VIAVISION

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GLASS

More Than a Clear View

91 percent
of used car glass was recycled in 2010.

4.6 square
metres of window surfaces are installed in a car.

Editorial

Dr. Ulrich Hackenberg, Member of the Board of Management of Volkswagen Brand with responsibility for Research and Development.

Car windows are high-tech products whose manufacture requires sophisticated processes. In terms of the design and safety of a car, the glass has to fulfil more functions than those of a mere window. In this issue *VIAVISION* shows the numerous applications of glass as a material.

I wish all readers a happy read.

Seen Through

Manufacture and Processing of Glass

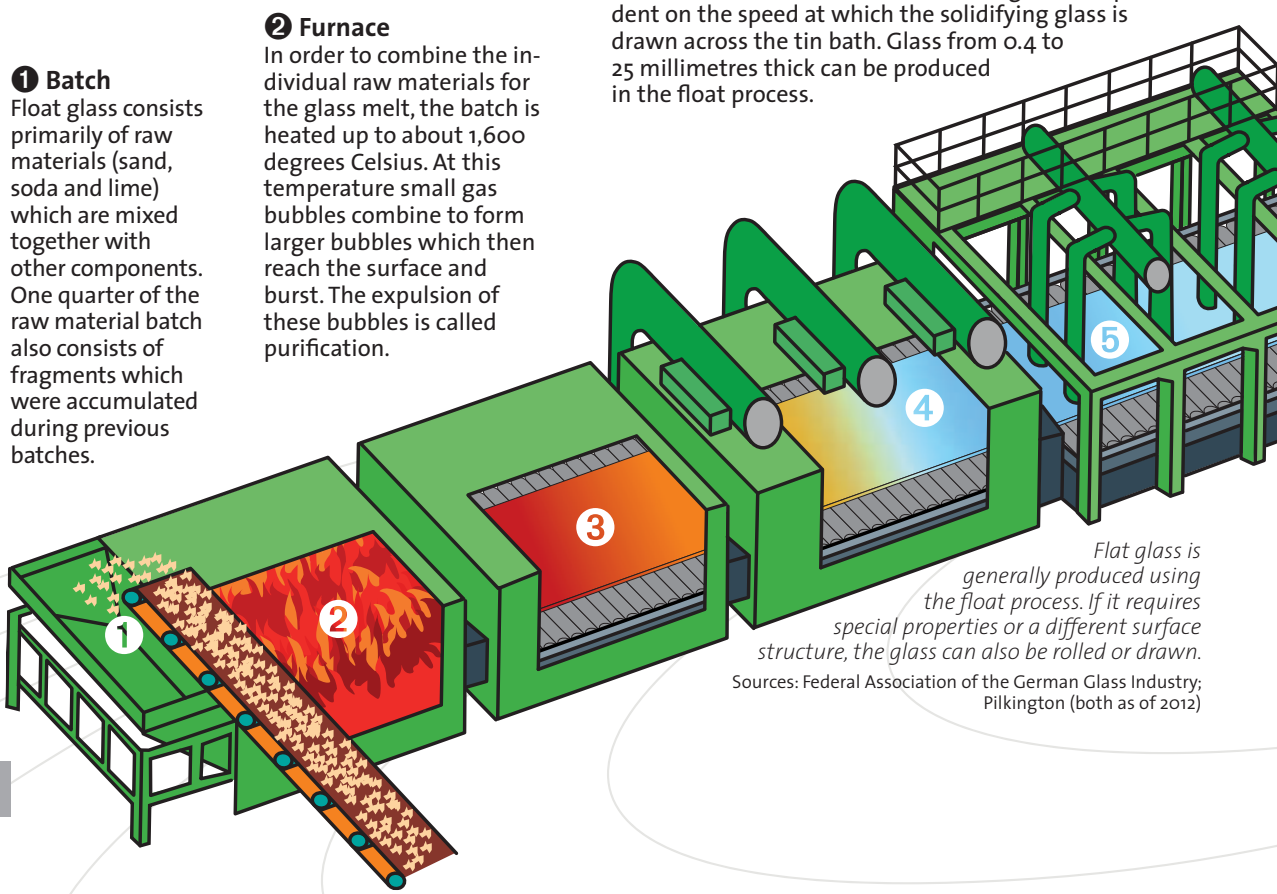
Whether for bottles, windows or mirrors – the applications of glass are as varied as the types of glass. They can be distinguished by various criteria such as chemical composition, method of production or purpose. Predominantly further processed flat glass is used in the automotive industry. When reinforced and toughened, safety glass protects the occupants during accidents. Special glass, equipped with a foil or a thin chemical layer, means the material can take on additional functions – such as tinted or self-cleaning glass.

