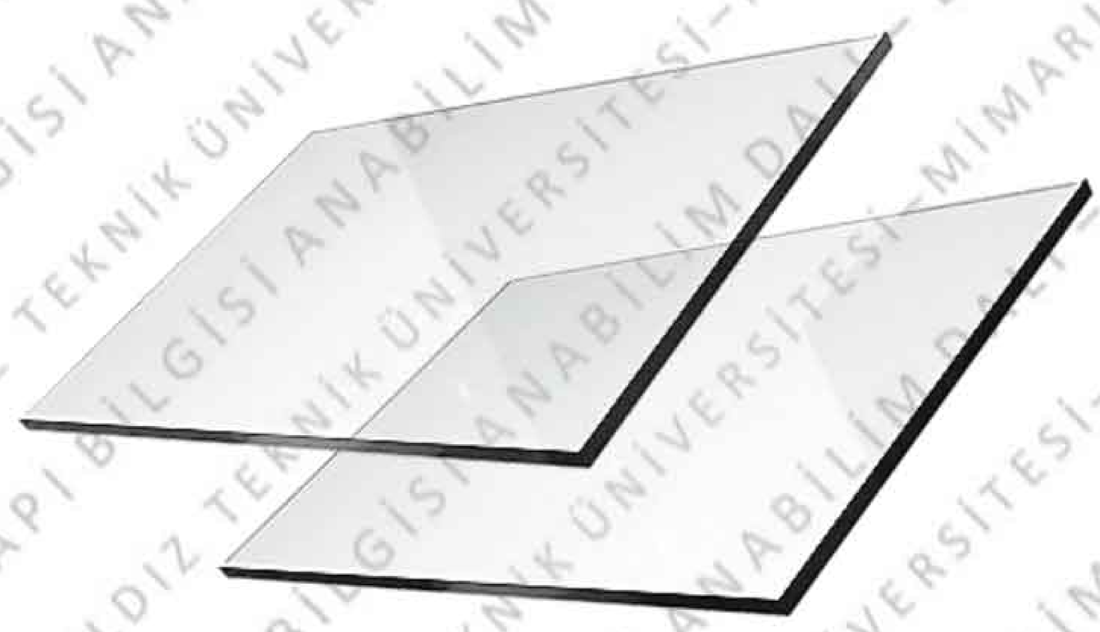
GLASS

Glass is a non-crystalline, amorphous solid, having homogeneous texture. It is a hard, brittle, transparent or translucent material. Most ordinary colorless glasses have tensile and compressive strengths of about 30–60 N/mm^2 and 700–1000N/mm^2, respectively. The strength is very much affected by internal defects, cords and foreign intrusions. The main shortcoming of glass is its brittleness which depends on a number of factors.



The raw materials used in manufacturing glass are sand, lime (chalks) and soda or potash which are fused over 1000° C. Oxides of iron, lead and borax are added to modify hardness, brilliance and color.

Silica (SiO_2) is used in the form of **pure quartz**, **crushed sandstone** and **pulverized flint**; should be free from iron contents for best quality glass. Since it melts at very high temperatures (1710° C) **carbonates of sodium or potassium** are added to lower down the fusing temperature to about 800° C. These also make liquid silica more viscous and workable.

quartz

silica

Lime ($CaCO_3$) is used in the form of **limestone**, **chalk** or **pure marble** and sometimes **marl**. The addition of lime makes the glass fluid and suitable for blowing, drawing, rolling, pressing or spinning. It also imparts durability and toughness to glass. Excess of lime makes the molten mass too thin for fabrication.

chalk

pure marble

Soda (Na_2CO_3) acts as an accelerator for the fusion of glass and an excess of it is harmful.

sodium carbonate (Na_2CO_3)

Potash (is any of various mined and manufactured salts that contain potassium in water-soluble form) renders glass infusible and makes glass fire resistant.

Lead oxide imparts color, brightness and shine. When 15–30% of it added to substitute lime, it lowers the melting point, imparts good workability, while its transparency is lost with the glass becoming brittle and crystalline.

Cullets are broken glasses added to act as a flux to prevent loss of alkali by vitalization during the process of forming glass and also to lower the fusion temperature. However, flux may reduce the resistance of glass to chemical attack, render it water-soluble or make it subject to partial or complete devitrification (crystallization) on cooling. These crystalline areas are extremely weak and brittle. Stabilizers are added to overcome these defects.

Titanic acid, oxides of nickel and cobalt are used for chromatic neutralization. Iron is not desirable as a constituent. However, when present, it imparts a bottle green color to the glass. To overcome this, manganese dioxide, known as glass maker's soap, is added which washes the liquid glass and removes the color.

