to allow the glass to be shuffled into the groove on the opposite side. The height of the setting blocks should be sufficient to support and locate the glass after it has been lifted into the head groove. Location blocks cannot be inserted and the system is therefore only suitable for the glazing of fixed lights.

105.10.1.2
Regardless of the actual type of fixing used the following general preparatory procedures should be used:
(a) Check all glass and rebate sizes
(b) Clean and dry all grooves and rebates to remove all dust, dirt, spillage, and accidental contamination; where necessary, degrease the surfaces with a solvent compatible with both frame material and compound
(c) Ensure any drainage holes are clear.

105.10.2
With extruded section

105.10.2.1
The system is commonly used in metal entrance screens and in shop fronts. Higher performance versions are used in curtain walling systems. Similar systems may be used for glazing to concrete and to masonry surrounds, generally using an elastomeric compound or using cellular strips and a capping of sealant.

105.10.2.2
The glazing procedure, in addition to that given in 105.8.1, should be as follows:

The back bedding inserts (including profiled strip gaskets) should be positioned at this stage, unless they are of the type that may be rolled into place after the glass has been put into the groove. Setting blocks appropriate to the size of glass should be put into position and the glass placed on them after observing the shuffle procedure. In cases where one bead only is used at the bottom edge, the setting blocks will need to be of suitable built-

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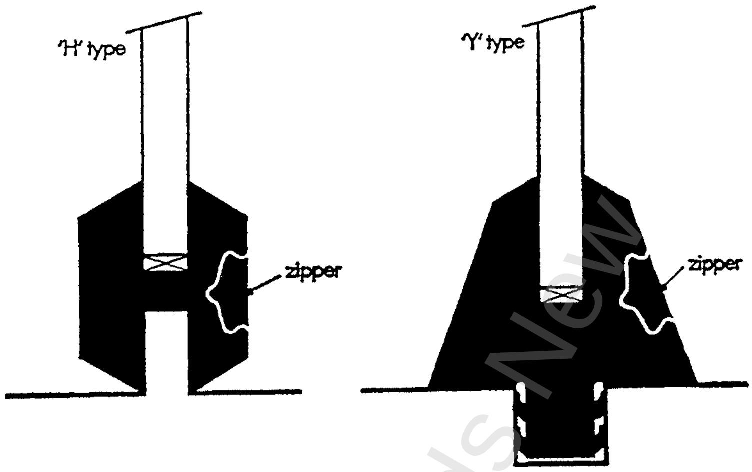

Fig. 39 STRUCTURAL GASKETS

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up height to support the glass after being lifted into the top groove. When the beads have been fixed, the glazing inserts should be rolled into position externally and internally, if not previously positioned. If the insert strip continues around the corners it is usual to ensure that the joint occurs on the top edge.

105.10.3
Channel gaskets

105.10.3.1
This system differs from all the others in that the glazing and surround assembly are carried out simultaneously. A channel-shaped synthetic rubber or PVC extrusion or strip is wrapped round the edge of the glass and the members forming the surround are forced on to the gasket. The system is therefore particularly applicable to the opening lights or presite glazed metal windows that can be readily removed and dismantled for reglazing, and is most commonly used in aluminium sliding windows and doors. This system is also used where the glass is not framed on all four sides.

105.10.3.2
Channel gaskets rely on a rigid member of the frame for supplying sealing pressure. Pressure may be derived by forcing the gasket and glass into a single piece channel, or by application of a second rigid member which, when in place exerts pressure at one side of the channel.

105.11
Structural gaskets

105.11.1
General
Structural gaskets not only have to provide an effective seal against the weather but also have to support the glass structurally.

105.11.2
Y-section into grooves

105.11.2.1
Y-sectioned gaskets are designed to fit into a groove in the surround. The sealing pressure on the periphery of the glass and on the surround is derived from a 'zipper' strip of a harder synthetic rubber than that used for the main gasket. It is important that the gasket provides a continuous seal and the gaskets are, therefore, usually made with moulded right-angled corners. They can also be made to suit radiused cornered surrounds. Glazing on site or presite glazing can be carried out from the inside or outside. These gaskets can be used in surrounds of any material in which a suitable groove can be formed.

105.11.2.2
When glass is to be inserted into Y-section structural gaskets, the edges of the glass should be arrised or covered with self-adhesive tape to avoid the gasket being cut.

The gaskets are required to perform two tasks: they should form an effective seal against the

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weather and they should support the glass structurally within the frame. Factory fabricated structural gaskets are made slightly larger than the frame into which they fit; this allows them to seat correctly ready for glazing and ensures compression against the frame. When gaskets are received on site they should be laid out flat in a dry preferably warm area for 24 hours to allow them to relax before they are used.

105.11.2.3
Variation will undoubtedly occur in the actual procedure adopted for glazing with structural gaskets but the following general points, in addition to those shown in fig. 38 should be noted.