The production of flat glass in the float process:

❶ Batch
Float glass consists primarily of raw materials (sand, soda and lime) which are mixed together with other components. One quarter of the raw material batch also consists of fragments which were accumulated during previous batches.

❷ Furnace
In order to combine the individual raw materials for the glass melt, the batch is heated up to about 1,600 degrees Celsius. At this temperature small gas bubbles combine to form larger bubbles which then reach the surface and burst. The expulsion of these bubbles is called purification.

❸ Float bath
The liquid molten glass flows at a temperature of 1,100 degrees Celsius over a bath of molten tin and spreads out continuously. This results in a particularly uniform and level surface. The thickness of the glass is dependent on the speed at which the solidifying glass is drawn across the tin bath. Glass from 0.4 to 25 millimetres thick can be produced in the float process.



Flat glass is generally produced using the float process. If it requires special properties or a different surface structure, the glass can also be rolled or drawn.

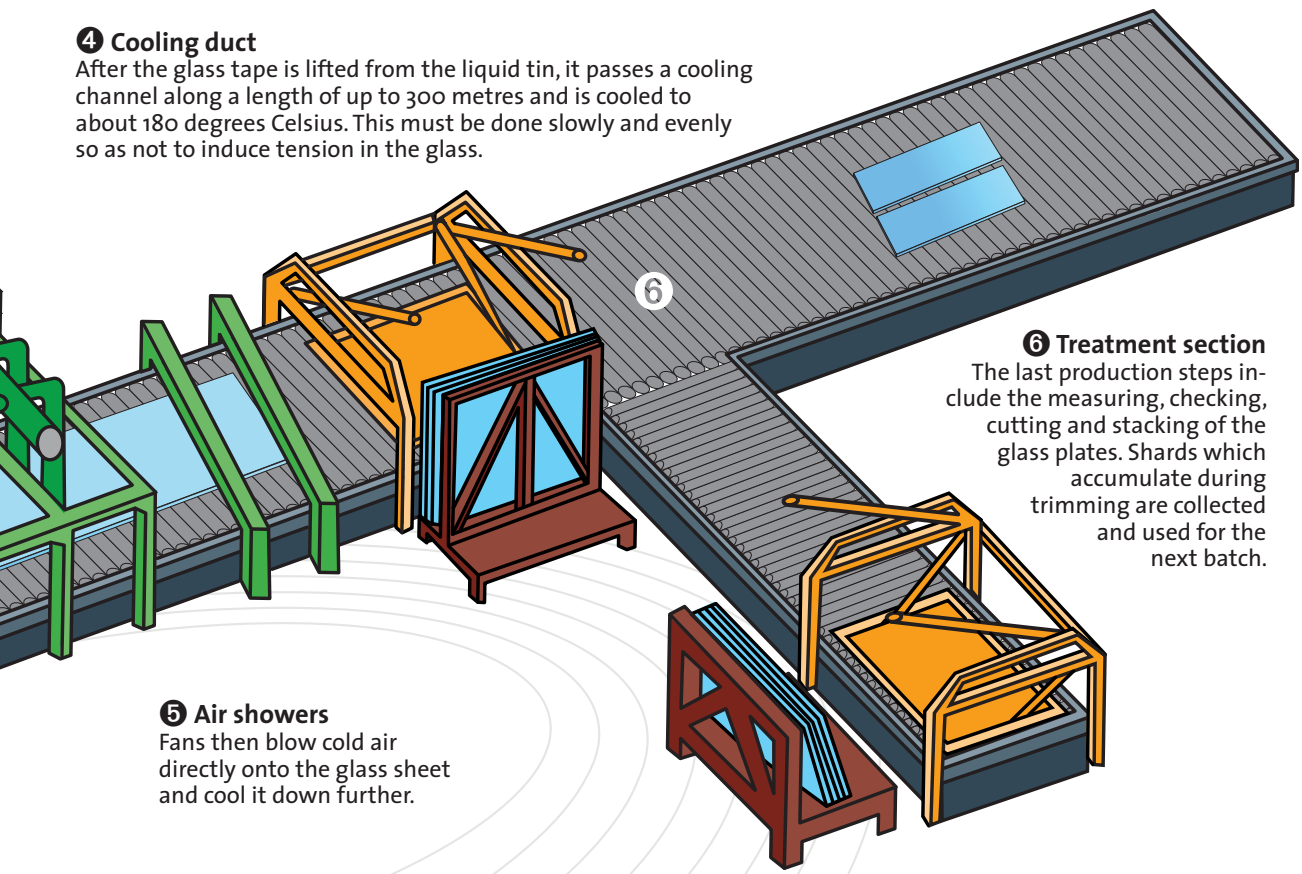
Sources: Federal Association of the German Glass Industry; Pilkington (both as of 2012)

