Information regarding Glass types and properties

1. Float Glass

Float Glass is annealed glass processed by combining all ingredients and heating them till molten. This molten glass is then poured over a layer of molten tin. The molten glass then 'floats' across the top of the molten tin. As molten tin creates a perfect surface, the finish of float glass is extremely flat.
Float Glass can then be processed as cut-to-size, and then further processed into a safety glass in the form of Toughened, or Laminated. Float glass comes in standard thicknesses of 3mm, 4mm, 5mm, 6mm, 8mm, 10mm, 12mm, 15mm, 19mm and 25mm.

Standard Clear float glass has an inherent green hue when viewed on its edge. This green colour is the result of the iron content in the ingredients when the glass is manufactured. This colour becomes visible when viewing through the face of the glass as the glass thickness increases. To overcome this colouring a Low Iron form of glass has being developed that has a lower iron content. It has a pale blue colour when viewed on its edge. Where a tinted glass is used the greenness of standard glass is less of an issue.

This image shows two pieces of glass highlighting the colour difference between standard float glass on the left and Low Iron glass to the right.

There are many colours of tinted glass available on the market produced by the various glass manufacturers. The colours are not standardized across the manufacturers and can be slightly different from one batch to the next from the same manufacturer so getting an exact match in colour when replacing one piece after a number of years can never be guaranteed and requires some careful colour matching.

Float glass or standard glass is very vulnerable to breaking when tension is applied or it is impacted. It will break into large, sharp splinters that can be very hazardous if not handled correctly. Cracked or broken float glass can fall out of its frame or collapse without warning and should be treated very carefully when removing or handling. Due to the danger of broken float glass and its vulnerability to breakage it is only used in fixed glazing or fully framed glazing where there are no special strength requirements such as fixed domestic glazing.

To improve the performance of standard glass in safety, strength and insulation it can be processed further by Laminating, Heat Strengthening, Toughening, incorporating it into a Double Glazed Unit or coating it with special coatings. A number of these processes can be combined to produce glass that can meet very specific requirements.

2) Heat Strengthened Glass:

Heat Strengthened Glass is commonly referred to as HS glass. This is float glass that has been thermally treated to gain strength. Float annealed glass is heated inside a roller-hearth furnace up to 670 degrees Celsius, and then cooled back to room temperature again within a few minutes.
This process creates stress layers throughout the glass, however not as much as toughened safety glass. HS glass has approximately twice the strength than that of standard Float Glass and normally would have a residual surface compression of no less than 50MPa.

HS glass is NOT a safety glass unless it is laminated to another panel of glass. When HS glass breaks, it cracks from edge to edge in larger pieces than that of toughened glass. Due to the HS glass process being less harsh in phases of heating and cooling to that of toughened glass, it is far less susceptible to roller wave and therefore is visually far superior to that of toughened safety glass.

HS glass can be laminated to the other types of glass to produce a Grade A safety glass or a glass with specific requirements. HS Glass is commonly used for Super Yacht marine windscreens where strength and optical perfection are required.

This image shows shattered Heat Strengthened Glass. Note the pieces are not in long splinters but an irregular shape and not as small or uniform as Toughened Safety Glass.

3) Toughened Safety Glass:

Toughened Safety Glass is commonly referred to as TSG. This is float glass that has been thermall treated to gain strength. Glass is heated inside a roller-hearth furnace up to 700 degrees Celsius, and then rapidly cooled back to room temperature, at a controlled rate.

This process creates stress layers throughout the glass, hence giving TSG up to 5-8 times more strength than standard Float Glass. TSG will typically have a polished edge to reduce failure during the toughening process. Toughened glass cannot be cut. All cutting and processing such as edge work, polishing, bevelling and holes must be completed to the annealed glass before the toughening process.
When TSG breaks, it shatters into small particles due to the tension in the glass. These pieces are cube shaped rather than splinters

This image is of shattered 6mm TSG showing the shattering pattern and particles. Note the shatter pattern leads to the point of breakage.

All TSG has some element of roller wave. Roller wave is an optical disturbance caused by the heating process required to soften the glass before being toughened. Visually roller wave produces distorted reflections on the surface of the glass. This feature is more prevalent in thinner glass than thicker glass. Expect roller wave to be present in glasses 4mm – 6mm. Glasses from 8mm – 12mm have slight roller wave, whilst glass thicker than 12mm have minimal roller wave. Please note that if 2 layers of TSG are to be laminated that the roller wave effect could double.

