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GLASS

COMPOSITION

- Main component - Soda lime silicate glass or silicon dioxide (silicate)
- Other ingredients such as soda and lime are added to lower the melting temperature of silicate and promote optical clarity of the finished glass product.
- The colour and solar properties of clear glass can be altered in two ways.
 - Firstly, the glass can be tinted (coloured) by adding small amounts of metallic oxides to the existing ingredients. For example, the addition of iron oxide produces a green glass. Bronze and grey are produced by the addition of selenium and nickel oxide.
 - Secondly, a thin metallic coating can be applied to the surface of clear or tinted glass. This is known as coated or reflective glass.

CHEMICAL COMPOSITION

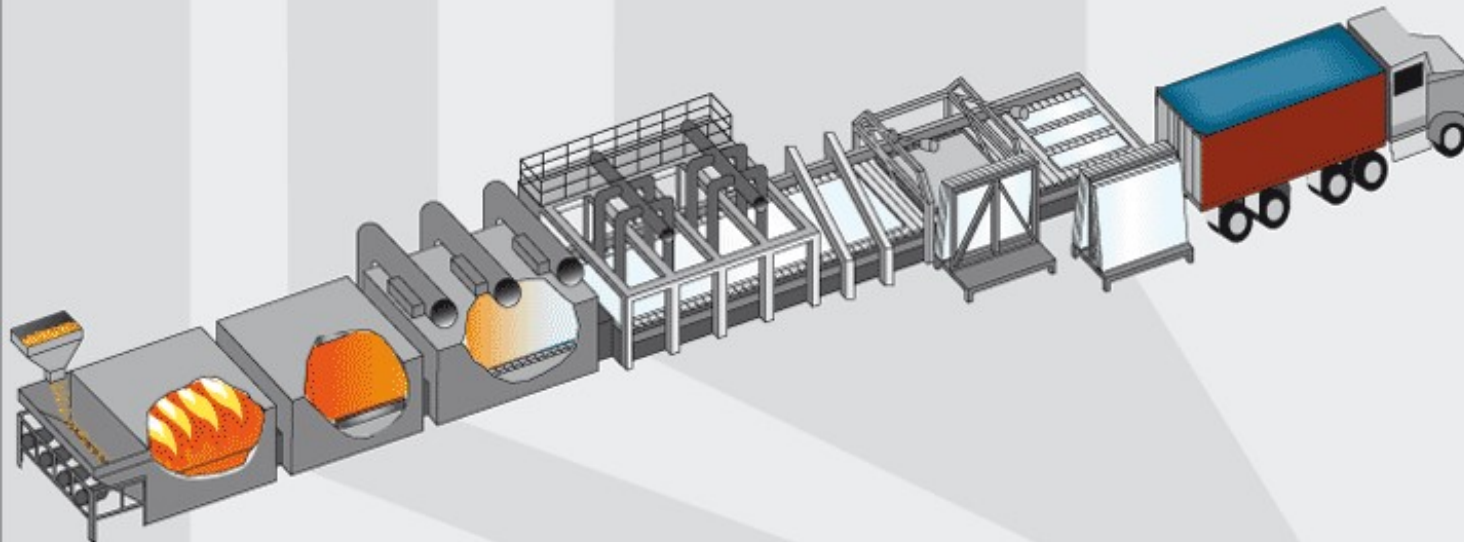
The magnitude of the proportions by mass of the principle constituents of soda lime silicate clear float glass are as follows:

CHEMICAL COMPOSITION		
Chemical	Symbol	Percentage
Silicon dioxide (silicate)	SiO_2	69 - 74%
Calcium oxide (lime)	CaO	5 - 12%
Sodium oxide (soda)	Na_2O	12 - 16%
Magnesium oxide	MgO	0 - 16%
Aluminium oxide	Al_2O_3	0 - 5%

MANUFACTURE

FLOAT GLASS MANUFACTURING PROCESS

Manufacturing Line



1. Batch House

The raw materials are weighed, mixed and charged into the furnace automatically and watered to prevent particles of the various constituents from separating and producing dust.

2. Furnace

Float glass manufacture consists of three main stages:

- Melting, when the raw materials become molten at a temperature of around 1550°C.
- Refinement, when the molten glass is homogenised and gas bubbles are removed.
- Temperature control, when the molten glass is cooled to a point where its viscosity is suitable for drawing into the tin float bath.

3. Molten Tin Float Bath

Liquid glass is floated onto the molten tin at approximately 1000°C forming a ribbon.

Since the glass is highly viscous, it does not mix with the very fluid molten tin, producing a perfectly flat contact surface. The thickness of the glass is controlled by increasing or reducing the rate at which it spreads.

4. Annealing Chamber

On leaving the bath of molten tin, the now rigid glass ribbon passes through a cooling tunnel called a "lehr". The temperature of the glass is gradually lowered from 620°C to 250°C.

The glass is further cooled in controlled conditions.

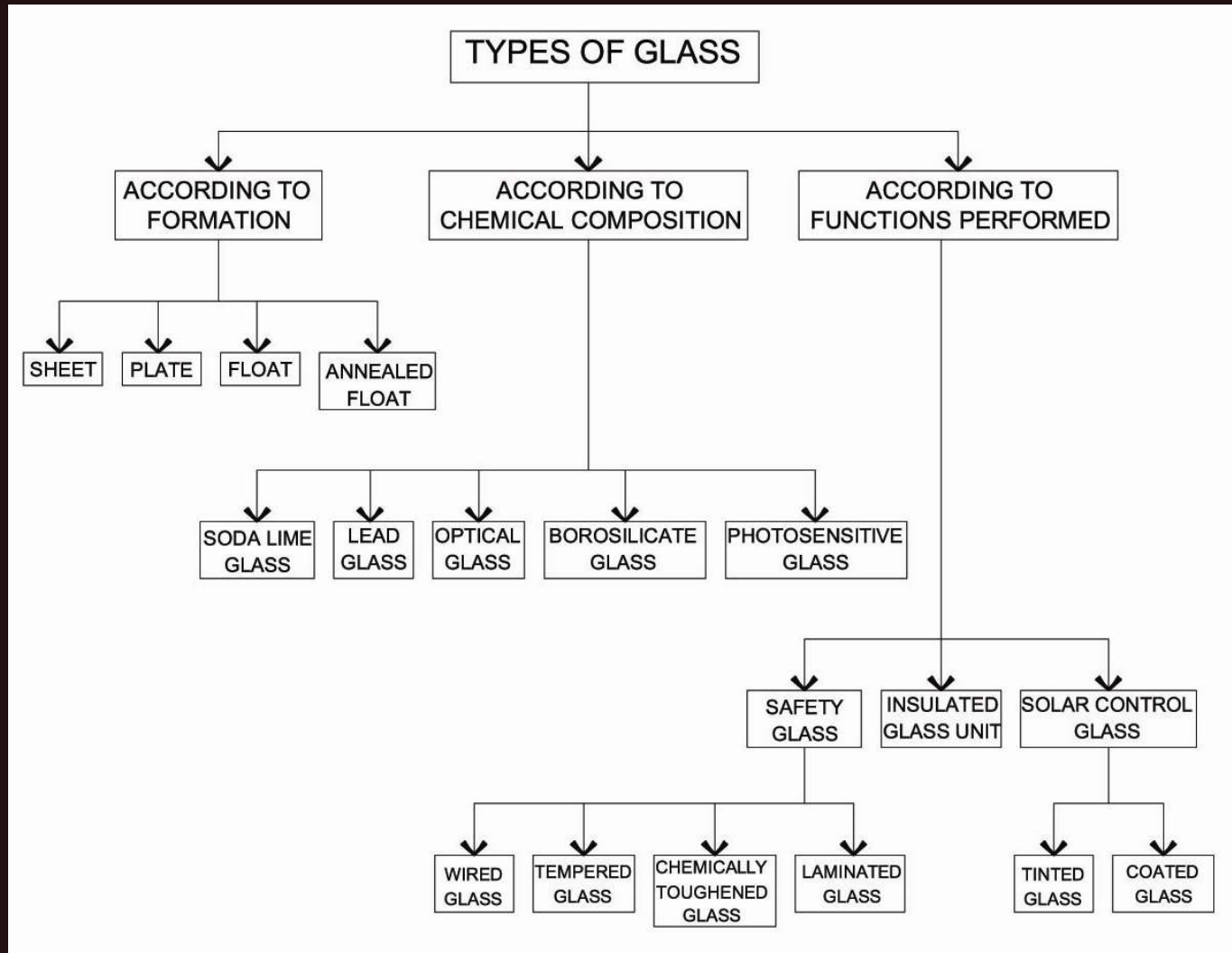
5. Cutting

The continuous cold glass ribbon is now automatically cut into sheets and stacked into packs or cases ready for despatch.