Safety glass

For use in cars, flat glass is further processed into toughened safety glass. Laminated safety glass (LSG), which consists of at least two layers of glass between which lies a plastic film made of polyvinyl butyral (PVB), belongs to this category. The individual layers are permanently connected with the help of pressure and heat. If the glass breaks, the interlayer keeps the resulting splinters together.
While LSG is used for windscreens, side and rear windows usually consist of single-pane safety glass. It is stronger because it is pre-stressed in a thermal process. Here, the cut glass is heated to at least 640 degrees Celsius and then abruptly cooled from the outside. The surface therefore solidifies in expanded condition, while the still fluid core cools slowly but is prevented from contracting by the expanded surface. This creates a tension. Thus, single-pane safety glass breaks into small, uniform pieces without sharp edges.

Sources: Bundesverband Flachglas; Federal Ministry of Transport, Building and Urban Development; Interpane (all as of 2012)

❹ Cooling duct
After the glass tape is lifted from the liquid tin, it passes a cooling channel along a length of up to 300 metres and is cooled to about 180 degrees Celsius. This must be done slowly and evenly so as not to induce tension in the glass.



❻ Treatment section
The last production steps include the measuring, checking, cutting and stacking of the glass plates. Shards which accumulate during trimming are collected and used for the next batch.

❺ Air showers
Fans then blow cold air directly onto the glass sheet and cool it down further.

Made Transparent

The Application of Special Glasses in Cars

Cars today have 4.6 square metres of glass surfaces – more space than a traditional double bed. This figure only takes windows into account, not the special glass that is installed, for example in the onboard electronics. *VIAVISION* shows the points at which glass is processed in and around the car and what properties it can have.

Heated windows

Because the windscreen is a supporting body part, it is made of laminated glass. It is heated by thin, barely visible tungsten filaments in the PVB interlayer between the plates or by a transparent silver coating on the inside of the windscreen. In order to make the single-pane safety glass (conventionally used in rear windows) heated, heating wires made from silver paste are printed on the still untreated float glass and are subsequently refined using heat. All variants generate heat when low power electricity is applied.
Examples of use: front and rear windows

Glass fibre

Fibre optic cables are made of thin glass fibres which transfer data via light signals. This transfer is free of interference. In addition, glass fibres, as opposed to copper wires, are bendable into almost any shape, resistant to chemical liquids and flame retardant.
Example of use: on-board electronics

Tinted glass

Tinted glass absorbs a large part of the incident heat radiation and thus keeps the temperature in the interior on a constant level.
In laminated glass the tinting is achieved with an additional coloured interlayer between the glass plates, in single-pane safety glass, the glass melt is mixed with colour pigments during the manufacturing process.
Examples of use: front, rear and side windows

Sources: Verband der keramischen Industrie (as of 2003); Auto Club Europe (as of 2009); Schott; University of Vienna, Core Facility Cell Imaging and Ultrastructure Research; FLABEG; Gabler Wirtschaftslexikon Online; DURAN; Saint-Gobain Sekurit (all as of 2012)

Aluminosilicate glass

The glass tubes of halogen lamps are made more durable and temperature resistant by the addition of aluminium and silicate, thus they do not break during rapid temperature changes.
Example of use: spotlights