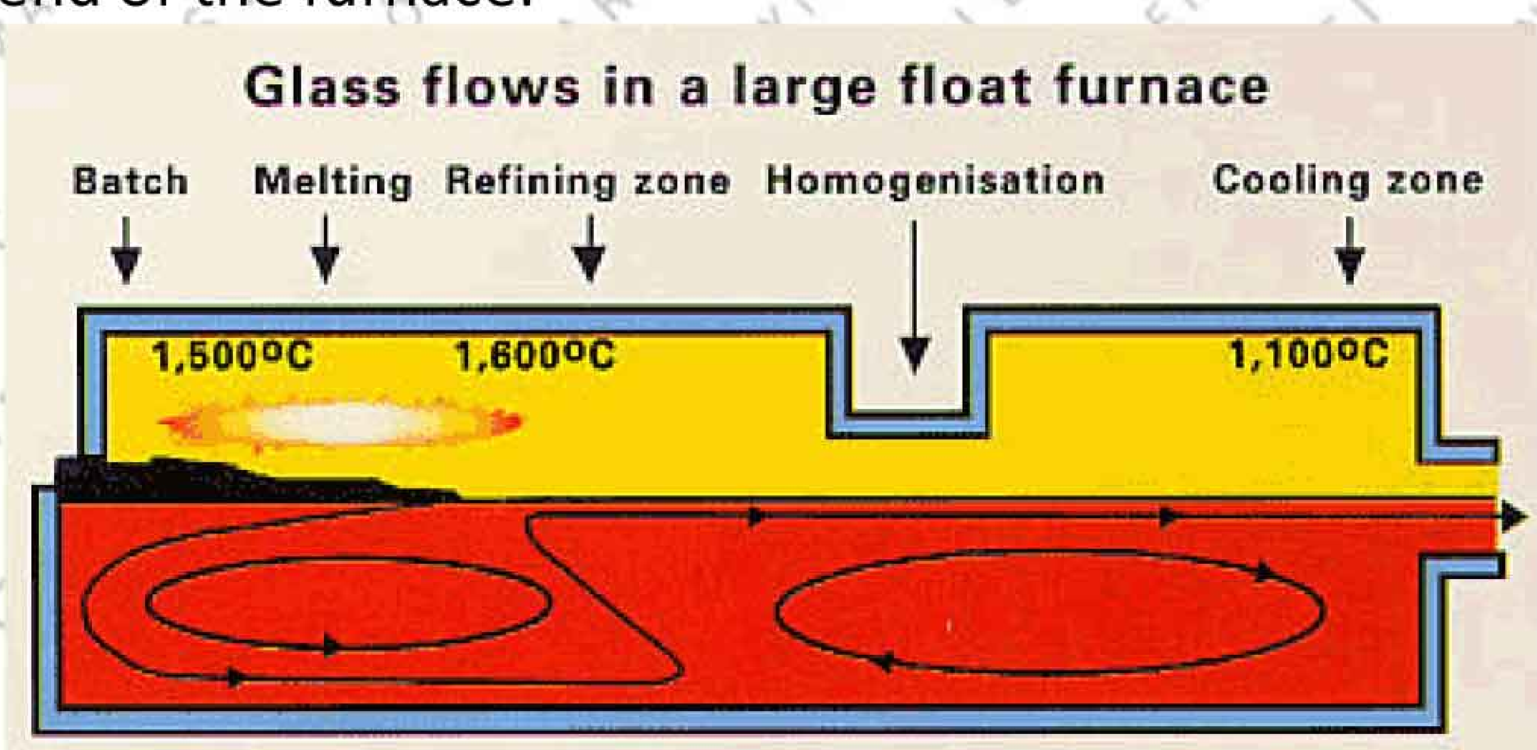
Manufacture of Glass

Glass is manufactured in the following four steps:

Melting: The raw materials — lime, soda and sand — separately cleaned, ground, sieved (called 'batch') in definite proportion and mixed with water are fused in a furnace. The charge, in the first stage, melts; forming a bubbly, sticky mass, and as the temperature is raised (1100° C–1200° C) it turns to a more watery liquid and the bubbles rise to the surface.

$CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2$
$Na_2CO_3 + SiO_2 \rightarrow Na_2SiO_3 + CO_2$

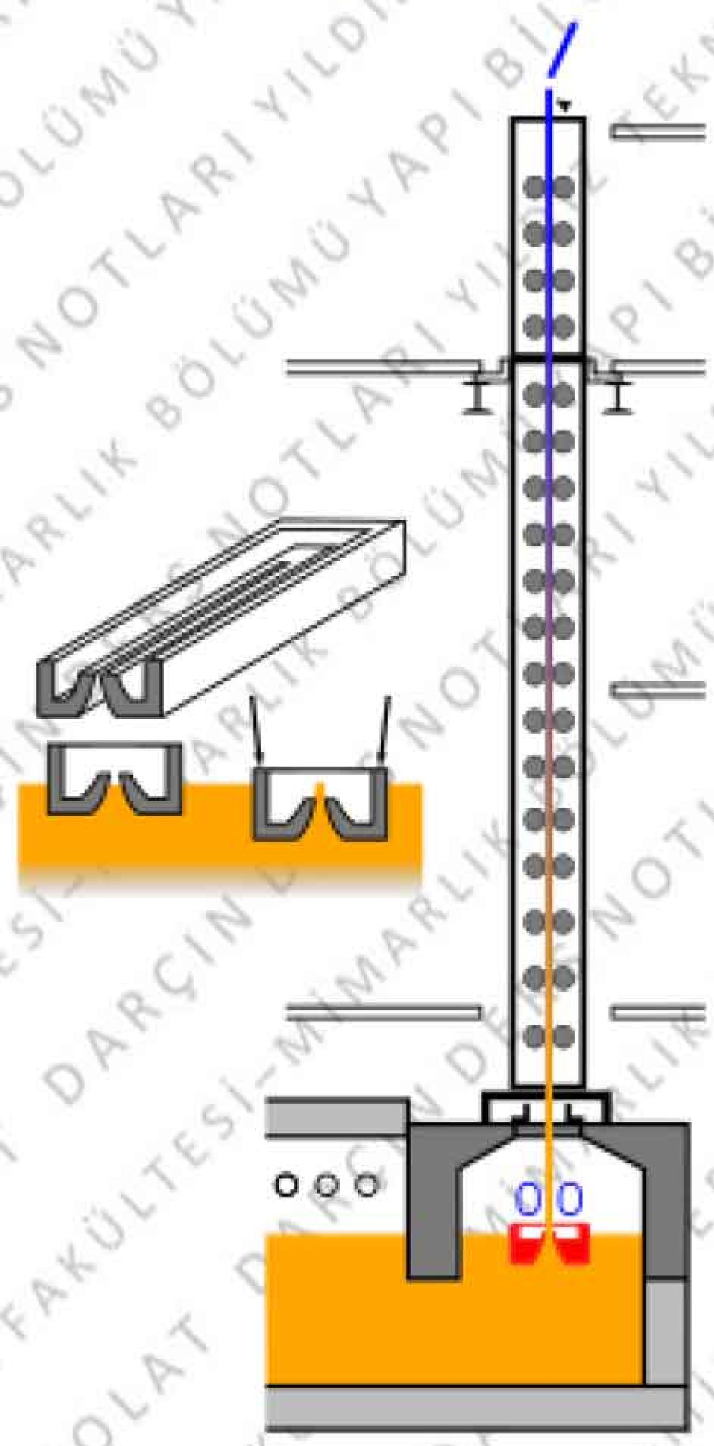
When all the carbon dioxide has escaped out of the molten mass, decolorizes such as MnO_2 or nitre (potassium nitrate) are added to do away with ferrous compounds and carbon. The coloring salts are added at this stage. Heating is continued till the molten mass is free from bubbles and glass balls. As the glass cools (800°C), it is ready to be drawn or floated to its desired thickness and size at the other end of the furnace.



Forming and shaping: The molten glass can be fabricated to desired shapes by any one of the following methods:

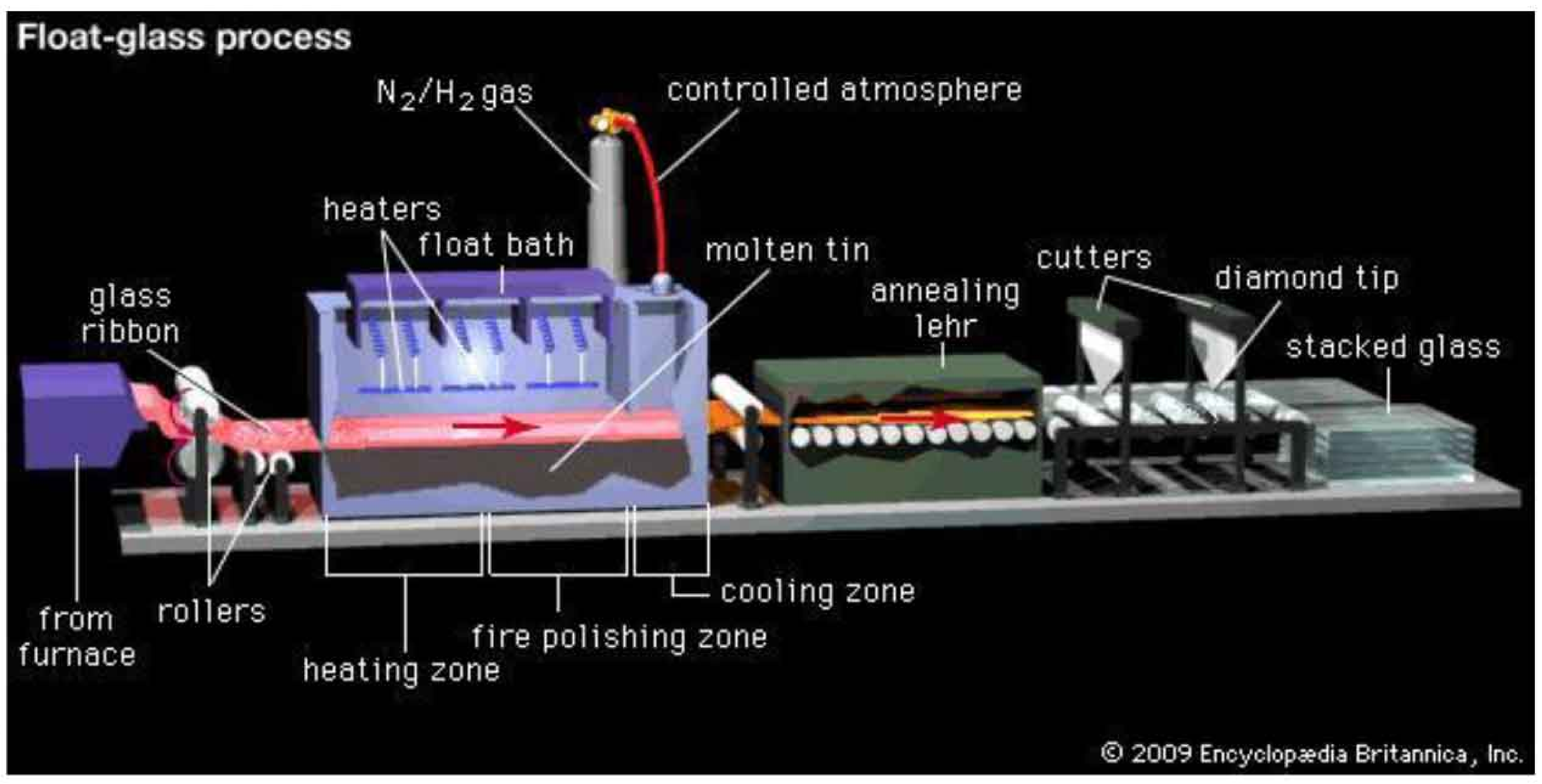
Blowing: A 2 m long and 12 mm diameter blow pipe is dipped in the molten glass and taken out. It is held vertically and is vigorously blown by the operator. The sticking molten glass takes the shape of a hollow ball. On cooling it is reheated and the blowing operation repeated a number of times till the desired products are ready.

Flat drawing: The process of drawing the glass up into a sheet begins when a grille (bait) is lowered into the glass in the kiln. In a short time the liquid molten glass adheres to the bait, and as the bait is slowly lifted it draws a sheet of glass. The bait and the drawn sheet of glass are then drawn through rollers, the bait is cracked off and a continuous sheet of glass is drawn up. This sheet is then slowly cooled in a chamber and annealed for cutting into proper size.



Floating: The molten glass is fed into a "tin bath", a bath of molten tin (about 3–4 m wide, 50 m long, 6 cm deep), from a delivery canal and is poured into the tin bath by a ceramic lip known as the spout lip. The amount of glass allowed to pour onto the molten tin is controlled by a gate called a tweel.

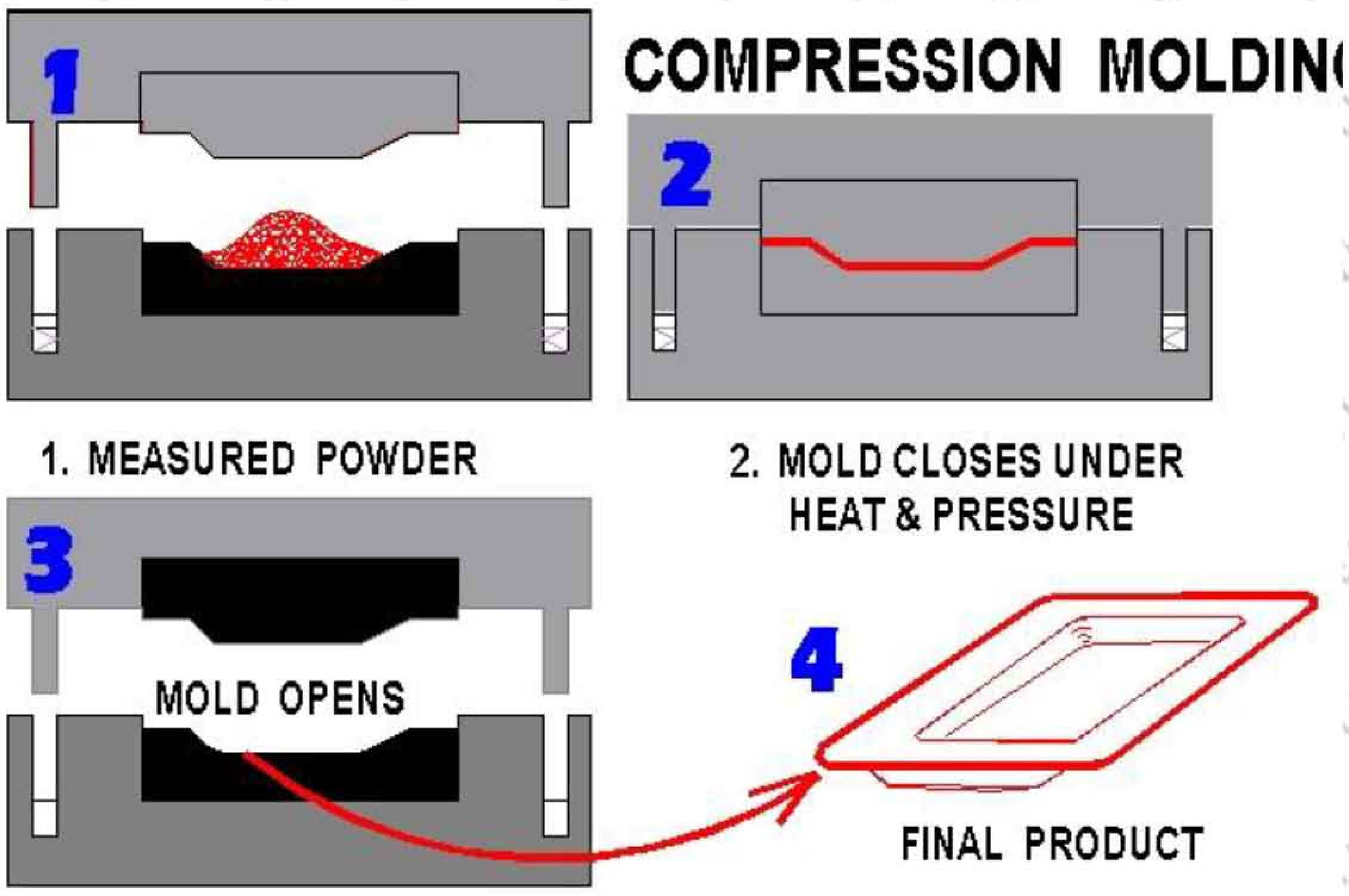
Tin is suitable for the float glass process because it has a high specific gravity, is cohesive, and is immiscible with molten glass. Ondördüncü şifre sözcüğü “disease” Tin, however, oxidizes in a natural atmosphere to form tin dioxide (SnO_2). Known in the production process as dross, the tin dioxide adheres to the glass. To prevent oxidation, the tin bath is provided with a positive pressure protective atmosphere of nitrogen and hydrogen.