6. Despatch

The packs or cases of glass are then loaded onto trucks or into open top containers and delivered to the customer.

TREE STRUCTURE FOR VARIOUS TYPES OF GLASS

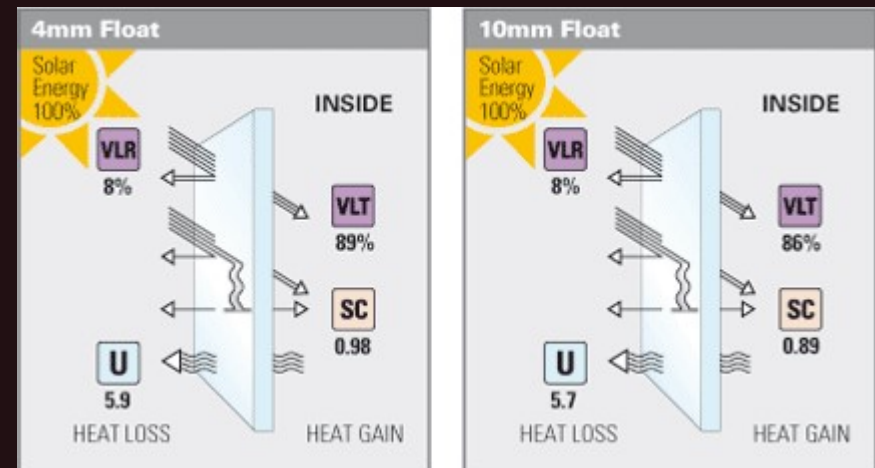


ACCORDING TO FORMATION

1. **SHEET GLASS** - Prepared by passing molten glass between water cooled liquid as it cools. The glass is cut to size at the top of the tower.
2. **PLATE GLASS** - It is similar to sheet glass except that it is ground and polished before being cut. Cutting takes place after both the surfaces have been ground and polished by fine sand and emery grains.
3. **FLOAT GLASS** - The float glass process is the most common method of flat glass production in the world. This process basically involves melting silicate (sand), lime and soda in a furnace and floating it onto a large bed of molten tin, hence the name float glass. This mixture slowly solidifies over the molten tin as it enters the annealing oven where it travels along rollers under a controlled cooling process. From this point the glass emerges in one continuous ribbon and is then cut and further processed to customers' needs. Float glass is also known as **soda lime silicate glass** as these are the major components used in manufacture.

3.1 **CLEAR FLOAT** - Clear float glass is transparent, offering high **visible light transmittance** (VLT).

Clear float can be processed into heat strengthened, toughened, laminated, curved glass and Insulating Glass Units.



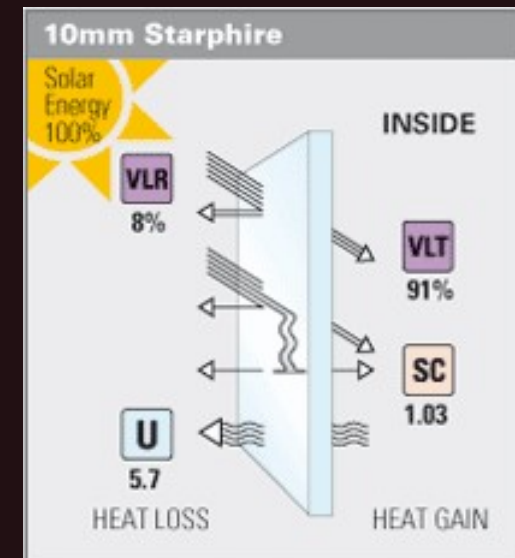
3.2 **EXTRA CLEAR FLOAT (LOW IRON)** –

Extra Clear low iron glasses contain approximately one quarter of the iron content of standard clear float glass, providing an extra clear glass that is crystal clear in appearance.

Ultra clear float glass product with **75% less** iron content than standard float glass.

Manufactured in 3 - 19mm
Available in 4, 5, 6, 8, 10, 12mm

It can be used in rooflights and atrium glazing when solar control is not a factor.



3.3 TINTED FLOAT - Tinted float is produced by adding metal oxides during float glass production.

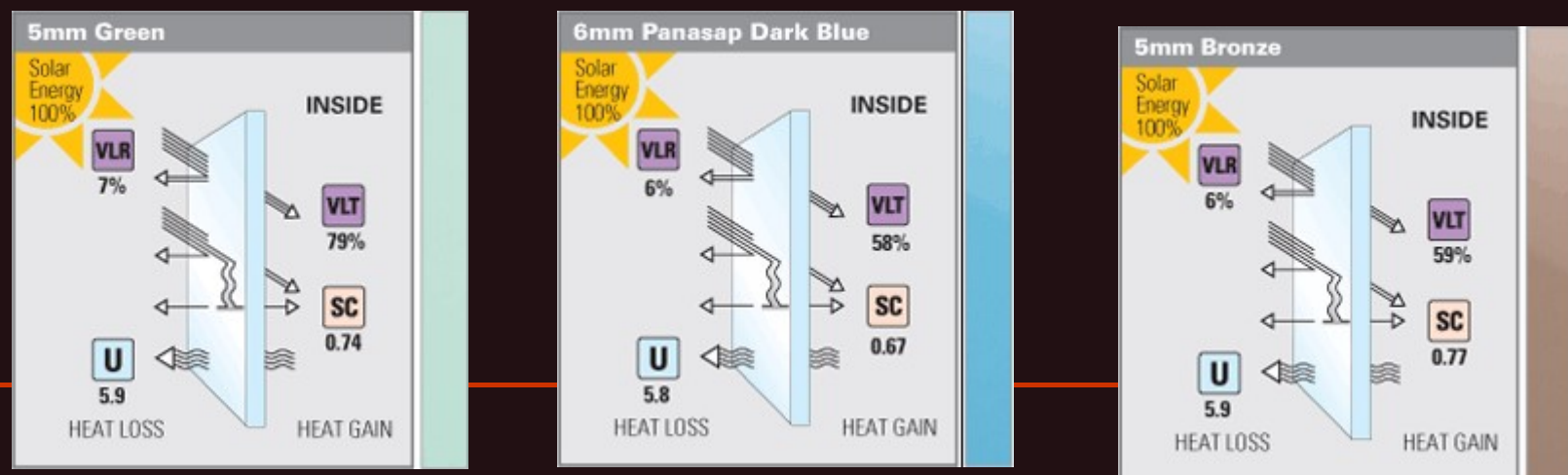
Apart from its function in an aesthetic sense, tinted float is primarily designed to reduce solar heat gain, UV and glare inside a building.

Tinted float glass achieves its performance by absorbing solar energy and so is sometimes referred to as heat absorbing glass.

Tinted float can be processed into heat strengthened, toughened, laminated, curved glass and Insulating Glass Units.

Tinted glass products are sourced from quality float glass manufacturers including Guardian, Glaverbel, Asahi and Pilkington.