Anti-reflective glass

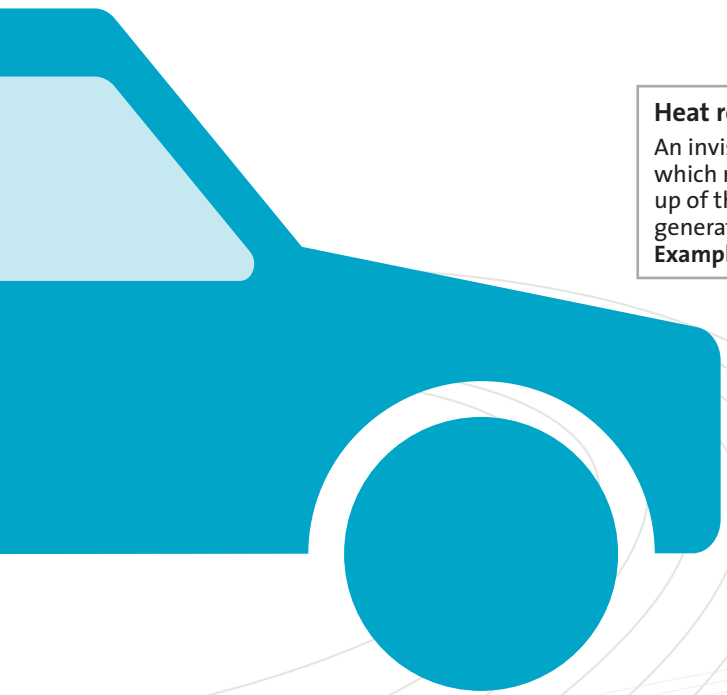
Anti-reflective glass reflects less of the incident light, allowing a better view. Combined metal oxide layers break incident light waves so that a large part is absorbed because of their precisely calculated thickness. Materials used are, for example, silicon and titanium oxides.
Example of use: instrument panel

Sound-reducing laminated glass

A total of three polyvinyl butyral interlayers are used in sound-reducing laminated glass: The two outer layers ensure the adhesive effect, while the inner film is highly dampening, thus absorbing vibration and reducing outside noise.
Example of use: windscreen

Glass-metal pipes (pressure glass lead-through)

Glass-metal pipes are fused together, vacuum-tight pipes which can be used to lead electrical conductors into hermetic housing. This is necessary where highly sensitive sensors must be protected by a casing against chemically aggressive substances, high temperatures or strong vibrations. Borosilicate glass, made especially corrosion and temperature resistant by the metalloid boron, is predominantly used here. The glass is fused with a metal such as iron, stainless steel or a nickel-iron alloy in order to be conductive.
Example of use: oil pressure sensors in the engine block



Heat reflective glass

An invisible coating of silver oxide is applied to the glass which reflects the sun's rays and so reduces the warming up of the vehicle's interior. When energized, it can also generate heat and serve as a window heater.
Examples of use: front, rear and side windows

Water-repellent glass

The glass surface is coated with a layer of polymers which acts as a barrier between the water and the glass – the water droplets drip off the surface without forming a lubricating film.
Examples of use: front, rear and side windows

New from Old

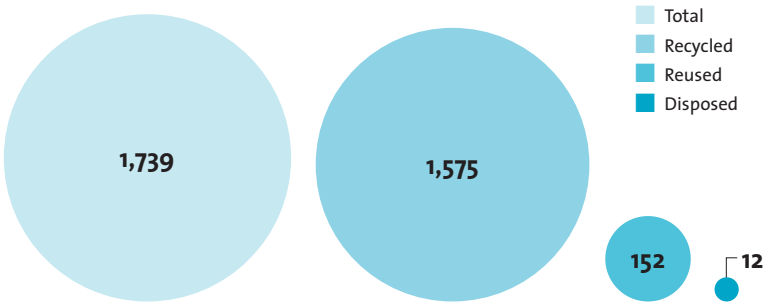
The Repairing and Recycling of Car Glass

Although the glass in cars is specially designed for strength, it can be damaged. If the damage cannot be repaired, windows generally end up being recycled. Glass is considered the showcase product when it comes to recycling: 91 percent of the glass from old vehicles is reused. For special and safety glasses the reprocessing takes place in several steps because the glass is mixed with other materials. The layers and chemicals that were added to the glass must again be separated in an elaborate process.

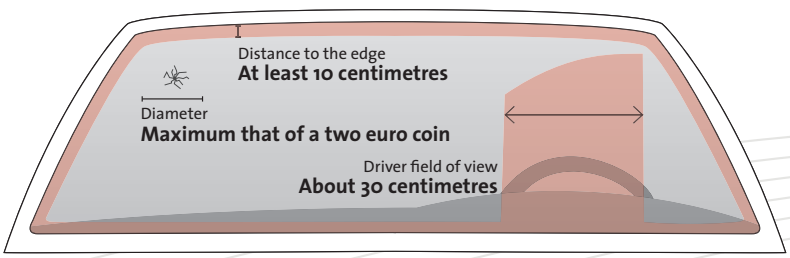
Glass recycling in cars:
(in tonnes)

1,739 tonnes of glass accumulated during the dismantling of old cars in Germany in 2010 – 1,575 tonnes of which were recycled, 152 directly reused and only 12 disposed of.