The toughening process can also produce an area of surface haze or pitting. This is caused by the weight of the glass on the ceramic rollers in the furnace and it occurs mostly with heavier glass.

This image shows the roller wave effect in the reflections of the back of the car and the house roof on a piece of 4mm + 4mm laminated TSG.

4)Heat Soaked Toughened

During float glass manufacture, impurities in the glass batch can result in inclusions in the finished product. These inclusions are so small that they are normally invisible to the naked eye and yet they can cause spontaneous breakage in Toughened Safety Glass.

The most notorious of these inclusions is nickel sulphide (NiS) crystals (stones), which can be contained in the raw material during the production of the glass.

The glass toughening process requires the glass to be heated to just below its softening point and then rapidly cooled. Because this heating and rapid cooling process induces substantial tension in the glass, nickel sulphide stone inclusions in the tension core can cause spontaneous breakage, as they are known to change phase (expand) sometime after the toughening process. Heat Soaking

Heat soaking involves heating the Toughened Safety Glass to 290°C for a given period of time, then slowly cooling it. This process accelerates the expansion of nickel sulfide stones, and at this temperature, glass panels with nickel sulfide stones are likely to shatter.

The purpose of heat soaking is to reduce the incidence of Toughened Safety Glass breaking spontaneously after installation. While the Heat Soak process does not guarantee there will be no spontaneous breakage after glazing, it is a safeguard for specifying glass in areas where safety from glass fallout is a concern and/or access for replacement is difficult.

Why Heat Soak?

In each case the specifier must assess the risk and consequences of failure before deciding whether to specify Heat Soaked Toughened Safety Glass.

Heat soaking will reduce the incidence of failure due to nickel sulphide inclusions, therefore reducing the associated replacement, maintenance and disruption costs and the risk of the building being classified as unsafe.

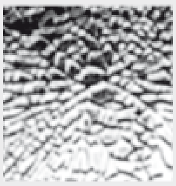
Heat Soaked Toughened Safety Glass is more expensive than ordinary Toughened Safety Glass, due to the additional processing. However, if a risk analysis indicates that the incidence of nickel sulphide induced or other inclusion failure should be minimised, Heat Soaked Toughened Safety Glass should then be specified unless a suitable alternative can be found.

When compared to the alternatives or the actual cost of replacing broken Toughened Safety Glass in the field, there is substantial justification for the cost of the additional process. The following applications should be considered for heat soaking:

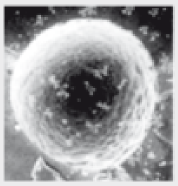
- Structural Balustrades.
- Infill Balustrades – if fallout is an issue.
- Sloped Overhead Glazing.
- Spandrels – if not Heat Strengthened.
- Structural Glazing with Spider or other fittings.
- Commercial Exterior Frameless Glass Doors.

TOUGHENED GLASS

NiS Inclusion



Typical failure pattern (butterfly wings) observed after spontaneous breakages of tougened glass due to NiS inclusion.



Scanning Electron Micrograph of a typical NiS inclusion observer after the spontaneous failure of toughened glass (about 0.2mm diameter). Note the rough aspect of the surface, as always seen on dangerous NiS stones.

5) Chemically Toughened Glass:

This is a form of toughening that produces a toughened layer on the surface of annealed glass. It is produced by immersing the glass into a bath of molten potassium nitrate. There is an exchange of ions between the glass surface and the potassium nitrate resulting in an increase of tension in the glass surface thus producing the toughening effect. The advantage of chemically toughening glass is that complex shapes of glass can be crafted before the toughening process and then toughened in a separate operation.

There are some disadvantages with chemically toughened glass;

1. The toughening is only on the surface of the glass.
2. The tensions in the glass surface relax back to an annealed state over time.
3. On large glass surfaces patches of discolouration are produced and become visible in certain lighting conditions.
4. Chemically toughened glass is not readily available in New Zealand and is produced by few companies overseas.
5. Chemical toughened glass is NOT a Grade A safety glass unless laminated.

6) Insulating Glass Units:

Insulating Glass Units (IGUs) are designed to provide thermal insulation for building envelopes. They are used to reduce building heat loss and heat gain depending on the climate and IGU combination. Insulating Glass Units are sometimes called Double Glazing, Double Glazed Units (DGU) or Sealed Insulating Glass Units (SIGU).