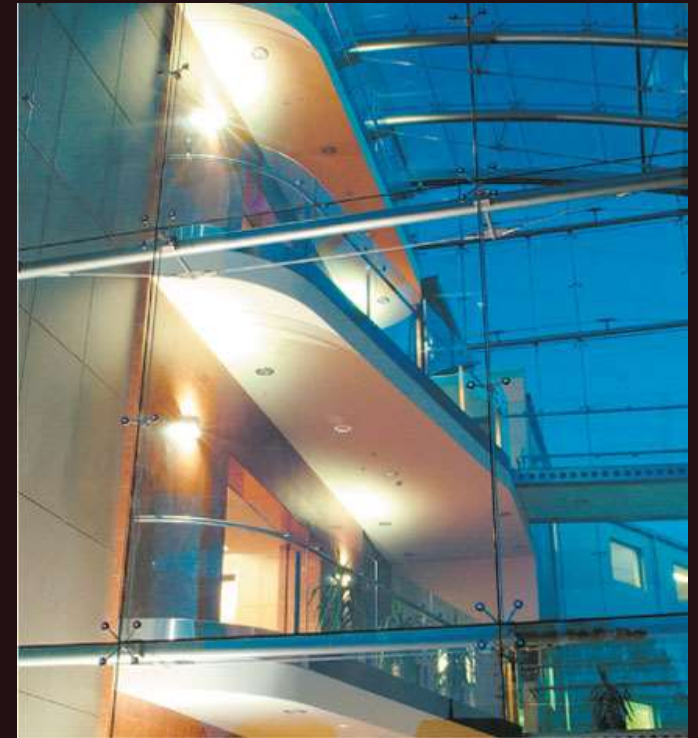
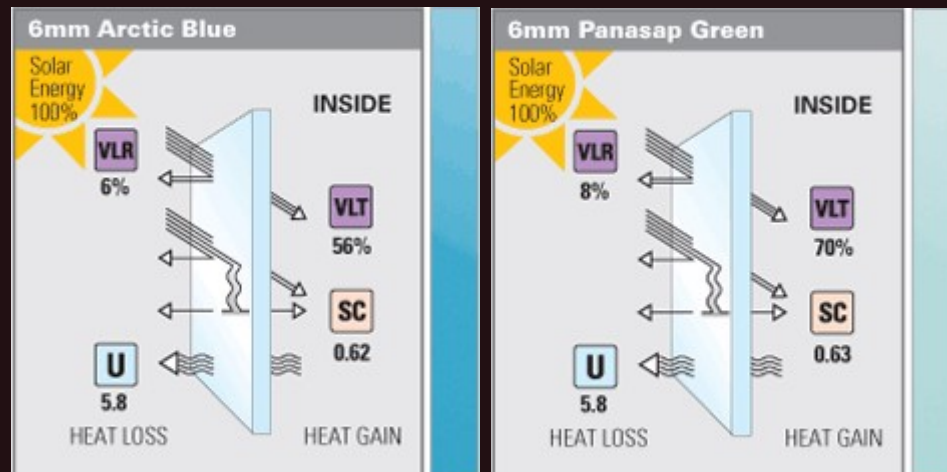
The most common colours are grey, bronze, green and blue.



3.4 HIGH PERFORMANCE TINTED FLOAT -

High performance tinted float products that are engineered to limit the traditional compromise between **high light transmission and low solar gain**.

These products have been designed for very low light transmission for privacy or to assist computer viewing.



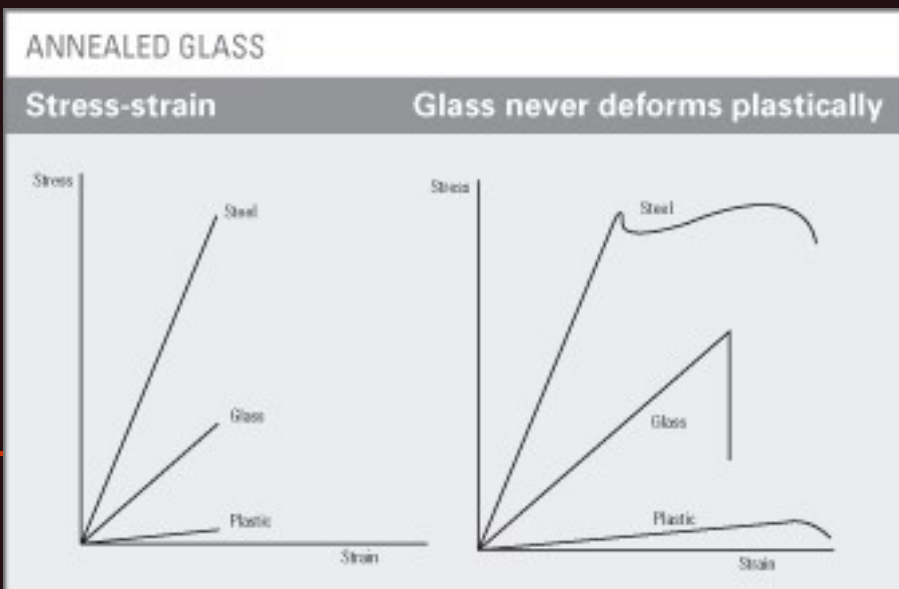
4. **ANNEALED FLOAT** - Glass is reheated to its annealing temperature for about 15 mins.

Then it is cooled gradually to room temperature at a predetermined rate to produce a glass that is stronger and more uniform.

This strengthening of glass is required for performance against wind (surface strengthening) and thermal expansion (edge strengthening).



When broken, it shatters into large sharp pieces.



The property of pure elasticity with brittleness means that the glass cannot be permanently deformed by load as is the case for most solids such as metals and plastics, and that it fails without warning as shown on a stress-strain curve.

ACCORDING TO CHEMICAL COMPOSITION

1. **SODA LIME GLASS** - Consists of **sand, soda-ash and Lime**. Addition of small amount of magnesium reduces its tendency to crystallize. It has a low resistance to thermal shock. This has a low softening temperature (600°C).
2. **BORO SILICATE GLASS**: In this type some of the sodium ions in the soft glass are replaced by **boron in the form of boric acid or borax**, to reduce thermal coefficient of expansion that is responsible for breakage due to sudden heating or cooling of glass. It is widely employed for cooking utensils, laboratory glassware, and chemical process equipment.
3. **LEAD GLASS** -The fine-quality table glass known as crystal is made from **potassium-silicate formulas** that include lead oxide. Lead glass is heavy and has an enhanced capacity to refract light, which makes it suitable for lenses and prisms, as well as for imitation jewels. Because lead absorbs high-energy radiation, lead glasses are used in shields to protect personnel in nuclear installations.
4. **OPTICAL GLASS**: The refractive index of the glass is adjusted by change in chemical composition of the glass. Molten glass is cooled gradually in this process.
5. **PHOTOSENSITIVE GLASS**: It is formed by incorporating **tiny crystals of chlorides of copper, silver or gold into molten glass**. Brief exposure to sunlight produces a temporarily darkened glass as the chloride is decomposed to form metal and chlorine.

ACCORDING TO FUNCTIONS PERFORMED

1. **SAFETY GLASS** - These are specially manufactured to avoid flying fragments and vandalism. It is of the following types:

- **WIRED GLASS** -

Wired glass has 13mm square electrically welded steel wire mesh sandwiched in its centre during the manufacturing process. It is commonly used in fire rated windows and doors to the maximum sizes. It is a Grade B safety glass.

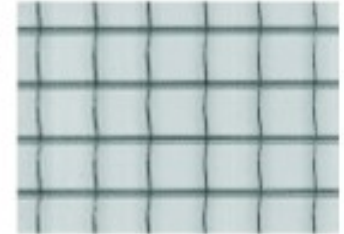
WIRED GLASS

6mm Pyroshield Clear (Polished Georgian Wired)

A clear transparent cross wire glass providing vision and light penetration.

Stocksheet Sizes:

3300 x 1985mm
2540 x 1905mm
2540 x 1984mm

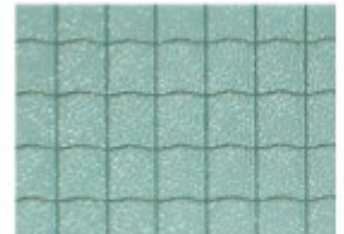


6mm Squarelite

An obscure wired glass, with a Stippolite pattern providing privacy and light penetration.

