# Glass unlimited

# SUMMARY



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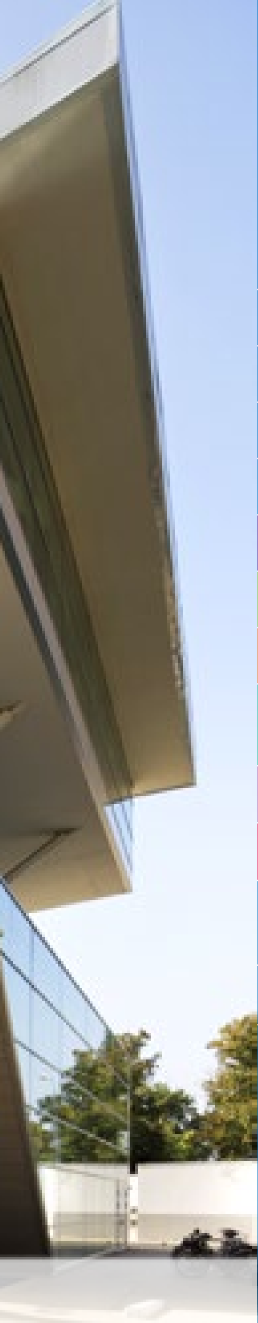
Ex-Sieroterapico - Milan, Italy - Architect: Dante O. Benini & Partners - iplus Energy$^{NT}$



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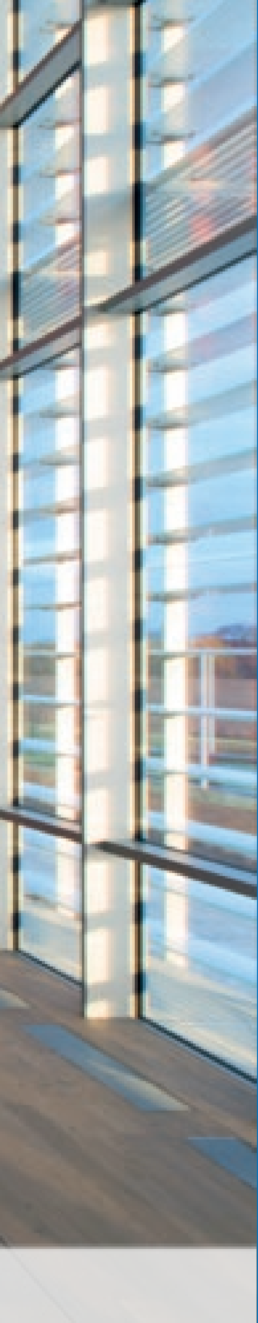
AGC Glass Building - Louvain-la-Neuve, Belgium - Architect: Philippe Samyn and Partners - Thermobel Top$^{N+}$ on Clearvision

Artistic integration: Georges Meurant - Photographer: Marie-Françoise Plissart



# I
# The AGC group

# 1
# INTRODUCTION

AGC Glass Building - Louvain-la-Neuve, Belgium - Architect: Philippe Samyn and Partners -
Glass louvres made of silk-screen printed laminated Planibel Clearvision

## AGC GLASS EUROPE

### ▼ A brief overview

AGC Glass Europe is the European branch of AGC Glass, one of the world's leading flat glass manufacturers. The AGC Group has 200 companies in over 30 countries, focusing on 3 main business segments: glass, electronics and chemicals.

AGC Glass Europe produces, processes and distributes flat glass for the construction sector (external glazing and interior decorative glass), the automotive industry (original and replacement glass) and specialist industries.

The company has 18 float lines, 6 automotive plants, a Research & Development Centre, as well as over 100 sites throughout Europe, from Spain to Russia, including a manufacturing network in Belgium, Germany, the Netherlands, France, Poland and the Czech Republic.

At AGC's R&D Centre, located in the heart of Belgium, 70% of the budget is devoted to sustainable products, solutions and manufacturing.

### ▼ AGC's distribution network

Since 2009, AGC offers a distribution network for raw glass, including 12 regional distribution centres (RDCs) and over 40 local distribution centres (LDCs). This number is set to grow in the years ahead.

Underlying this logistical infrastructure is a decidedly new market strategy that will benefit customers. Large customers can choose from a wide selection of available products (including glass manufactured in other regions), order mixed deliveries of different types of glass in the same truck, and enjoy shorter delivery times. By way of comparison, the LDC delivers smaller quantities of glass (per stack, whether it's homogeneous or mixed, and even per sheet) to glass processors. Customers can enjoy additional services such as the possibility of picking up their orders themselves and, if necessary, benefit from cutting and grinding services.

## ▼ Glass experts at your service

In addition, AGC Glass Europe offers real support for architects and customers in planning, designing and processing glass via four support teams:

### > IBP: International Building Projects

International Building Projects (IBP) is a team of glass and architectural experts responsible for supporting investors, architects, engineering firms, facade makers and processors in specific technical solutions, with a focus on glass facades, glass roofs and other special exterior applications.

### > IDC: Interior Design Consultant

Interior Design Consultant (IDC) is a team of glass and design experts that helps architects, planners, designers, furniture producers and processors to choose the right AGC glass for interior design projects and furniture applications.

### > TAS: Technical Advisory Service - Products

The AGC Technical Advisory Service is a team of glass experts offering technical support on the company's glass products to customers with a focus on specialty glass. This technical support covers topics, such as: technical data sheets, static calculations, thermal analysis including evaluation of the risk of thermal stress, acoustic advice, installation guidelines, engineering support for special glass applications, etc.

### > TAS: Technical Advisory Service - Process

The TAS Process Team advises clients that process AGC glass, focusing on the toughening and heat-strengthening processes.

The team members of these four support groups are spread throughout Europe, including Russia.

# A PIONEERING HISTORY

## ▼ A great glassmaking tradition

In the 19th century, Belgium was the largest exporter of glass in the world and one of the main producers of polished glass. At the dawn of the 20th century, with the help of Emile Gobbe, Belgian engineer Emile Fourcault introduced the first mechanical system for glass production. This vertical drawing system influenced the entire glass industry around the world, replacing the manual glassblowing method universally used until then for making window glass.

With the rapid development of mechanisation, the industry concentrated in Belgium. This ultimately led in 1961 to a merger between the two largest producers of flat glass, "Glaces et Verres" (Glaver S.A.) and "Union des Verreries Mécaniques Belges" (Univerbel S.A.), to form Glaverbel.

## ▼ The float revolution

In 1963 Glaverbel expanded into the Netherlands, building a glass drawing plant in Tiel. In 1965, Glaverbel opened the first float glass line in continental Europe, at Moustier, Belgium. In 1972 the French company BSN (Danone) took control of Glaverbel and integrated the Belgian company into its own flat glass division. The technological revolution engendered by the float process brought radical restructuring of the glass industry, with the shutdown of sheet glass furnaces. The worldwide recession added to the crisis in the glass industry, with a drastic impact on employment. Glaverbel began to diversify into glass processing.

## ▼ From the Benelux to a multinational group

In 1981, BSN shed its flat glass activities and Glaverbel was acquired by Asahi Glass Co. Ltd. (Japan). Enjoying a great degree of management independence, Glaverbel expanded in western Europe through investments, partnerships and acquisitions. The stock exchange flotation in 1987 gave it the resources needed to engage in an ambitious strategy of growth, with geographical expansion of its industrial base and investment in high-tech products.

## ▼ Pioneer and leader in Eastern Europe

In 1991, Glaverbel was the first western industrial company to invest in the former Czechoslovakia, with the phased acquisition of the national flat glass producer (now AGC Flat Glass Czech). Glaverbel subsequently expanded in central Europe, setting up a vast distribution and processing network. In 1997, Glaverbel continued its eastward march, becoming the first western glass producer to invest in Russia, again with the phased acquisition of the country's leading flat glass producer (now AGC Bor Glassworks). It also set up an extensive distribution network in Russia. In 1998, Glaverbel acquired the European flat glass activities of PPG Glass Industries, mainly located in France and Italy. Finally, Glaverbel confirmed its leadership in Russia with the construction in 2004 of an industrial complex in Klin for the production of float glass, mirrors and superinsulating glass. This was the first plant to be built by a western glass producer on a greenfield site in Russia.

## ▼ Becoming a full part of AGC

In 2002, as part of its worldwide re-organisation, AGC took full control of Glaverbel, which was delisted from the stock exchange. In 2007, AGC adopted a single name for all its companies around the world, and so Glaverbel became AGC Flat Glass Europe, and in 2010, AGC Glass Europe.

## ▼ Strategic alliance with Interpane

July 2012 saw the start of a new alliance in the glass industry: AGC and Interpane, a leading German glass producer and processor, joined forces to better serve customers in the German-speaking regions.

# 2
# CONTACTS

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Glass louvres on Planibel Clearvision, Thermobel Top$^{N+}$, Lacobel T Crisp White for spandrels
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AGC Glass Europe has representatives worldwide.

*See www.yourglass.com for further addresses.*

# 3
# CARING ABOUT THE ENVIRONMENT


AGC Technovation Center - Gosselies, Belgium - Architect: ASSAR Architects - SunEwat XL

Although energy-saving building remains the greatest architectural challenge of our times, sustainability in construction and renovation – and therefore in the building components used – will become a major focus.

The EU construction industry is entering a greener era, driven by four major shifts:

> The construction sector is affected by **legislation** on environmental protection, energy efficiency and well-being

> **Natural materials** that preserve the indoor health of the building are increasingly preferred

> **Rising prices** of resources create a preference for energy-efficient and recyclable materials

> **Investments in certified green buildings** are gaining ground and these require the use of environmental friendly products.

## AGC AND CRADLE TO CRADLE: A SUSTAINABLE COMBINATION

Cradle to Cradle® (C2C) is the brainchild of German chemist Michael Braungart and American architect William McDonough. Together, they developed a programme called McDonough Braungart Design Chemistry (MBDC), challenging the business community, the authorities, academia, builders and designers to design products, buildings and houses more intelligently by optimising the use of production processes that make a positive contribution to their environment (for example, energy generation and air pollution reduction).

The C2C philosophy imagines a world where there are no resource constraints:

> The concept of waste does not exist anymore – resources can be reused infinitely
> All materials are safe and healthy because they have been designed with the right ingredients
> Carbon is no longer the primary concern, because processes are powered with clean renewable energy.

This philosophy is in line with our Going Green approach. AGC is the first and so far the only European glass manufacturer to offer a wide range of products bearing the Cradle to Cradle Certified™ label.

## C2C: GROWING RECOGNITION FOR BUILDING AND INTERIOR APPLICATIONS

Over 60% of Cradle to Cradle Certified™ products (so far, around 500 products have been certified globally) are for construction and building interiors: floor tiles, glazing, furniture, etc. The Cradle to Cradle Certified™ programme for products is gaining recognition internationally, since certified products come from global market leaders and more and more national C2C platform initiatives are being launched in Europe.

## OUR COMMITMENT TO CRADLE TO CRADLE®

While many certifications address one particular aspect of a product, the C2C Product Standard addresses five categories relating to human and environmental health. In order to achieve certification, a product must meet strict standards in all five categories. AGC exceeds the basic requirements in each of these categories.

> Material health
> Material reutilisation
> Renewable energy
> Water stewardship
> Social fairness.

## ▼ The added value of Cradle to Cradle Certified™ products

The new LEED Version 4 for new constructions, officially launched on the market at the end of November 2013, gives more points to Cradle to Cradle Certified™ products. In this new version, Cradle to Cradle Certified™ products contribute up to two points in the Materials & Resources section. This credit encourages project teams to choose "healthier products and materials" in order to minimise the use and generation of harmful substances. Hence, by using AGC's Cradle to Cradle Certified™ products, architects and builders are eligible to earn more points.

AGC has achieved Cradle to Cradle Certified™ Silver for the following products:

> Float glass products

> Magnetron coated glass products

> Lacobel, Matelux, Matelac and Mirox

> Laminated products (Stratobel and Stratophone).

## ▼ There are 5 certification levels:

Basic, Bronze, Silver, Gold and Platinum. With a view to retaining its Silver certification and attaining yet higher levels, AGC has pledged to continuously improve its products and production processes.

Ghelamco Arena - Ghent, Belgium - Architect: Bontick - Stopray Ultra-50 on Clearvision

# 1
# INTRODUCTION

AGC float line

The first glass in building applications appeared a little over 2,000 years ago and was used to seal off entrances to structures. Even back then, the main functions of glass were being used: letting in light while providing a certain level of protection against wind, cold and rain.

However, the use of glass in buildings did not become widespread until a few centuries ago and it was not until the 20th century that glass performance began to evolve significantly for residential housing and commercial buildings.

In the late 1940s, the concept of double glazing to enhance thermal insulation began to develop but its real growth in Western Europe came about in the wake of the energy crisis in the 1970s.

Since then, the development of coated glass, laminated glass and other derived glass products (as well as active glass products with Building-Integrated Photovoltaics) has provided high-quality solutions for functions such as improved light comfort, less overheating, optimal use of free solar energy, increase in thermal insulation, built-in safety and security performance and acoustic comfort.

Today, there is an increasing demand for combining various functions in glass products for architectural applications.

In the following three chapters, AGC will:

> Describe the glass characteristics

> Illustrate the building functionalities of AGC glass products

> Show an overview of the AGC glass products.

# 1.1 – Nomenclature

Standards EN 410 and EN 673 set out the names for the characteristics. The corresponding names and scientific symbols are given in the table below.

**EN 410**

| Characteristic | Name | Symbol |
|---|---|---|
| Light reflection factor | LR | $\rho v$ |
| Light transmission factor | LT | $\tau v$ |
| Direct solar transmittance | DET | $\tau e$ |
| Direct solar absorption | EA | $\alpha e$ |
| Direct solar reflectance | ER | $\rho e$ |
| Solar factor | SF | g |

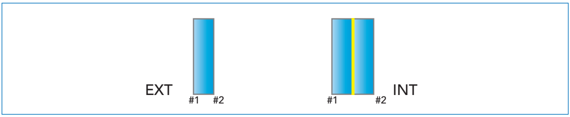
**EN 673**

| Characteristic | Name | Symbol |
|---|---|---|
| Thermal transmittance | $U_{glass}$ | $U_g$ |

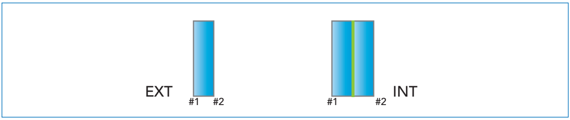
# 1.2 – Conventions

The numbering of glass surfaces and position of coatings for various glass build-ups (also applicable for www.yourglass.com site) are given below.

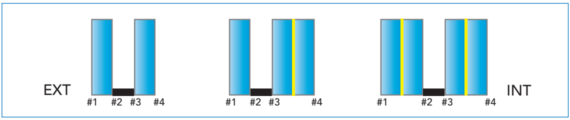
### Monolithic glass (always between 1 and 2)



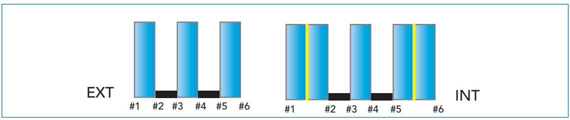

### Laminated glass (always between 1 and 2)




### Double glazing (always between 1 and 4)



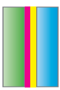

### Triple glazing (always between 1 and 6)



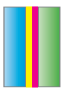

### Example: How to describe Stopsol Classic green assembled into laminated glass

= Stopsol Classic green #1
+ Planibel Clear

= Planibel Clear
+ Stopsol Classic green #2



= Stopsol Classic green against PVB
+ Planibel Clear



= Planibel Clear
+ Stopsol Classic green against PVB

# 1.3 – Solar radiation

The basics of solar radiation and its relation to electromagnetic radiation are critical to understanding the sections dealing with light and energy characteristics and thermal insulation.

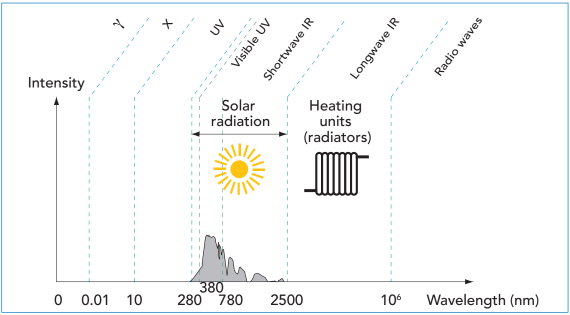
Every day we are exposed to different types of radiation, including radiation from the sun. The table and figure below show how these different types of radiation are classified according to their wavelength.

**Classification of electromagnetic radiation by wavelength**

| Type of radiation | Wavelengths (nm)(1) |
|---|---|
| Gamma rays | 0 to 0.01 |
| X-rays | 0.01 to 10 |
| Ultraviolet (UV) rays | 10 to 380 |
| UV C | 10 to 280 |
| UV B | 280 to 315 |
| UV A | 315 to 380 |
| Visible rays | 380 to 780 |
| Infrared (IR) rays | |
| shortwave IR A | 780 to 1,400 |
| shortwave IR B | 1,400 to 3,000 |
| longwave IR C | 3,000 to 15,000 |
| far Infrared | 15,000 to 1,000,000 |
| Microwave | 1mm to 1m |
| Radio waves | 1mm to 100,000km |

(1) 1nm = 1 nanometre = $10^{-9}$ m.

**Different types of electromagnetic waves**



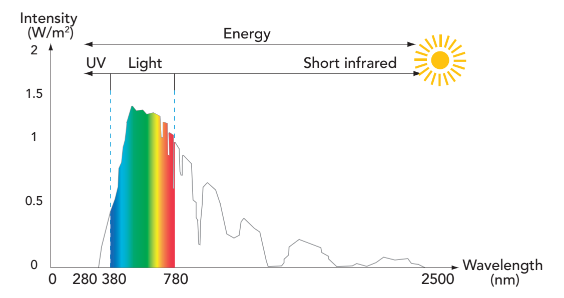
## 1.3.1 SOLAR RADIATION

Solar radiation accounts for only a small proportion of the spectrum of electromagnetic waves. Its composition is shown in the table and figure below. The spectrum of visible light forms a small part of the solar spectrum.

**Composition of the solar spectrum**

| Type of radiation | Wavelength (nm) | Proportion of energy |
|---|---|---|
| UV | 280 to 380 | approx. 5 % |
| Visible | 380 to 780 | approx. 50 % |
| IR | 780 to 2,500 | approx. 45 % |

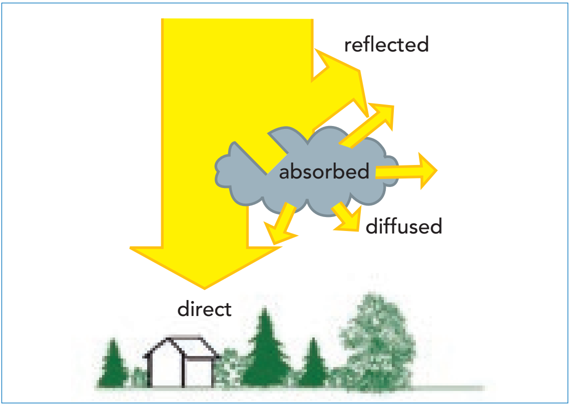
**Solar spectrum**




The sun is the source of solar radiation. It gives off 66 million W/m$^2$ of energy, produced by nuclear chain reactions. Only a fraction of this energy ends up anywhere near our atmosphere. This fraction – 1.353 W/m$^2$ – is called the solar constant.

The energy received from the sun is less than the solar constant since the atmosphere absorbs approximately 15% of solar radiation and reflects a further 6% back into space. The total solar radiation is therefore defined as being the sum of direct and diffused radiation.