The glass in an IGU is assembled with a separating spacer around the edges to keep the panels of glass separated by the required amount. The edges of the glass and separating spacer are then sealed with a secondary sealing compound. Commonly the air in the space between the panes of glass is replaced with a dry inert gas such as argon. This prevents condensation developing within the unit and also increases the thermal performance of the unit by up to 10%.

There are a number of optical effects associated with IGUs.

Brewster's fringes are a visual effect seen as a rainbow visible within an IGU. Brewster's fringes are not a deterioration of the unit or glass but an effect created when light passes through two panes of glass of the same thickness, the resulting light refraction becoming visible as a rainbow effect. Brewster's fringes can be confirmed by pressing one surface of the unit. The rainbow effect will move and colours change as the one glass surface is depressed and released. Brewster's fringes are normally avoided by using different thickness of glass for each pane of the IGU.

Newton's rings are a visual effect created when the centre area of the glass panes making up an IGU come into close proximity to each other or in fact touch. Newton's Rings appear as a circular or semi-circular rainbow effect in central areas of the unit. This could be the result of the incorrect airspace for the unit size, manufacturing faults, temperature related pressure changes and/or improper pressure equalization.

Multiple reflections can be present when viewing an object's reflected image in an IGU. The use of reflective glass as outside panes, and/or Low E glass as the inside pane, gives a greater reflection. Whilst it is not a common problem, a certain amount of double imaging is inherent in an IGU due to the glass deflecting under normal temperature and pressure changes.

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7) Laminated Glass:

Laminated glass is a process that involves a thin layer of plastic sheet adhering two or more glass panels together. If the laminated glass panel is broken, the plastic interlayer is designed to hold the broken glass together, thus making is a safety glass. Either annealed float glass, HSG or TSG, flat or curved glass can be laminated together.

Glass can be either laminated by a cast-in-place resin system, or a sheet film system (PVB & EVA).

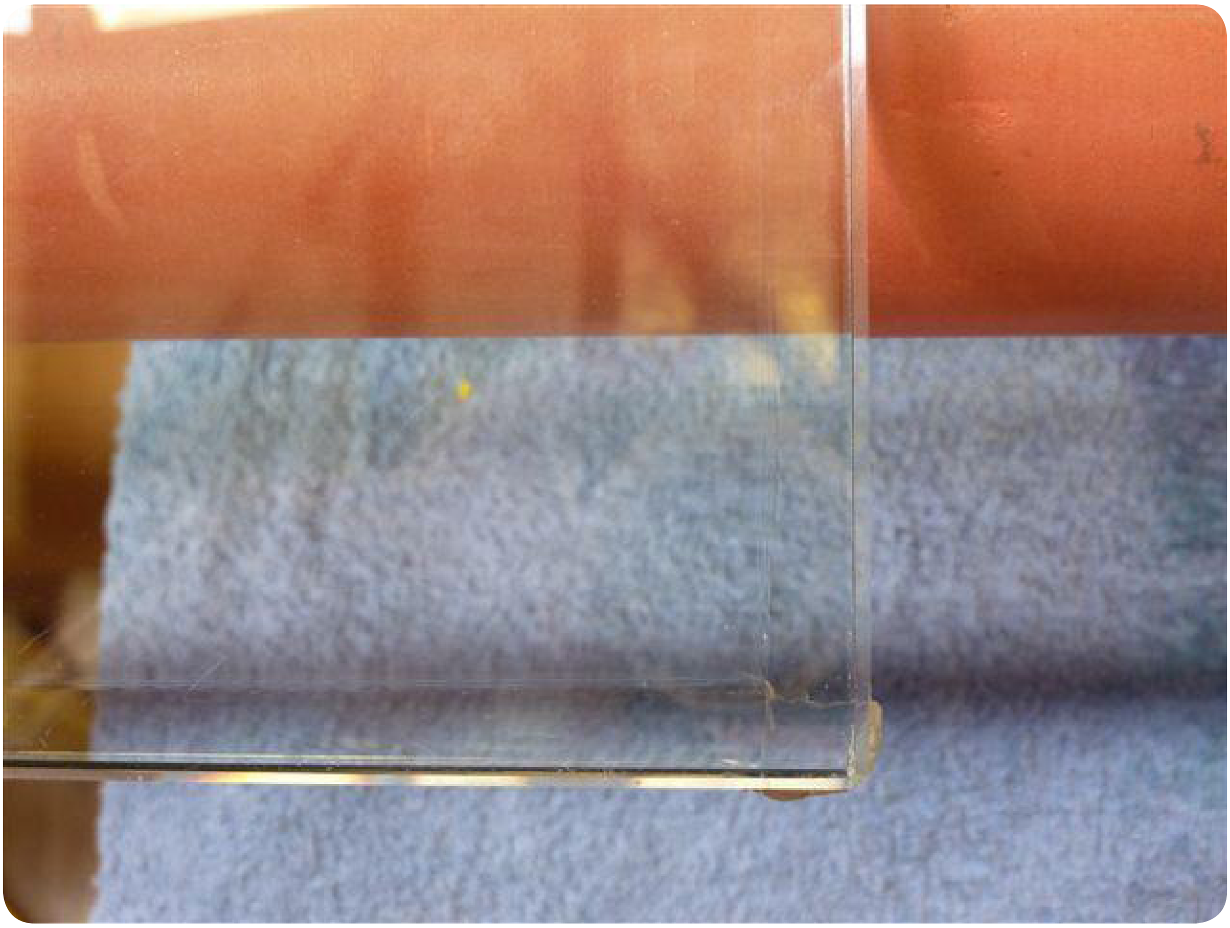
A resin system requires clear or white-edge tape around the perimeter, of which you can see a faint line approx 6mm in from the edge. A film system eliminates the requirement for edge tape, however is more vulnerable to moisture ingress up to 9mm into the edge of the panel that can cause the film to become opaque.