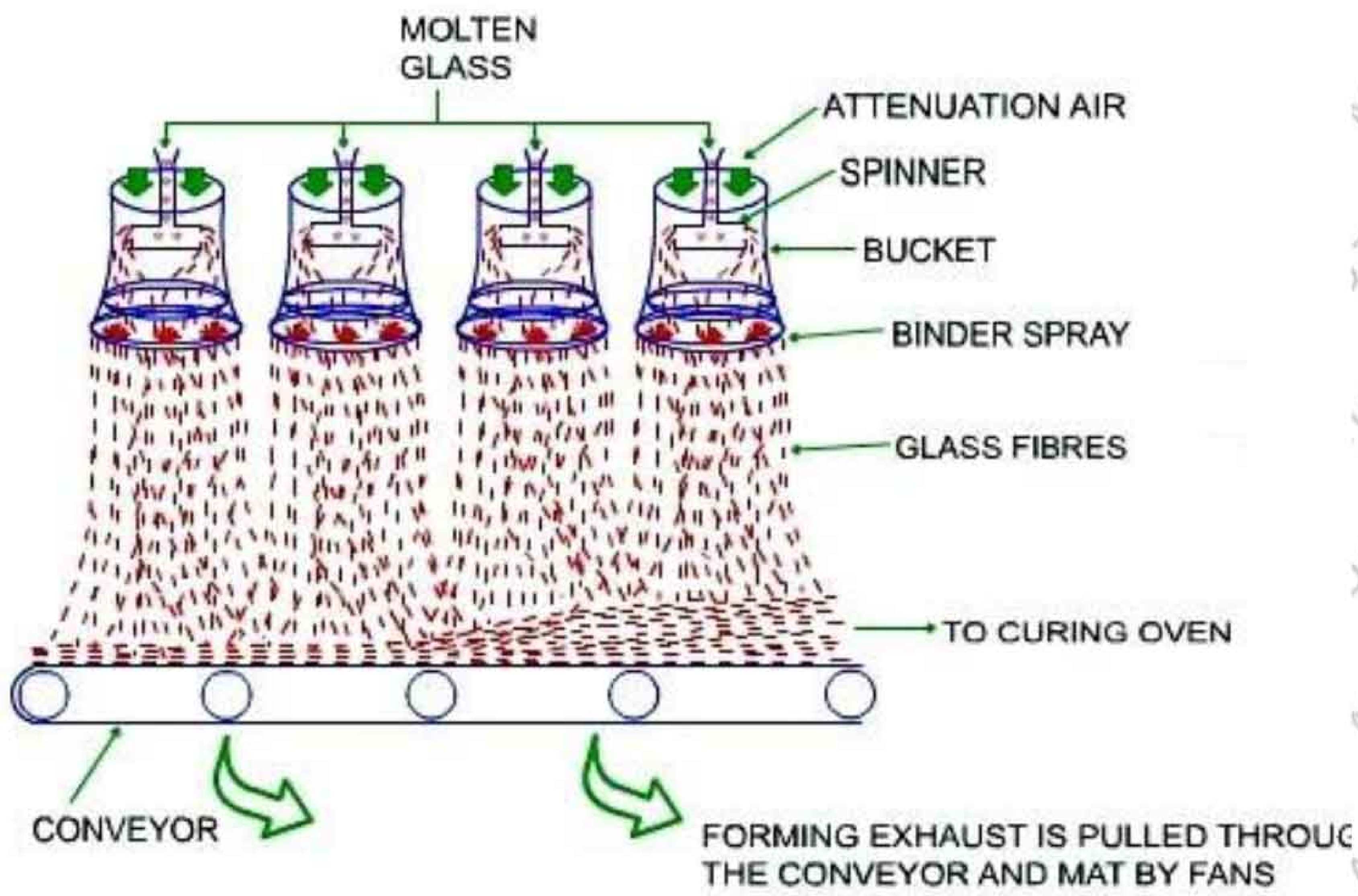
The glass flows onto the tin surface forming a floating ribbon with perfectly smooth surfaces on both sides and of even thickness. As the glass flows along the tin bath, the temperature is gradually reduced from 1100 °C until at approximately 600 °C the sheet can be lifted from the tin onto rollers. The glass ribbon is pulled off the bath by rollers at a controlled speed. Variation in the flow speed and roller speed enables glass sheets of varying thickness to be formed. Top rollers positioned above the molten tin may be used to control both the thickness and the width of the glass ribbon.

Once off the bath, the glass sheet passes through a lehr kiln for approximately 100 m, where it is cooled gradually so that it anneals without strain and does not crack from the temperature change. On exiting the "cold end" of the kiln, the glass is cut by machines.

Compression molding: In this process moulds are used to obtain the products of desired shapes.

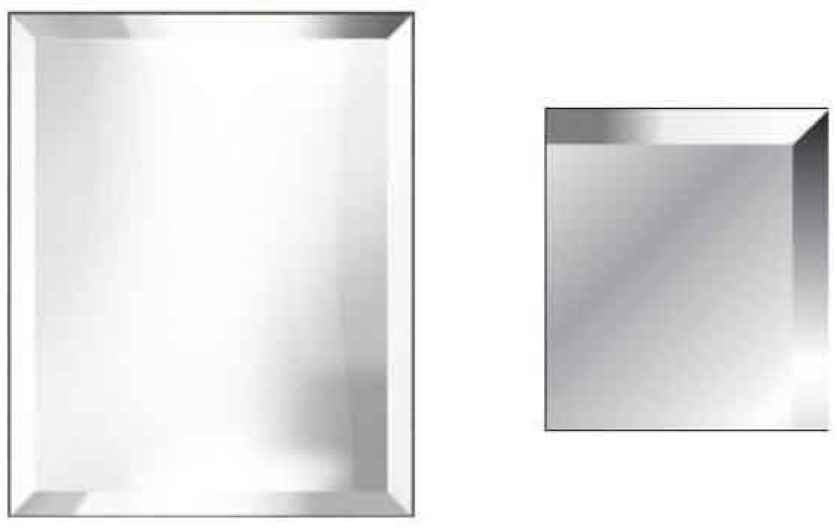


Spinning: A machine is used to spin the molten glass. The fibers so produced are very fine and are used for heat and sound insulation.