**Atmospheric influence on solar radiation**




The energy received also depends on the season (the angle of incidence of the sun in relation to the earth), latitude, weather conditions (cloud coverage), contours, pollution, the orientation of the facade, etc.

## 1.3.2 SOLAR LIGHT

Light is that part of the solar spectrum – from 380 nm to 780 nm – that is visible to the human eye.

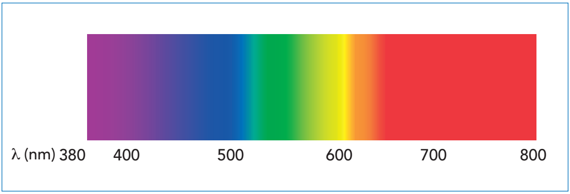
The table and figure below show the composition of light.

**Composition of light**

| Colour | Wavelengths (nm)(1) |
|---|---|
| Violet | 380 to 462 |
| Blue | 462 to 500 |
| Green | 500 to 577 |
| Yellow | 577 to 600 |
| Orange | 600 to 625 |
| Red | 625 to 780 |

(1) 1nm = 1 nanometre = $10^{-9}$ m.

**Light**




We perceive light visually but light can also be perceived in the form of energy. Light also represents approximately almost half of solar energy.

## 1.3.3 SOLAR ENERGY

The energy we receive on earth comes from solar radiation and is generated by:

> UV radiation

> visible light

> short infrared waves.

The energy received on earth can also come from another source, the long-wavelength infrared radiation emitted by objects like radiators, heating devices and lamps.

# 2
# GLASS CHARACTERISTICS

Porta Nuova - Milan, Italy - Architect: Piuarch - Stopray Vision-60T

The following chapter will describe a series of basic characteristics of glass products:

> light characteristics
> energy characteristics
> thermal insulation
> acoustic performance
> safety & security
> fire performance.

# 2.1 – Light and energy characteristics

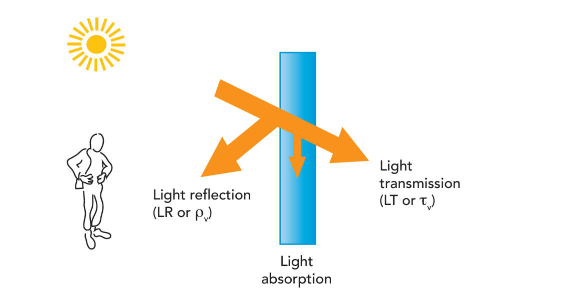
## 2.1.1 LIGHT CHARACTERISTICS

The light characteristics are defined solely on the basis of the visible part of the solar spectrum (between 380 nm and 780 nm).

Light transmission $\tau_v$ (LT) and light reflection $\rho_v$ (LR) factors are defined respectively as being the fractions of visible light transmitted and reflected by the glazing.

The radiation absorbed by the glazing is not visible and is not generally taken into account.

**Light factors**




## 2.1.2 ENERGY CHARACTERISTICS

When the sun's rays hit a glazing, the total incident solar radiation (between 300 nm and 2,500 nm) $\phi e$ is split up into:

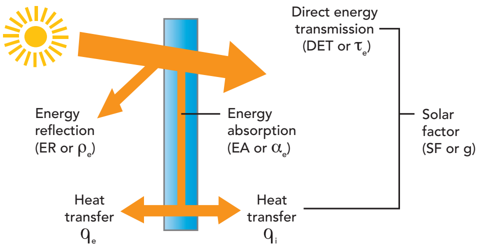
> a fraction $\rho\varepsilon\ \phi\varepsilon$ reflected outwards, where $\rho e$ (or ER) is the direct energy reflection of the glazing

> a fraction $\tau\varepsilon\ \phi\varepsilon$ transmitted through the glazing, where $\tau e$ (or DET) is the direct energy transmission of the glazing

> a fraction $\alpha_e \phi_e$ absorbed by the glazing, where $\alpha_e$ (or EA) is the direct energy absorption of the glazing; the energy absorbed by the glazing is then divided up into:

- a fraction $q_i \phi_e$ emitted back to the inside, where $q_i$ is the secondary internal heat transfer factor
- a fraction $q_e \phi_e$ emitted back to the outside, where $q_e$ is the secondary external heat transfer factor.

**Energy factors**




These different factors are linked by the formulae:

$$\rho_e + \tau_e + \alpha_e = 1 \quad \text{or} \quad ER + DET + EA = 100$$

and

$$\alpha_e = q_i + q_e$$

The solar factor g (or SF) represents the total energy transmittance (or solar heat gain coefficient) transmitted through the glazing; it is therefore the sum of the radiation transmitted directly and that which is absorbed and emitted back to the inside:

$$g = \tau_e + q_i$$

## 2.1.3 SELECTIVITY

The solar energy entering a given room comes entirely from solar radiation, i.e. ultraviolet rays, visible light and infrared radiation.

The amount of solar energy entering a building can be limited without reducing light levels by using high-performance coated glass, which prevents UV and infrared radiation from passing through while letting in visible light. These coated glass products have a feature called 'selectivity'.

The selectivity of a glazing is the ratio of its light transmission (LT) and its solar factor (SF): selectivity = LT/SF.

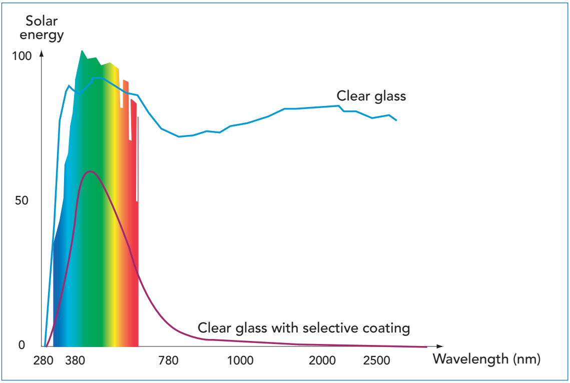
Selectivity always measures between 0.00 and 2.33:

> 0 is an opaque glass which has a light transmission level of 0

> 2.33 is the best possible selectivity since light represents 43% of the solar spectrum.

The closer the value is to 2.33, the more selective the glazing.

**Selectivity**



# 2.2 – Colour rendering index

Objects we can see – whether they are transparent, translucent or opaque – all have a specific colour.

The colour depends on several parameters such as:

> incident light (type of illumination)
> the reflection and transmission properties of the object
> the sensitivity of the eye of the observer
> the environment surrounding the object observed and the contrast between said object and those around it.

The colour of an object depends on all these factors and an observer will not always see the object in the same way depending, for example, on the time of day or the level of natural light.

Clear glass has as an inherent slightly green transmission colour due to the chemical composition of its key constituent, i.e. sand. The optical qualities of coloured glass vary widely depending on the thickness. Bronze, grey, blue and green float glass products reduce the amount of solar energy and therefore the level of light transmission.

The view through coloured glazing is therefore influenced by the colour of the glass itself.

The colour rendering index RD65 (Ra): this index quantifies the difference in colour between eight samples of test colours lit directly by a reference illuminant D65, and the light emanating from the same illuminant, transmitted by the glazing. The higher this value, the less the colour is altered when looking through the glazing.

## Overview of LT, g, $U_g$ and RD65 values

| Product Name | Glass Composition | LT (%) | g (%) | $U_g$ | RD65 (%) |
|---|---|---|---|---|---|
| Planibel Clear | 4 | 90 | 86 | 5.8 | 99 |
| Planibel Clearvision | 4 | 92 | 91 | 5.8 | 100 |
| Stratobel | 44.2 | 88 | 77 | 5.5 | 98 |
| Stratobel Clearvision | 44.2 | 91 | 84 | 5.5 | 100 |
| Thermobel Advanced | 4 / 16 / :4 | 76 | 55 | 1.0 | 97 |
| Thermobel TG Top(1) | 4: / 14 / 4 / 14 / :4 | 72 | 51 | 0.6 | 96 |
| Thermobel TG LS(1)(2) | 4: / 14 / 4 / 14 / :4 | 75 | 61 | 0.7 | 99 |

(1) Filled with 90% argon.
(2) With Clearvision as middle pane.

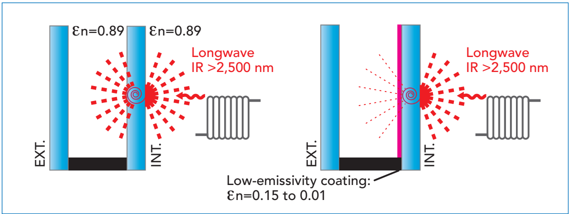
# 2.3 – Emissivity

The emissivity of a material (usually written ε or e) is the relative ability of its surface to emit energy by radiation. It is the ratio of energy radiated by a particular material to energy radiated by a black body at the same temperature. A true black body would have an $\varepsilon = 1$ while any real object would have $\varepsilon < 1$. Emissivity is a dimensionless quantity.

Emissivity depends on factors such as temperature, emission angle and wavelength.

Window glass is by nature highly thermally emissive. To improve thermal efficiency (insulation properties), thin film coatings are applied to the raw soda-lime glass. There are two primary methods in use: pyrolytic coatings via Chemical Vapour Deposition and magnetron coating.

**Double glazing and high-performance double glazing**




For example, an emissivity of 0.2 means that 80% of the heat flow absorbed by the glazing is reflected into the building.

The mathematical formula is:

$$\varepsilon = AE = 1 - TR - RE = 1 - RE \quad \text{(because } TR = 0\text{)}$$

Standard EN 12898 describes the method used to measure normal emissivity $\varepsilon_n$. In practice, the corrected emissivity value $\varepsilon$ is used in heat transfer calculations by multiplying normal emissivity by a factor taking account of the angular distribution of the emissivity.

A sheet of clear glass has a normal emissivity of 0.89, while pyrolytic coatings result in emissivity values of between 0.15 and 0.30 and magnetron coatings in values between 0.01 and 0.04.

# 2.4 – Thermal insulation

## 2.4.1 HEAT FLUX THROUGH GLAZING

A difference in temperature between two points of any body will result in a heat flux from the hot point to the cold point.

Heat may be transferred in various ways:

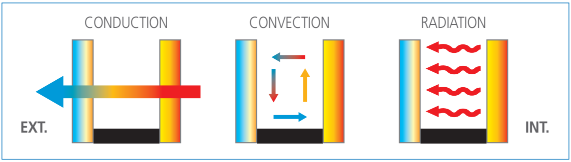
> by conduction, i.e. within the material itself. The heat is transferred from one molecule to the next when heated, for example a metal rod with one end heated up

> by convection in liquids and gases. The temperature variations prompt differences in density which cause the molecules to move since the hot molecules have a lower density and rise while the opposite occurs for the cold molecules. These movements balance out temperatures, for example hot air rising from a heating element to the ceiling of a room

> by radiation. Any heated body gives off energy in the form of electromagnetic radiation.

An insulating glazing is designed to reduce heat flux by means of reducing the conduction and the convection by using a cavity (standard filled with a thermal gas in combination with a low-e coating) between glass panes.

**Fundamental mechanisms of heat transmission through a glazing (where the outside temperature is lower than the inside temperature)**



## 2.4.2 THERMAL TRANSMITTANCE AND THERMAL CONDUCTIVITY

### ▼ Introduction

The heat flow density $q$ (W/m²) per second passing through the glazing from the warm atmosphere to the cold atmosphere can be expressed by the following equation:

$$q = \frac{(\theta_i - \theta_e)}{R} = U\,(\theta_i - \theta_e)$$

where
- $\theta_i$ and $\theta_e$ are the temperatures of the internal and external atmospheres
- R is the thermal resistance of the glazing m²K/W
- U = 1/R is the thermal transmittance of the glazing W/(m²K)

### ▼ Thermal transmittance U

Defined as the amount of heat passing through the glazing, in a steady state and per unit of surface area, for a difference in temperature of 1 °K on each side of the glass between the environments.

The amount of heat per second $Q$ (W) passing through a glazing with surface area $S$ (m²) from the hot atmosphere to the cold atmosphere is therefore:

$$Q = S\,U\,(\theta_i - \theta_e)$$

For a solid isotropic material, thermal resistance $R$ is defined as the relationship between its thickness $e$ (m) and its thermal conductivity λ W/(mK):

$$R = \frac{e}{\lambda}$$

To minimise energy transfer and therefore to ensure maximum thermal insulation, the thermal transmittance $U_g$ of the insulating glazing must be as low as possible (i.e. the thermal resistance R of the glazing must be as high as possible).

Standard EN 673 details the method used to calculate the thermal transmittance $U_g$ of glazing. The value obtained using this calculation is the $U_g$ value at the centre point of glazing, i.e. excluding edge effects due to the presence of the spacer and frame, which influences heat transfer.

The table below shows the thermal transmittance values of different types of insulating glazing. The most widely used spacers are between 12 and 15 mm thick.

**$U_g$-values for different types of glazing [W/(mK)]**

| Composition | DGU | DGU High performance with iplus Advanced 1.0 (#3) | | | TGU with iplus LS (#2 and 3) | | |
|---|---|---|---|---|---|---|---|
| | air | air | 90% argon | 90% krypton | air | 90% argon | 90% krypton |
| 4 / 12 / 4 | 2.9 | 1.5 | 1.2 | 1.0 | 1.0 | 0.8 | 0.6 |
| 4 / 14 / 4 | 2.8 | 1.3 | 1.1 | 1.0 | 0.9 | 0.7 | 0.6 |
| 4 / 15 / 4 | 2.7 | 1.3 | 1.0 | 1.0 | 0.9 | 0.7 | 0.6 |
| 4 / 16 / 4 | 2.7 | 1.3 | 1.0 | 1.0 | 0.9 | 0.7 | 0.6 |

### ▼ Thermal conductivity $\lambda$

Defined as the amount of heat passing per second through a pane with 1 m thickness and with a surface area of 1 $m^2$ where there is a temperature difference of 1 °K between two environments.

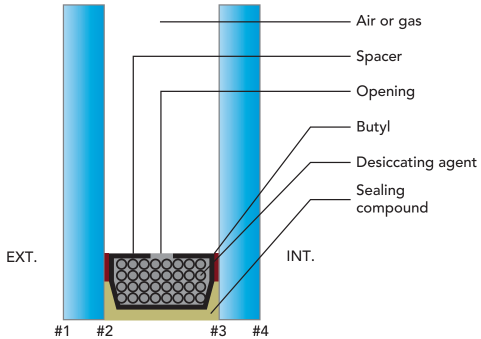
The thermal conductivity of the glass is 1.0 W/(mK). Monolithic glass panes as such can therefore not be considered as an insulating material since insulating materials have a thermal conductivity of less than 0.065 W/(mK).

## 2.4.3 DIFFERENT TYPES OF INSULATING GLAZING

### ▼ Standard double glazing

The standard double glazing is made out of two sheets of glass separated by a spacer having the cavity filled with dehydrated air. Since the air has a thermal conductivity of 0.025 W/(mK) (at 10°C) while that of glass is 1.0 W/(mK), the layer of air enhances the insulating properties and reduces the $U_g$ value of the glazing.

**Double glazing: components direction and numbering of sides**




The surfaces of the double glazing are generally numbered from 1 to 4 (outside to inside) and numbered from 1 to 6 for a triple glazing.

An improvement is achieved by replacing the dehydrated air in the cavity ($\lambda$ = 0.025 W/(mK), $\rho$ = 1.23 kg/$m^3$, at 10°C, i.e. under standard conditions set out in EN 673) with a thermal insulating gas which has both a lower thermal conductivity so as to limit the conduction and a greater volumic mass to restrict convection (reduce the ability of movement of the gas molecules).

The thermal insulating gases decrease the $U_g$ value of the insulating glazing by a value between 0.2 and 0.3 W/($m^2$K) and are only used in combination with low-emissivity coatings. Thus giving the best improvement in thermal insulation performance.

In practice the following two gasses are used in insulating glass processing: argon ($\lambda$ = 0.017 W/(mK), $\rho$ = 1.70 kg/$m^3$) and krypton ($\lambda$ = 0.009 W/(mK), $\rho$ = 3.56 kg/$m^3$) are used.

## ▼ High-performance double glazing

The technological progress made in the production of high-performance insulating coatings was decisive in the commercialisation of a range of high-performance thermal insulating glazing.

These high-performance insulating coatings are called low-emissivity coatings (or low-e coatings) and can either be a:

> soft low-e coatings produced in a magnetron

> hard low-e coatings produced online during the float fabrication.

The following points characterise these coatings:

> Neutral aspect in reflection

> Transparent in transmission

> Preserve colours in transmission

> Combine a high light transmission with a high solar factor.

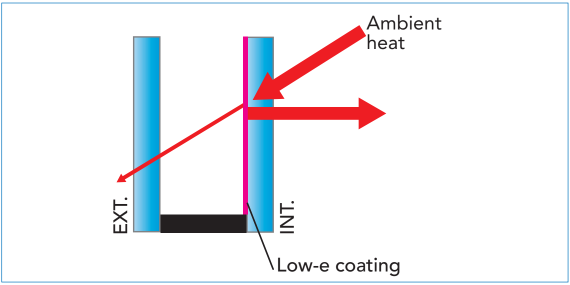
Emissivity affects long-wavelength infrared radiation. By contrast, though, it has virtually no effect on solar radiation. Using high-performance double glazing therefore enhances thermal insulation while at the same time allowing high solar energy gains.

To combine thermal insulation with solar control, other types of coatings must be used which combine these two functions.

AGC does not recommend installing standard and high-performance double glazing units side by side since there is a slight difference in colour (due to the presence of the low-emissivity coating) which may alter the visual appearance in reflection under certain conditions.

By default the low-e coatings are assembled on surface 3 (position 3) in a double glazing unit. Surface 2 (or position 2) is also a possibility.

**Low-emissivity glazing**




The conventional metal spacer made out of aluminium or steel can on demand be replaced by a warm-edge-type spacer (which can be reinforced by a metallic structure in some cases). The thermal conductivity of warm-edge-type spacers is far superior to that of steel or aluminium and thus reduces heat loss through the edges of the glass.

Using a warm-edge spacer does not alter the $U_g$ value of the glass (which is the U-value in the centre of the glass according to EN 673), but rather the $U_w$ value which is the heat loss of the window as a whole (i.e. glass + spacer + frame).

## ▼ High-performance triple glazing

Since insulation is increased by the presence of a gas-filled spacer, the next stage is triple glazing, i.e. glazing made up of three sheets of glass separating two cavities.

Thanks to the second cavity, acting as another insulating layer, $U_g$ values typically range from 0.5 to 0.7 W/(m²K), depending on the structure used (coatings, gas, spacer thicknesses, etc.). This solution is used when very low $U_g$ values are required, especially in new constructions, major renovations, low-energy and passive homes or buildings.

The components and processes used to manufacture triple glazing are similar to the ones used for double glazing. In particular, low-e coatings are used and usually put in positions 2 and 5. Solar control properties can be obtained by using dedicated coatings.

The main drawbacks of triple glazing are its thickness, its weight, its reduced light transmission and total solar transmittance, all of these directly linked to the increased number of glass panes. To countervail the two latter points, specific low-e glazings have been developed (iplus LS and iplus LST) to achieve light transmission and solar factor values in the same range as standard values for double glazing.

It is worth noting that, due to the increased thermal insulation of triple glazing, it is even more advisable (compared to double glazing) to evaluate the risks of thermal shocks, especially for the central glass pane.

Like double glazing units, warm edge spacers can be used to improve the total insulation performance.