Laminated Glass Edge information

All types of laminated glass have an imperfect visual appearance at the edge. This is because there are multiple layers of glass and plastic tapes or resin terminating at an edge. All these elements have different properties of hardness and clarity.

a. Where a high quality edge is required the glass should have a Flat Polish finish with arrised edges and the laminating tape or film would be recessed to the edge of the arris. This results in the polished edges of the glass being the most visible element and provides the highest standard visually. This makeup can be used for both annealed glass and TSG. This type of edge is typically used with frameless balustrades and decorative panels in the residential and corporate sector.

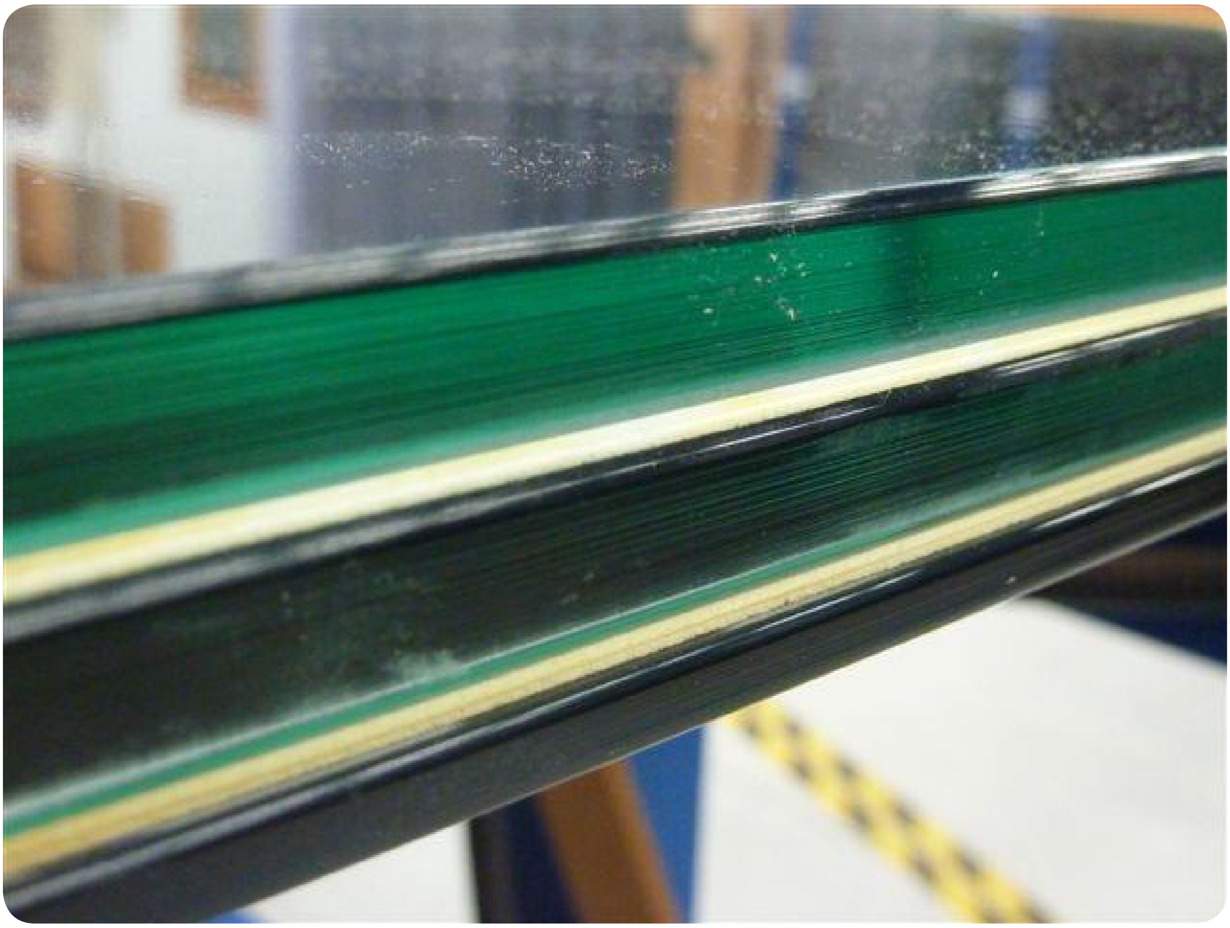
This image shows a laminated balustrade made up of 6mm glass + 2mm interlayer + 6mm glass with Flat Polished edges.