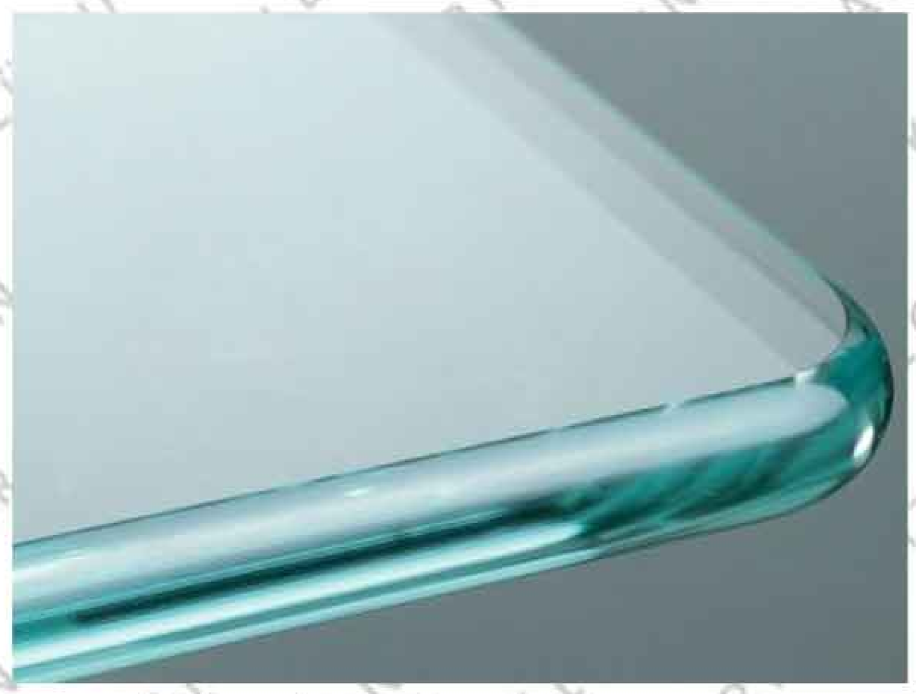


Annealing: Glass articles are allowed to cool under room temperature by passing through different chambers with descending temperature. If cooled rapidly, the glass being bad conductor of heat, the superficial layer cools down first and strain develops in the interior portions, which causes unequal expansion and the articles are likely to crack.

Finishing: After annealing the glass articles are cleaned, ground, polished, cut, beveled, grinded and sand blasted.



beveled edges (bizote)



grinded edges (rodaj)

sand blasted (kumlama)

Classification

Depending upon the constituents glasses are classified as soda-lime glass, lead glass and borosilicate glass.

Soda-lime glass: is also known as soda-ash glass, soda glass or soft glass. Soda-lime glass is obtained by fusing a mixture of silica, lime and soda. The quality of this glass can be improved by adding alumina and magnesium oxide and the glass is then called crown glass. This is the most common type of glass used in doors, windows and for making glass-wares such as bottles.

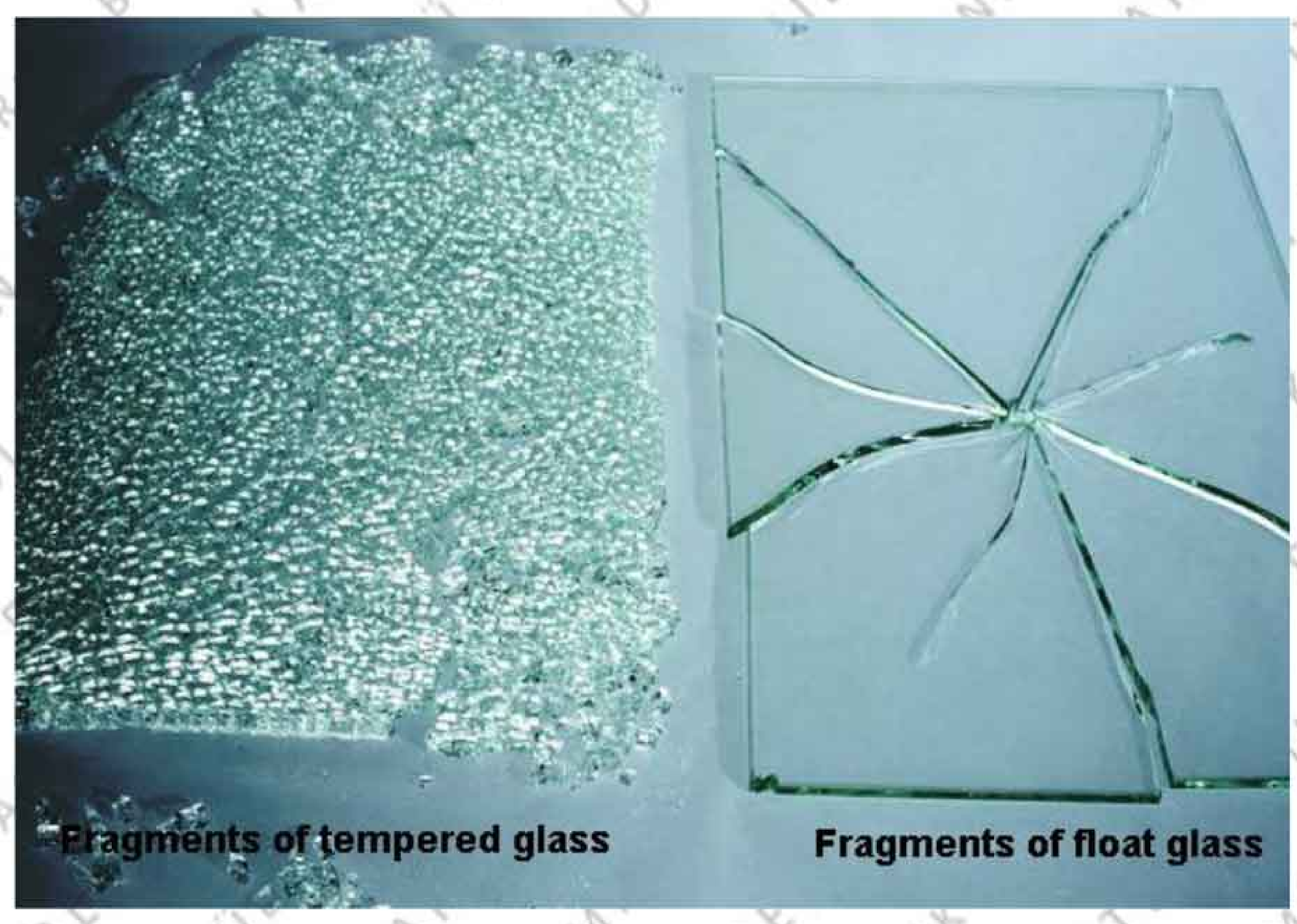
Lead glass: also known as flint glass is obtained by fusing a mixture of silica, lead and potash. It is free from iron impurities and is colorless. Lead glass has high shining appearance and can take polish. It is not affected by temperature. Electric bulbs, optical glasses, cut glass, ornamental glass works and radio valves are some of the products made from it.

Boro-silicate glass: is obtained by fusing a mixture of silica, borax, lime and feldspar. The examples are pyrex glass and heat resisting glass. Boro-silicate glass can withstand high temperatures and is most suitable for making laboratory equipments and cooking utensils.