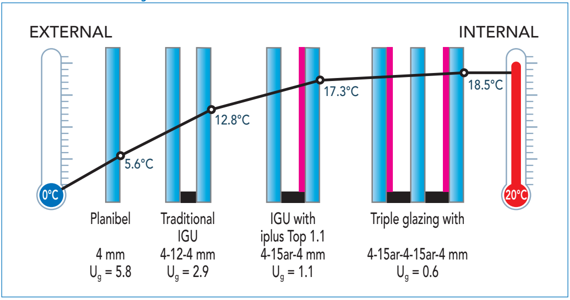
### 2.4.4 SURFACE TEMPERATURE OF INSULATING GLASS

Assessing thermal comfort at a given location depends not only on the ambient air temperature but also on the potential proximity of cold surfaces. The human body – where the (skin) temperature is approximately 28 °C – acts as a "radiator" when it comes close to cold surfaces such as single glazing (providing little thermal insulation).

The energy dissipated in this way results in an uncomfortable feeling of coldness.

As shown in the next figure, using high-performance glazing not only limits energy loss but also prevents the uncomfortable feeling caused by cold surfaces.

**Change in temperature of the internal side of the glazing depending on the $U_g$ value**




## 2.4.5 CONDENSATION ON THE SURFACE OF INSULATING GLAZING

Three types of condensation are likely to occur on a glazing:

> surface condensation on the internal side (surface 4 of a DGU/ surface 6 of a TGU): this occurs if the internal relative humidity is high and/or the temperature of the internal side of the glazing is low. Under normal internal conditions (heated buildings with no specific source of humidity), this type of condensation very rarely occurs with high-performance insulating glazing

> surface condensation on the external side (surface 1 of a DGU or a TGU): this can sometimes occur at dawn on high-performance insulating glazing but only following clear nights with little to no wind. Under these conditions, given the high-performance thermal insulation of these insulating glazing, the external pane cools to such a point that condensation forms on the outside. This is temporary and proves the insulating efficiency of the glazing.

> condensation inside the cavity of an insulating glazing unit: this indicates a defective insulating glazing unit whose seal is no longer hermetic against vapour and humidity.

If the desiccant becomes ineffective or if the seal is no longer hermetic, condensation will form inside the glazing unit and the insulating glazing will need to be replaced.

AGC's knowledge of insulating glazing and use of advanced technology ensure that its insulating glazing units have a long service life.

# 2.5 – Acoustic performance

## 2.5.1 BASICS OF ACOUSTICS

### ▼ Sound, pressure and frequency

The movements of a vibrating body disturb the environment around it. These disturbances gradually spread in all directions from the source to the receiving body, for example the ear. The speed at which they move depends on the physical properties of the environment (in air at 20 °C this speed is 340 m/s). They do not spread in a vacuum.

Under certain conditions, these disturbances can be perceived by the ear, causing what we call "sound". The sound heard by the ear is a variation in pressure on the eardrum transmitted by movement in an environment, generally the air. The eardrum harnesses this change in pressure and the ear's neuroacoustic system transforms it into a sound sensation.

Two values are required to measure a sound:

> its pressure, expressed in Pascal, or more generally the level of sound pressure, expressed in decibels

> its frequency, which depends on the duration of a complete vibration. This is measured by taking the number of vibrations per second expressed in Hertz (Hz).

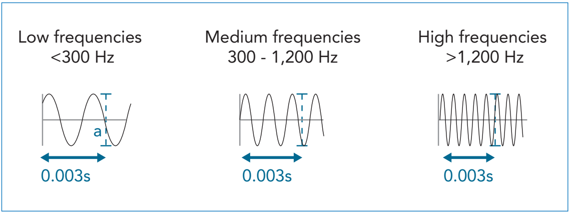
  The higher the frequency, the higher the pitch of the sound. There are three different frequency ranges:

  • low frequencies, below 300 Hz

  • medium frequencies, between 300 and 1,200 Hz

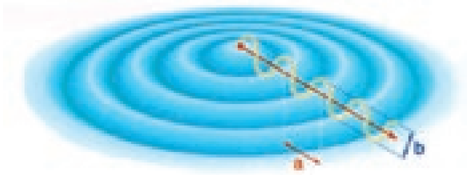
  • high frequencies, above 1,200 Hz.

**Frequency ranges**



The movement of sound through the air can be likened to waves on the surface of water:

**Frequency and intensity**




a = number of waves per second = frequency
b = height of wave = intensity

The hearing threshold for the human ear is a pressure of $2.10^{-5}$ Pa. It can withstand pressures of up to 20 Pa undamaged while the pain threshold is approximately 200 Pa. The human ear is so sensitive that the minimum audible change in pressure is over 10 million times less than that of its pain threshold.

In terms of frequencies, the ear can, on average, hear sounds ranging from approximately 20 Hz up to between 16,000 and 20,000 Hz.

## ▼ Acoustic pressure

In practice, the acoustic pressure is not used to measure the intensity of a sound because:

> the pressure range is too large: from $2.10^{-5}$ to 20 or indeed 100 Pa

> the relationship between the human ear and acoustic pressure is not linear but logarithmic.

The level of acoustic pressure Lp of a sound is therefore calculated using the formula:

$$L_p = 10 \log \frac{p^2}{p_0^2} = 20 \log \frac{p}{p_0} \text{ (dB)}$$

where p is the sound pressure (Pa) of the sound wave in question, and
$p_0$ is the reference pressure equivalent to the hearing threshold of $2.10^{-5}$ Pa

This value is expressed in decibels (dB).

Example: if a sound has a sound pressure of 10 Pa, its acoustic pressure will be:

$$L_p = 10 \log \frac{10^2}{(2.10^{-5})^2} = 114 \text{ dB}$$

The table below shows the correlation between acoustic pressure (Pa), levels of acoustic pressure (dB) and details of physiological effects and examples of corresponding sounds.

**Sound pressure and level of acoustic pressure**

| Effect | Example | Sound pressure p (Pa) | Acoustic pressure $L_p$ (dB) |
|---|---|---|---|
| Blackout | | 200,000 | 200 |
| | | | 190 |
| | | 20,000 | 180 |
| | | | 170 |
| | | 2,000 | 160 |
| | | | 150 |
| Pain threshold | | 200 | 140 |
| | Aircraft engine | | 130 |
| Danger | Klaxon | 20 | 120 |
| | Lawnmower | | 110 |
| | Metro train arriving | 2 | 100 |
| | Large orchestra | | 90 |
| | Heavy traffic | 0.2 | 80 |
| | Busy street | | 70 |
| | Loud voices | 0.02 | 60 |
| | Quiet apartment | | 50 |
| | Normal voices | 0.002 | 40 |
| | Quiet in the mountains | | 30 |
| | Whispers | 0.0002 | 20 |
| | Silence in the desert | | 10 |
| Hearing threshold | Total silence | 0.00002 | 0 |

## ▼ Decibels in practice

When several independent sources produce sound pressures ($p_1$, $p_2$, $p_3$,...), at the same time, the resulting pressure p is calculated using the formula $p^2 = p_1^2 + p_2^2 + p_3^2 + \ldots$, and the resulting acoustic pressure using the formula:

$$L_p = 10 \log \frac{p_1^2 + p_2^2 + p_3^2 + \ldots}{p_0^2}$$

This means that it is incorrect to add together all acoustic pressure values expressed in dB.

Two sounds with the same acoustic pressure combine to produce a noise measuring 3 dB higher than that of each constituent part.

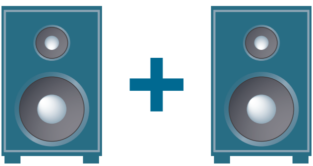
Example: if a noise has a sound pressure of 0.2 Pa, its acoustic pressure is calculated using the formula:

$$L_p = 10 \log \frac{0.2^2}{(2.10^{-5})^2} = 60 \text{ dB}$$

If two sounds measuring 60 Pa are combined, the acoustic pressure is calculated using the formula:

$$L_p = 10 \log \frac{0.2^2 + 0.2^2}{(2.10^{-5})^2} = 63 \text{ dB}$$

**Example of combining acoustic pressure**



60 dB + 60 dB
= 63 dB

Important: even if a difference of 3 dB in the insulation between two products is equivalent to a 50% reduction in sound intensity, the same does not apply to the sound heard by the ear. To the ear, a difference of:

> 1 dB is virtually inaudible

> 3 dB is barely audible

> 5 dB is clearly audible

> 10 dB is equivalent to a 50% reduction in the perception of sound intensity

> 20 dB is equivalent to a 75% reduction in the perception of sound intensity.

This difference of 20 dB is roughly equivalent to the range covered by AGC brands of acoustic glass.

## ▼ Acoustic comfort

The table below shows the maximum acoustic pressure levels depending on the type of area or activity performed there.

**Maximum levels of acoustic pressure in rooms**

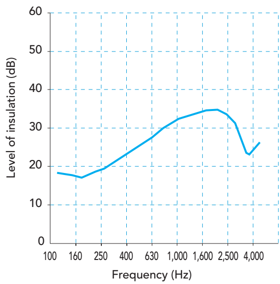
| Area | Level of acoustic pressure (dB) |
|---|---|
| Bedrooms, libraries | 20 to 30 |
| Apartments, living areas | 20 to 40 |
| Schools | 25 to 40 |
| Cinemas and conference rooms | 30 to 40 |
| Individual offices | 30 to 45 |
| Shared office | 40 to 50 |
| Office with people typing, large shops, restaurants | 45 to 55 |

## ▼ Sound spectrum

In reality, the sounds we hear are not made up of repeated frequency cycles and identical pressure levels but of different frequencies and sound pressures superimposed on each other, creating a continuous spectrum containing all the frequencies.

To represent a sound comprehensively, it is therefore necessary to show it in a diagram called a sound spectrum, which expresses the level of pressure (or sound insulation) depending on the frequency. The table below gives an example of a sound spectrum.

**Example of a sound spectrum**




## ▼ Sound reduction index

### > Introduction

The sound insulation spectra provide full details of the acoustic performance of a glazing.

The data given in a sound insulation spectrum are processed for ease of use and to facilitate the choice of the right glazing for acoustic applications.

For this reason, it is preferable to deduce from these curves various indices which "sum up" the sound insulation spectrum. The benefit of these indices is that they can be used to easily classify the acoustic performance of various elements.

The acoustical performance is given by a single number indicator $R_w$ (C; $C_{tr}$) detailed in standard EN ISO 717-1.

### > Single number quantity $R_w$ (C; $C_{tr}$)

The single number quantity, according to European standard EN ISO 717-1, in reality comprises three terms and is defined as follows:

$$R_w\ (C;\ C_{tr})$$

where
- $R_w$ is the single number quantity known as the weighted sound-reduction index
- $C$ is the pink noise spectrum adaptation term (higher-pitched sounds)
- $C_{tr}$ is the traffic noise spectrum adaptation term (lower pitched-sounds).

The two adaptation terms have been determined in such a way as to take account of the type of sound against which insulation is required:

> the first index (pink noise) is equivalent to predominantly high and medium frequencies

> the second (road traffic noise) is equivalent to predominantly low and medium frequencies.

To classify performance levels or set requirements, the single number is added to the appropriate adaptation factor, which is chosen according to the noise source.

Therefore, depending on the scenario, the values required to measure the sound insulation provided by a particular glazing are $(R_w + C)$ or $(R_w + C_{tr})$.

The table below gives details of which adaptation term to use depending on the noise source.

**Choice of adaptation term to determine the single number quantity to be used depending on the noise source**

| Noise source | $R_w + C$ | $R_w + C_{tr}$ |
|---|---|---|
| Children playing | ✓ | |
| Domestic activities (talking, music, radio, television) | ✓ | |
| Disco music | | ✓ |
| Highway road traffic (> 80 km/h) | ✓ | |
| Urban road traffic | | ✓ |
| Medium- to high-speed rail traffic | ✓ | |
| Slow-moving rail traffic | | ✓ |
| Jet aircraft, short distance | ✓ | |
| Jet aircraft, long distance | | ✓ |
| Propeller driven aircraft | | ✓ |
| Factories emitting mainly medium- and high-frequency noise | ✓ | |
| Factories emitting medium- and low-frequency noise | | ✓ |

It is important to point out that the sound reduction index values measured in this way are equivalent to laboratory measurements and are generally more favourable than those obtained in situ for the same noise source. In practice, though the sound reduction is lower in situ.

However, single number quantities mean that glazings can be classified depending on noise source. In other words, if one type of glazing has a better quantity than another, it will also perform better in situ when exposed to the same noise source.

Example: a glazing where sound insulation $R_w$ (C; $C_{tr}$) is 38 (-2; -5) will show the following values:

> For low-frequency noise:
insulation of $R_w + C_{tr} = 38 – 5 = 33$ dB

> For high-frequency noise:
insulation of $R_w + C = 38 – 2 = 36$ dB.

## ▼ Outside noise

The level and tone of background noise together with the level of noise from unidentifiable sources are factors that must be taken into account at the design stage in order to select the appropriate sound insulation for a facade.

Not only can outside noise have a very different sound level depending on its source but it can also vary in tone:

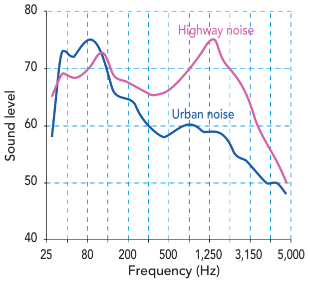
> fast-moving traffic, which is more high-pitched, has a different tone to that of the low-pitched sound of a bus engine or slower-moving urban traffic

> the sound of a plane or a train also has a different tone.

This consideration is all the more important when designing a facade since it is far more difficult, in practice, to insulate against low-pitched sounds.

To illustrate this, the table below shows the spectra for two types of sound sources (urban traffic and highway traffic).

**Examples of spectra for urban and motorway traffic**




The sound levels required for internal acoustic comfort depend on the environment in which the building is located.

Noise passing through the glazing will be considered more annoying in a very calm environment than in an urban centre.

The greater the difference between noise from a specific recognisable source entering the building from the outside (a passing motorbike, for example) and that from an unrecognisable source (much greater in a town centre), the more of a disruption it causes. Designers must bear this information in mind.

## 2.5.3 SOUND INSULATION OF GLAZINGS

### ▼ Introduction

Any glazing fitted in a frame provides sound insulation. However, some types of glazing such as laminated glass with resin or acoustic PVB together with some specific types of insulating glazing significantly improve acoustic performance.

The acoustic behaviour of different types of glazing is described on the following page.

## ▼ Single glass

In terms of sound insulation, single-pane glass acts as a simple partition and as such it respects two acoustic laws that apply to all single-pane partitions, regardless of the material they are made out of:

> the law of frequencies

> the law of masses.

The law of frequencies states that, in theory, for thin partitions of any size, sound insulation increases by 6 dB by doubling the average frequency.

In practice, this law is not always respected and there are three frequency zones within a sound spectrum:

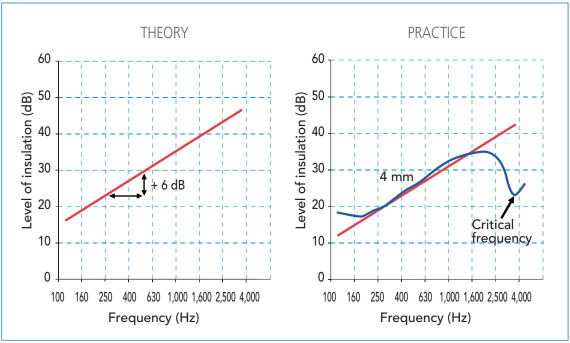
- In the first zone, the law of frequencies is respected in most cases and insulation increases with frequency. However, partitions are of a specific size and have a muffling effect, which means that the insulation gains achieved are only as much as 4 or 5 dB at the most when the average frequency is doubled, i.e. up to approximately 800 Hz
- In the second zone, the level of sound insulation drops due to the critical frequency of the pane of glass: the critical frequency of a thin pane of glass is the frequency at which the free-bend speed on the partition and the air speed are equal, i.e. the frequency at which a pane of glass spontaneously vibrates following a wave
- In the third zone, following coincidence, insulation increases rapidly by doubling the frequency – in theory by 9 dB but in practice, the increase is less.

At ambient temperature, critical frequency is equivalent to approximately

$$f_{cr} = \frac{12{,}800}{\mathbf{e}}$$

where
- **e** is the thickness of the pane of glass expressed in mm.
- The site of this zone depends on the elasticity of the material; the more rigid it is, the closer the coincidence zone is to the low frequencies.

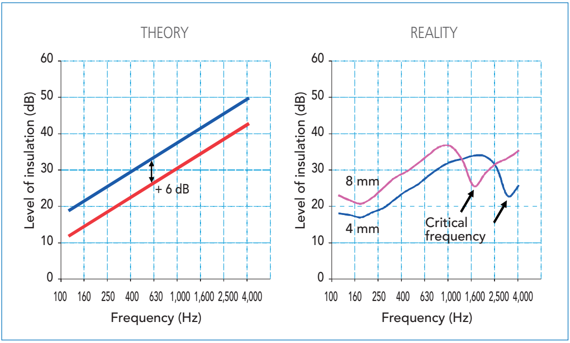
**The law of frequencies: in theory and in practice**




The law of masses states that, in theory, if the mass of a partition is doubled then the sound insulation it provides increases by 6 dB at a constant frequency.

In practice, this law is respected in most cases except in the coincidence zone. However, increasing the thickness of a single-pane glazing also pushes the critical frequency into a lower frequency area (cf. law of frequencies).

**The law of masses: in theory and practice**



The table below shows the critical frequency of single glass panes according to their thickness.

**Critical frequency (coincidence) of single-pane glazings**

| Thickness (mm) | Critical frequency (Hz) |
|---|---|
| 4 | 3,200 |
| 5 | 2,560 |
| 6 | 2,133 |
| 8 | 1,600 |
| 10 | 1,280 |
| 12 | 1,067 |
| 15 | 853 |
| 19 | 674 |

Conclusions:

> In light of the law of frequencies, all materials naturally provide better sound insulation against high frequencies than against low ones. However, the noise against which buildings require sound insulation often contains low frequencies.

> Increasing the thickness of a single-pane glass which, in theory, enhances said glass' sound insulation, has the disadvantage of shifting the critical-frequency trough towards lower frequencies and thereby weakening the insulation provided against low-pitched sounds. At low frequencies, though, increasing the thickness of the glass can improve performance to some extent.

> Single-pane glazings provide an insulation level ($R_w$) of approximately 29 dB for a thickness of 4 mm up to 35 dB for a thickness of 12 mm.

## ▼ Laminated glass

In terms of sound insulation, there are two types of laminated glass:

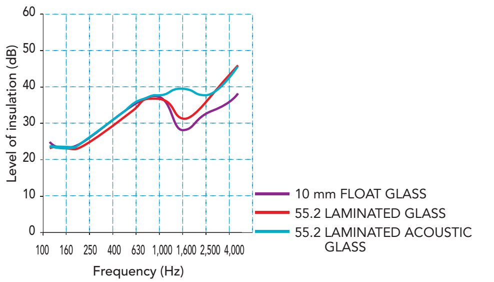
> Laminated safety glazing with a PVB (polyvinyl butyral) interlayer: the main function of this type of glazing is to provide protection from burglary and to ensure safety. However, such glazing also offers enhanced sound insulation.

> Laminated safety glazing with an acoustic PVB: this safety PVB was developed to provide better sound insulation. It performs to the same level in terms of safety and burglary-resistance properties.

Given their elasticity, acoustic PVB can separate the two glass panes making up the laminated glass and prevent it from acting as a monolithic glass. The critical-frequency trough is less pronounced and is shifted towards the high frequencies.

The table below shows the sound spectra for float glass and these two types of laminated glass with the same total thickness.