(a) The gasket should first be fitted to the surround at the four corners and gradually eased onto or into the surround, working from the centres out towards the corners. This causes the gasket to be put into slight compression even before the glass is inserted. The portion of the gasket to receive the glass should be lubricated with water or liquid paraffin at this stage. The glass should be entered into the gasket about 50 mm above each of the two bottom corners and gradually into the bottom of the gasket, which can be carefully lipped over the bottom edge of the glass by inserting hardwood, plastics or similar spatulas. The glass should be kept tilted back towards the operatives at an angle of about 15°

(b) Spatulas should be inserted in each of the two vertical lips of the gasket and simultaneous upward progress made, at the same time gradually reducing the angle of tilt until the glass is virtually upright. Both sides of one top corner should be raised with spatulas the glass pressed in. This procedure should be repeated on the other top corner

(c) Before the zipper strip is inserted, it is recommended that the glass edge clearances are equalized, inserting setting blocks of appropriate size if necessary in the bottom channel of the gasket

(d) The zipper groove should be lubricated thoroughly with water or liquid paraffin with a cloth. The zipper should be cut oversize by 50 mm to 75 mm and inserted, using a zipper tool, up to the corners and left hanging out at the ends. After a minimum of 4 hours (preferably overnight) to allow for retraction, the corners should be cut a mitre and pushed into position.

105.11.3
H-section

105.11.3.1
Structural gaskets similar to those described in 104.7 but of H- section profile are designed to fit over a projected nib in the surround. The zipper strip provides compression on the periphery of the glass and the surrounding nib.

105.11.3.2
The glazing procedure is similar to that described in 104.7 for Y- section gaskets.

105.12
Internal glazing

105.12.1
Many of the systems described in this section may be modified if used internally as the glazing does not need to be weathertight. They merely consist of a means of providing a spacer between the glass and the surround and support for the glass against internal pressures and sometimes against body impact.

105.12.2
Self-adhesive glazing tapes, plastics, or synthetic rubber gaskets or strips may be used.

105.12.3
In situations where excessive condensation may occur such as in bathrooms and kitchens, the materials used should be as for external glazing.

105.13
Fixing of mirrors

105.13.1
Glass selected for mirrors should be silvering quality

105.13.1.1
Mechanical damage

105.13.1.1.1
Mirrors can be distorted or even broken by being forced into clips or screwed down too tightly. Where local irregularities occur in a wall, they should be overcome by the use of compensating washers, and for large areas of irregularity the mirror should be bedded on to a minimum thickness of 5 mm of fixing compound.

105.13.1.1.2
It is also important, where fixing is by means of screws, that the screws are prevented from coming into contact with the glass by sleeves and washers. The holes in the glass should therefore be large enough to accommodate both sleeves and screws.

105.13.1.2
Damage by sulphur
Some buiding materials, e.g. clinker blocks, and certain fixing media, such as latex cement, contain sulphur. Care should be taken to

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ensure that the sleeve and washer materials do not contain sulphur compounds, as these can migrate through the protective mirror backing and attack the silver film. One of the most satisfactory barrier materials for this purpose is polyethylene.

105.13.1.3
Damage by alkali
Where a mirror is to be in contact with mortar, concrete or plaster, it may be liable to damage by alkali. The alkali can attack any unprotected backing paint of a mirror. Alternatively, the risk of alkali attack can be largely avoided by spacing the mirror from the wall, leaving a gap of at least 3 mm, or by applying additional backing protection, e.g. lead or aluminium foil.

105.13.1.4
Damage by excessive exposure to water
In places where a high humidity occurs, as in bathrooms or kitchens, provision should be made for the free circulation of air behind the mirror, to prevent deterioration from protracted exposure to water vapour. This can be achieved by the use of distance pieces (washers where screws are used, and packing pieces behind clips) to leave a gap of not less than 3 mm.

105.13.1.5
Miscellaneous factors
Mirrors to be fixed with mastic should be fixed with suitable mastic to avoid attack of the backing paint and the silver. The wall surface should also be sealed to prevent oil absorption from the mastic.

For all mirrors over 1 m^2 in area and fixed by clips or screws, additional support adequate to carry the weight of the mirror should be provided at the bottom edge by, for example, supplementary clips, anchors or a fixing bead.

105.13.1.6
Fixing methods
Mirrors can be fixed in any one of the following ways:

(a) Directly to a permanently dry background, as in a living room, or to an independently fixed background using clips or screws with decorative covers
(b) With a freely ventilated airspace between the mirror and the wall, using clips or screws with spacing washers or packing pieces
(c) With edge beads, either to a flat surface or on battens spaced not more than 400 mm apart. The battens should be sealed and fixing compound used as a bedding
(d) To a background using an adhesive. (The manufacturer should be consulted). To protect the backing paint, silver and adhesive from timber movement, protection should be first applied to the backboard and then the mirror fixed
(d) To a flat background using foam self-adhesive strips or pads applied directly to the backing paint. In all cases, the mirror manufacturers should be consulted and their instructions followed. This method of fixing should be limited to mirrors up to 1 m^2 in area.