Source: German Federal Environment Agency, Altfahrzeug-Verwertungsquoten in Deutschland im Jahr 2010



Glass repair:



The removal of stone chips in windscreens counts among the most common repairs. However, not all such damage can be repaired because the damaged area must meet certain conditions: it must be at least ten centimetres away from the edge of the windscreen, may not lie in the driver's field of vision and must not exceed a certain size. The specifications of the repair shops vary between the size of a two cent coin and a two euro coin. During repair, the damaged area is cleaned first. Then a vacuum is created over it and synthetic resin is filled in. This hardens under UV light. Excess resin is removed afterwards and the spot polished.

Sources: Carglass; Wintec; A.T.U. (all as of 2012)

3.7 million Germans had their car windows damaged between 2009 and 2011.

Source: Verbrauchs- und Medienanalyse 2012

Glass recycling:

❶ First the windows are shredded to fist-size so the pieces can be transported on the plant's conveyor belt.

❷ Then large contaminants, such as rubber parts, are removed by hand.

❸ Using a mill, the presorted fragments are ground to a maximum of 14 millimetres in size. This separates the glass from the existing interlayers which are not crushed.

❹ Now the clearly smaller and heavier glass pieces can be sieved. At the same time, foils are removed by a vacuum.

❺ In the next step the ground glass parts undergo what is called CSP separation. CSP stands for ceramic, stone, porcelain. Here light is shined through the fragments and their transparency is checked. In the following free fall non-transparent fragments are sorted out using compressed air nozzles.

❻ Then the metal separators employ a rapidly rotating permanent magnet system that generates strong eddy currents. These produce a magnetic field opposed to the field of the permanent magnet. As a result possible metal parts are repelled and ejected.

❼ What remains is glass granulate which can be used in the manufacture of glass containers or glass bricks. It does not enter the production of float glass because that has higher quality requirements.

The special glasses used in the automotive industry usually contain other materials. These metals, foils and chemicals have to be removed during recycling, in order to obtain pure glass at the end which can be reused. To this end, the glass undergoes a multi-stage process. In Germany it is mandatory that the glass roofs, as well as the front, rear and side windows of old cars be removed and recycled.

Sources: Reiling Glas Recycling; Altfahrzeug-Verordnung (both as of 2012)

Picture: PhotoSG – Fotolia.com

New Perspectives

Plastics for Greater Lightness

Glass has many advantages: it resists high temperatures, has dimensional stability and is relatively scratch-resistant. But it is not particularly light. In some parts, glass can be replaced by plastics, in order to save weight during automobile construction and consequently fuel when driving. Polycarbonate (PC) and polymethyl methacrylate (PMMA), commonly referred to as acrylic glass, are used most frequently. Another advantage of these substitute materials: they are more easily shaped, compared to glass, offering greater flexibility to the designer.

20 kilograms of CO_2 are saved by each kilogram of polycarbonate that replaces glass.* A weight reduction of 20 kilograms approximately equates to the CO_2 emissions of a 1,800 kilometres long flight.

Sources: Bayer MaterialScience; International Economic Platform for Renewable Energies (IWR) (both as of 2012)

* Over the course of a car's lifetime, at a mileage of 150,000 kilometres.

Plastics versus glass:

Desired property	Glass	PC	PMMA
Low weight	−−	++	++
Scratch resistance	++	−	+
Break resistance	−	++	+
Impact resistance	−−	++	+
Stiffness	++	−	+

Glass, PC and PMMA have one thing in common: they are transparent. As materials they differ significantly in other aspects. The plastics are lighter and have a higher break and impact resistance than glass – thus absorbing hits and impacts better, without breaking. They are however neither as scratch resistant as glass nor as stiff, thus deforming more readily under mechanical impact.

Sources: *lightweightdesign*; 3 Pi Consulting & Management; HUG Industrietechnik und Arbeitssicherheit (all as of 2012)

40 to 50 percent is how much lighter plastic components are compared to glass components.

Source: *lightweightdesign* (as of 2012)

Plastics in the car

Even today, polycarbonate and acrylic glass can be found in headlights and as rear, roof and fixed side windows instead of glass. For emergency vehicles, used by police and firefighters, there are special permits for windscreens made of polycarbonate, as these provide better protection against vandalism. In order to approve the use of plastics in the windscreens of ordinary cars in the future, they will have to pass rigorous testing. The problem with polycarbonate above all is that it is not as scratch resistant. Therefore, it is coated, for example for car roofs, in a complex, multi-stage paint process with glass-like silicates. Acrylic glass has the disadvantage that it is both more brittle and not as tough as polycarbonate.

Sources: Bayer MaterialScience; Evonik Industries; University of Kassel, Department of Materials Engineering; 3 Pi Consulting & Management (all as of 2012)

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