This image shows a laminated balustrade made up of 6mm glass + 2mm interlayer (poured resin type with the clear edge tape visible) + 6mm glass with polished edges.

b. Specialist marine glass requires a higher performing system to meet the requirements and challenges of the marine environment and the desire of clients for a light weight, strong glass in the super yacht industry. The points of difference are in the resin laminating system used. The resin system used by Glasshape for marine applications is called DSM-PU. It has been developed for Glasshape by an independent resin manufacturer to exceed the requirements for marine use. The strength and durability of DSM-PU enables thinner glass to be used to achieve the same strength compared to other laminating systems. DSM-PU is also a 99% ultra violet light block, thus reducing fading and damage to marine interiors. DSM-PU resin is also impervious to water. It is less likely to be damaged or change colour when exposed to water or long term damp conditions. This resin system incorporates an open cell foam edge tape in the manufacturing process. This foam tape is a white colour and is usually hidden behind a blackout frit applied to the inner surface of the laminated glass prior to applying the laminating resin.

This system is suitable for laminating annealed flat glass, flat HSG and TSG glass, annealed curved glass and HSG and TSG curved glass in multiple layers that are body bonded into a sill. The glass edge preparation requirements are the same as other laminating systems.



This image shows a laminated marine window using the open cell foam edge tape. The glass makeup is 10mm glass + 2mm interlayer (DSM-PU resin type with the open cell edge tape visible) + 10mm glass + 2mm interlayer + 6mm glass with polished edges.

c. The DSM-PU lamination system can also be used to produce a high quality exposed laminated edge where the resin is drawn to the edge of the glass without the use of edge tapes. This would be used on exposed balustrades, doors, fashion panels and wind break glass where the superior performance of the polyurethane resin system is desired without the visible edge tape.