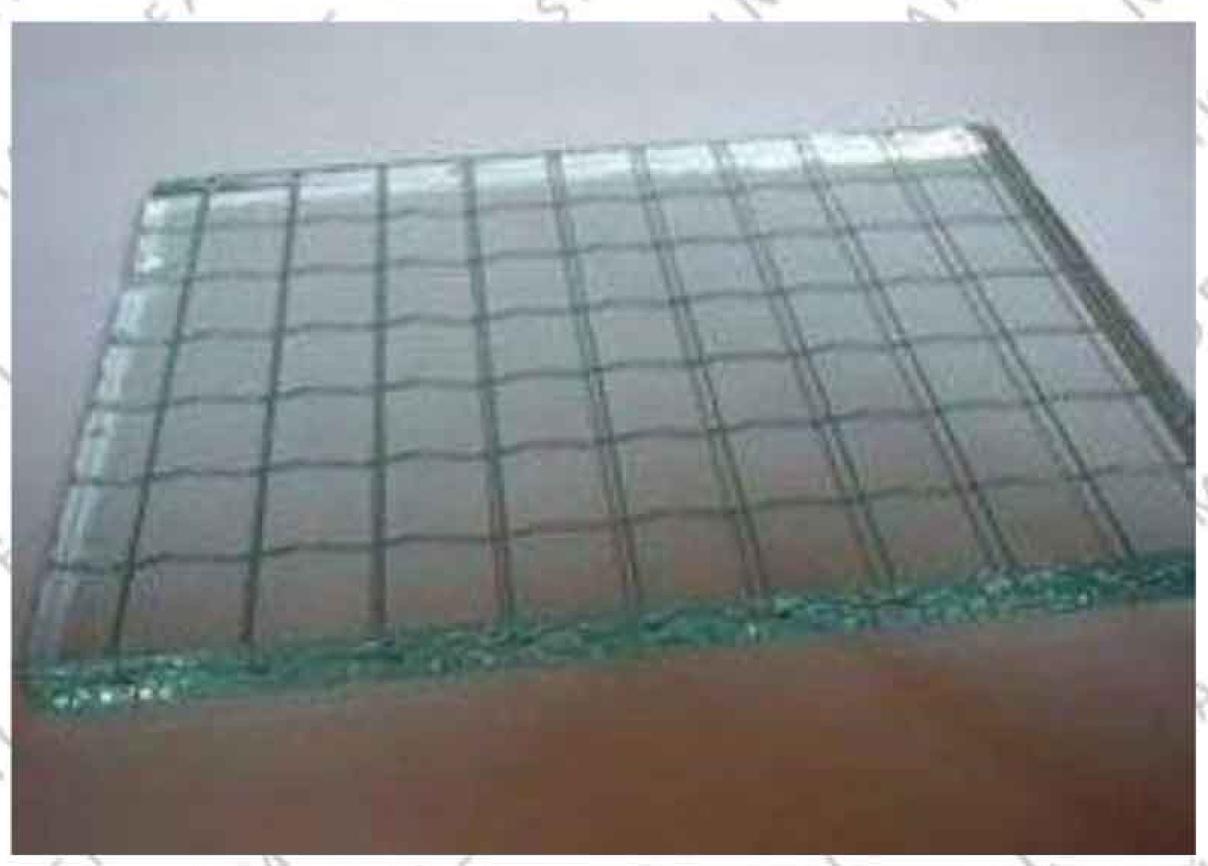
Sheet glass: is used for glazing doors, windows and partitions and is obtained by blowing the molten glass into the shape of a cylinder. The ends of the cylinder so produced are cut away and the cylinder is flattened over a plane tray.

Plate glass: is used for all engineering purposes and is superior to sheet glass. A plate glass differs from a sheet glass in that it has a parallel, distortion-free surface obtained by grinding or floating process. It is produced by pouring the molten glass on casting tables and leveling it to a uniform thickness. Both the glass surfaces are then ground, smoothened and polished. Glass so produced is clear and contains unblemished true plane surfaces.

Tempered glass: is made from plate glass by reheating and sudden cooling and is 3 to 5 times stronger than plate glass. Although not unbreakable, it resists bending stress better than plate glass and, when broken, the pieces are relatively small in size. It is used extensively in sports arenas, sliding doors and curtain walls.



Wired glass: is produced by embedding wire nets 0.46 to 0.56 mm into the centre of sheet glass during casting. The minimum thickness of wired glass is 6 mm. When broken it does not fall into pieces. It has higher melting point than ordinary glass. Wired glass can be used for fire resisting doors and windows, for sky lights and roofs.



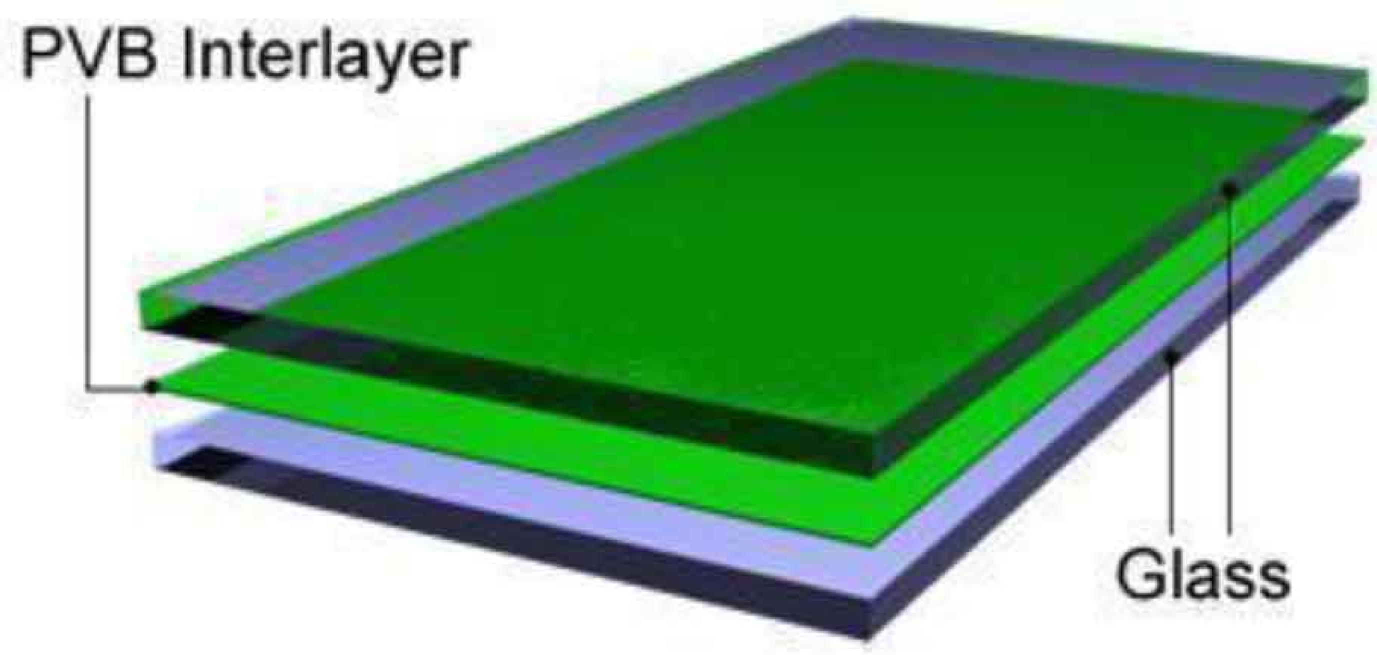
Obscured glass: is made comparatively opaque to sunlight. Also known as patterned glass. They are classified as frosted, rolled and ribbed.