**Spectra of sound insulation for a single-pane glass and laminated glass of the same thickness**




Conclusions:

> For a laminated glass of equal mass, sound insulation generally increases in the zone in which it coincides with the critical-frequency. The sound-insulation trough is restricted by the muffling of the vibrations by the interlayer. This effect is more pronounced for acoustic PVB. In addition, in some cases the resonance trough is shifted towards the high frequencies

The overall effect can be seen mainly in $R_w + C$, less so in $R_w + C_{tr}$

> Laminated glass has performance levels $R_w$ of approximately 33 dB for 33.2 up to 39 dB for 88.2

> Laminated glass with acoustic PVB has performance levels $R_w$ of approximately 36 dB for 33.2 up to 41 dB for 88.2.

*Note: Dissymmetrical laminated glass does not improve the sound insulation value.*

## ▼ Insulating glazing

The performance levels of symmetrical double glazings are often lower than those of a single-pane glazing with the same total glass thickness.

The table below shows the sound insulation spectra of a 4-12-4 double glazing as compared with that of single-pane glazings with a thickness of 4 mm and 8 mm.

This shows:

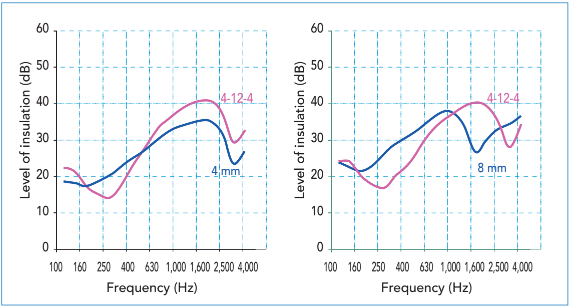
> A logical reduction in sound insulation of approximately 3,200 Hz for double glazing equivalent to the critical-frequency of 4 mm thick panes of glass in relation to single-pane glazing, a lower level of insulation at low frequencies.

> This trend can be explained by the fact that double glazing acts as a mass-spring-mass (m-r-m) system.

> This mass-spring-mass system has a resonant frequency (entire system) located in the low-frequency zone of approximately 200 to 300 Hz depending on the thicknesses involved. Sound insulation is significantly reduced in this zone between the resonance trough due to the mass-spring-mass system and the critical-frequency trough of the individual panes of glass, the sound insulation increases sharply (in theory, increase of 18 dB by doubling the frequency).

To provide the building with efficient sound insulation, the resonant frequency of the mass-spring-mass system must be below 100 Hz. This condition is not met by double glazing made up of two panes of glass of the same thickness and an air space of 12 or 15 mm, and the sound insulation of double glazing in the low- and medium-frequency zone is limited.

**Sound insulation spectrum for 4-12-4 double glazing as compared with single-pane glazings with a thickness of 4 mm and 8 mm**




To eliminate the mass-spring-mass effect, the air space between the panes of glass must be widened in order to make the spring created by the air space more flexible. However, this solution would result in glazing which is too thick and which would therefore require a correspondingly wider – and therefore heavier – frame.

This solution would also increase convection within the air or gas space, which would be detrimental in terms of thermal insulation. This is not widely used in practice.

Conclusions:

> The acoustic performance of symmetrical double glazing is limited.

> One might draw the conclusion that when modernising a building, replacing single-pane glazing with double glazing is not a viable option. This is an incorrect assumption for two reasons:
  - Replacing a single-pane glazing with double glazing generally also means replacing the frame, which will also provide a greater level of sound insulation than the old frame. The level of sound insulation provided by the entire window unit will therefore be higher.
  - In terms of thermal insulation, the gain afforded by double glazing in relation to single-pane glazing means that it is the only viable solution.

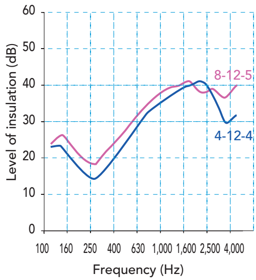
> Moreover, the level of sound insulation provided by double glazing can easily be enhanced (see below) by using dissymmetrical forms or laminated glass.

> Symmetrical double glazings has performance levels $R_w$ ranging from 29 dB for 4-12-4 up to 34 dB for 10-12-10.

## ▼ Dissymmetrical double glazing

To enhance the level of sound insulation provided by double glazing, the first step is to use glass panes with sufficiently different thicknesses to ensure that each can hide the weaknesses in the other when the unit reaches its critical frequency. This therefore produces a coincidence trough in a broader frequency zone but in which the peaks are less marked in the figure below, the trough around 3,200 Hz disappears). In this case, the increase in mass in relation to 4-12-4 glazing also helps to reduce the trough at low frequencies.

**Sound insulation spectra for 4-12-4 and 8-12-5 double glazings**




Conclusions:

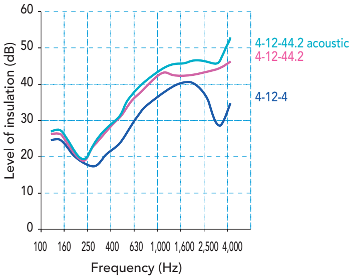
> Using two glasses of different thicknesses in a double glazing unit significantly improves performance in relation to symmetrical solutions.

> Dissymmetrical double glazings has performance levels $R_w$ of approximately 34 dB for 6-15-4 up to 38 dB for 10-15-6.

## ▼ Double glazing units with laminated glass

Laminated glass can also be used in double glazing. The figure below shows the improvement in performance when laminated glass is used. The gain can be seen primarily in the high-frequency zone since it flattens out the critical-frequency trough.

**Sound insulation spectrum for conventional 4-12-4 double glazing, 4-12-44.2 double glazing with laminated glass and 4-12-44.2 with acoustic laminated glass**




The direction in which dissymmetrical double glazing and/or double glazing with laminated glass are installed has no effect on the acoustic performance of the glazing. It is advisable to position any laminated glazing with the PVB on the inside to ensure safety in the event of breakage.

Conclusions:

> If the performance levels of dissymmetrical double glazings are insufficient, better results can be achieved by replacing one or both of the two single panes with a laminated glass or an acoustic laminated glass.

> Improvements are generally seen at the high-frequency level, i.e. the $R_w$ + C index.

> Laminated glass achieves performance levels $R_w$ of approximately 36 dB for 6-12-44.2 and up to 41 dB for 10-12-66.2.

> Acoustic laminated glass achieves performance levels $R_w$ of approximately 40 dB for 6-12-44.2, up to 44 dB for 10-12-66.2 and 50 dB for 44.2-20-66.2.

## ▼ Triple glazing units

Compared to a single glazing, a triple glazing unit will generally perform slightly better due to higher acoustic performance below 250 Hz. However, compared to a double glazing unit, the triple glazing unit has two resonant frequencies to take into account.

In general, TGU's are better than single or double glazing at high frequencies, but the overall glass thickness is much different.

Improved acoustic performance can be obtained taking into account the same points given for the double glazing.

## ▼ Conclusion

The factors that affect the levels of sound insulation provided by various types of glazing can be summarised as follows:

> Single-pane glazing:
  - increased thickness: slight improvement
  - using laminated glass and acoustic laminated glass: significant improvement in performance levels.

> Insulating glazing
  - always use dissymmetrical glazing
  - use a substantial air space
  - use thick glass in most instances
  - use a laminated glass (conventional PVB or safety) in place of a monolithic glass pane
  - use a laminated glass with acoustic PVB for high levels of sound disturbance.

By contrast, the following factors have no effect on the level of sound insulation provided by glazings:

> the direction in which the glass is installed
> whether the glass is coated
> toughened glass
> using argon (thermal insulation).

# 2.6 – Safety and security

## 2.6.1 GENERAL

Safety is a far-reaching concept covering many areas, protecting individuals from the risk of injury due to:

> sharp, broken glass

> falling (defenestration).

In trying to avoid the risk of injury only, it is the breakage pattern of the glass which is significant: it is important to ensure that if the glass breaks, it does not produce pieces which are likely to cause injury. If the aim is to provide protection against falling as well, care must be taken to ensure that the glazing is not obliterated:

> protecting goods and providing protection from burglary and vandalism for private homes, shops and offices; in this context, the glazing should remain in place and should prevent anyone or anything penetrating it

> protection against firearms

> protection against explosions.

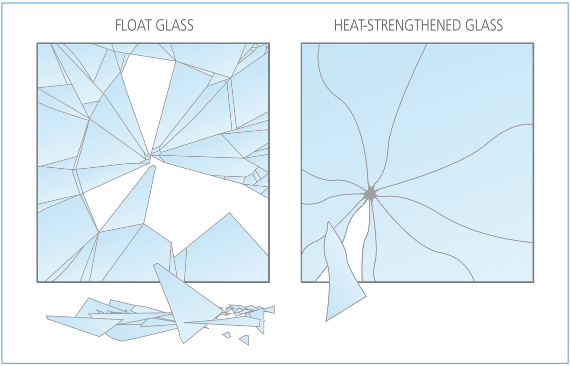
Very few glass products meet the break pattern, defenestration and resistance criteria described above. These are thermally toughened and laminated glass products. Other glass products – including float, heat-strengthened and wired glass – are not safety glass.

The properties of these products are described briefly below.

### ▼ Float, heat-strengthened and wired glass

Since it breaks into large sharp pieces, float glass cannot be considered a safety glass. The same applies to heat strengthened glass, which has a similar break pattern to that of float glass.

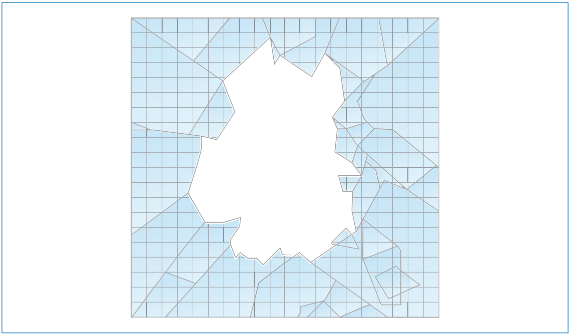
**Break patterns of float and heat-strengthened glass**




Wired glass (flat or profiled) has a metallic wire mesh built into it during the manufacturing process, the aim being to hold pieces of glass together in the event of breakage. Nevertheless, if it sustains an impact, the pieces of glass and the wire mesh may come apart thereby risking injury.

As such, this type of glazing may not be used as a safety product to prevent injury or people falling through it.

**Break pattern of wired glass**



## ▼ Thermally toughened glass

Due to the internal stresses inherent in the manufacturing process, when impacted, thermally toughened glass breaks up into small, blunt pieces.

**Break pattern of thermally toughened glass**

Thermally toughened glass is considered to be a safety glass if it meets the relevant break pattern criteria. These criteria are set out in standard EN 12150, which also describes the test to be carried out to ascertain this break pattern.

The table below shows the minimum number of pieces into which a thermally toughened safety glass(1) must break in a window measuring 50 mm x 50 mm. In addition, the length of the largest fragment may not be more than 100 mm.

**Minimum number of fragments within a 50 mm x 50 mm square of a thermally toughened float glass (according to standard EN 12150)**

| Thickness (mm) | Minimum number of pieces |
|---|---|
| 3 | 15 |
| 4 to 12 | 40 |
| 15 to 19 | 30 |

(1) Standard sample dimension 1,100x300 mm.

For reference, the main differences between float glass and thermally toughened glass are:

> much greater characteristic bending resistance: 120 N/mm² as compared with 45 N/mm²
> higher level of impact resistance
> higher level of resistance to thermal shock (approximately 200°C)
> breaks into small, blunt pieces
> cannot be cut or processed after toughening
> heat soak tests can be applied if required
> anisotropy of the material: in natural lighting conditions, the refraction properties vary from point to point and the superficial aspect of the pane of glass may have differently coloured designs due to interference known as leopard spots.

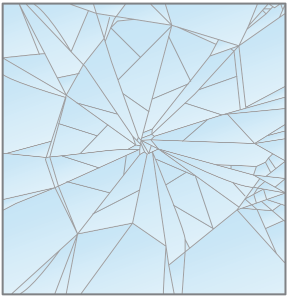
Comparing the impact resistance of a 30 cm x 30 cm piece of float glass to that of a similar-sized piece of thermally toughened glass:

> float glass measuring 6 mm withstands a ball weighing 250 g falling from a height of 30 cm
> thermally toughened safety glass measuring 6 mm withstands a ball weighing 250 g falling from a height of 3 m
> thermally toughened safety glass measuring 8 mm withstands a ball weighing 500 g falling from a height of 2 m.

## ▼ Laminated safety glass

Laminated safety glass is an assembly comprising at least two panes of glass, bonded together across their entire surface by an interlayer. For laminated safety glass, the most widely used interlayer is a plastic PVB (polyvinyl butyral) film, but EVA (ethylene vinyl acetate) films or a safety resin may also be used. In the event of breakage, the bond between the glass and the interlayer ensures that the broken pieces remain in place (at least for a certain period or up to a specified load level).

**Break pattern of laminated glass**



Laminated safety glass with PVB has its own system to denote composition. This takes the form of two (or more) figures indicating the thickness of the different panes of glass in mm, followed by a further figure separated from the rest by a dot giving the number (rather than the thickness) of the PVB films between each pane of glass. The PVB films are calculated with a thickness of 0.38 mm.

Examples:

> A glazing denoted as 66.2 has two panes of (float) glass measuring 6 mm separated by two PVB films each 0.38 mm thick. Some countries also describe laminated glass by giving its total thickness, e.g. 12.76 in the case of 66.2 laminate.

> A double glazing unit comprising a single-pane glazing measuring 4 mm, an air space of 12 mm and a laminated glazing denoted as 66.2 is detailed as 4-12-66.2 (composition given from outside to inside).

According to standard EN ISO 12543-2, a laminated glass may be considered as a laminated safety glass if it meets at least one 3B3 resistance class following the pendulum impact test detailed in standard EN 12600.

In some specific cases, thermally toughened or heat-strengthened glass is used to manufacture laminated safety glass.

As such, in cases where the glass element is subject to important loads, a laminated glass made up of thermally toughened and heat-strengthened glass is sometimes used. The former provides mechanical strength while the latter gives adequate residual stability if the glass breaks and until it is replaced.

### ▼ Glass with a self-adhesive film

A self-adhesive film may be applied to a glass to keep fragments in place in the event of breakage.

Such films are generally used for applications such as mirrors and opaque painted glass. See the availability of the SAFE and SAFE+ adhesive films for AGC's decorative glass products.

*Note: These films are only effective if they are applied to the glazing before it is placed in the glazing rebate. Sticking a film to the visible part of a glazing already in the rebate is not effective if the glass breaks. Moreover, some films applied in situ can cause problems in terms of breakage due to thermal shock.*

The adherence of the self-adhesive film must be submitted to resistance tests.

## 2.6.2 STANDARDS AND TESTS

European (conform EN Standards) testing has been in place and has been carried out at national level for some years. These European standards are due to replace national ones.

### ▼ Impact resistance - EN 12600

Standard EN 12600 "Pendulum test – Impact test method and classification for flat glass" details the classification of glass products according to impact by soft material. The test detailed uses a twin-tyre impactor and is used to classify glass products in terms of risk of injury and defenestration.

**Impact test**

The classification makes a distinction between the fall height and the type of breakage.

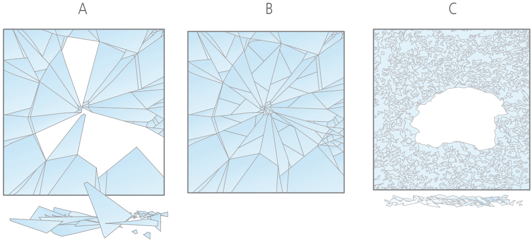
> Fall height:

- 1: 1,200 mm
- 2: 450 mm
- 3: 190 mm.

> Type of breakage:

- A: cracks with separated fragments (annealed, heat-strengthened, chemically toughened)
- B: cracks with combined fragments (laminated, film on annealed glass)
- C: disintegration into small particles (thermally toughened).

**Types of fragmentation**



Performance classification of a glass product is expressed as follows using two figures and one letter: $\alpha$ ($\beta$) $\Phi$

where:
- $\alpha$ is the highest class of drop height during which the glass either breaks or does not break in accordance with one of the two breakage patterns described below
- $\beta$ is the type of breakage
- $\Phi$ is the highest class of drop height during which the glass either breaks or does not break without allowing penetration (in accordance with the first of the two criteria listed below); where a glass breaks during a lowest fall height allowing penetration, it is denoted as 0.

The two fragmentation methods accepted by the standard for criteria $\alpha$ are:

> Numerous cracks appear, but no shear or opening is allowed within the test piece through which a 76 mm diameter sphere can pass when a maximum force of 25 N is applied (in accordance with annex A). Additionally, the total weight and the dimension of particles that can detach are limited.

> Disintegration occurs and the weight of the 10 largest crack-free particles collected within 3 minutes after impact is limited.

For a 4 mm glass, this represents a weight of 65 g. For a 19 mm glass, this weight is 309 g.

The test must be conducted on four test pieces, for each drop height. Laminated dissymmetric glass panes which are used in more than one direction must be tested on both sides.

Examples:

> A laminated glass is classified as 1B1 if it resists an impact from a fall height of 1,200 mm without allowing penetration
> A laminated glass is classified as 2B2 if it resists an impact from a fall height of 450 mm without allowing penetration
> A thermally toughened glass is classified as 1C1 if it resists an impact from a fall height of 1,200 mm without breaking
> A thermally toughened glass is classified as 1C2 if it resists an impact from a fall height of 450 mm without breaking and if it falls from a height of 1,200 mm and fragments in accordance with toughened glass.

When a glass undergoes a test for a certain class (for example 44.2 = 1B1), it is commonly accepted that the thickest glass with the same number of PVB films falls into the same class (in this case 55.2 and 66.2 also fall into class 1B1).

Standards prEN 13049 and 14019 describe the methods to be used to test the impact resistance of windows and curtain wall facades respectively. There are five classes of resistance.

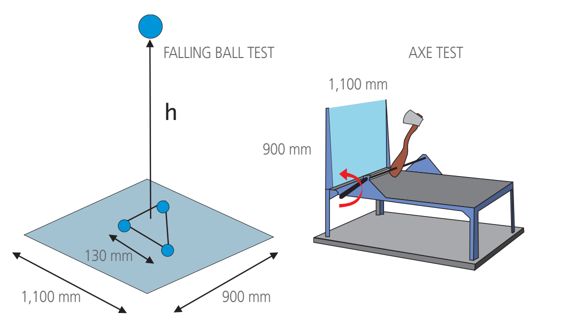
## ▼ Burglar-resistant glass - EN 356

Standard EN 356 "Security glazing – Testing and classification of resistance against manual attack" sets out the testing methods to be used to classify glass products in terms of their resistance to burglary. There are eight classes of increasing resistance:

> The first five classes, denoted P1A to P5A, are based on the falling ball test

> The next three classes, denoted P6B to P8B, are based on an axe test.

## Test of impact resistance




In falling ball tests, a test sheet measuring 1,100 mm x 900 mm is positioned horizontally and is impacted by a ball weighing 4.1 kg in a triangular area in the centre of the glass (13 cm between impacts). The impact number and the drop height vary depending on the class.

In the axe test, a test sheet measuring 1,100 mm x 900 mm is positioned vertically. First, the different test-sheet panes are broken using hammer blows (minimum of 12). Next, axe blows are used to try to make a hole in the centre of the glass.