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Part 2
The selection and installation of manufactured sealed insulating glass units

201
SELECTION AND INSTALLATION OF SASH AND FRAMES

201.1
Sashes and frames

The following criteria shall apply to sashes and frames:

(a) They must be designed to support the additional weight of insulating glass units with special attention given to horizontal members to prevent the glass taking vertical load
(b) They must allow for contraction and expansion of the building and comply with relevant clauses of NZS 4203
(c) They must be installed to avoid undue pressures on the installed unit
(d) They must have a "drained glazing system" to allow entrapped moisture to escape. Weep holes are intended to indicate necessity and desirability, not design location. If a weep system cannot be incorporated into the design there must be a positive wet seal to the exterior.

201.2
Rebates and grooves

The following criteria shall apply to rebates and grooves:

(a) They must be of sufficient depth and width to allow for the manufacturer's prescribed tolerance. The rebate depth shall cover the unit border to the sight line of the cavity spacer, or be at least 3 mm higher for metal banded units. For solar control glasses consult the unit manufacturers
(b) They must be completely free from obstructions and protrusions which may come into contact with the unit during glazing
(c) They must be designed so they will not roll, twist, or warp after setting.

201.3
Aluminium bars

201.3.1

Bars to incorporate draining channels and low top profile to reduce shading of glass for thermal reasons.

201.3.2

Care is needed in choosing sloped glazing systems that underneath glass of insulation unit does not project to the outside. The glass would not accept the two extremes of temperature to which it would then be exposed.

202
Preparation of sash and frames

202.1
Timber parts

Timber parts shall be prepared as follows:

(a) Timber parts must comply with NZS 3619
(b) Glazing materials and rebate sealer must be compatible
(c) Timber parts must be dry and free from dust before application of glazing material to assure good adhesion.

202.2
Metal parts

Metal parts shall be prepared as follows:

(a) Aluminium parts must comply with NZS 3504
(b) Steel sashes shall be zinc sprayed, galvanized, or prime painted and dried.

203
Blocks

203.1
Materials

Setting blocks shall be rot-proof, non-absorbent, and load bearing capable of maintaining the requisite edge clearance without presenting local areas of stress to the glass through being non-compressible or non-resilient. Location blocks shall be of resilient non-absorbent material.

203.2
Placement of blocks

203.2.1

Two setting blocks shall be used as shown in fig. 40 except that for designs where the actual positions are critical these shall be stated by the window manufacturer. With stepped units, both panes of the unit must be independently supported by setting blocks at the sill. The placement and size of setting blocks shall be such that drainage of the rebate cavity is not impeded.

203.2.2

Two or more location blocks shall be fitted at intervals of 450 to 600 mm.

203.3
Size of setting blocks

203.3.1

Each block must exceed the thickness of the unit in order to support the unit as a whole.

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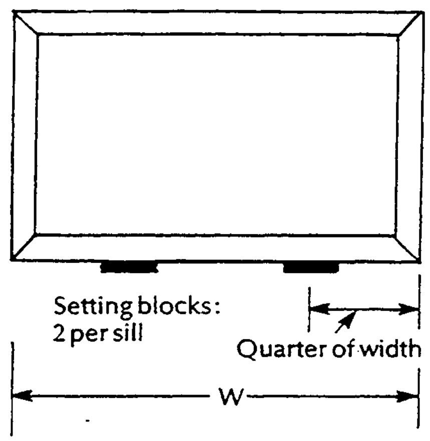

Fig. 40 SETTING BLOCKS

203.3.2
Setting block lengths shall be not less than those given in table 29.

204
EDGE AND FACE CLEARANCES

204.1
Edge and face clearances shall be provided as shown in table 30.

Table 30 EDGE AND FACE CLEARANCES

Area (m^2)	*Edge clearances* (*mm*) (*minimum*)
Up to 2	3
Over 2	5

NOTE –
(1) Edge clearance determines setting block thickness. For solar control glasses irrespective of size the manufacturer should be consulted.
(2) Clearances must be maintained between the unit and rebate back check, and unit and bead. The amount will vary according to the glazing system adopted, except in the case of non-setting compound which must be not less than 3 mm and not more than 6 mm.

205
HEAT, DRAPES, SHADES, FILMS

205.1
Heat ducts

205.1.1
Air flows should never be directed against the insulating glass unit as certain weather conditions can induce breakage if large temperature differentials occur. Excess heat could also cause edge sealant failure.

205.1.2
The sash or frames must not contain an abnormal amount of heat which may be transferred to the glass. Ducts should be at least 100 to 500 mm from glass surfaces. Careful attention should be paid to heavy metal or concrete heat sinks.

205.2
Ventilation
For the gap between the glass and drapes to be considered as ventilated there must be 50 mm minimum space between the glass and the blind and at least a 50 mm gap at the top and bottom of the blind.