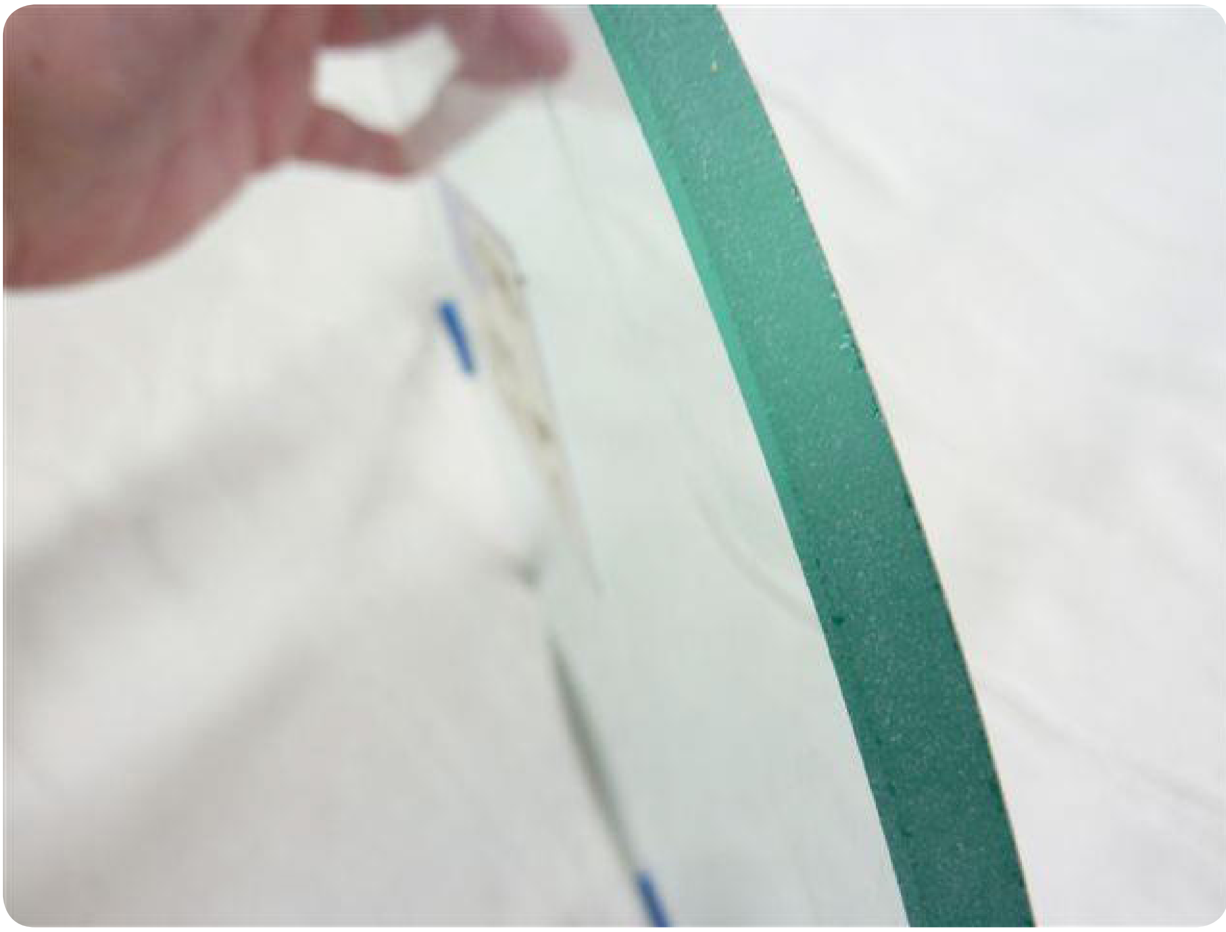
This image shows a laminated marine window using the DSM-PU laminating system without the foam edge tape. The glass edges and resin have being polished together after the laminating process producing a high quality finish.

Glass edge information

1) The most basic edge is where the glass is scribed with a manual cutter and snapped along the scribe. The glass edge has a shiny finish but is not flat like a polished edge. The sharp edges are arrised to reduce the danger of being cut on the sharp edge and reduce the risk of the glass edge chipping. This method is most suitable for straight cuts and regular shapes on thinner glass up to 10mm. Over 10mm the cut tends to flair with the cut no longer being 90 degrees to the surface of the glass. This edge type is used when the edge of the glass is not visible and is being glazed into a frame.