Stocksheet Sizes:

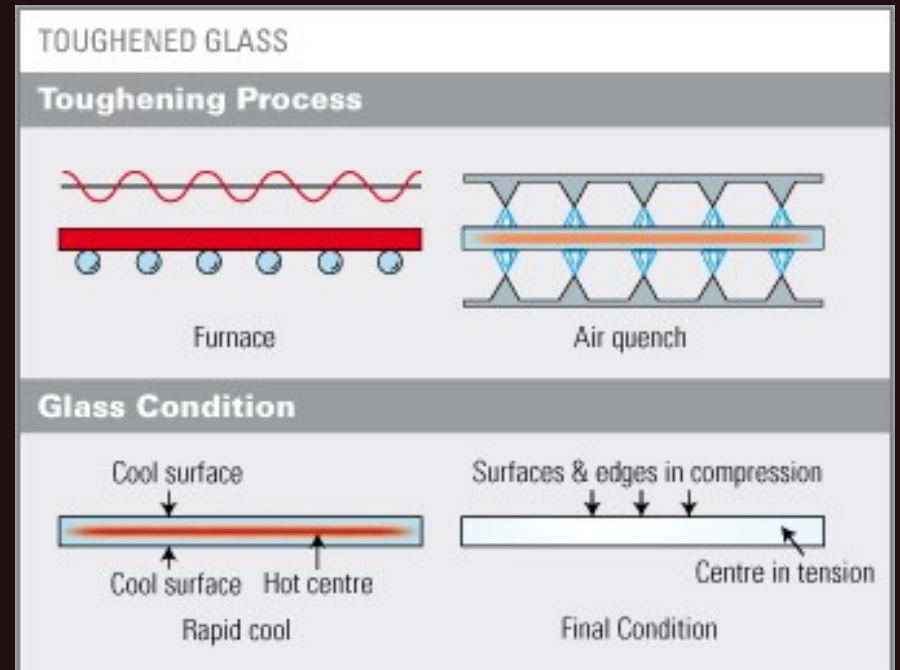
2540 x 1850mm
2760 x 1840mm
3200 x 1840mm



■ TOUGHENED GLASS -

Toughened glass is also known as tempered glass.

- It is produced by first cutting and processing sheets of glass, which are then loaded into a furnace, that has a bed of oscillating rollers.



□ The glass is heated to a plastic **state at around 650°C**, and then by computer control, the glass is moved into the quench area where it is rapidly cooled by a series of high pressure air nozzles.

□ This **rapid cooling or quenching** induces high compression stress in the glass surface, while the centre remains in tension. Although the physical characteristics remain unchanged, the additional stresses created within the glass **increases its thermal and mechanical strength**

THICKNESS TOLERANCE FOR TOUGHENED GLASS

Nominal	Tolerance	Range
4mm	$\pm 0.2\text{mm}$	3.8 - 4.2mm
5mm	$\pm 0.2\text{mm}$	4.8 - 5.2mm
6mm	$\pm 0.2\text{mm}$	5.8 - 6.2mm
8mm	$\pm 0.3\text{mm}$	7.7 - 8.3mm
10mm	$\pm 0.3\text{mm}$	9.7 - 10.3mm
12mm	$\pm 0.3\text{mm}$	11.7 - 12.3mm
15mm	$\pm 0.5\text{mm}$	14.5 - 15.5mm
19mm	$\pm 1.0\text{mm}$	18.00 - 20.0mm

IMPACT STRENGTH

Toughened Safety Glass



ADVANTAGES OF TOUGHED GLASS

- **Safety** - It fractures into small particles, significantly reducing the risk of injury; Grade A safety glass
- **Strength** - High mechanical strength and is 4 to 5 times stronger than annealed glass of the same thickness due to the stresses induced during toughening. It also has high thermal strength, when compared to annealed glass, can withstand a temperature differential of 250°C, and is stable in temperatures ranging from -70°C to 300°C.
- **Mechanical Fixing** - High mechanical strength and can therefore be used with mechanical fixings, such as patch, spider, hinge, point and countersunk fixing.
- **Security** - Much harder to break than annealed float or laminated glass. If broken it will not provide security, however the noise due to breakage is often a deterrent.
- Sound and Solar control same as annealed float glass
- **Applications** - Frameless Glass Doors and Entries, Structural Glass Walls, Glass Canopies, Internal Partitions, Low Level Glazing

- **LAMINATED GLASS** – Laminated glass consists of two or more sheets of glass permanently bonded together by a plastic or resin interlayer. Laminated glass offers superior safety. Although it will break on impact, the fragments are held by the interlayer. The layered nature of laminated glass means that it blocks more noise and UV light than single glass. It can also be made with Low E glass and used in Insulating Glass Units for increased environmental benefits.



BENEFITS AND APPLICATION

- **SAFETY & PROTECTION** - When subjected to impact, the bond between the glass and interlayer adhere any broken fragments, keeping the glass intact and resisting penetration.
 - This important breakage characteristic significantly reduces the likelihood of serious injury, qualifying laminated glass as a Grade A safety glass
 - In addition, the glass will not fall out if used in sloped or overhead glazing applications providing environmental protection.
- **SECURITY** - Laminated glass offers greater protection for people and property by providing an effective barrier from attack. Although the glass will break if hit with a hammer, brick or similar object, the interlayer can resist penetration, ensuring any attempt to enter a premises will be slow and noisy.

- **FADING CONTROL** - PVB laminated glass products absorb the sun's UV radiation while allowing important visible light to pass through. It therefore helps protect curtains, furnishings and carpets from fading caused by the damaging effects of short-wave ultra-violet radiation.
 - **SOUND CONTROL** - Laminated glass is very effective in reducing the transmission of noise through glazing. This is achieved through the sound dampening properties of the interlayer, which will vary with the type and thickness of the interlayer.
 - **CLIMATE CONTROL** - Laminated glass can have a tinted interlayer or be made with tinted or reflective glass to reduce glare and heat gain in a building.
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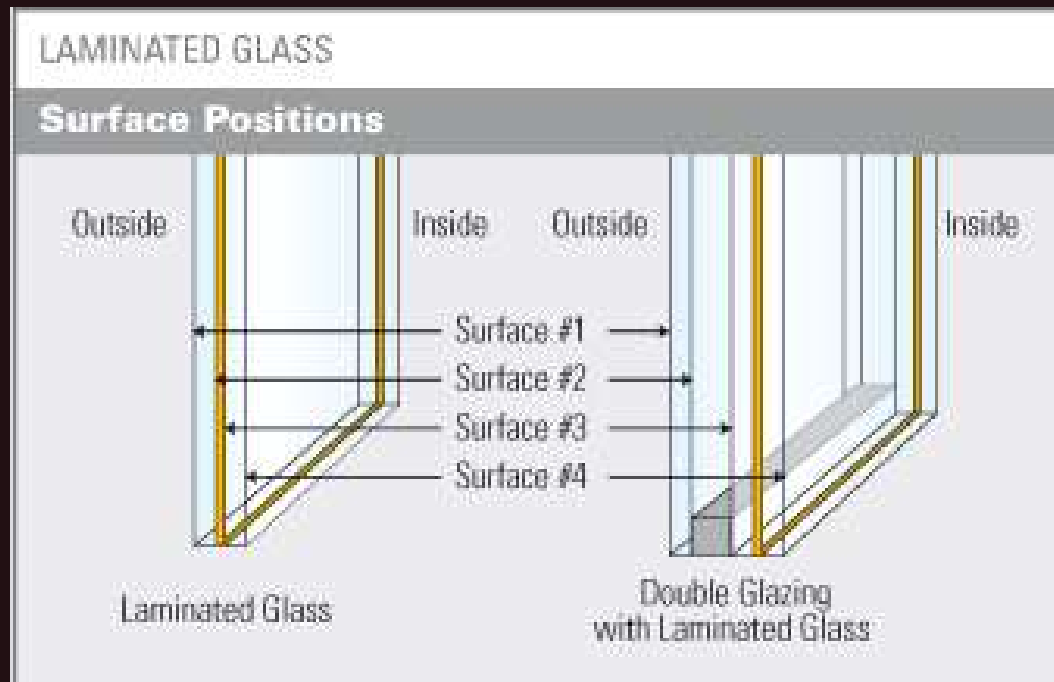
COLOUR AND LIGHT - Laminated glass can be made with a wide range of coloured PVB interlayer to provide special lighting effects. These colours can be combined with tinted and/or printed glass to provide special effects.