205.3
Organic coating films
Reflective films must not be applied to the interior pane. Deviations from the above principles may be permitted if the manufacturer is consulted.

206
TREATMENT OF THE UNIT

206.1
Storage procedures

206.1.1
Units should be uncrated and inspected for moisture. Any units found to be wet must be dried before storage. To avoid thermal stress, all units must be stored inside or under an opaque cover and not under transparent sheeting.

206.1.2
Uncrated units must be stored in the manner shown in fig. 41. The weight of an insulating unit should be equally distributed over both sheets.

206.2
Glazing

206.2.1
Edge wraps should not be removed unless advised by the manufacturer. Spacing blocks, structural gaskets, or glazing wedges should where applicable, conform to the edge profile of the unit. This is critical where the unit edge is metal banded. Edge pressure on insulating units should not exceed 2 N/mm.

206.2.2
Care should be taken not to damage exposed glass edges.

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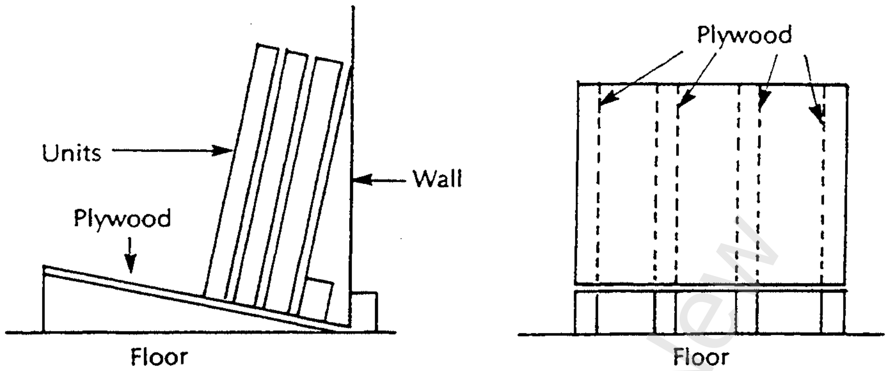

Fig. 41 STORAGE OF UNITS

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206.3
After glazing

206.3.1
Upon installation, immediately remove all labels as they may cause heat concentration and result in staining or breakage. Under no circumstances should advertising labels or whiting be applied to the glass.

207
SOLAR CONTROL AND SPECIAL PRODUCT REQUIREMENTS IN INSULATING GLASS UNITS

207.1
General
Units incorporating heat absorbing solar control glass, heat reflecting solar control glass or special products such as wired glass, have different characteristics from clear glass, particularly in relation to thermal stress and it is important to take additional precautions when installing this type of unit.

207.2
Installation

207.2.1
Units with one light of tinted or reflective glass should normally be installed with that light to the exterior. When the tinted or reflective light is to be installed to the interior, it should be clearly stated in the plans and specifications and have been the subject of a thorough study of edge stresses by the responsible design professional. Such studies may show a need to heat strengthen or temper one or both lights to minimize thermal breakage when the tinted or reflective light is to be the interior glass.

207.2.2
Observe all previously stated recommendations for sash selection clearances, setting blocks, and placement of the unit in relation to heating ducts and drapes.

207.2.3
When using sealed insulating units it is advisable to carry out thermal safety checks as either toughened or heat strengthened glass may be required. This is particularly necessary in areas of unusual shading conditions.

207.2.4
For units incorporating solar control glass in annealed form, greater than 5 m^2, the unit manufacturer should be consulted.

208
Procedures for glazing

208.1
General

208.1.1
The procedures set out in 207 of this Standard apply also to the installation of Insulating Glazing (IG) Units. Points of difference from the glazing of single glass sheets are noted below.

208.1.2
Warranties
Warranties given by makers of IG Units are normally valid only if the units are glazed in accordance with the makers' instructions or recommendations at the time of supply. Requirements may differ with individual makers and these take precedence over general procedures.

208.1.3
Important property
IG Units are hermetically sealed and subject to

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continuous flexing due to changes in atmospheric pressure and temperature. It is therefore essential that glazing methods allow for expansion and contraction of all components in the system.

208.1.4
Glazing techniques
These must:
(a) Prevent water from lodging in the frame in the neighbourhood of the edge seal
(b) Provide adequate weep systems
(c) Keep edge seals dry
(d) Prevent water penetration into the building
(e) Support the unit adequately
(f) Allow the unit to 'float' in the opening
(g) Employ glazing materials compatible with unit edge seals.

NOTE – The above precautions (a, b and c) apply to IG Units themselves if edge wrapped and edge banded.

208.1.5
Rebates

208.1.5.1
See that rebate width is sufficient to accommodate the thickness of the unit plus face clearances plus bead (if used).

208.1.5.2
Minimum rebate depths are 12 mm for units up to 3.0 m^2 and 15 mm for those up to 8.5 m^2. Deeper rebates may be required for some types of unit.