- **frosted glass:** is produced by subjecting the polished face of the glass to a sand blast which grinds off the surface. It can also be produced by etching on glass by hydrofluoric acid.

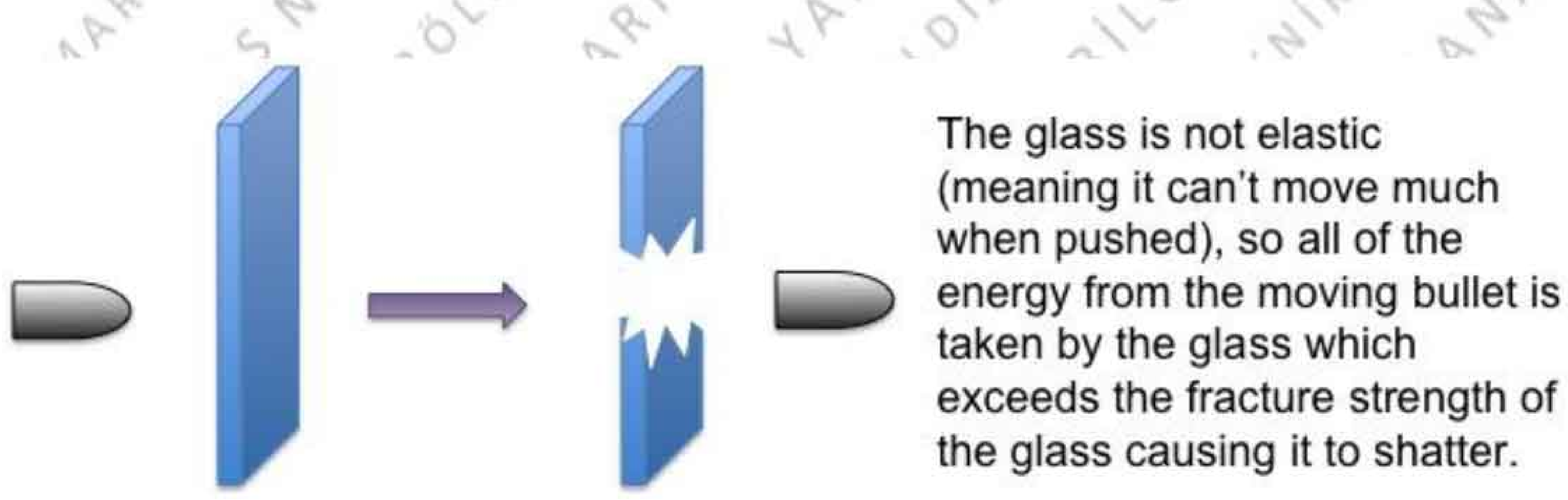
- **rolled glass:** has a series of waves of desired pattern on the surface and is also known as figured rolled glass.

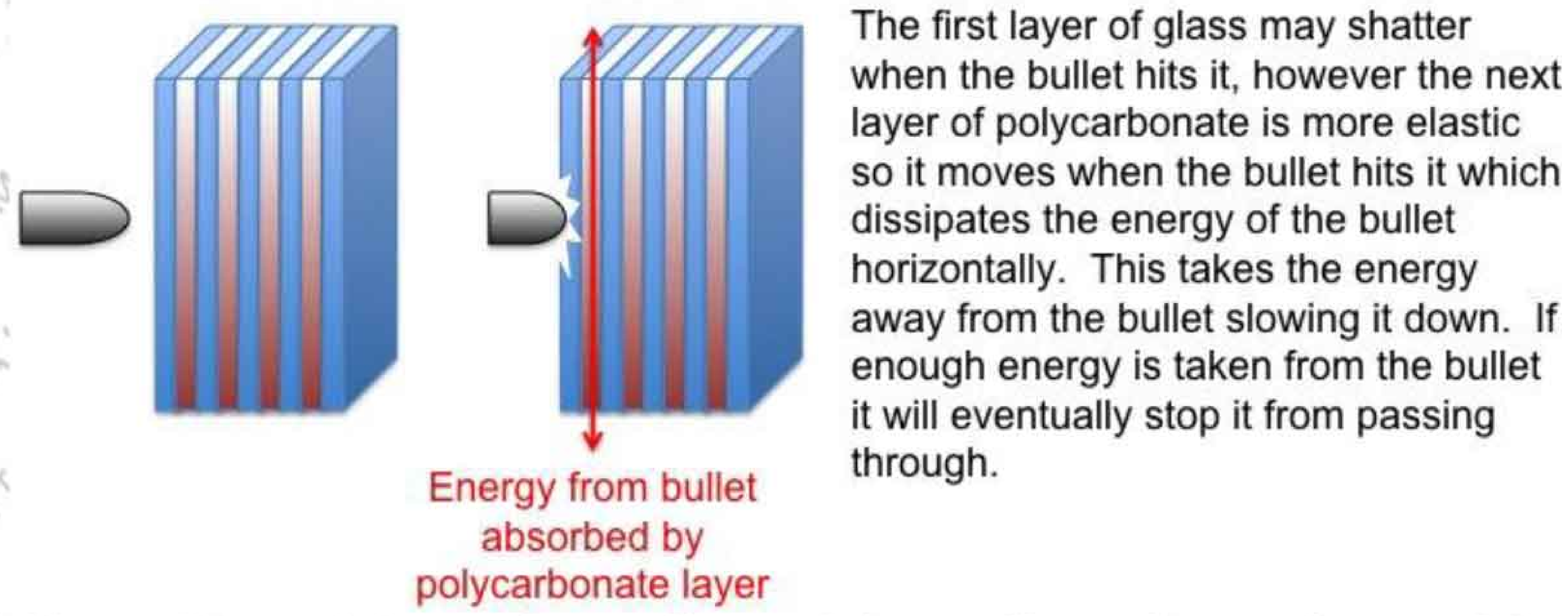
- **ribbed glass:** A series of triangular ribs are produced in the glass during casting.

Laminated glass: is made by sandwiching a layer of polyvinyl butyral between two or more layers of plate or sheet glass.