### Class of burglary resistance according to standard EN 356

| Test | Class | Drop height of the ball | Number of blows |
|---|---|---|---|
| Ball | P1A | 1,500 mm | 3 in a triangle |
| | P2A | 3,000 mm | 3 in a triangle |
| | P3A | 6,000 mm | 3 in a triangle |
| | P4A | 9,000 mm | 3 in a triangle |
| | P5A | 9,000 mm | 3x3 in a triangle |
| Axe | P6B | - | 30 to 50 |
| | P7B | - | 51 to 70 |
| | P8B | - | > 70 |

The ball test is considered successful if the ball does not pass through the test sheet entirely within five seconds of the moment of impact.

The axe test is considered successful if the area (measuring 400 mm x 400 mm) subject to the axe blows does not become completely detached from the rest of the test sheet.

When a glass undergoes a test for a certain class (for example 44.2 = P1A), it is commonly accepted that the thickest glass products with the same number of PVB films fall into the same class (in this case, 55.2 and 66.2 also fall into class P1A).

Draft standard prEN 1627 describes the methods used to classify the burglar-resistance of windows, doors and closings.

There are six classes of resistance (from 1 to 6 in increasing order of resistance).

The standard also details the class of glazing (according to standard EN 356) to be used for each frame class to achieve a "homogenous" burglar-resistant window.

**Corresponding prEN 1627 and EN 356 classes**

| Frame class | Glazing class |
|---|---|
| 1 | P4A |
| 2 | P5A |
| 3 | P6B |
| 4 | P7B |
| 5 | P8B |
| 6 | P8B |

Draft standard prEN 1627 describes limitations in terms of dimensions to be used as opposed to dimensions to be tested.

## ▼ Bullet resistance - EN 1063

Standard EN 1063 "Security glazing – Testing and classification of resistance against bullet attack" describes the methods to be used to classify bullet-resistant glass products.

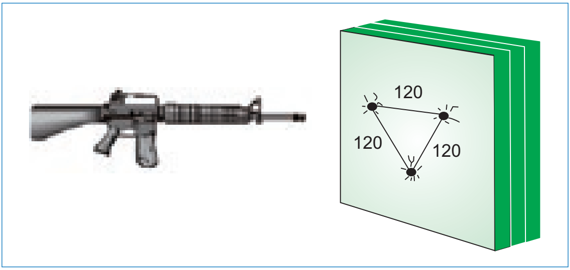
The standard draws a distinction between resistance to two types of weapon:

> handguns and rifles (class BR)

> shotguns (class SG).

There are nine classes. For each category of weapon tested, the glass is classed as bullet-resistant if it stops all the bullets on the three sheets tested (500 mm x 500 mm dimensions). The report also states whether or not there are any splinters – (S) or (NS) – behind the glazing.

**Bullet-resistance tests**




Classes BR1 to BR7 contain glass products offering increasing levels of protection. This means that a glass meeting the requirements stipulated for a given class also meet those of the classes below it.

There is no correlation between SG and BR classes.

The same testing method and classification system is used for doors and windows (EN 1522 and EN 1523). Classification is therefore denoted FB1 to FB7 and FSG (for class SG2 glass). There is no corresponding classification for class SG1.

## ▼ Explosion resistance - EN 13541

Standard EN 13541 "Security glazing – Testing and classification of resistance against explosion pressure" classifies explosion-resistant glass (so-called "shock-tube" method).

The glass is positioned at the end of a tube. At the other end a charge is exploded to create overpressure.

There are four classes of glass from ER1 to ER4. The report also states whether or not there are splinters – (S) or (NS) – behind the glass.

**Classes of explosion resistance according to standard EN 13541**

| Class | Positive Maximum overpressure Pr (kPa) | Positive Specific impulse i+ (kPa ms) | Duration of the positive pressure phase t+ (ms) |
|---|---|---|---|
| ER1 | 50 ≤ Pr < 100 | 370 ≤ i+ < 900 | ≥ 20 |
| ER2 | 100 ≤ Pr < 150 | 900 ≤ i+ < 1,500 | ≥ 20 |
| ER3 | 150 ≤ Pr < 200 | 1,500 ≤ i+ < 2,200 | ≥ 20 |
| ER4 | 200 ≤ Pr < 250 | 2,200 ≤ i+ < 3,200 | ≥ 20 |

The test is considered successful if three test sheets show no sign of "transversal" perforation of the side exposed to the rear side or any opening between the bracket of the glass and the edges of the test sheet.

Explosion resistance is only meaningful in relation to protection of individuals inside a building against an explosion outside.

Standards prEN 13123-1 & 2 and 13124-1 & 2 set out the methods to be used to test the explosion resistance of frames.

Part 1 in each standard is based on a tube test and classes are denoted EPR1 to EPR4. Part 2 in each standard is based on an arena test and the classes are denoted EXR1 to EXR5.

# 2.7 – Fire performance

## 2.7.1 INTRODUCTION

Protection against fire is an increasingly important consideration when designing buildings and facades.

Two separate concepts should be highlighted: reaction to fire and fire resistance:

> Reaction to fire measures the behaviour of a given material when exposed to fire and its contribution to fire propagation.

  For example, a distinction is drawn between non-combustible materials (which do not release any noticeable quantity of heat), combustible materials (which tend to emit heat depending on the level of heat to which they are exposed) and inflammable materials (materials liable to release gas, the nature and quantity of which are likely to generate gaseous-phase combustion, i.e. to produce flames).

  Each product can be placed in a fire-reaction class.

> The fire resistance of a unit is the time in minutes during which that element meets the criteria of loadbearing capacity and/or integrity and/or insulation. Fire resistance concerns the unit glass and frame as a whole rather than a part thereof.

## 2.7.2 REACTION TO FIRE

### ▼ European classification

On 8 April 1999, the European bodies issued a favourable opinion (Construct 98/319 rev. 3) on Euro classification. Progressively, fire evaluation methods and national classifications will be phased out and replaced with this new reference system.

This new Euro classification system for reaction to fire should be used concurrently with standard EN 13501–1:2007 +A1:2009 "Classification using test data from reaction to fire tests"

Under the system, construction products are divided into seven Euro classes: A1, A2, B, C, D, E and F. The best materials in terms of reaction to fire will be classified in A classes while the worst will be classified into class F. There are two classes (A1 and A2) for the highest exposure level.

A distinction is made between classification of floor coverings and other materials. As such, the abbreviation FL (which stands for “floor“) is added to the index for floor coverings (e.g. $A_{FL}$, $B_{FL}$, etc.).

A conventional classification for reaction to fire of construction materials in class A1 (no test necessary) has also been confirmed.

For the materials to be tested, three levels of thermal stress in respect of fire spread are simulated: ***low, medium*** and ***high***.

These three separate levels of stress represent three possible phases of fire in a building. To measure products at low and high levels, the same tools are used for all materials. By contrast, reaction to fire for a medium level of stress is measured differently. The table below sets out the relevant test standards on a case-by-case basis.

**Test standards for reaction to fire**

| | Floor coverings | Other products |
|---|---|---|
| Low stress level | Stress via direct impingement of flame (EN ISO 11925-2) | |
| Medium stress level | Radiation stress arising from hot gases released under the ceiling (EN ISO 9239-1) | Stress through contact with the flame of a single burning item (EN 13823) |
| High stress level | General conflagration of combustible items in a room (EN ISO 1716 and EN ISO 1182) | |

These five test methods are linked to two others which pertain to classification (EN 13501-1) and conditioning and choice of stillage (EN ISO 13238).

In conclusion, it should be noted that additional classifications highlight two further aspects of contribution to fire growth.

The first involves the production of smoke (“s” for smoke): s1, s2 and s3, where s3 represents a material which produces no smoke.

The second refers to the production of droplets (“d” for droplets): d0 (no flaming droplets occur within 600 seconds when tested according to EN 13823), d1 (no flaming droplets, persisting longer than 10 seconds, occur within 600 seconds when tested according to EN 13823) and d2 (if no performance is declared or if the product does not comply with the d0 and d1 classification criteria or ignites the paper in the ignitability test EN 11925-2).

There is no requirement to state these results as there is in the case of Euro classes.

### ▼ Performance of glass products

According to the Euro classification system, float, patterned, heat-strengthened, thermally toughened, chemically toughened, inorganically coated and wired glass are included in a list of materials considered to fall into class A1 without any test being performed (Official Journal of the European Communities 96/603/EC and 2000/605/EC).

Other types of glass must be tested if they contain an organic proportion in excess of 0.1% of their weight.

## 2.7.3 FIRE RESISTANCE

### ▼ European classification

The Standing Committee on Construction, which is responsible for overseeing implementation of the Construction Products Regulation (CPR), issued a favourable opinion on a European system of classification for fire resistance.

Under the system, fire resistance is measured in time (minutes).

Three main levels of performance are used to determine the period of fire resistance:

> R (loadbearing capacity)

> E (integrity)

> I (insulation).

In general, the classes are expressed as follows:

> Loadbearing elements:

- REI tt: tt being the period during which all criteria (loadbearing capacity, integrity and insulation) are met
- RE tt: tt being the period during which the loadbearing capacity and integrity criteria are met
- R tt: tt being the period during which the loadbearing criterion is met.

> Non loadbearing elements:

  - EI tt: tt being the period during which the integrity and insulation criteria are met
  - E tt: tt being the period during which the integrity criterion is met.

The classification system details the Eurocodes (to determine the fire resistance by calculation) and the list of EN 13501 classification standards (to determine fire resistance via tests):

> EN 13501-2: Fire classification of construction products and building elements – Part 2: Classification using data from fire resistance tests, excluding ventilation services

> EN 13501-3: Fire classification of construction products and building elements – Part 3: Classification using data from fire resistance tests on products and elements used in building service installations: fire-resisting ducts and fire dampers.

### ▼ Application of glass classification

For glass, the following indices are used:

> E: Integrity or ability of the element to prevent the passage of flames and hot gases. Heat transfer is allowed

> EW: Integrity and Low Heat Radiation or the ability of the element to prevent the passage of flames and hot gases and to limit the level of heat transfer through the element

> EI: Integrity and Insulation or the ability of the element to prevent the passage of flames and hot gases and to block the heat transfer through the element.

Thus, the following examples of classes may be defined for glass: EI 30, EW 60, E 30, etc.

## ▼ Fire-resistance tests

It is also important that a series of fire-resistance test standards be drawn up to cover all products and all scenarios. A test is needed for each type of element. For example, the conditions required to test a fire door are very different from those for testing a beam.

To conduct a fire-resistance test on a construction product, the General Requirements (EN 1363-1) – subsequently amended by alternative methods of operation – and the relevant test method for the construction element to be tested should be used.

Performance tests on glazed partitions are generally carried out in accordance with EN 1364-1 "Fire resistance tests for non-load bearing elements – Part 1: Walls".

### > Brief description of the test

The element to be tested is placed in front of a furnace. The specimen is tested at full size.

**Testing method**

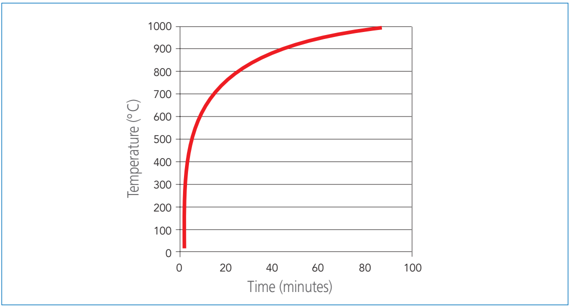
The standard temperature/time curve is applied for the full duration of the test. The relationship, which is a model of a fully developed fire in a compartment, is given by the following formula:

$$T = 345 \log 10 (8\tau + 1) + 20$$

where
- $\tau$ is the time from the start of the test in minutes (min)
- $T$ is the mean furnace temperature in degrees Celsius (°C) at time $\tau$

The radiation on the unexposed side is measured using a radiometer and the temperature on the unexposed surface is measured using thermocouples.

**Curve showing temperature rise in the furnace**




The result of the test is expressed as follows:

> Integrity: This is the time in completed minutes for which the test specimen continues to maintain its separating function during the test without either causing the ignition of a cotton pad applied for 30 seconds in front of the partition, or permitting the penetration of a gap gauge, or resulting in sustained flaming on the unexposed side

> Low Heat Radiation: this is the time in completed minutes for which the radiation, measured at a distance of one metre from the unexposed surface, is lower than 15 $kW/m^2$

> Insulation: this is the time in completed minutes for which the test specimen continues to maintain its separating function during the test without developing temperatures on its unexposed surface which either:

a) increase the average temperature above the initial temperature by more than 140 °C; or

b) increase the temperature at any location (including the roving thermocouple) above the initial average temperature by more than 180 °C.

## ▼ Fire-resistant glass products

Some glass products such as single-pane annealed glass, laminated glass (PVB, EVA, resin) and standard double glazing do not offer any substantial fire resistance since they can break when exposed to thermal shocks due to the rapid rise in temperature.

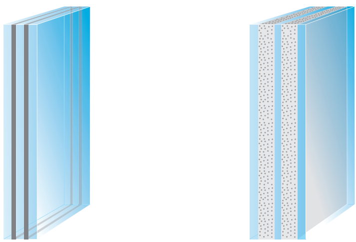
The following glass products can be used to provide fire resistance:

> Polished wired glass: in the event of a fire, the glass breaks but remains in place thanks to a metal mesh and remains transparent. Moreover, as soon as the softening point is reached, the cracks knit together again. Flames only spread when the creep is so great that a gap forms in the glazing.

> Thermally toughened glass: thermally toughening enhances glass resistance to tensile stress and thermal shocks. The toughening process is specially designed for fire-resistant products to achieve a high level of performance. Combined with a coating, this enables it to limit radiation. It may be used in single pane or double glazing.

> Laminated glass with an intumescent interlayer: this is a laminated or multilaminated glass containing a solid interlayer which expands in the event of a fire.

**Laminated glass with expanding interlayer**



Pyrobel assembly
with intumescent transparent
interlayers

Pyrobel assembly
Reaction to fire: the interlayers expand
and provide a barrier against the fire

Under normal conditions, the interlayers are transparent. In the event of a fire, the interlayers will expand and transform into a rigid, opaque and heat-absorbing fire shield.

The more layers there are, the longer the glazing will remain resistant to fire.

**Reaction of a laminated glass with an intumescent interlayer to fire**

To be used in this way, glass products must be accompanied by a test report certifying their performance.

AGC offers a range of toughened glass products (Pyropane) as well as a range of laminated products with an intumescent interlayer (Pyrobelite and Pyrobel) offering various levels of fire resistance. The table below gives a summary of these brands, followed by further details.

| | Laminated glass with an intumescent interlayer | Toughened glass |
|---|---|---|
| E | Pyrobelite | Pyropane |
| EW | Pyrobelite | Pyropane |
| EI | Pyrobel | - |

## ▼ Pyropane

Pyropane is AGC's range of toughened fire resistant glass. The range includes products obtained by treating and toughening glass products which may or may not be coated with a special metallic coating. They conform to specific European standards and are classified according to tests in appropriate frames.

Multiple applications:

> Fire resistant insulating double glazing (E/EW 30 and E/EW 60) for facades

> Interior fire resistant glazing for partitions and doors (E 30/ EW 20)

> Smoke barrier (DH 30).

As a toughened glass, Pyropane offers all the usual safety benefits in terms of protection from injury.

### ▼ Pyrobel and Pyrobelite

Pyrobel and Pyrobelite are laminated glass products containing intumescent interlayers. In the event of fire, the interlayers expand when the partition reaches a temperature of approximately 120 °C and form a rigid screen which acts as a barrier to flames, hot gases and heat radiation.

If a fire occurs, Pyrobelite transforms into a refractory and opaque screen which is resistant to flames, gas and smoke, and significantly reduces the amount of heat radiated through the partition. It can reach performance levels of EW 30 and EW 60.

In a fire, Pyrobel changes into a refractory opaque screen which keeps out flames, gas and smoke, and blocks heat transfer through the partition. It can reach performance levels ranging from EI 15 to EI 120.

— 3 —

# OVERVIEW OF AGC GLASS PRODUCTS

Galeo - Issy les Moulineaux, France - Architect: Christian de Portzamparc - Stratobel and Artlite

The most common type of flat glass used in building applications is a soda-lime silicate glass obtained by melting the batch-mixed raw materials in a furnace where it is heated to approximately 1,550 °C.

The principal constituents of soda-lime silicate glass are:

> Silica [silicon dioxide or sand ($SiO_2$ for 69% to 74%)], which gives the glass its texture. This is known as the glass former or $SiO_2$ network former

> Soda [sodium oxide ($Na_2O$ for 10% to 16%)], used as a melting agent to lower the melting temperature of the silicon dioxide and as a fining agent to homogenise the melting mixture and to eliminate bubbles

> Calcium [calcium oxide ($CaO$ for 5% to 14%)], used as a stabiliser giving the glass its chemical resistance

> Other materials are:

- refining agents, which are designed to agitate the melting mixture, thereby releasing gases and standardising quality and thus adjusting the physical and chemical properties of the glass
- various metal oxides, which enhance the mechanical characteristics of the glass and its resistance to atmospheric agents
- colorants.

The various glass products can be grouped per type of processing activities:

> Raw glass products, i.e. the flat glass sheets from the float glass process and undergoing no further treatment

> Processed glass products, i.e. products obtained by processing raw glass products.

### Overview of the main raw glass and processed glass products

| | |
|---|---|
| Raw glass | Float glass<br>Laminated safety glass<br>Coated glass<br>Mirror - Painted glass<br>Patterned glass & Wired patterned glass<br>Acid-etched glass |
| Processed glass | Insulating glass (double and triple glazing unit)<br>Heat-treated glass (Toughened safety glass / Heat-strengthened glass / Heat Soak Test / Bent glass)<br>Chemically toughened glass<br>Laminated safety glass for bullet and explosion applications<br>Enamelled glass<br>Silk-screen printed glass<br>Active glass (Building-Integrated Photovoltaics)<br>Surface treatment (etching, sandblasting, etc.)<br>Fire-resistant glass |

In the overview given on the following pages, the European standard to which the product complies is given between brackets.

# 3.1 – Raw glass products

## 3.1.1 FLOAT GLASS (EN 572-1 AND EN 572-2)

Flat, transparent, clear and coloured (green, grey, bronze, blue) soda-lime silicate glass.

Standard thicknesses for architectural applications are 3, 4, 5, 6, 8, 10, 12, 15, 19 and 25 mm and the standard dimension is up to 6 m by 3.21 m.

Float glass is the basic substrate component for all further glass processing operations.

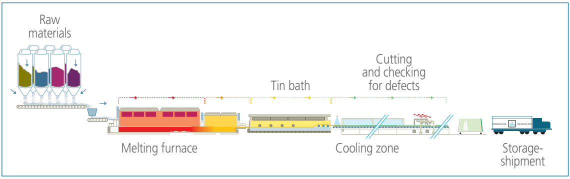
The final glass sheet is produced by an online production process, the so-called float process, where the raw materials are mixed in a batch process, then fed together with suitable cullet (waste glass), in a controlled ratio, into a furnace where it is heated to approximately 1,550 °C.

Once molten, the temperature of the glass is stabilised to approximately 1,200 °C to ensure a homogeneous glass mass.

The molten glass is poured on a "tin bath" from a delivery channel, the glass then "floats" on the liquid tin bath to form a sheet of glass. Regulating the flow rate determines the thickness of the final glass sheet.

As the glass ribbon flows along the tin bath, the temperature is gradually reduced to approximately 600 °C so that the glass ribbon can be lifted from the tin onto rollers. In a controlled manner the temperature of the glass ribbon is reduced to around 50 °C, where the glass ribbon can be cut in flat glass sheets by machines and stored for shipping.