208.1.6
Setting blocks
Use setting blocks at least equal in width to the thickness of the unit and normally 3 mm wider so that effective support is given across the unit thickness and to each pane of glass.

208.1.7
Edge clearances
Ensure edge clearances are not less than 3 mm for units up to 3 m^2 and not less than 5 mm for larger units.

208.1.8
Opening windows
Special consideration may need to be given to the design of the frame and the method of glazing where units are glazed into opening windows.

208.1.9
Timber frames

208.1.9.1
Front putty glazing techniques are not recommended.

208.1.9.2
Whether internal or external, bed beads to the frames subject to the need to ensure free drainage to the glazing cavity.

208.1.10
Steel frames

208.1.10.1
Front putty glazing techniques are not recommended. Some forms of 'clip on' or 'clip in' beads may be unsuitable if they are required to be pressed down when in contact with preformed strip materials. In these cases design the system so that the bead exerts an adequate and uniform compressive force upon the strips but does not distort the preformed glazing strip.

208.1.10.2
The bedding of metal beads to the frame is unnecessary provided that the frame itself is watertight and permits drainage to the outside.

208.1.10.3
Glazing compounds or systems may comprise, either singly or in combination, preformed compression strips, sealants, and glazing wedges. Selection of the glazing system must be confirmed with the manufacturer of the IG Units.

209
PERFORMANCE OF MANUFACTURED SEALED INSULATING GLASS UNITS

209.1
Evidence shall be available that the unit has been type tested to cover the following features:
(a) Cleanliness
(b) Initial seal
(c) Initial dew point temperature
(d) Ultraviolet exposure
(e) Weather cycling
(f) High humidity cycling

In accordance with BS 5713 or ASTM Standard test specifications E773 and E774 requirement.

Compliance with other internationally accepted specifications which embody these features will also be deemed to comply.

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APPENDIX A
BASIS FOR DETERMINATION OF THICKNESS OR AREA OF GLASS IN ACCORDANCE WITH THE REQUIREMENTS FOR WIND LOADING

A1
Rectangles of glass supported on all sides

A1.1
Fig. 20 is based on AS 1288 *Glass installation code*.

A1.2
The following equations are derived from AS 1288 and were used to formulate the figures.

(a) For glass up to and including nominal 6 mm thickness
$Pz^A = K_1 = 0.2t^{1.8}$ .... (A1)

(b) For glass greater than nominal 6 mm thickness
$Pz^A = K_2 = 0.2t^{1.6} + 1.9$ .... (A2)

where
Pz = design wind pressure, in kilopascals
A = area of the glass, in square metres
t = thickness of the glass, in millimetres
K = a constant for a given glass thickness.

A2
Rectangles of glass supported on two opposite sides only

A2.1
Fig. 21 is based on the standard engineering formula for a simply supported beam with uniform cross-section and uniformly distributed load.

A2.2
Thus the maximum dimension of the span for any glass thickness or design wind pressure is calculated from the following equation:

$b^2pz = c = \frac{t^2f}{750}$ .... (A3)

where
b = span, in metres
t = thickness of glass, in millimetres
f = design stress of the glass, in megapascals
pz = design wind pressure, in kilopascals
f = a constant for a given glass thickness.

A2.3
In these tables the design stress used for glass was 16.7 MPa (the design stress for sheet and float glass).

A3
Maximum aspect ratios for rectangles of glass supported on all sides

A3.1
For each thickness of glass there is an aspect ratio, a/b above, which the rectangle of glass given by the figures for glass supported on all sides would be more conservative than that given by the graphs for glass supported on two opposite sides only, it being assumed that the span between the supports is the short side, b. The value of a/b at which exactly the same area, A, of glass would be given by either criterion can be determined as follows:

(a) For glass up to and including 6 mm thickness:
  (i) For 4-edged support, equation (A1) can be written as:
  $abp_z = 0.2t^{1.8}$ .... (A4)
  (ii) For 2-edged support, equation (A3) can be written as:
  $b^2pz = 16.7t^2/750$ .... (A5)
  Dividing (A4) by (A5), $a/b = 8.98/t^{0.2}$ .. (A6)
  This gives the maximum aspect ratio for the application of fig. 20 for any thickness, t, up to 6 mm.

(b) For glass thicker than 6 mm:
  (i) For 4-edged support equation (A2) can be written as:
  $abp_z = 0.2t^{1.6} + 1.9$ .... (A7)
  (ii) For 2-edged support equation (A3) can be written as:
  $b^2pz = 15.2t^2/750$ .... (A8)
  Dividing (A7) by (A8), a/b = 49.34 $(0.2t^{1.6} + 1.9)/t^2$ .... (A9)
  This gives the maximum aspect ratio for the application of thickness, t, greater than 6 mm.

It will be noted that the values of a/b given by equations (A6) and (A9) are independent of pz.