PICTURES AND IMAGES - New techniques allow PVB interlayers to be printed with coloured pictures or images before laminating to create special effects

VISIBLE DISTORTION - Due to the controlled nature of the laminating process, façades glazed with annealed laminated glass avoid the risk of visible distortions that are sometimes created by the heat treatment processes, providing significantly sharper visual transmission and reflections.

- In addition to this they are resistant to attack by bullets blast , cyclones

SURFACE POSITIONS



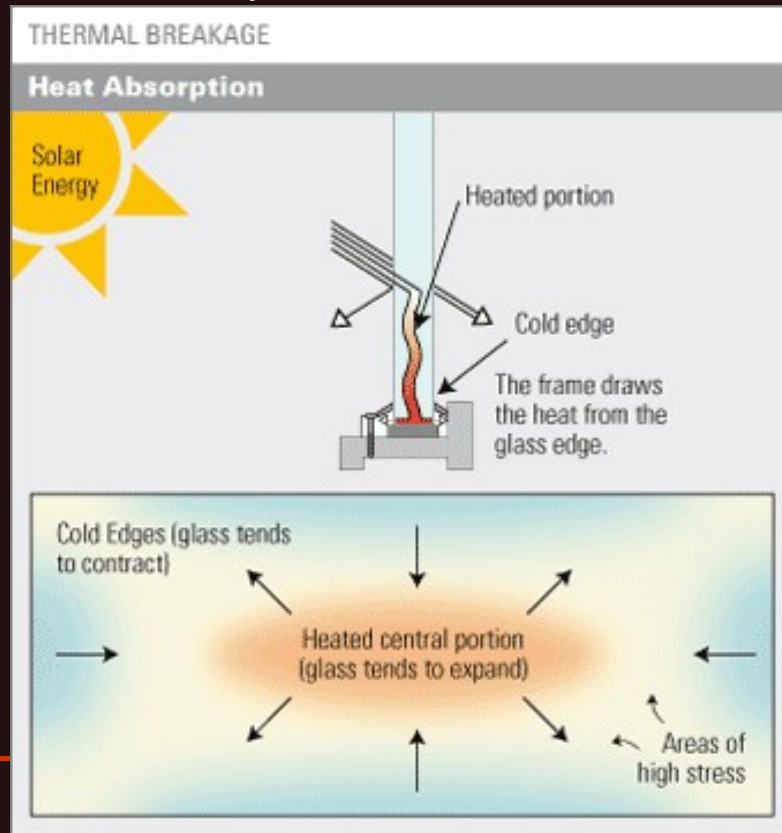
- **HEAT STRENGTHED GLASS** - Heat strengthened glass is about twice as strong as annealed float glass and is used generally as a protection against thermal breakage and breakage fallout. It is not a safety glass.



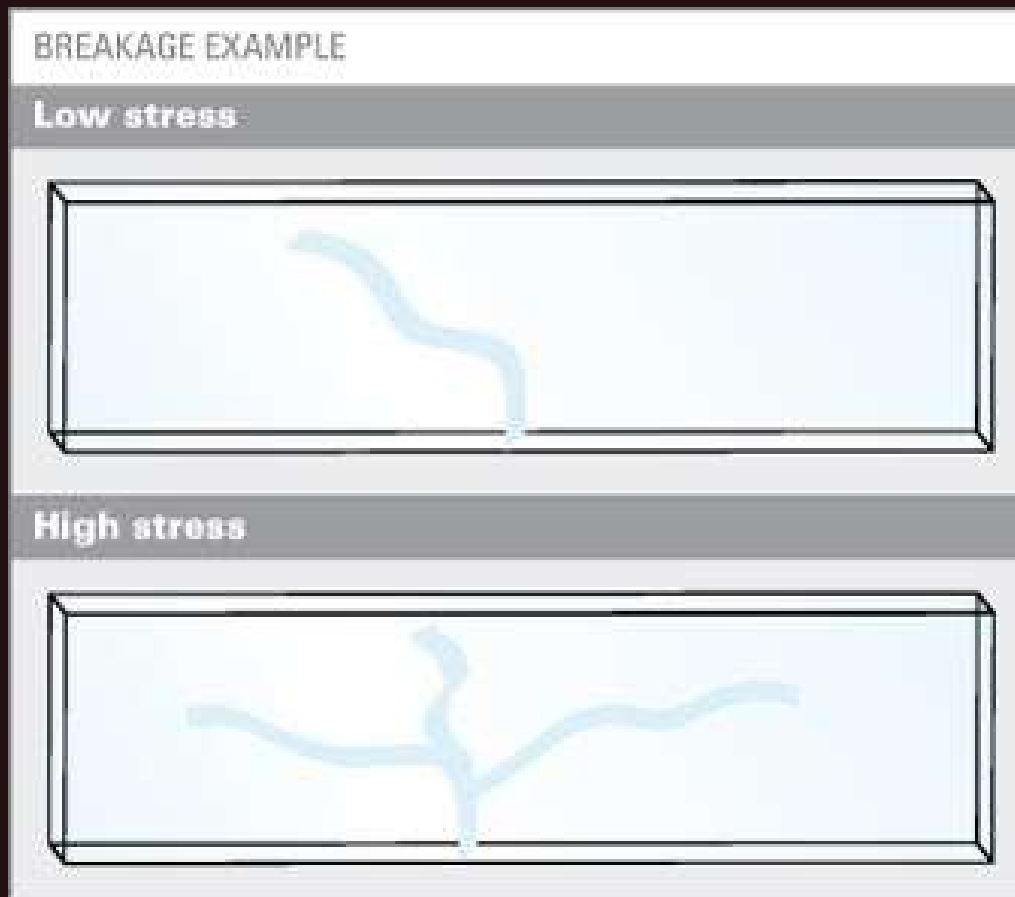
THERMAL BREAKAGE

In annealed glass the risk of thermal breakage is greatest and in applications where the thermal stresses is of concern, heat strengthened or toughed glass is used.

The risk of thermal breakage is also influenced by the condition of the glass edge. For applications where thermal breakage is a concern, heat treated glass should be specified.