**Float process**



## General characteristic values
## Main properties of soda-lime silicate glass

| Characteristic | Symbol | Numerical value and unit |
|---|---|---|
| Density (at 18 °C) | $\rho$ | 2,500 kg/m³ |
| Hardness (Knoop) | $HK_{0.1/20}$ | 6 GPa |
| Young's modulus (modulus of elasticity) | E | 7 x $10^{10}$ Pa |
| Modulus of rigidity | G | 2,92 x $10^{10}$ Pa |
| Poisson's ratio | $\mu$ | 0.2 |
| Characteristic bending strength | f | 45 x 106 Pa |
| Specific heat capacity | C | 0.72 x $10^3$ J / (kg.K) |
| Average coefficient of linear expansion between 20 °C and 30 °C | $\alpha$ | 9 x $10^{-6}$ $K^{-1}$ |
| Resistance to temperature differential and sudden temperature change | | 40 K |
| Thermal conductivity | $\lambda$ | 1 W/(mK) |
| Mean refractive index to visible radiation (380nm to 780nm) | N | 1.5 |
| Melting temperature | | ≈ 1,550 °C |
| Glass transition temperature | | ≈ 630 °C |
| Light transmission (clear float 4mm) | $\tau_v$ | 90% |
| Solar factor (clear float 4mm) | g | 87% |
| Normal emissivity | $\varepsilon_n$ | 0.89 |

Main AGC ranges: Planibel Clear, Planibel Clearvision, Planibel Linea Azzurra, Planibel Coloured

## 3.1.2 LAMINATED SAFETY GLASS (EN 12543-1 TO EN 12543-6)

Set of at least two sheets of glass assembled with a full surface safety interlayer. The interlayer may be one or more plastic films (PVB, EVA, etc.), resin, silicate or gel and designed to bond the sheets of glass while further enhancing the safety performance of the end product.

The high performance level of the glass may pertain to:

> safety for people and property (limiting the risk of injury in the event of breakage, protection from defenestration, vandalism and burglary, etc)

> protection from bullets and explosions

> fire protection

> sound insulation

> decoration.

<u>Main AGC ranges:</u> Stratobel, Stratophone

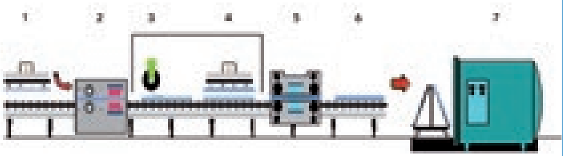
Producing laminated glass with PVB interlayers involves the following stages:

> The film(s) is/are applied to the first glass and the second glass is then applied to the films

> The glass is passed into a calender where a roller passes over it at a very high temperature to eliminate any air bubbles and to ensure preliminary bonding of the glass to the PVB

> Processing in an autoclave for the final curing of the PVB interlayer.

**Laminating process**



1. Loading the glass
2. Washing machine
3. Application of PVB to the lower sheet
4. Upper sheet placed on the PVB
5. Calendering
6. Loading onto rack
7. Autoclave

### 3.1.3 COATED GLASS (EN 1096-1, EN 1096-2 AND EN 096-3)

Glass obtained via an inorganic coating to alter its electromagnetic properties (light characteristics, energy characteristics, solar factor, emissivity, and colour).

The coated glass can be grouped on the basis of the following criteria:

> industrial process used to apply the coating:
  - magnetron (offline)
  - pyrolytic (online).

> the functionality of the coating:
  - thermal insulation
  - solar control
  - thermal insulation and solar control.

The standard EN 1096-1 lists the various classes of coated glass according to their use and properties:

> Class A: Coated glass may be used either internally or externally

> Class B: Coated glass may be used in monolithic form but the coated side must be inside the building

> Class C: Coated glass may only be used in insulating glazing and must be on the spacer side

> Class D: Coated glass may only be used in insulating glazing and must be on the spacer side. The insulating glazing must be assembled directly after manufacture of the coating. These coatings are therefore not available in monolithic form

> Class S: Coated glass may be used internally or externally but only for certain well-defined applications (for example shop windows).

### ▼ Glass with pyrolytic coatings

The metal oxide-based coatings are applied on clear or coloured float glass during the glass production (online process). These coated glass sheets have the feature to be installed as single glass, and can be heat treated and enamelled or silkscreened.

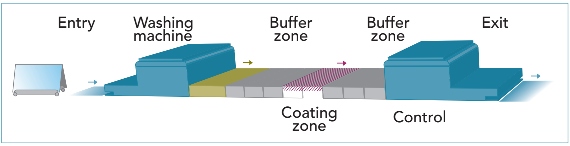
Main AGC ranges: iplus AF (anti-fog), Stopsol (solar control), Sunergy (thermal insulation and solar control)

### ▼ Magnetron-coated glass

Metal oxide-based or metal-based coatings vacuum-sputtered onto clear or colored float glass in a vacuum coater (offline coating process). The vacuum coater consists of various coating chambers to produce high-performance, multicoated products.

This magnetron coating process is also known as "vacuum sputtered coating".

**Magnetron coating process**




Main AGC ranges: iplus (thermal insulation), ipasol bright (solar control), Stopray and ipasol (thermal insulation and solar control)

## 3.1.4 PAINTED GLASS

Glass covered on one side with a high-quality paint. The paint is homogeneously applied onto the glass surface using a "curtain coater" process, giving it a uniform appearance.

The painted glass range features a vast palette of standard colours, ranging from 25 glossy colours to 12 satin-finish variations and 15 toughened versions. Check the MyColour for Lacobel option to specify custom colours.

Main AGC ranges: Lacobel, Lacobel T, Matelac.

The above mentioned products are also available in SAFE and SAFE+ versions: the back of the glass is covered with a polypropylene or PET film to provide protection from injury. If the glass breaks, the fragments are not scattered, but remain attached to the film.

### 3.1.5 MIRROR (EN 1036-1)

Glass to which a silver-coating is applied to create the mirror-reflection. This silver-coating is itself protected by a paint.

The process of manufacturing mirrors is called silvering.

<u>Main AGC ranges:</u> Mirox MNGE (New Generation Ecological), Mirox 3G, Mirold Morena, Sanilam Easycut

The above-mentioned products are also available in SAFE and SAFE+ versions: the back of the glass is covered with a polypropylene or PET film to provide protection from injury. If the glass breaks, the fragments are not scattered, but remain attached to the film.

### 3.1.6 PATTERNED GLASS (EN 572-1 AND EN 572-5)

Glass with a design on one or both sides, obtained by passing the sheet of glass between two textured rollers during the manufacturing process. Patterned glass is also known as “cast glass”.

The production line for cast glass is similar to a float line, except that the stage of floating on a tin bath is replaced by a shaping stage between two rollers.

<u>Main AGC ranges:</u> Imagin, Oltreluce

### 3.1.7 WIRED GLASS (EN 572-1 AND EN 572-6)

Patterned glass into which a wire mesh is incorporated just prior to the shaping stage. The wiring is designed to hold pieces of glass in place in the event of breakage but also improves mechanical strength.

<u>Main AGC range:</u> Imagin wired

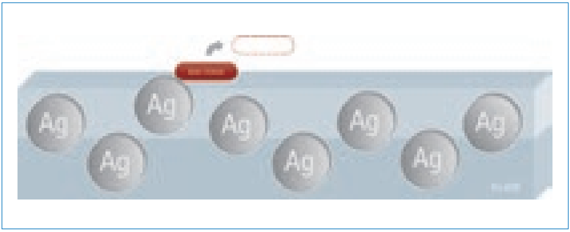
## 3.1.8 POLISHED WIRED GLASS (EN 572-1 AND EN 572-3)

Polished wired glass is a wired glass patterned with a very faint surface design. This design is then softened and polished to achieve the transparency and clarity of float glass.

Main AGC range: polished wired glass (see Imagin wired)

## 3.1.9 ANTIBACTERIAL GLASS

The process developed and patented by AGC involves diffusing silver ions into the upper layers of the glass. The ions interact with bacteria and destroy them by disabling their metabolism and disrupting their ability to divide. The antibacterial effect of the glass is permanent, particularly in moisture and temperature conditions favouring the development of bacteria and mould.




Main AGC ranges: Planibel AntiBacterial, Lacobel AntiBacterial, Mirox AntiBacterial

## 3.1.10 SATIN-FINISH GLASS

Full surface acid-etched glass. The acid attacks the surface of the glass and gives it a matt translucent appearance and a smooth, satin feel.

Main AGC ranges: Matelux, Matobel One Side, Matelac

# 3.2 – Processed glass products

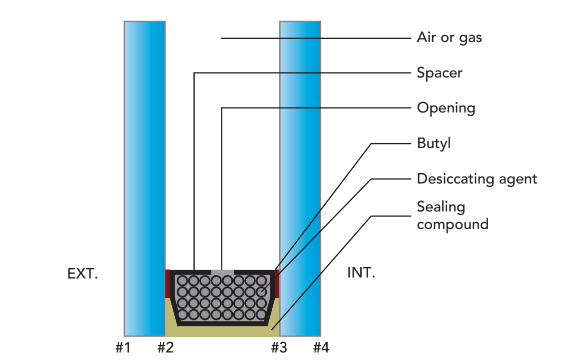
## 3.2.1 INSULATING GLASS (EN 1279-1 TO EN 1279-6)

Insulating glazing with a perimeter seal and comprising two sheets of glass (double glazing) or three sheets of glass (triple glazing) separated by a spacer(s) filled with dehydrated air or thermal gas.

The main purpose of the insulating glazing is to provide a higher level of thermal insulation than single glazing. The thermal insulation characteristics of the insulating glazing can be combined with properties such as solar control, sound insulation and safety by using the appropriate glass products as components of the insulating glazing unit.

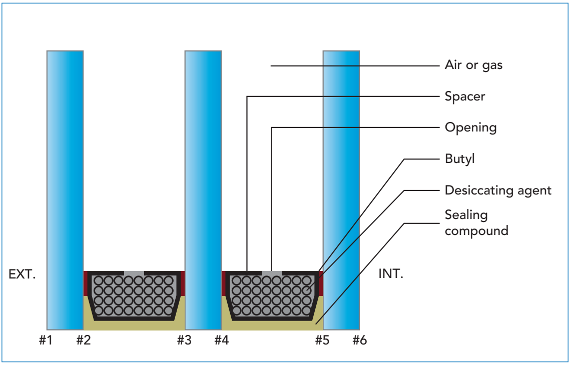
Below is the typical numbering of the surfaces in double glazing and triple glazing.

**Insulating glazing: components, direction and numbering of sides**




<u>Main AGC range:</u> Thermobel

**Triple glazing**




Main AGC range: Thermobel TG

### ▼ Insulating glazing with integrated blinds

Blinds are integrated between two sheets of glass.

Main AGC range: Thermobel Store

## 3.2.2 HEAT-TREATED GLASS (EN 1863, EN 12150, EN 14179)

### ▼ Heat-strengthened glass (EN 1863-1)

Glass which has undergone heat treatment, during which it has been heated to approximately 600 °C and then cooled in a controlled manner using jets of air. In this case, the cooling process is slower than it is for thermally toughened glass.

The surface of the glass is then locked in a state of compression, making it more resistant to mechanical and thermal stresses and giving it the required fragmentation characteristics.

When broken, heat-strengthened glass splits into large sharp pieces like float glass. Accordingly, it is not considered a safety glass.

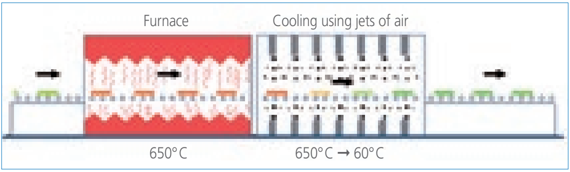
Heat-strengthened glass does not need to be heat-soaked.

Main AGC range: Heat-strengthened glass

## ▼ Thermally toughened safety glass (EN 12150-1)

Glass which has undergone heat treatment. It is heated to approximately 600 °C then cooled rapidly.

**Thermal toughening process**




The surface of the glass is then locked in a state of compression. This makes it more resistant to mechanical and thermal stresses and gives it the required fragmentation characteristics. If the glass breaks, it fragments into blunt pieces smaller than those from annealed glass, thus limiting the risk of cuts. Thermally toughened glass is considered a safety glass that provides protection from injury and can be used for certain specific applications (shower cubicles, partitions, etc.).

Main AGC range: Thermally toughened safety glass

## ▼ Thermally toughened safety glass and heat-soaked tested (EN 14179-1)

Additional heat treatment is applied to thermally toughened glass to eliminate to a maximum the eventual unstable nickel sulphide inclusions, thus preventing spontaneous breakage.

Main AGC range: Heat Soak tested thermally toughened safety glass

## ▼ Bent glass

Bent (or curved) glass is obtained by bending the glass (at a high temperature) to fit the mould on which it is resting.

**Bending process**

Main AGC range: Bent glass

## 3.2.3 CHEMICALLY TOUGHENED GLASS (EN 12337-1)

Glass obtained when float glass undergoes an ion-exchange process to make it more resistant to mechanical and thermal stresses. Small-diameter ions found in the surface and the edge of the glass are replaced with larger-diameter ions; this is done by compressing the surface and the edges of the glass.

Chemically toughened glass is mainly used in specific applications such as aeronautics and lighting.

## 3.2.4 LAMINATED SAFETY GLASS

### ▼ Protection from injuries

Laminated safety glass having at least one PVB interlayer for prevention of cuts and injuries due to accidental impact.

### ▼ Protection from falling

For preventing individuals from falling through the glass even when the glass is accidentally broken. Laminated safety glass having at least two PVB interlayers.

### ▼ Protection

Laminated safety glass having at least two PVB interlayers giving basic protection (using up to six PVB interlayers gives enhanced protection).

Main AGC ranges: Stratobel, Stratobel security burglary

#### > Protection from armed attack

Laminated safety glass capable of withstanding bullets. The class is determined according to the type of weapon and ammunition.

Main AGC range: Stratobel security bullet

#### > Protection from explosion

Laminated safety glass capable of withstanding an explosion.

Main AGC range: Stratobel security explosion

## 3.2.5 ENAMEL SURFACE PROCESSING

### ▼ Enamelled glass (EN 1863-1, EN 12150-1, EN 14179-1)

In this process, the full surface of the glass is covered with a coating of enamel and vitrified during the heat treatment. Enamelled glass is very often used in spandrel panels.

Main AGC ranges: Colorbel[1], Lacobel T

(1) Availability depending on markets.

### ▼ Silk-screen printed glass (EN 1863-1, EN 12150-1, EN 14179-1)

Process similar to enamelling in which an enamel is applied to parts of the glass, either using a screen or using digital printing, and is vitrified during toughening or strengthening.

Main AGC range: Artlite

## 3.2.6 BUILDING-INTEGRATED PHOTOVOLTAICS

AGC's BIPV glazing is a range of laminated safety glass products featuring embedded photovoltaic cells. By merging glass (the construction material) with photovoltaic cells, AGC effectively combines design with electricity generation.

AGC's BIPV photovoltaic modules meet all aesthetic and functional requirements for seamless integration into buildings. They can be used instead of conventional materials and comply with the relevant standards for both building- and photovoltaic products.

Since AGC's BIPV modules are custom made they can be tailored specifically to each project. This gives architects many options for combining electricity generation with facades, canopies, sunshades, balustrades, louvers, spandrels and so on.

The assembly comprises two sheets of toughened glass, with the external sheet ideally being made of extra-clear glass in order to maximise electricity production. The inner sheet can be clear, extra-clear, coloured, screen-printed or any other type of glass. The BIPV modules can be assembled in insulating glazing (Thermobel) to provide the required level of thermal insulation.

Deploying AGC's BIPV modules improves the building's energy performance and enhances its environmental image.

<u>Main AGC range:</u> SunEwat

## 3.2.7 SANDBLASTED GLASS

Glass which undergoes a sandblasting treatment, i.e. high-pressure abrasive etching. This process can be used to obtain uniform or multi-relief motifs.

<u>Main AGC range:</u> Sandblasted glass

## 3.2.8 FIRE-RESISTANT GLASS

<u>Main AGC ranges:</u>

> Pyrobel - Pyrobelite: fire-resistant glass units assembled using two or more intumescent interlayers which expand in the event of fire

> Pyropane: thermally toughened safety and fire-resistant glass.

# 4
# GLASS FOR FACADES AND WALLS

Vinprom - Plovdiv, Bulgaria - Architect: Atanas Panov - Stopray Vision-50

Glass can be used to control most types of radiation. The following pages give a brief outline of the solutions available.

Private Passive House - Moxhe, Belgium - Architect: Adelin Lecef - Thermobel TG

# 4.1 – Protection from UV radiation

Solar radiation can degrade and fade the colour of objects exposed to it. This gradual degradation of molecular structures due to high-energy photons is caused by ultraviolet radiation and, to a lesser extent, shortwave visible light (violet and blue). Solar radiation also causes the temperature to rise, thus accelerating the process.

Some glass products reduce the level of degradation and discolouration:

> laminated glass with PVB interlayers absorbs over 99% of UV radiation

> coloured glass with a predominantly yellow-orange tint partially absorbs violet and blue light

> glass with a low solar factor limits temperature rises.

That said, no glass product can fully eliminate discolouration.

In fact, in some cases interior artificial lighting can also cause discolouration.

Various indices are used to quantify the protection from UV radiation and the risk of discolouration and chemical degradation:

> UV transmission

> the CIE damage factor. This index is set out in ISO 9050 and pertains to the transmission of radiation for wavelengths in the range 300 nm to 600 nm, i.e. those causing objects to discolour

> skin protection factor (SPF). This index is also set out in ISO 9050 and pertains to transmission of radiation for wavelengths in the range 300 nm to 400 nm, i.e. those causing skin damage.

# 4.2 – Protection from Infrared Radiation

## 4.2.1 PROTECTION FROM SHORTWAVE INFRARED RADIATION

Solar control glass with an appropriate solar factor provides protection from shortwave infrared radiation and heat in general.

When designing a building, the percentage of the glazed surface and the solar factor impact directly on the performance and (peak) capacity of the HVAC system.

## 4.2.2 CONTROL OF LONGWAVE INFRARED RADIATION

Controlling longwave infrared radiation involves preventing longwaves – i.e. the heat emitted by objects – from leaving buildings to enhance thermal insulation.

Low-emissivity coated glass can be used to control longwave infrared radiation.

When designing buildings, the level of thermal insulation of the glazing (and of the building envelope in general) will directly affect the HVAC system used.

# 4.3 – Light comfort

The amount of light, entering the residential house or commercial building, can be controlled using coloured or coated glass.

The location of a building has a substantial impact on its light control requirements. In very sunny countries, the general aim is to limit light transmission (and solar factor). By contrast, in countries with less sunshine, it is important to make the most of the natural light available.

Glass for building applications meets all these requirements since light transmission levels ranging between a very low percentage (for applications designed to reduce glare) and 90% (for extra clear glass) can be achieved.

Moreover, depending on the type of coating or glass used, these levels of light transmission can be combined with low, medium or high values of solar factor.

When designing a building, the glazing surface and its level of light transmission has a direct impact on the level of artificial lighting required.

Natural lighting of rooms is a complex process. In this publication, we detail only a few general rules in relation to private homes rather than office buildings where artificial lighting is always present.

For each project, the architect must modify the position and the size of the openings depending on the location of the building and the direction it faces, and must choose the appropriate glazing.

## ▼ Natural lighting

The amount of natural light available depends on weather conditions, the season, the time of day and any obstacles close to the window bays (trees and so on).

As with energy throughput, light throughput depends on the direction the window is facing: north-facing windows receive virtually no sun (valid for the northern hemisphere) and most of the light available is natural light. By contrast, east-, south- and west-facing windows receive direct light throughput in winter.