A4
Consideration of glass other than transparent annealed glass

NOTE – The following approximate factors can be used to calculate the strength of different types of glass. The graphs shown in figures 20 to 29 should be used if more accurate calculations are required.

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Table A1 FACTORS FOR RELATIVE RESISTANCE TO WIND LOAD FOR GLASSES OF EQUAL THICKNESS

Type of glass	*Pressure factor F*	
	Area factor	*Span factor*
Transparent annealed	1.0	1.0
Wired	0.5	0.7
Laminated	0.8	0.9
Patterned*	1.0	1.0
Double glazed units factory sealed†	1.5	1.2
Toughened fully‡	2.0	1.4

* For any patterned glass, the thickness is measured at its minimum from where the appropriate relationship applies. Figures 26 and 27 have been calculated using the minimum thickness of each nominal thickness glass.

† Use thickness of the thinner of the two panes.

The area and span factors are based on the double glazing units with two panes of equal thickness to a single pane of annealed glass. If other types of glass are to be used the manufacturer should be consulted.

‡ Toughened. Allowable deflection is $\frac{\text{Span}}{60}$ for both four and two edge support. If the system can allow greater deflection the manufacturer should be consulted.

A4.1

Sandblasting will significantly reduce the strength of glass by as much as 50 %.

NOTE – Where satisfactory experimental evidence is presented and approved by the Engineer, more favourable pressure factors than those in table A1 may be used.

A4.2

The maximum area of any of the types of glass shown in table A1 that can be used in 4-edged support shall be obtained by determining the area of annealed glass that could be used and multiplying by the area factor of the actual glass to be used.

A4.3

The maximum span of any of the types of glass shown in the above table A1 that can be used in 2 opposite edges supported shall be obtained by determining the span of float glass that could be used and multiplying by the span factor of the actual glass to be used.

A4.4

EXAMPLE

Double glazed units, factory made, consisting of 6 mm float glass for both glasses are required to withstand a design wind pressure, p_z, of 2400 Pa. Determine the maximum area permissible.

The area factor for a double glazed unit is 1.5. From fig. 20 at a design pressure of 2400 Pa, the maximum area of annealed glass is 1.95 m^2. Using the area factor of 1.5 from table A1, the maximum area of a double glazed unit will be $1.95 \times 1.5 = 2.93$ m^2.

Toughened allowable deflection is span/60 for both 4- and 2- edged support. If the system can allow greater deflection, the manufacturer should be consulted.

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APPENDIX B
EXAMPLES OF CALCULATIONS FOR SLOPED AND OVERHEAD GLAZING

B1
Example 1

B1.1
A conservatory is to be built next to the side of an existing house. The roof is pitched and at an angle of 45 degrees. The height to the apex is 4 metres. The building is located in Dunedin at an estimated altitude of 100 m. Glass is to be supported on the two long edges with the suggested span between aluminium supports at 610 mm. What type of thickness of glass should be used.

B1.2
Determine design loads on glass due to:
(a) Wind
(b) Snow
(c) Maintenance
(d) Glass and glazing

(a) *Windload Pw*
From table 21 for Dunedin
Basic wind speed = 38 m/s
Glazing height = 4 m
Ground roughness = 3
Therefore corrected wind pressure = 440 pa

From table 21. At a corrected wind pressure of 552 pa (next highest to 440 pa) with a 45° pitched roof the design wind pressures are: +414 pa and −607 pa = Pw

(b) *Snowload Ps*
From NZS 4203
For Dunedin take Zone 5
Therefore load at 45° and 100 m height
= 300 pa = Ps

(c) *Maintenance Pm*
As the sloping roof is readily accessible to clean by hosing and as we would not expect maintenance to be undertaken in windy or snow conditions, it is fair to leave off the maintenance load from this example.
Then Pm = 0

(d) *Glass and glazing*
From table 19. At 45°, single glazing with aluminium bars
Pd = 127 pa

B1.3
Design loads on the glass are:

	+2.6 (Pd + Ps) + Pw	(1)
or	Pd − Pw	(2)
or	+2.6 Pd − 2.0 Pm	(3)
(1)	+2.6 (127 + 300) + 414	= + 1524 pa
(2)	127 − 607	= − 480 pa
(3)	330 − 0	= + 330 pa

As the largest pressure is equation (1) then the design load is 1524 pa.

B1.4
Glass size and thickness
If the conservatory is to be used as a sun room and not just as a Green house safety glass must be used in the roof.

From fig. 25, for 2-edge supported laminated glass at a load of 1524 pa and a span of 610 mm then minimum glass thickness is 6 mm.

B2
Simplified design method for calculating glass thickness for sloped glazing where there are no snow or maintenance loads

B2.1
General

B2.1.1
Within a set of stated conditions it is possible, without too much loss of accuracy, to draw up generally applicable tables of design loads for patent glazing in buildings of simple form, placed on sites where wind conditions are unlikely to be complex. The treatment described in the remainder of this Appendix relates to these relatively uncomplicated circumstances. Where the limiting conditions are not fully satisfied, each building has to be considered as a separate design problem.