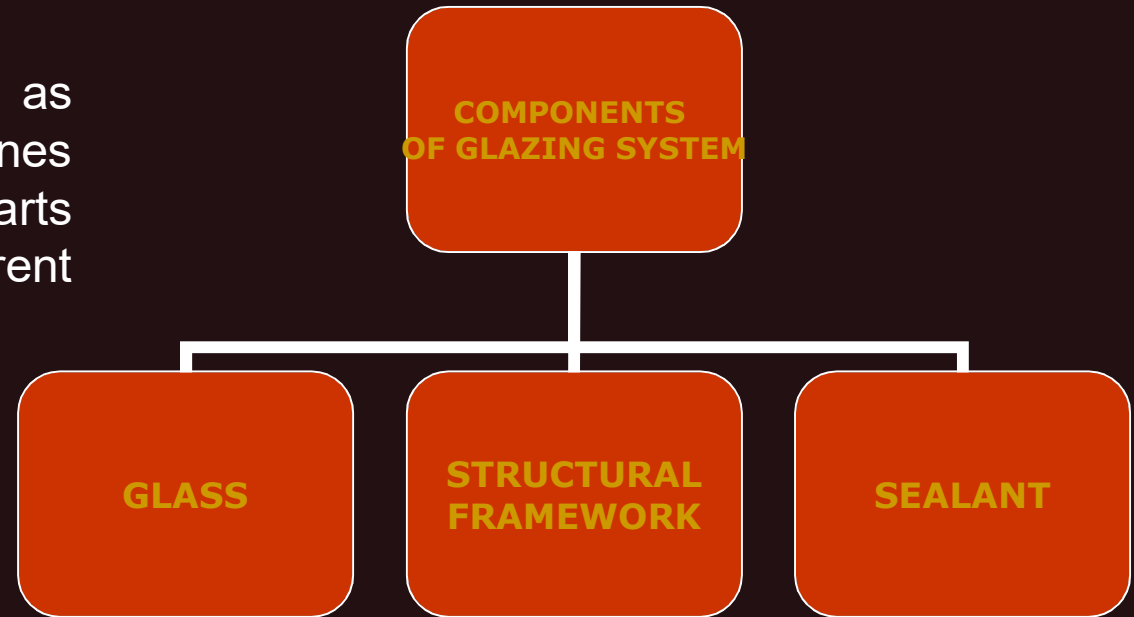


The crack in thermally broken glass is initially perpendicular to the edge and glass face for 20-50mm and then branches out into one or more directions. The number of branches or secondary cracks is dependent on the amount of stress in the glass.



GLAZING SYSTEM

SYSTEM is defined as Instrumentality that combines interrelated interacting parts designed to work as a coherent entity



- ❑ In a glazing system the above mentioned three elements perform together under any circumstances.
- ❑ It is their composite performance that determines the performance of the system as a whole as regards different performance characteristics.

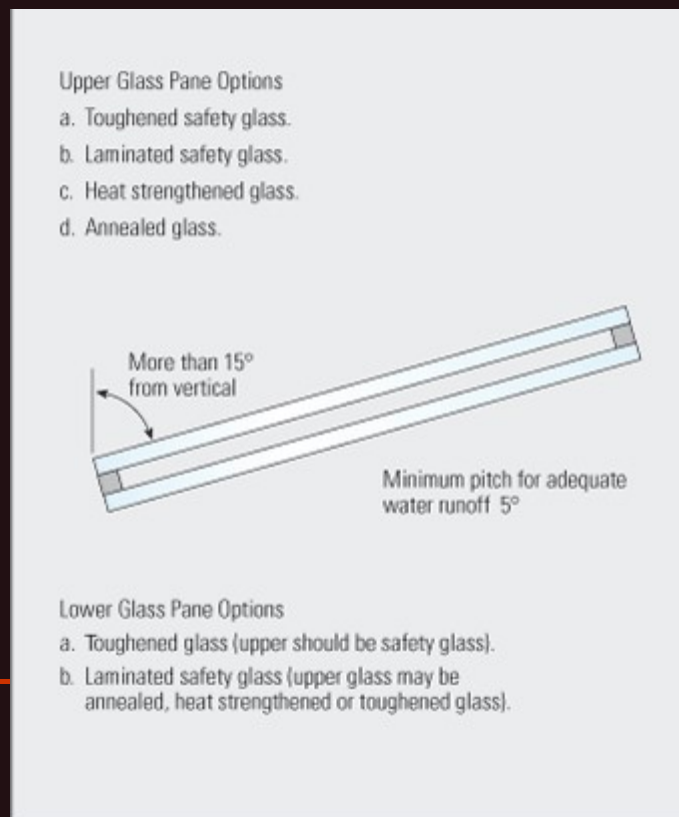
DESIGN OPTIONS

■ **SLOPED OVERHEAD GLAZING**

- Sloped Glazing is glazing which is sloped more than 15° from the vertical. When sloped glazing is used over populated areas, an A Grade Safety Glass is required to be used and has to withstand a greater range of loadings than vertical glazing.
- **Sloped Glass Loads**
 - Any overhead glazing system must be designed to meet the stress and deflection resulting from windloads. These can be either positive load from wind, or negative when the wind acts in suction. Unlike vertical glazing, loads caused by snow, maintenance and water and the dead load (the self weight of the glass as a permanent load) need to be considered

PERFORMANCE CHARACTERISTICS

- The sloped orientation of overhead glazing can result in increased heat gain and solar intensity thus increasing the levels of thermal stress particularly with solar control glass. The level of heat loss can also be higher making the installation of insulating glass units desirable.
- For adequate water runoff over sealant joints and flashings the pitch should not be less than 5°. Condensation is likely to drip from sloped glazing at angles of 30° or less.



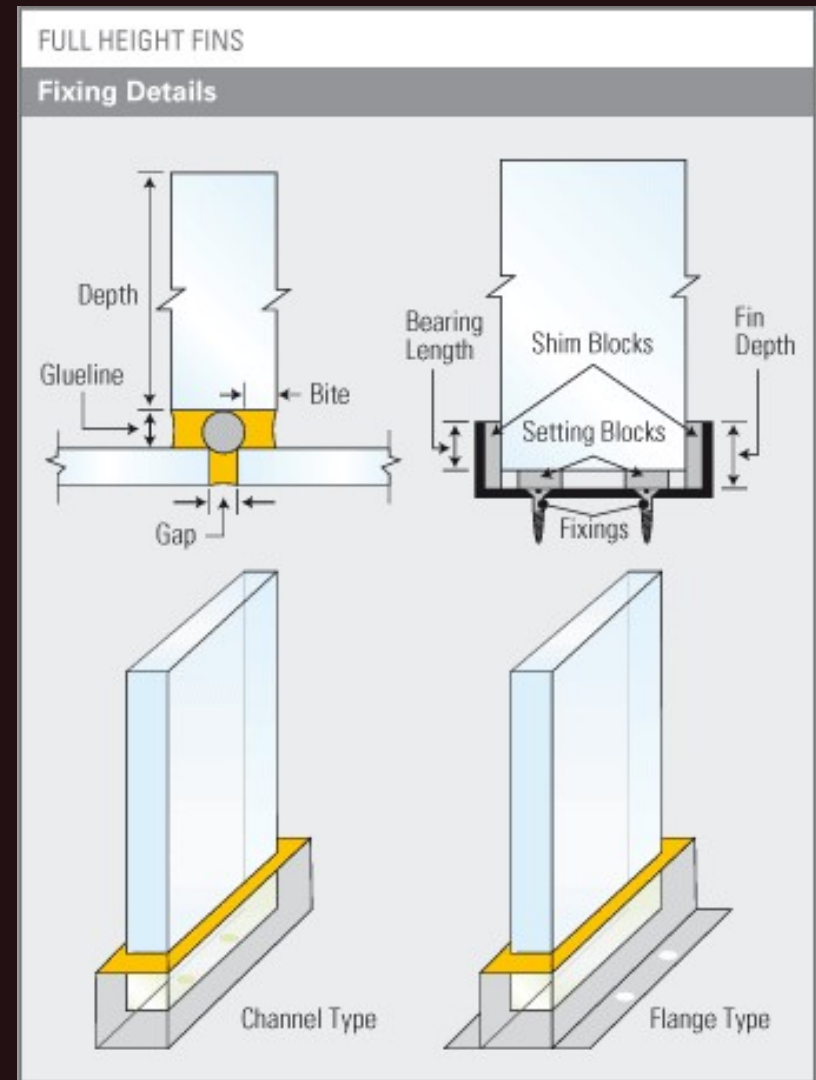
For sloped overhead glazing utilising insulating glass units, at least one pane must be Grade A safety glass, always the underside glass.

Where laminated glass is the lower pane annealed can be the upper pane. Where toughened is used as the lower pane, safety glass should also be used for the upper pane.

■ FULL HEIGHT GLASS FINS -

Glass fins are used to achieve the 'all glass' clarity required by designers while meeting the structural requirements of the glazing system.