## ▼ Position of window

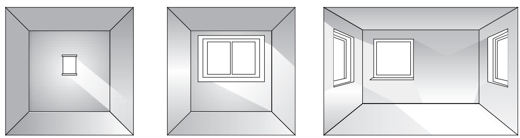
Since light travels in a straight line, the upper parts of the window are a room's main light source. It is advisable to position the glazing so that its upper edge is at least halfway up the wall.

Using glass in roof applications is a smart way to let solar light in.

Distribution of light is also the key to high-quality lighting. It is not enough to allow light into spaces; it also has to be distributed harmoniously. Since light is reflected by ceilings, floors and walls, care should be taken to avoid dark colours which absorb light.

It is therefore advisable to position glazed openings in the upper sections of multiple walls. Where this is not possible, use should be made of reflection on surfaces inside the room, which act as secondary light sources. An imbalance between the intensity of multiple light sources can be offset by an appropriate choice of light transmission levels.

**Distribution of light depending on the size and position of windows**



Finally, although it is nice to have plenty of light, care should be taken to ensure that the intensity is not so high that it causes glare. Glare is caused by the presence of overly intense light sources in the field of vision. Reducing the surface area of openings is not a viable solution since it accentuates the contrast between the window and the wall in which it is set, thus further increasing discomfort. On the other hand, glare can be lessened by using coated glass to reduce levels of light transmission.

## ▼ Surface area of glazing

To provide good natural lighting in rooms, the surface area of the openings must be large enough and the proportion of non-transparent elements (for example frame subdivisions) limited. In fact, the glazed surface area is always smaller than the surface area of the opening.

## ▼ Vision protection

In some specific instances, it is important to maintain privacy by preventing people from looking into a room. Several types of glass products offer solutions to this:

> coated glass: this partially obscures a room from prying eyes provided that the room in question has a lower light level than the environment outside

> translucent and/or coloured glass: patterned glass, laminated glass with matt or coloured PVB, acid-etched or sandblasted glass or glass blocks

> silk-screen printed or enamelled glass

> two-way mirrors: these are glazings which allow vision in one direction only to enable those inside to see out, but prevents those outside from seeing in (airports, large shops, etc.). Two conditions are required for good two-way mirrors:
  - a coated glass must be used with a low level of light transmission
  - the glass used must have a much lower level of luminosity on the viewing side than on the viewed side.

# 4.4 – Thermal comfort

## 4.4.1 HEATING ROOMS - GREENHOUSE EFFECT

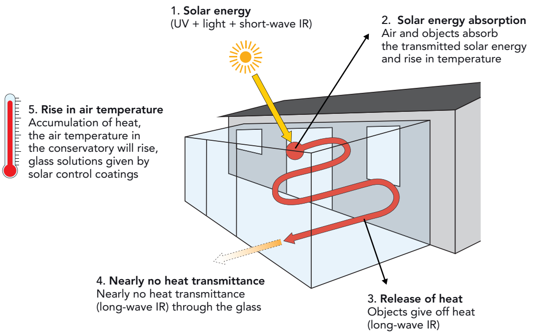
Thermal comfort depends on the location, the percentage of glass in the facade and the type of glass. The temperature in the room depends on the solar heat gain through the glass. The solar energy entering a building reaches walls, floors and furniture, which partially absorb it and then heat up. The interior finishing returns this heat in the form of longwave infrared radiation with a wavelength in excess of 3,000 nm.

This causes the interior temperature to rise gradually, leading to a greenhouse effect.

A body-tinted glass or a glass element with solar control coating allows less heat to pass through it and therefore causes less warming up.

The figure below shows the greenhouse effect in the conservatory exposed to sun.

**The greenhouse effect**



## ▼ Free solar energy

The greenhouse effect is appreciated in residential and commercial buildings during cold periods of the year since it saves energy due to the free solar heat.

During warm periods of the year, the free solar heat gain leads to a higher temperature in rooms and office spaces requiring more energy for cooling purposes. In commercial buildings the free energy released by occupants, lighting and electrical equipment increase the free internal energy and leads to a higher interior temperature.

## ▼ Direction of windows

Clearly, the amount of solar heat gain depends on the direction a window faces. In the northern hemisphere, north-facing windows generate less throughput. South-facing windows receive a lot of sun in the winter and little sun in the summer.

West- and east-facing windows receive solar throughput throughout the year. West-facing windows also have the disadvantage of receiving throughput towards the end of the day when the building has already had time to heat up. This building orientation is therefore the most critical for an optimal amount of free solar heat.

## ▼ Desired performance of glazing

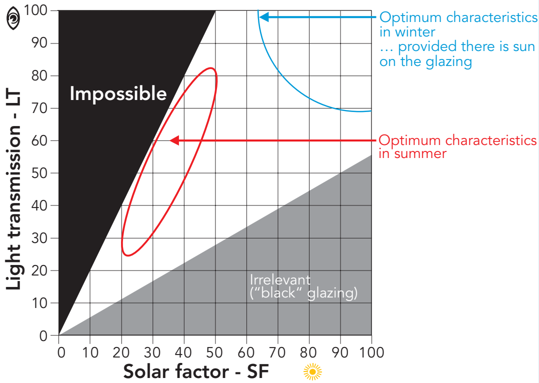
The following graph shows the combinations of SF and LT values. There are several different zones:

> Since visible radiation represents almost half of the solar spectrum, the solar factor may not be less than half the light transmission. This is equivalent to the upper black area of the graph, which is therefore physically impossible to achieve.

> Achieving a high solar factor (significant energy throughput) with low light transmission (little light throughput) is irrelevant. This is equivalent to the lower grey area of the graph.

The central white area of the graph is equivalent to those characteristics that are theoretically possible to achieve. Some sections of this area are more worthwhile from the point of view of solar and light control.

**Graph: Solar factor SF (or g) – Light transmission LT (or $\tau_v$)**




> In residential buildings:

- in summer, a low (and therefore high-performance) solar factor is desirable combined with a more or less high level of light transmission (red-outlined area)
- in winter, a high solar factor and a high level of light transmission are desirable (blue-outlined area).

> In office buildings, in contrast with residential buildings:

- in winter, efforts may also be made to limit solar gains if internal heat gains are high.

All points within the white area may theoretically be achieved, but please consult the tables with the light characteristics and solar factor in the Brands & Products section.

These selected criteria only take account of energy and light transmission. In reality, when choosing a glazing one should also keep in mind thermal insulation requirements.

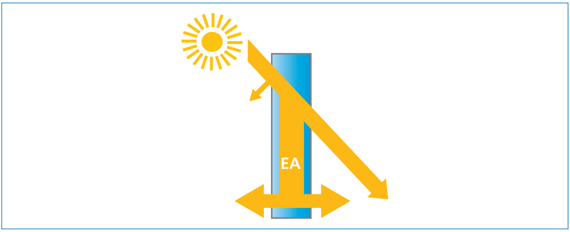
## 4.4.2 SOLAR CONTROL GLASS

### ▼ Absorbent glass

Such glass is body-tinted (bronze, grey, green, blue, etc.) by adding metal oxides. Depending on the colour and the thickness of the glass, the solar factor varies between 8% and 80%.

This type of glass absorbs some of the energy from solar radiation before emitting it back inside and out.

**Absorbent glass**




The amount of energy emitted to the outside and the inside depends on the wind speed and the respective external and internal air temperatures. To dispatch the heat radiated to the outside as efficiently as possible, the absorbent glass must be installed as close to the front of the facade as possible. In flat facades, the heat absorbed can escape more easily and the level of radiation to the inside is lower.

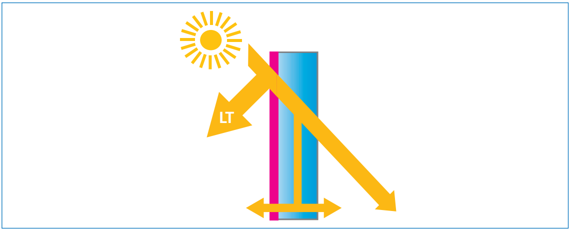
Absorbent glass has been used less and less as a solar control glass since techniques for applying coatings have made it possible to manufacture high-performance coated glass.

Absorbent glass warms up more quickly than conventional glass. In some cases, a study should be conducted into the risk of breakage by thermal stresses.

## ▼ Coated glass

This is coated glass which reflects some incident solar energy.

**Coated glass**




There are several types of coatings:

> metal oxide-based pyrolytic coatings applied to a clear or coloured glass on the glass production line: they are applied in position 1 or 2, in single or insulating glazing

> metal-based or metal oxide-based vacuum coatings: since these coatings oxidize in contact with air, they are always assembled into insulating glazing on position 2 facing the cavity. Such glass is available in a wide range of colours.

As with absorbent glass, the problem of thermal breakage must be borne in mind when using coated glass. In some cases, a study should be conducted into the risk of breakage by thermal stresses.

*Notes:*

> *It is important to use the same type of glazing (thickness, colour, coatings, etc.) side by side to ensure the uniform appearance of a facade.*

> *Coated glass reflects light from the "brightest" area. When it is dark outside and artificial light is used to light rooms, this light will be reflected into the building and it will no longer be possible to see out.*

AGC offers a full range of solar control glass: coloured glass, glass with pyrolytic coatings and glass with magnetron coatings.

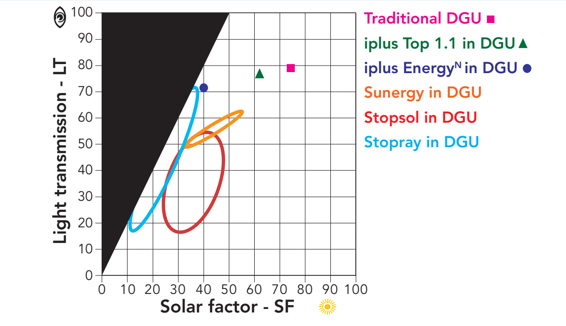
The table below sums up the ranges.

**AGC solar control glass brands**

| Coloured glass | Pyrolytic coatings | Magnetron coatings |
|---|---|---|
| Planibel Coloured | Stopsol<br>Sunergy | Stopray<br>ipasol |

The graph below gives an overview of the position of the different families of AGC solar control glass in double glazing units (6-12-6 configuration).

**Performance ranges of AGC solar control glazing in DGU**



The two tables below show the various processing options and the properties of AGC's solar control coated glass products.

## Use and processing of solar control glass

| | Glass with pyrolytic coatings | | Glass with magnetron coatings |
|---|---|---|---|
| | Stopsol | Sunergy | Stopray / ipasol / iplus Energy N |
| Use in single glazing | # 1 or 2 | # 2 | - |
| Use in insulating glazing | # 1 or 2 | # 2 | # 2 |
| Edge stripping | no | no | yes(2) |
| Processing options | Laminating | Laminating | Laminating(1) |
| | Toughening | Toughening | Toughening, Enamelling, Bending } iplus Energy NT, Stopray T |
| | Enamelling | Enamelling | |
| | Bending | Bending | |

(1) The coating may not come into contact with the PVB.
(2) Edge stripping not required for Stopray SMART. Please consult the Processing Guide.

## Properties of solar control glass

| Properties | Glass with pyrolytic coatings | | Glass with magnetron coatings |
|---|---|---|---|
| | Stopsol | Sunergy | Stopray / ipasol / iplus Energy N |
| Light reflection | High (# 1) Low (# 2) | Low | Low to high |
| Thermal insulation | Low | Medium | High |
| Selectivity | Low | Medium | High |
| Neutrality | Low | Medium | High |

*NB: Coloured and coated glass can show slight colour variation.*

# 4.5 – Acoustic comfort

## 4.5.1 INTRODUCTION

The sound-reduction indices given in this chapter are obtained through acoustic tests in notified laboratories (conform standard EN ISO 140-3) for glazing with the following dimension: 1.23 m by 1.48 m.

In situ sound insulation performance may vary according to various parameters, such as:

> the actual size of the glazing/frame

> assembly conditions

> the air-tightness of the window

> the acoustic environment for the application (type of sound source, location in relation to said source, etc.)

> the sound quality of other aspects of the unit.

To evaluate in situ performance, following parameters should be noted when choosing a glazing. Given the complex nature of evaluating these different parameters in some cases, assistance from a third party being expert in the field of acoustics might be required.

### ▼ In situ acoustic performance of windows and facades

The in situ performance of windows and facades depends not only on the glazing itself but also on its size, the frame and assembly type, surrounding noise, how airtight the facade is and so on.

> The results are those of laboratory tests according to the criteria applied by European laboratories. The size tested is always 1.23 m x 1.48 m in line with standard EN ISO 140-3. Accordingly, one might reasonably expect a lower level of performance for a significantly larger glazing. This reduction is approximately 2 to 3 dB in sizes of 5-6 $m^2$. This must be borne in mind when choosing a glass.

> Windows and glazing provide insulation against airborne noise (noise passing through the air) in particular, rather than contact noise (impact) through partitions (low-pitched, low frequency noise passing through partitions).

> The frame must be free of gaps and to this end dual joints should be used to prevent air and water from entering the frame. A good, airtight frame can improve performance by up to 2 dB compared to the values detailed for the glazing.

By contrast, large gaps can reduce the stated insulation by 10 dB.

> Windows fitted with shutters in an outside housing require that the housing be insulated using sound-absorbing material (fibreglass or equivalent material, as example).

> Care must be taken to ensure that the area between the fixed window of the frame and the masonry is airtight. The external finishing between the frame and the masonry should be done with a flexible, airtight filling rather than a cement-plaster filling.

> The presence of ventilation grills or air entry points can significantly reduce acoustic performance.

> In situ performance of windows also depends on the type of external noise and the angle of incidence of the noise on the facade.

> For high levels of insulation, it is advisable to choose a glazing for which performance levels are slightly higher than those actually required.

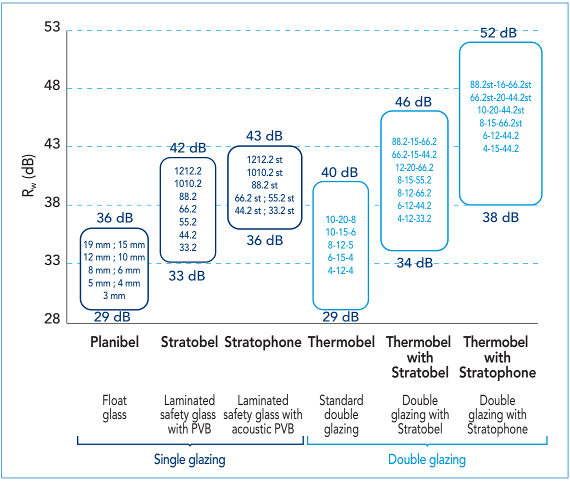
> The correct sound reduction index $R_w + C$ or $R_w + C_{tr}$ should be chosen depending on the type of noise concerned.

Monolithic glazing (float and laminated) covers a range of acoustic performance levels (value $R_w$) from 29 to approximately 43 dB.

Insulating glazing covers acoustic performance levels ranging from 32 dB to approximately 51 dB.

The figure below shows the indicative performance levels achieved in single-pane glazing using Planibel, Stratobel and Stratophone as well as in double glazing using two Planibel panes, one or two Stratobel panes and one or two Stratophone panes.

**Indicative acoustic performance levels of different glazings**




Considering single glazing, for an equivalent level of performance, Stratobel is thinner than Planibel and Stratophone is thinner than Stratobel.

Example: The table below shows the monolithic glass to be used to achieve a performance level $R_W$ of 35 dB and the corresponding thicknesses.

| Glazing | Total thickness | $R_w$ |
|---|---|---|
| Planibel 12 mm | 12 mm | 35 dB |
| Stratobel 44.2 | 9 mm | 35 dB |
| Stratophone 33.1 | 7 mm | 35 dB |

By the same token, in insulating glazing with an equal level of performance, a double glazing unit with Stratobel is thinner than one with Planibel, while a double glazing unit with Stratophone is thinner than one with Stratobel.

# 4.6 – Safety and security

## 4.6.1 SAFETY GLASS APPLICATIONS

The following paragraphs give general information on the use of safety glass. The list of scenarios is not exhaustive.

These general outlines should also be supplemented on a case-by-case basis according to specific site requirements and local regulations.

In all cases, the actual thicknesses to be used should be adapted in line with the real size and loads, and with the glazing fitting system. The thicknesses corresponding to a particular class are merely a minimum level for test purposes.

### ▼ Protection for individuals from injury and falls

There are two distinct aspects of safety for individuals:

> preventing the risk of injury caused by sharp pieces of glass

> preventing the risk of falling through the glass (defenestration).

In the former case, both thermally toughened and laminated safety glass can be used; in the latter case, only laminated safety glass may be used.

The actual thicknesses of the glass to be used should be determined on a case-by-case basis in line with impacts, the actual size of the glass and the way in which it is fixed.

Although it is impact-resistant, annealed float glass is not a safety glass.

## ▼ Protection from injury

To limit the risk of injury caused by shattered pieces of glass, only thermally toughened or laminated safety glass (with at least one PVB film) should be used. Such glass can be used in the following applications:

> shop windows

> internal partitions (if the bottom of the glass is close to ground level) where there is no difference in the level on either side

> doors and windows in public places

> street furniture: bus shelters, telephone boxes, etc.

> shower cubicles, shelves, furniture, etc.

> in the case of roof glazing, laminated safety glass is essential for protecting people beneath the glazed opening from the risk of injury caused by glass splinters that become detached, in particular when external objects have fallen on it. However, there is no guarantee that objects will not fall through it. It will only be effective if the stresses produced by the impact do not exceed the performance levels afforded by the product used.

Moreover, where the edges of a glass are visible, they should be ground (and in some cases, the glass should be thermally toughened).

## ▼ Protection from falls

To limit the risk of falls, laminated safety glass (with at least two PVB films) should be used in the following applications, among others:

> internal windows and doors (if the bottom of the glass is close to ground level) where there is a difference in level

> balustrades

> floors and staircases.

## 4.6.2 POSITION OF SAFETY GLASS

In the case of double glazing and the intention to protect individuals, the laminated glass should be positioned on the side on which the impact is likely to occur.

Two panes of safety glass may be used in an insulating glazing assembly if the impact might occur on both sides (for example in the case of insulating glazing fitted in a door to a public place). The permissible combinations in insulating glazing units are therefore thermally toughened-thermally toughened, thermally toughened-laminated or laminated-laminated.

Insulating glazing comprising float and thermally toughened glass provides no protection since if the two panes break at the same time, there is a risk of injury.

For insulating glazing in roofs, the internal glass should be laminated safety glass.

## 4.6.3 BURGLARY RESISTANCE

Only laminated safety glass may be used to provide protection from vandalism and burglary (or in certain cases escape, for example in prisons or hospitals).

The following table gives the indicative value of the number of PVB films to be used depending on the level of protection required. Whether the aim is to provide protection from vandalism or to protect homes and shops from theft, the laminated safety glass used should comprise two panes of glass and an increasing number of PVB films depending on the level of security required and/or insurance company requirements. For very high levels of security, multilaminated glass should be used, eventually incorporating polycarbonate.

In the case of burglar-resistant safety glass assembled into an insulating glazing unit, it is advisable to fit the laminated safety glass on the inside.

**EN 356 Standard**

| | Level of protection | Recommended class | Sample applications |
|---|---|---|---|
| Protection from vandalism | Protection from random vandalism | P1A<br>P2A<br>P3A | Ground-floor dwelling (shop windows presenting a limited risk or containing large objects) |
| Protection from burglary | Protection from basic burglary | P4A<br>P5A | Ground-floor dwelling (shop windows presenting a limited risk or containing large objects) |
| | High-level protection | P6B<br>P8B | Shop windows presenting a high risk or containing small objects |
| | Very high level of protection from all forms of attack with a bladed weapon | | Shop windows presenting a very high risk or for high-value items |

## 4.6.4 BULLET AND EXPLOSION RESISTANCE

Laminated or multilaminated safety glass products, sometimes containing polycarbonate, are resistant to bullets and explosions.