B2.1.2
To further simplify the designing of sloped and overhead glazing in this Standard, tables 19 and 21 have been combined and are shown in tables B1 and B2.

B2.1.3
This simplified method does not take into account snow or maintenance loads, or high pressures around the edges of roofs. If the glazing system is to be designed with these loads, then the first part of this Section must be used.

B2.2
Example 2
Sloped glazing forms a monopitched roof of a conservatory built onto the side of a house in Wellington. The roof is sloped at 30° to the horizontal with its apex at 4 metres. The glass is to be 2-edge support at 750 mm centres. Laminated glass to be glazed in aluminium bars.

1. Determine design loads on glass due to:
   (a) Wind
   (b) Glass and glazing
   (a) *Wind load*

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From table 20
For Wellington, basic wind speed = 50 m/s
Glazing height = 4 m
Ground roughness = 3
Therefore corrected wind pressure = 751 pa
(b) *Glass and glazing*
From table B1, single glazing aluminium bars, at 751 pa corrected wind pressure, and a 30° monopitch roof, the working pressure on the glass and glazing is = −800 pa

2. *Determine glass size and thickness*
From fig. 25, for 2-edge supported laminated glass, at load of 800 pa
Glass span of 750 mm
The minimum thickness of laminated glass is 6 mm

NOTE – The maximum span of 6 mm glass shown on fig. 25 at 800 pa is 870 mm.

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Table B1 WORKING PRESSURES FOR GLASS (SINGLE GLAZING, WITH GLAZING BARS)

Glazing angle	*0° to 30°*		*45°*		*60°*		*90° Vertical*
Roof type	*Pitched*	*Monopitch*	*Pitched*	*Monopitch*	*Pitched*	*Monopitch*	
Corrected wind pressure (Pa)	*Pressures (Pa)*						
245	+ 610	− 150	+ 510	+ 330	+ 460	+ 230	± 370
383	+ 700	− 320	+ 620	− 370	+ 580	− 410	± 580
552	+ 810	− 540	+ 740	− 590	+ 730	− 630	± 830
751	+ 940	− 800	+ 890	− 850	+ 910	− 890	±1130
981	+1090	−1100	+1070	−1150	+1120	−1190	±1470
1240	−1310	−1440	+1260	−1490	+1350	−1520	±1860
1530	−1660	−1820	−1560	−1860	+1610	−1900	±2300
1850	−2050	−2230	−1910	−2280	−1950	−2320	±2780
2210	−2480	−2700	−2300	−2750	−2340	−2780	±3310
2590	−2930	−3190	−2720	−3240	−2760	−3280	±3890
3000	−3430	−3730	−3170	−3770	−3210	−3810	±4510

NOTE – The numbers in this table have been rounded up or down to the nearest 10 after calculation.

Table B2 WORKING PRESSURES FOR GLASS (DOUBLE GLAZING, WITH GLAZING BARS)

Glazing angle	*0° to 30°*		*45°*		*60°*		*90° Vertical*
Roof type	*Pitched*	*Monopitch*	*Pitched*	*Monopitch*	*Pitched*	*Monopitch*	
Corrected wind pressure (Pa)	*Pressures (Pa)*						
245	+1010	− 10	+ 810	+ 620	+ 660	+ 440	± 370
383	+1100	− 170	+ 910	+ 620	+ 790	+ 440	± 580
552	+1210	− 390	+1040	+ 620	+ 940	− 550	± 830
751	+1340	− 650	+1190	− 740	+1120	− 810	±1130
981	+1490	− 950	+1360	−1040	+1330	−1110	±1470
1240	+1660	−1290	+1550	−1370	+1560	−1440	±1860
1530	+1850	−1660	+1770	−1750	+1820	−1820	±2300
1850	+2066	−2080	+2010	−2170	+2110	−2240	±2780
2210	−2320	−2500	+2280	−2630	+2430	−2700	±3310
2590	−2780	−3040	−2610	−3130	+2770	−3220	±3890
3000	−3270	−3570	−3060	−3660	−3140	+3730	±4510

NOTE – The numbers in this table have been rounded up or down to the nearest 10 after calculation.

NOTES

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Pr 00

Code of practice for
GLAZING IN BUILDINGS

AMENDMENT No. 1

July 1992

EXPLANATORY NOTE – This Amendment applies when this Standard is used as an Acceptable Solution that is referenced in Approved Document B1 Structure – General, to the New Zealand Building Code. The Amendment need not apply when this Standard is used under the Model Building Bylaw system which remains in operation until 31 December 1992.

To ensure receiving advice of the next amendment to NZS 4223:1985 please complete and return the amendment request form.

APPROVAL

Amendment No. 1 was approved in July 1992 by the Standards Council to be an amendment to NZS 4223:1985 pursuant to the provisions of section 10 of the Standards Act 1988.