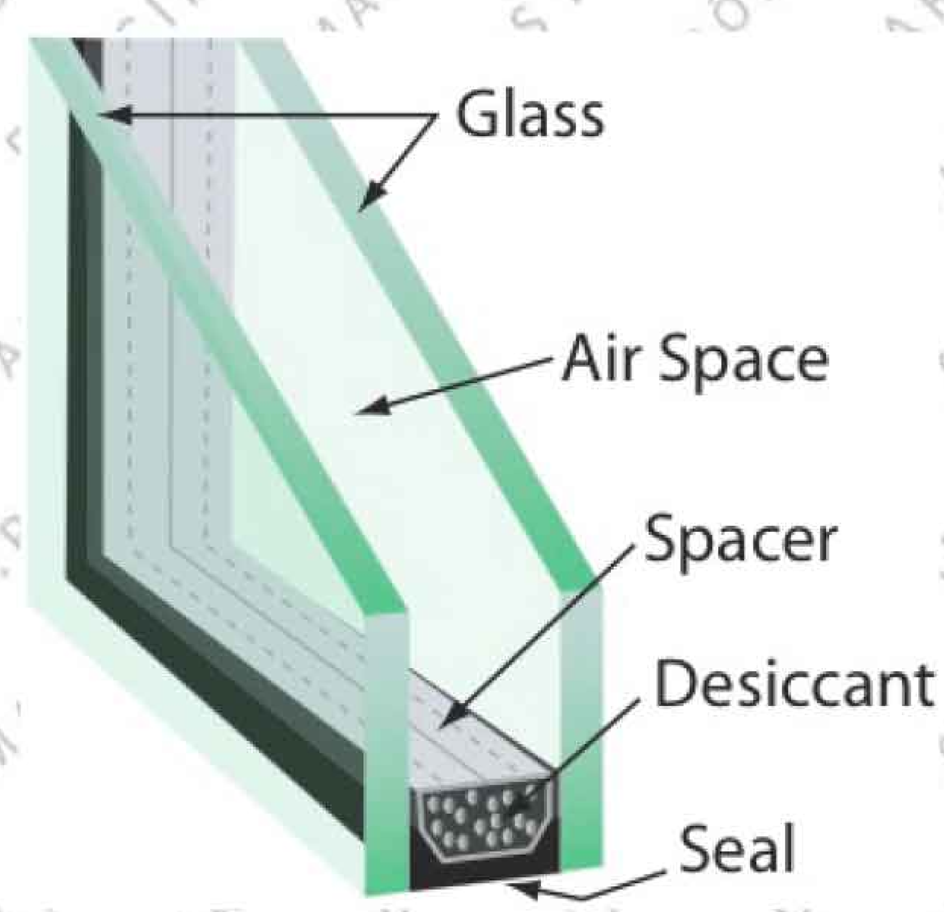


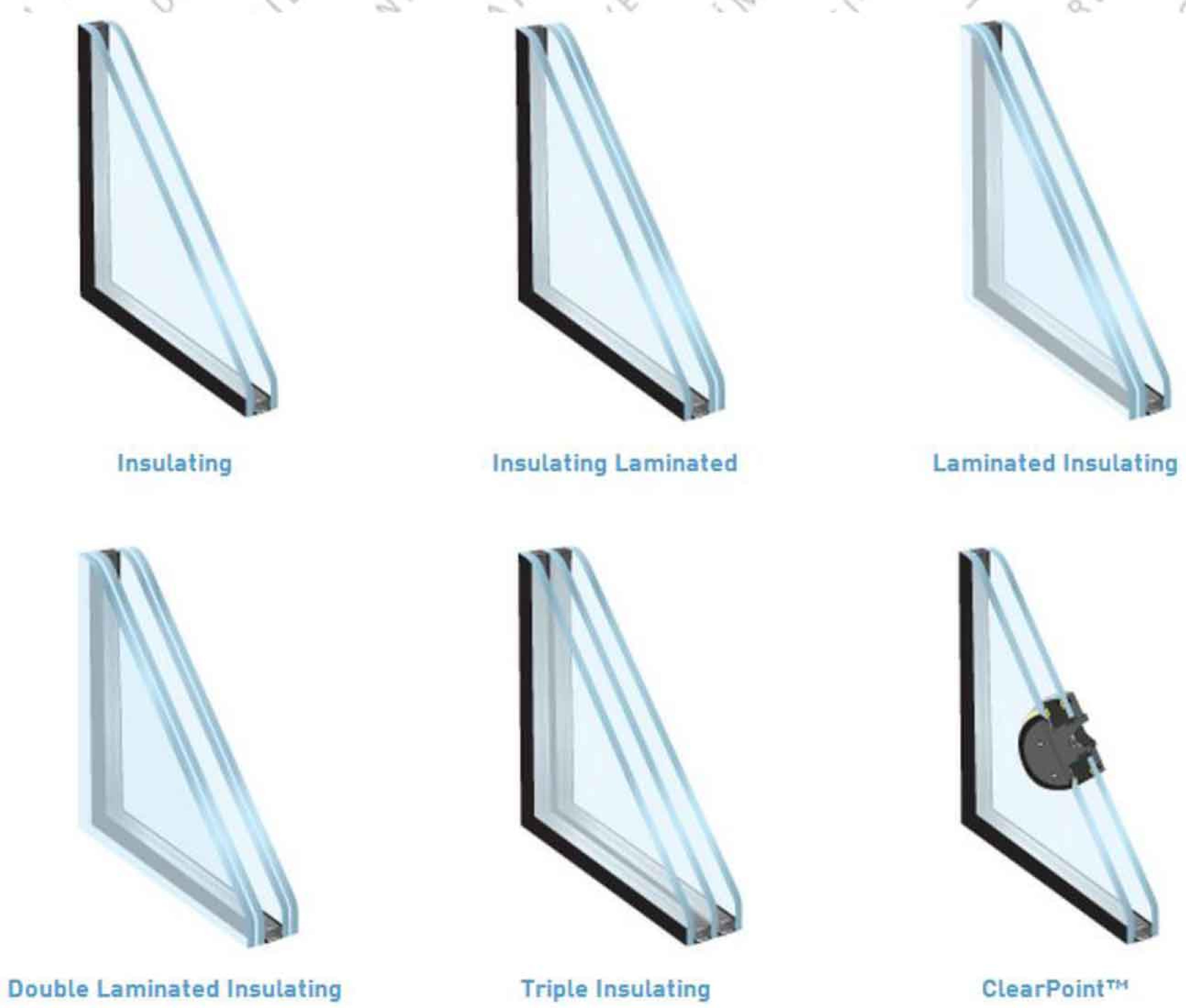
Bullet proof glass: is produced by placing vinyl plastic and glass in several alternate layers and pressing them with outer layers of glass. It is used in banks, jewellery stores and display windows.





Insulating glass: is composed of two glass plates into which a layer of 6–13 mm thick dehydrated air is sealed. The round edges are formed by fusing together the two glass plates. These glasses reduce the heat transmission by 30–60 per cent.





Block glass: is hollow sealed made by fastening together two halves of pressed glass. It is used for making partitions.

Glass wool: When silicate rock or flint is melted (1650° C) with a small quantity of calcareous matter and the liquid is blown by steam jet, it splashes out in the form of small globules which are hurled in a large container at a great speed to cause them to be drawn into very soft and flexible fibers of not more than 10 micron diameter. The source material is glass bottle waste melted at 1300–1400° C temperature. It can be packed into small pads or formed into (5–6 μ) boards or blankets. The fibers are chemically inert. Glass wool has high tensile strength and chemical resistance and, low sound and heat conductivities. It can absorb high amounts of water. They contain air in the pores forming a useful filter media for air conditioners and an insulating material for heat and sound.