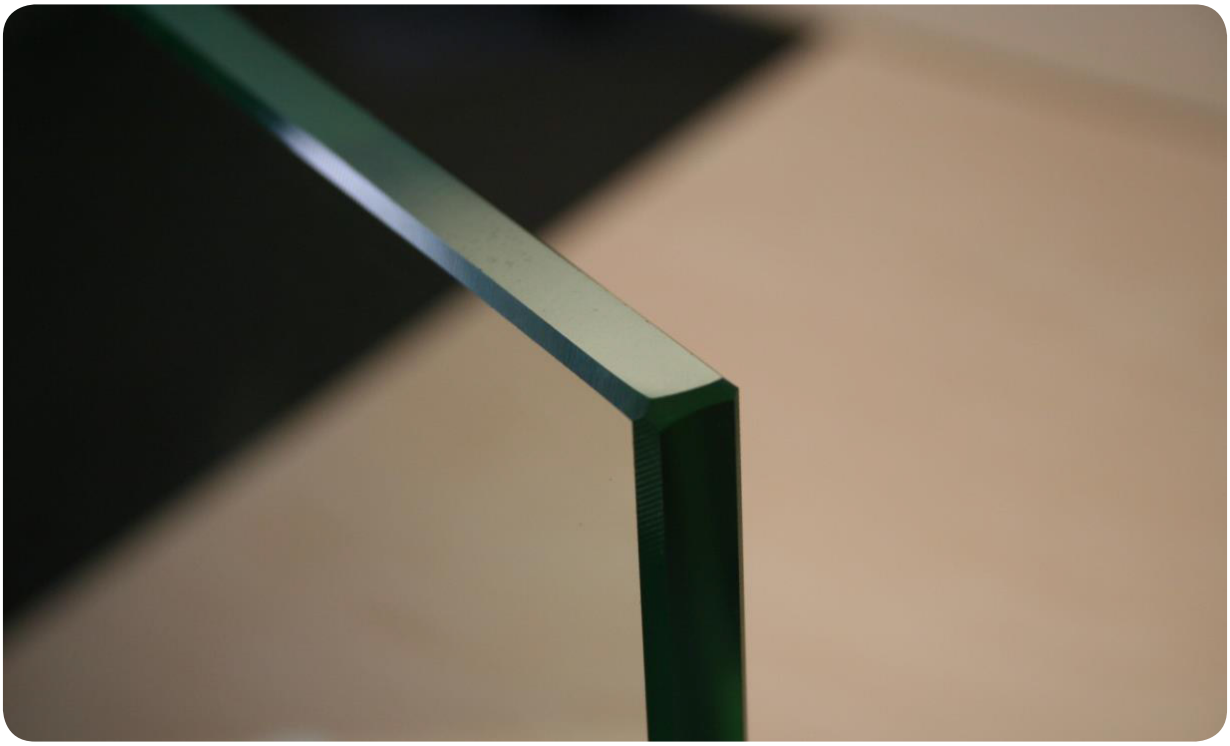
This image shows the manually cut edge and sanded arris on 10mm clear float glass.

2) A water cut edge is the result of the glass being cut with a high pressure water cutting machine. These machines are computer controlled and are ideal for cutting very thick glass or complex shapes and laminated glass. The glass edge has a sanded appearance due to the garnet sand used in the cutting process. Typically the sharp edges would be arrised afterwards to reduce the danger of being cut on the sharp edge and reduce the risk of the glass edge chipping. This edge type is used when the glass is of a more complex shape and the glass edge will not be visible.



This image shows the water cut and arrised edge of 10mm clear float curved glass.

3) A polished edge is the result of the glass being processed by a Polishing Machine. There are two main types of polishing finish. A Straight Line Edger machine produces a Flat Polish where the edge of the glass is polished flat with a sharp flat angled bevel. Only straight edges can be polished with this machine. A CNC Polishing Machine is a computer controlled cutting and polishing machine that uses a CAD file to produce the shape required. This machine produces a more rounded edge with a radii edge. These edge types are used where the glass edge is exposed or visible and a high quality finish is required. TSG will typically have a rough arrised edge for flat glass or a polished edge for curved glass to reduce failure during the toughening process.


This image shows the Flat Polish edge and 1mm bevel of 10mm clear float glass.


This image shows the CNC Polish edge and bevel of 10mm clear glass.

Notes on Curved Glass

Please note that curved or bent glass may;

(a) have fine distortions or markings (such as stretch marks) which appear on or in the glass;

(b) show the presence of "roller wave" (a surface distortion produced by a reduction in surface flatness) or "roller pickup" (which can be shown as small imprints in the surface);

(c) be some degree of visual distortion that will vary depending the glass type, thickness, and shape.

Strain patterns and iridescence may become apparent under certain lighting conditions or viewing angles.

The characteristics described above (and any similar characteristics) are not defects, but are a result of manufacturing processes (including bending, heat-strengthening, toughening, etc) and are acceptable characteristics of such glass. The presence of distortions, marks or other manufacturing effects shall not, directly or indirectly, give rise to a warranty claim or any other claim whatsoever against Glasshape.

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