(Amendment No. 1, July 1992)

1.1
Delete the clause and **substitute**:

1.1
This document provides an acceptable solution for the sizing of glass to carry wind loads. It also covers sizing for human impact but only for the situation where the glass is within 200 mm of the floor. Specific design shall be carried out for glazing that measures more than 200 mm from its lower edge to the floor.

Clauses 104 onwards deal with glazing materials and systems, which are to be used with glass sized as above".

NOTE – BRANZ Bulletin No. 270 "Human impact on glass in high-rise buildings" can be referred to for additional information.

(Amendment No. 1, July 1992)

Sections 101 and 102
Delete these sections.

NOTE – These sections provide useful information but are not essential to the use of the Standard as an Acceptable Solution to NZBC B1.

(Amendment No. 1, July 1992)

103.1
Delete the clause and **substitute:**

"The size and thickness of glass required to sustain loading from wind and human impact can be determined from the use of this document. The glass types called for comply with the performances of NZBC F4".

(Amendment No. 1, July 1992)

103.2, 103.3, 103.4.1 and 103.4.2
Delete these clauses.

NOTE – These clauses provide useful information but are not essential to the use of the Standard as an Acceptable Solution to NZBC B1.

(Amendment No. 1, July 1992)

103.5.4.10
In line 6 **delete** the words "approved by the Engineer"and **substitute** "the subject of specific design".

(Amendment No. 1, July 1992)

103.6, 103.7 and 103.8
Delete these clauses.

NOTE – These clauses provide useful information, but where security, fire safety and durability are concerned they should be the subjects of specific design. Reference should be made where appropriate to other NZBC clauses.

(Amendment No. 1, July 1992)

103.9.2.5
In item (m), **delete** the words "by the Engineer".

(Amendment No. 1, July 1992)

103.10.1
At the beginning of the clause, **add** a new paragraph:

"Clause 103.10 describes an acceptable solution for sizing glass once a design load has been established. The clause gives a procedure for determining design dead and wind loads only. Other loads such as snow and maintenance as applicable, require specific design".

(Amendment No. 1, July 1992)

103.12, 103.13 and 103.16
Delete these clauses.

NOTE – These clauses provide useful information but are not essential to the use of the Standard as an Acceptable Solution to NZBC B1.

(Amendment No. 1, July 1992)

105.9.7
Delete the clause.

NOTE – This clause provides useful information but is not essential to the use of the Standard as an Acceptable Solution to NZBC B1.

(Amendment No. 1, July 1992)

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NEW ZEALAND STANDARD

Code of practice for
GLAZING IN BUILDINGS

AMENDMENT No. 2

August 1993

EXPLANATORY NOTE - This Amendment is consequential to the issue of NZS 4223:Part 3:1993, *Human impact safety requirements* which supersedes clauses 103.4.3 and 103.5 of Part 1 of this Standard. The opportunity has been taken to update the Related Documents.

APPROVAL

Amendment No. 2 to NZS 4223:1985 was approved on 5 July 1993 by the Standards Council to be a New Zealand Standard pursuant to the provisions of section 10 of the Standards Act 1988.

RELATED DOCUMENTS

Delete the list of New Zealand, American, Australian and British Standards referred to and **substitute** the following:

NEW ZEALAND STANDARDS

NZS 3504:1979	Aluminium windows
NZS 3619:1979	Timber windows
NZS 4203:1992	Code of practice for general structural design and design loadings for buildings

AMERICAN STANDARDS

ASTM E773-1988	Test method for seal durability of sealed insulating glass units
ASTM E774-1988	Specification for sealed insulating glass units

AUSTRALIAN STANDARDS

AS 1263:1972	Oil-based putty
AS 1288:1989	Glass in buildings - Selection and installation
AS 2208:1978	Safety glazing materials for use in buildings (human impact considerations)

BRITISH STANDARDS

BS 544:1969	Linseed oil putty for use in wooden frames
BS 2750:- - - -	Measurement of sound insulation in buildings and of building elements
BS 4255:- - - -	Rubber used in preformed gaskets for weather exclusion from buildings
Part 1:1986	Non-cellular gaskets
BS 5516:1991	Code of practice for design and installation of sloping and vertical patent glazing
BS 5713:1979	Specification for hermetically sealed flat double glazing units

(Amendment No. 2, August 1993)

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103
DESIGN CONSIDERATIONS

103.4.3
Safety
Delete the whole of clause 103.4.3 which is superseded by NZS 4223:Part 3:1993.

103.5
Safety (Human impact safety requirements)
Delete the whole of clause 103.5 which is superseded by NZS 4223:Part 3:1993.

(Amendment No. 2, August 1993)

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APPROVED TO NEW ZEALAND STANDARD

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Declared on 27 September 1985 by the Standards Council to be a Standard specification pursuant to the provisions of section 23 of the Standards Act 1965.

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