- A glass fin replaces a frame or mullion and must be assessed as to size and thickness and securely fixed or supported at the head and sill.
- The fins must be adhered to the façade glass with silicone sealant to cope with positive and negative loads.

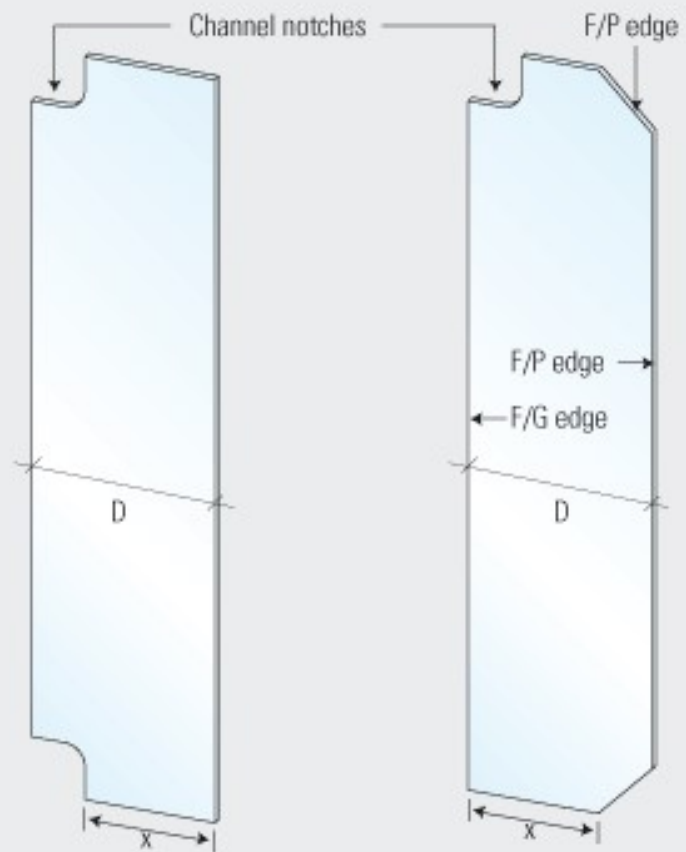


CRITICAL SILICON JOINT - The amount of silicone used to bond the fin is known as the 'bite'. The depth of the joint is known as the glue line and is normally 6mm.

Clear silicone is commonly used but the absence of a bond breaker can inhibit the quality of the joint. Black silicone allows the use of a bond breaker, hides any minor bubbles and gives a better long term joint particularly with tinted and reflective glasses.

GLASS FINS

Cutbacks & Notches



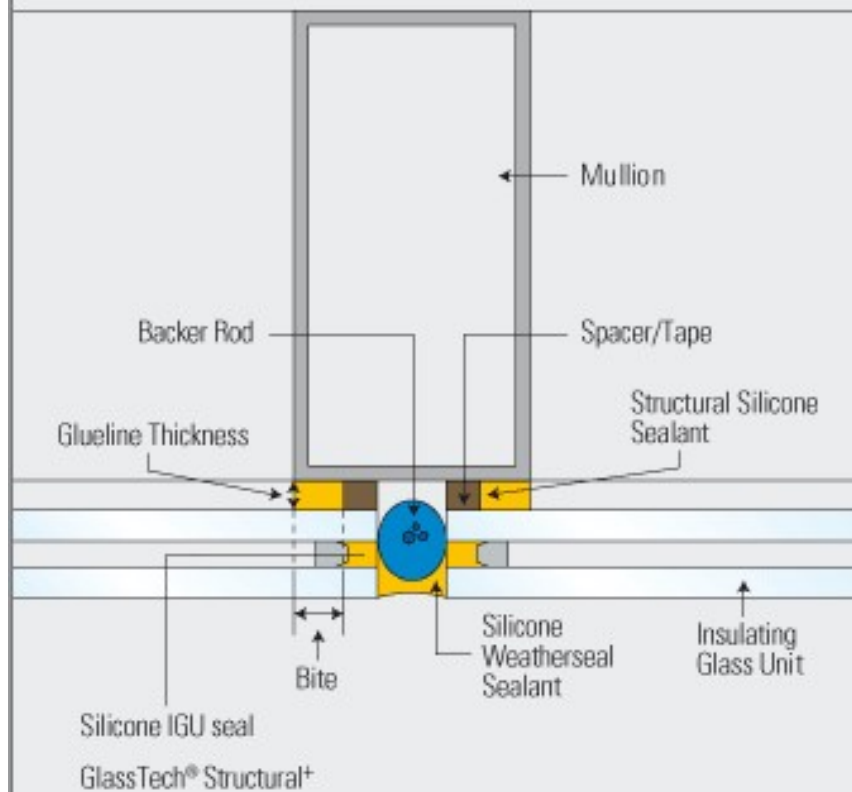
SILICONE STRUCTURAL GLAZING

- Silicone Structural Glazing (SSG) is a method of attaching a glass panel to a metal frame using a structural silicone adhesive sealant. The sealant contact dimension (bite) and thickness are designed to provide a method of structural support to glass, an airtight and weather-tight seal and a flexible connection that absorbs differential movements between dissimilar materials from wind, thermal or seismic loading.
- The joints are not intended to absorb live load movements due to floor loadings.
- This method of glass attachment provides a smooth exterior glass facade on a building either as a 2 sided, 3 sided or 4 sided system.

2 Sided Structural Glazing involves adhering the glass or cladding to aluminium on opposite sides, either vertically or horizontally, with the other two edges held captive with an aluminium bead or cover strip. Generally an on-site application

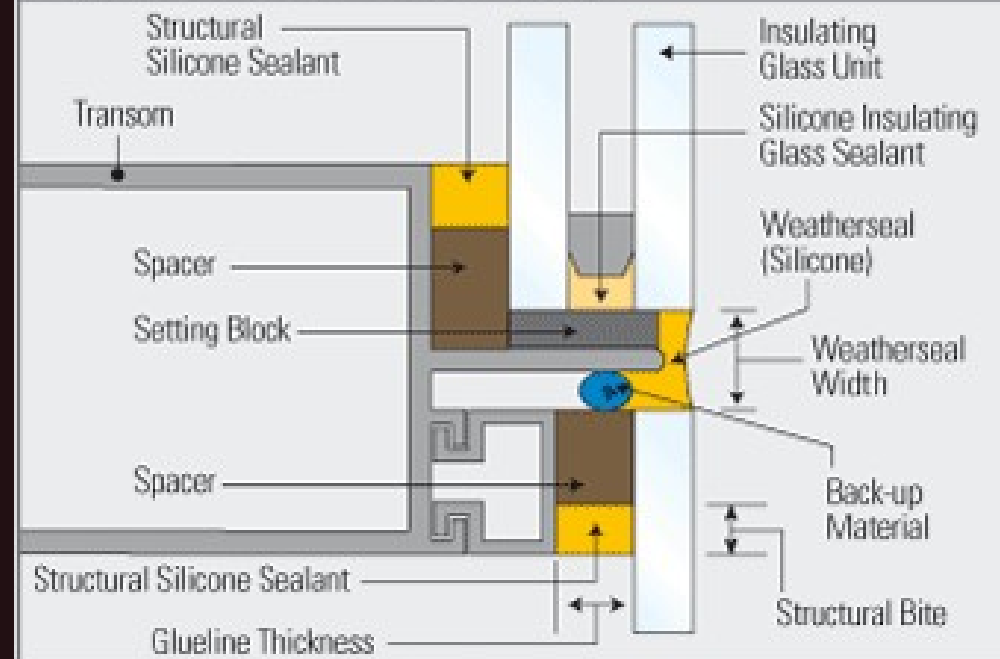
SILICONE STRUCTURED GLAZING

Typical Structural Mullion Design



SILICONE STRUCTURED GLAZING

Typical Structural Transom Design



GENERAL PRINCIPLES FOR SELECTION OF GLASS AND GLAZING SYSTEMS

- The ability of the framing to support and retain the glass under dead weight, wind and seismic loads.
- The allowance of adequate edge cover and clearances.
- Edge clearance is critical as the glass should not become load bearing.
- The correct blocking and drainage.
- The provision of an effective weather-tight seal.
- The use of compatible glazing materials.
- The use of durable glazing materials.
- The ability to easily re-glaze the system.

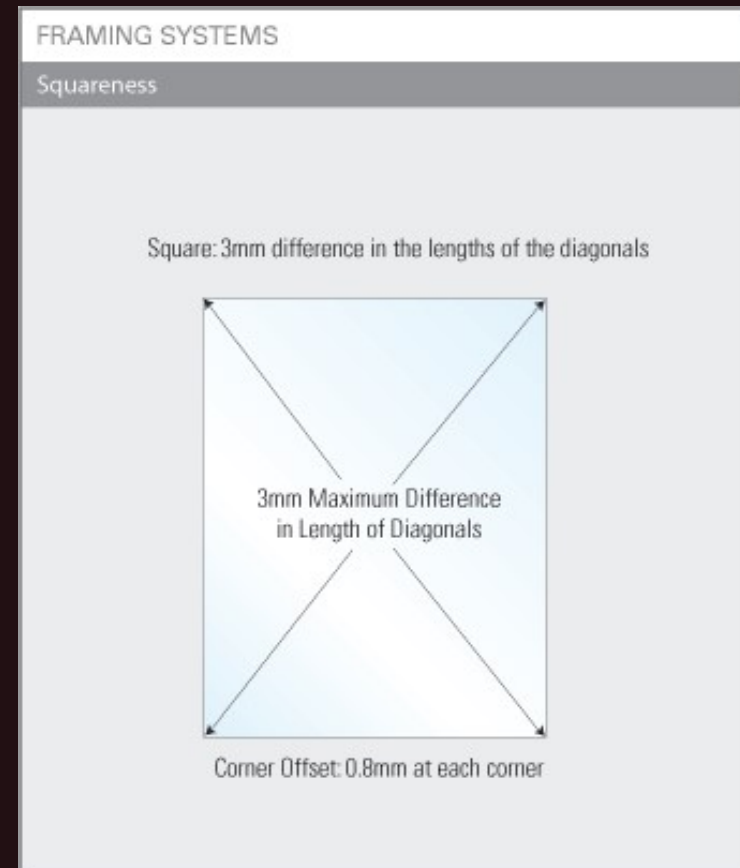
FRAMING SYSTEMS

- The framing system must structurally support the glass under static and dynamic loads and provide openings within specified limits for squareness, corner offset and bow.
- Typical limits are:
 - Square: 3mm max difference in diagonal length.
 - Bow: 1.6mm in any 1.2m length of framing.
 - Corner Offset: 0.8mm at each corner

DEFLECTION

The deflection of the glass framing members under design load should not exceed $\text{Span} \div 175$ or 19mm, whichever is less.

The deflection of horizontal members due to the weight of the glass should be limited to 3mm or 25% of the design edge clearance, whichever is less.



GLAZING SYSTEMS

■ DRY GLAZING SYSTEMS

- Dry glazing is the installation of glass using extruded gaskets in PVC, EPDM or Santoprene to one or both sides of the glass to provide a compressed weather seal. No sealants or putties are present in this system and the windows are designed to be self-draining.
- Installation of gaskets commences from the corner of a frame and they are inserted under pressure to form a tight compressed weather seal. Gaskets should be cut over-size to allow for shrinkage and to assist with installation they can be lubricated and softened by immersion in hot soapy water
- It is recommended that Santoprene gaskets be used in buildings over 3 stories and/or in high exposure conditions.

- **WET GLAZING SYSTEMS** - Wet glazing is the installation of glass using elastomeric sealants and butyl tapes to bed the glass and seal it at either face to the framing. Silicone and MS sealants are the most commonly used but polyurethane and polysulphide sealants are also used.
- It is important to use the correct product for the application to ensure adhesion to the substrate as some sealants adhere better than others to materials such as paints, wood, anodised and powder coated surfaces. In addition some sealants such as polyurethane are not UV stable
- **SILICONES** - All silicone sealants are UV resistant and have excellent adhesion to glass. They act as adhesives and sealants for both interior and exterior use and are not generally paintable. There are two basic types, Neutral Cure and Acid Cure and a range of strengths known as the modulus
- **ELASTOMERIC SEALANTS** - A number of elastomeric sealants are available such as MS sealants, polysulphides, polyurethanes, acrylics and butyls in either one-pot or two-pot products. When selecting a sealant for a glazing situation it is important to consider the properties of the sealant and its compatibility with the glass type and other construction sealants which may be present.

PUTTY GLAZING

- Putty glazing is the traditional method for glazing timber and steel windows. It is largely being replaced by more modern techniques and/or higher technology sealants
- E.g - Woodsash putty, Steel sash putty

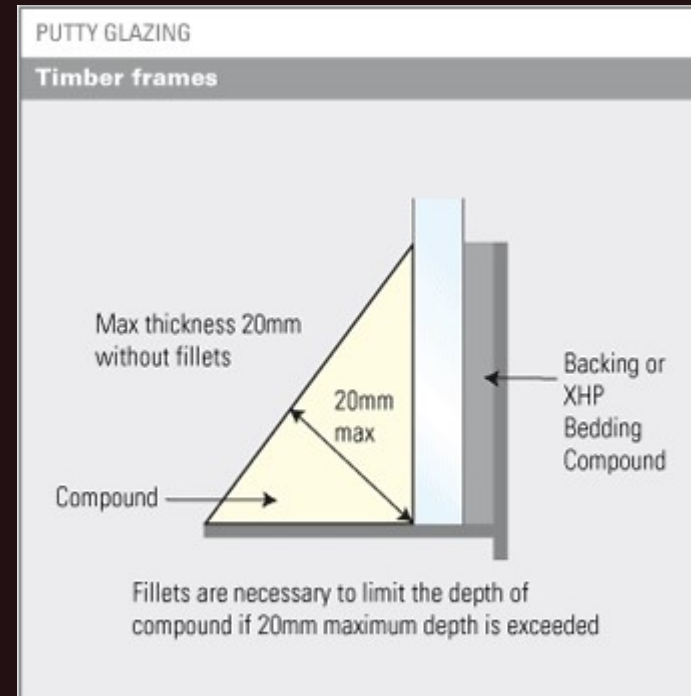


Table 1 : Maximum Areas of tempered / laminated glass for Framed Glass Doors, Framed Glass side Panels, and other Glazed Panels

Type of glass	Standard nominal thickness (mm)	Maximum area (m ²)
Tempered safety glass	3	1.0
	4	2.0
	5	3.0
	6	4.0
	8	6.0
	10	8.0
	12	10.0
Laminated safety glass	5.38	2.0
	6.38	3.0
	8.38	5.0
	10.38	7.0
	12.38	9.0

Where sealed insulating glass units are used the maximum areas specified in may be multiplied by 1.5 provided that each of the component glasses of the unit otherwise comply with the relevant requirements.

Table 5.2: Maximum areas of Normal Glass for Framed Glass Doors, Framed Glass Side Panels and other framed glazed panels

Standard nominal thickness (mm)	Maximum area (m ²)
3	0.1
4	0.3
5	0.5
6	0.9
8	1.8
10	2.7
12	4.5
15	6.3
19	8.5
25	12.0

Table 5.3 : Maximum areas of Normal (Annealed) Glass for Shop fronts, Internal Partitions, and other Glazed Panels

Standard nominal thickness (mm)	Maximum area (m ²)		
	Framed		Top edge unframed
	Side panels and internal partitions	Shopfront side panels and shopfronts	
3	0.8	0.8	0.1
4	1.4	1.4	0.3
5	2.2	2.2	0.5
6	3.3	3.3	0.9
8	4.5	6.0	1.8
10	6.0	9.0	2.7
12	8.0	12.0	4.5
15	10.0	15.0	6.3
19	12.0	15.0	8.5
25	15.0	15.0	12.0