Using glass as a source of resistance to bullets and explosions is a highly specialised field. It is the responsibility of the user to ascertain the level of protection required and users are ultimately advised to contact a specialist in deciding which glass products provide the level of performance required depending on the specific nature of the project and the type of protection needed.

## 4.6.5 FRAME QUALITY

In all cases, safety glass is only useful if the accompanying joinery has the same resistance qualities since the level of resistance of the weakest component therein will determine the resistance of the assembly as a whole.

## 4.6.6 FITTING INSTRUCTIONS FOR SAFETY GLASS

When fitting safety glass, the general installation instructions as well as those specific to safety glass should be followed.

# 4.7 – Inherent features of glass

## 4.7.1 THERMAL BREAKAGE

Breakage caused by thermal stresses occurs if the temperature difference between two areas of annealed glass is too great. If the temperature of the glass rises, the glass expands. This process causes no difficulty if the temperature is uniform throughout the glazing. By contrast, however, if part of the glazing remains cool, it will prevent the warm section from expanding freely.

This gives rise to tensile stress, which can exceed the permitted level of stress in the glass. If there is a risk of this happening, the glass must be thermally toughened or heat-strengthened.

Except where a preliminary study is carried out, spandrels must be thermally toughened or heat-strengthened. Regarding the vision part where the temperature is close to the limit, we advise to evaluate the use of Clearvision glass, offering a low energy absorption.

## 4.7.2 INSULATING GLASS EFFECT

The space between the panes of an insulating glass unit is a hermetically sealed volume, in which the universal gas laws apply. The panes are firmly fixed at the edges by the adhesive and thus act as membranes.

The volume between the panes changes with all air pressure and temperature fluctuations, thus the glass panes deflect accordingly.

The deflection is visible as a distortion of the reflections from the glass panes. This physically unavoidable phenomenon is called the insulating-glazing effect.

This effect is actually a proof of quality for insulating glazing. It indicates that the space between the panes is hermetically sealed.

The insulating-glazing effect depends particularly on the size and geometrical configuration of the panes, as well as on the width of the space between the panes and the glass thickness.

## 4.7.3 INTERFERENCE PHENOMENA IN INSULATING GLAZING

As the two surfaces of a float glass pane are extremely flat and excellently parallel, optical phenomena may be visible under certain lighting conditions.

These are evident as rainbowtype spots, stripes and rings that change their position when pressure is applied to the pane.

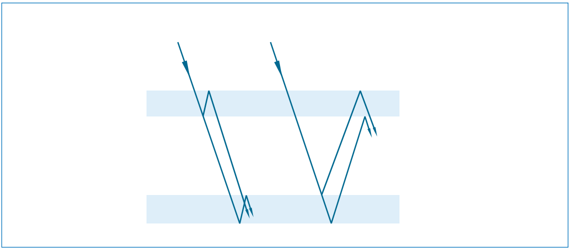
Interference phenomena are purely physical effects caused by refraction and superposition.

They only occur in situations where two or more float glass panes are positioned behind each other.

As the magnitude of the phenomenon depends on the local lighting conditions, the position of the pane and the incidence angle of the light, it only occurs rarely and only if several factors coincide. Interference phenomena mainly occur under a certain viewing angle in reflection, seldom in transmission.

Thus, these interference phenomena are physical occurrences that can be interpreted as a hallmark of excellent float glass quality.

**Interference phenomena in insulating glass units with panes of the same thickness**



## 4.7.4 ANISOTROPY

These are iridescent effects that can occur in thermally treated panes (thermally toughened safety glass and heat-strengthened glass).

Thermally toughened safety glass and heat-strengthened glass are produced in special thermal processes.

These manufacturing processes generate stress zones in the glass that lead to birefringence under polarised light. If the heat treated glass is observed under certain light conditions, polarisation fields are visible as patterns.

This effect is characteristic of thermally toughened safety glass and heat strengthened glass and is caused by physical factors.

Natural daylight contains varying proportions of polarised light, depending on the weather or time of day.

## 4.7.5 CONDENSATION

The dew-point is the air temperature at which the relative humidity reaches a value of 100 %. If the air temperature decreases with unchanged moisture content, condensation occurs.

Dew-point temperatures can occur at various positions:

### ▼ Condensation on glass surface oriented to the inside

Condensation can form on the indoor surface of an insulating glazing unit under the following conditions:

> Moisture is added to relatively cold air. This occurs very frequently in kitchens, bathrooms, laundries and bedrooms. In these areas, an annoying condensation film can form within a short time as the moisture condenses on the cold pane surface.

The tendency to condensation can be considerably reduced by the use of thermally insulating glazing with low-e coatings, such as iplus Top 1.1 or iplus Advanced 1.0, as the indoor surface temperature of the pane is increased due to the improved U value. This can be seen clearly in the dew-point diagram.

A high level of water vapour can be prevented by appropriate ventilation.

### ▼ Condensation on glass surface oriented to the outside

In specific cases, condensation can also occur on the outside oriented glass surface of an insulating glazing.

It occurs in the early morning if the outside air contains a high level of moisture.

In the early morning, the temperature of this glass pane can drop below the dew-point. The origin is that the glass surface of an insulating glazing unit cools off appreciably at night due to the high level of thermal insulation, which means that the indoor temperature hardly affects the outdoor pane.

If the temperature of the outdoor air then rises more quickly than that of the panes, condensation can occur. However, the condensation disappears again quickly with the first rays of the sun.

The formation of condensation, both on the indoor and the outdoor surfaces, is due to physical and climatic factors.

AGC offers a special anti-condensation coating which delays the appearance of external condensation. Clear float glass is covered with a transparent pyrolytic coating. The low-emissivity iplus AF coating is applied to the outside of the glass (position 1). This coating keeps the external temperature of the glass higher and therefore delays the onset of condensation.

Porta Nuova - Milan, Italy - Architect: Piuarch - Photographer: Andrea Martiradonna - iplus I-Top

Conseil national Principauté de Monaco - Monaco, Monaco
Architects: ArchiStudio Monaco - Jean-Michel UGHES Architecte - Artlite Digital

# III
# Choosing a glass

This chapter aims to help glass designers, engineers (specialized in the field of structural design, HVAC, acoustics, fire, etc.) facade builders and architects to choose the right glass by taking them through various key stages.

A different approach will be taken when designing and choosing the glass elements depending on the type of building:

## ▼ Residential housing

For residential applications such as private homes, whether for renovation or new construction, several criteria are usually considered when choosing a glass and a window.

Energy savings and thermal comfort can be achieved by using insulating glazing and low-emissivity coatings, thus achieving high levels of thermal insulation.

Visual comfort also needs to be considered, and the windows of our homes are expected to let a large amount of natural light enter the building, as well as a large amount of sunlight, serving as a free source of heat energy. The use of low-emissivity coatings, for example combined with extra-clear glass, helps to achieve this.

Sound insulation – and its important impact on comfort, well-being and health – is also one of the most important properties expected of a window. Insulating glazing, such as those using specific laminated safety glass, have been specially designed to achieve a high level of acoustic insulation without sacrificing thermal performance.

Finally, safety functions, from injury prevention to anti-burglary solutions, must also be considered in the choice of the glazing. Here again, laminated safety glass is the natural solution to provide various levels of protection.

## ▼ Commercial buildings

Generally speaking, the steps involved in the design and selection of glazing for a commercial building are more complex than for a residential building. The process involves multiple actors in the different phases of the building design and construction.

Several key parameters need to be taken into account: light and thermal comfort, energy efficiency, acoustic performance, safety requirements, etc. It is necessary to have an expert team appropriately execute these kind of commercial buildings and deliver a level of comfort and performance for the building occupants.

AGC offers a high level support to architects and customers via its special teams of glass experts of the International Building Project team, the International Design Consultants and the Technical Advisory Service.

*See also page 12 for further details.*

For more information, please contact your local AGC representative.

There are two major types of applications for glass products:

> Exterior glass applications (facade and roof)

> Interior glass applications (interior design and furniture).

# 1
# FACADE AND ROOF GLASS

Torre Iberdrola - Bilbao, Spain - Architect: César Pelli - Stopray Vision-60[T]

# 1.1 – Stages in choosing a glass

When choosing a type of glass and specifying its composition, several factors should be taken into account, such as mechanical stability, light and energy characteristics, thermal insulation, degree of light and solar control, colour, acoustic performance, safety requirements, and many more.

It is therefore important to investigate these topics. The relevance of each of these depends on the type of building (residential, commercial, public), the glass applications and the required functions.

## 1.1.1 MECHANICAL STABILITY

The minimum glass composition required for mechanical stability is determined by a mechanical calculation based on the specified loads.

These loads are either defined in the national or European standard (e.g. Eurocode). For glass it mostly concerns wind load, self weight of the glass (for inclined applications), snow load, imposed load represented in form of uniformly distributed load, line load, concentrated load or impact load. Specific loads can be defined for each project.

The glass thickness has to be determined according to loads using local standards if existing or using a software based on finite elements. Post breakage behaviour should also be integrated in the analysis. The design is often complicated and may require knowledge of available technologies, therefore it should be done by an engineer, who has experience in the field of glass.

This will depend on the self weight, wind load, snow load, imposed loads, climatic loads and others.

The thickness of the glass components must conform to the deflection and stress levels in order to prevent the glass element from collapsing due to excessive deflection and/or stress.

Below you will find a list of the minimum required information:

> type of glass
> size of the glass element
> dimensions of the building
> position (vertical, horizontal or inclined)
> installation height and position in the facade or roof
> type of installation (rebate, pressure gasket, structural sealant, etc.).

Plus:

> available standard on load determination
> additional information, i.e.:
  • benchmark standard
  • the building's surroundings (by the sea, in a rural area, in a town, etc.)
  • whether there is internal partitioning
  • for roof glazing: the slope of the roof
  • proximity to a tall building or hill, wind tunnelling effect.

## 1.1.2 ACOUSTIC PERFORMANCE

Depending on the requirements for the acoustic performance and level of acoustic comfort, the composition of the glazing (whether a single glass, a laminated safety glass or an insulating glazing) needs to be modified. Under no circumstances may the modified and final composition be mechanically weaker than the minimum required glass composition for withstanding the loads.

Acoustic performance requirements will have an impact on the structure of the glass since higher levels of acoustic performance generally require more massive – and thus thicker – glass. For high levels of acoustic performance the glass composition is characterised by:

> increased glass thickness
> the use of laminated safety glass, eventually with an acoustic PVB-interlayer

> the use of insulating glazing with:
  - asymmetric structure
  - larger cavity
  - integrated laminated safety glass.

Consequently, mechanical stability and sound insulation requirements are integrated.

Acoustic performance levels are expressed using the index $R_w$ (C; $C_{tr}$), expressed in decibels (dB), as follows:

> $R_w$ is used to categorise products and compare them to each other

> The index $R_w$ + C determines the sound insulation level of a particular element for noise containing predominantly high- and medium range frequencies.

> For noise containing predominantly low- and medium-range frequencies, the sound insulation level of a product is determined using the index $R_w + C_{tr}$.

**Typical acoustic performance levels ($R_w$-values)**

| Type of glass | Typical range for acoustic performance $R_w$ [dB] |
|---|---|
| Monolithic glass | from 29 to 36 |
| Stratobel | from 33 to 42 |
| Stratophone | from 36 to 43 |
| Double glazing | from 29 to 52 |
| Triple glazing | from 32 to 51 |

For illustration, the following solutions in double glazing are available in ascending order of acoustic performance:

> dissymmetrical double glazing: to increase the mass of the glass by using two glass panes of different thicknesses

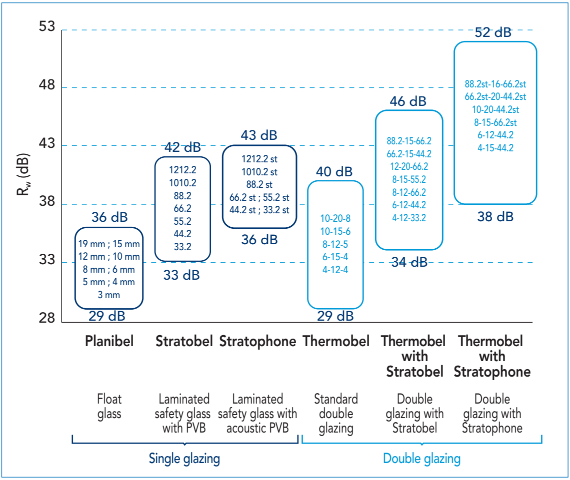
> insulating glazing incorporating one or two Stratobel components

> insulating glazing incorporating one or two Stratophone components.

The diagram below details the anticipated performance levels using Planibel, Stratobel and Stratophone in monolithic glazing and insulating glazing (double and triple glazing).

Please refer to www.yourglass.com for the latest available values.

### Acoustic performances of glass products




At equivalent levels of acoustic performance, Stratophone compositions are thinner than Stratobel ones. In practice, this means, for example, that to achieve a performance level ($R_W$) of 36 dB, either a Stratobel 66.2 or a Stratophone 33.2 glass may be used.

Equally, at equivalent levels of performance:

> Double glazing with laminated acoustic PVB is thinner than double glazing with laminated PVB

> Double glazing with laminated PVB is thinner than dissymmetrical double glazing.

These sound reduction indexes correspond to glass elements which are 1.23 m by 1.48 m according to EN ISO 10140-3 and which are tested in laboratory conditions.

To determine the performance levels of frames and facades, AGC recommends consulting an acoustic specialist or referring to the tests conducted on the full elements.

## 1.1.3 REQUIREMENTS FOR LIGHT AND ENERGY CHARACTERISTICS

Depending on the type of building (residential, commercial, public), the glass application and the required functions, a set of values are determined concerning the light and energy characteristics and the thermal insulation for glass in a given building envelope.

Values for the light and energy characteristics can be found in standards, building codes or project-specific requirements.

It is useful to visit a building project where AGC glass is used. Pay attention to the building-specific elements: facade orientation, percentage of glass in the facade or roof, interior finishing, etc.

### ▼ Light characteristics

Light transmission determines the level of visual and light comfort for the occupants.

Light reflectance determines the visual aesthetics of the building from high to mild or low reflective aspect seen from the outside.

### ▼ Energy characteristics

An initial key energy characteristic is the solar factor (or Solar Heat Gain Coefficient), which determines the free solar heat gain. This is an important characteristic for determining thermal comfort under summer and winter conditions.

### ▼ $U_g$-value of the glass

A second key energy characteristic is the thermal insulation $U_g$, which determines the energy flow through a glass element. This is an important characteristic for setting the energy balance between the outside and the inside of the building.

Both the solar factor and the $U_g$-value determine the energy need for heating, cooling and ventilation.

## ▼ Thermal performance

As awareness grows about reducing energy consumption in residential homes, commercial and public buildings, insulation regulations become more stringent. They are key drivers for installing high-performance insulating glazing.

> Residential housing

- Double glazing with low-e coatings is now seen in European markets as a minimum, and is gradually being replaced by triple glazing as the standard solution in more and more countries. In residential applications, insulating glazing assemblies (commercialised by AGC under the Thermobel brand) generally use low-e coatings (commercialised by AGC under the iplus brand) to provide enhanced thermal insulation, a large amount of light and free solar gains. Depending on the applications, additional functions may also be required, such as solar control and anti-condensation.

> Commercial buildings. Insulating glazing with solar control coatings are generally used:

- coated Stopray glass providing a $U_g$-value of 1.0 W/(m²K)
- coated Sunergy glass providing a $U_g$-value of 1.8 W/(m²K)
- coated Stopsol glass do not affect thermal insulation and, like uncoated double glazing, provide a $U_g$-value of 2.6 W/(m²K)
- coated Sunergy or Stopsol glass, assembled in double glazing with a coated iplus Advanced 1.0 glass, which also provide a $U_g$-value of 1.0 W/(m²K).

The following table shows the range of available $U_g$-values for double- and triple-glazing with a spacer either air filled (100%) or argon filled (90%).

| Glazing | $U_g$-value (W/m²K) | |
|---|---|---|
| **Single Planibel glazing, 6 mm** | 5.7 | |
| **Double glazing unit 6/ 16/ 6** | Air 100% Spacer 16 mm(1) | Argon 90% Spacer 16 mm(1) |
| Planibel + Planibel | 2.7 | 2.6 |
| Stopsol + Planibel | 2.7 | 2.6 |
| Sunergy + Planibel | 2.0 | 1.8 |
| Planibel + Planibel G | 1.7 | 1.5 |
| Planibel + iplus Advanced 1.0 / iplus Advanced 1.0$^T$ | 1.3 | 1.0 |
| Planibel + iplus Top 1.1 / iplus Top 1.1$^T$ | 1.4 | 1.1 |
| iplus Energy$^N$ / iplus Energy$^{NT}$+ Planibel | 1.3 | 1.0 |
| Stopray + Planibel | 1.3 ~ 1.4 | 1.0 ~ 1.1 |
| Stopsol + iplus Top 1.1 | 1.4 | 1.1 |
| Sunergy + iplus Top 1.1 | 1.4 | 1.1 |
| **Triple glazing 4-gas-4-gas-4 with two iplus LS coatings** | | |
| Ar or Kr, 6-15 mm | 0.6 ~ 0.9 | |

(1) Identical values for 15 or 16 mm spacer.

Most of the national insulation regulations stipulate minimum performance levels in terms of the window ($U_w$-value) rather than only the glazing ($U_g$-value).

## ▼ Key factors for choosing a solar control glass

The following key characteristics should be taken into account when choosing a solar control glazing:

> solar factor (SF or g)

> thermal insulation ($U_g$)

> light transmission (LT)

> external light reflection (LR).

The total energy used for heating, cooling and ventilation will be determined to a great extent by the solar factor and the U-glass value of the chosen glass in the building envelope. The solar factor will indicate the amount of free solar heat gain.

The level of light inside the building, the visual comfort (likelihood of glare) and the type of lighting all depend on the LT level.

Light reflection (transparency or mirror effect) and colour are aesthetic criteria.

The characteristics above are all interrelated and choosing certain values for one criterion may restrict the choice available in others.

The levels of solar and light performance are achieved by using coloured or coated glass. The latter achieve higher performance levels.

AGC uses two coating technologies:

> pyrolytic coatings: Stopsol, Sunergy

> magnetron coatings: ipasol, Stopray.

In certain cases silk-screen printed glass, coated laminated glass and glass with coloured interlayers can also provide a degree of solar control.

Check the thicknesses available for a given coating.

The main features of these coatings are detailed in the table below.

| | Stopsol | Sunergy | Stopray / ipasol | iplus Energy$^{N}$ |
|---|---|---|---|---|
| Use in single glazing | Yes (# 1 or 2) | Yes (# 2) | No | No |
| Use in double glazing | Yes (# 1 or 2) | Yes (# 2) | Yes (# 2) | Yes (# 2) |
| External light reflection | Medium (# 2) to high (# 1) | Medium | Low to medium | Low |
| Solar factor | High to low | Low to medium | Low to medium | Medium |
| Selectivity | Low | Average | High | High |
| Processing options | Toughenable | Toughenable | Toughenable | Toughenable [NT] |
| | Bendable | Bendable | Bendable [T] | Bendable [NT] |
| | Laminated | Laminated | Laminated[1] | Laminated[1] |
| Thermal insulation | Low | Medium | High | High |

(1) Coating cannot be processed if it is in contact with the interlayer of a laminated glass.

To choose the correct product, the designer should consider the following criteria:

> the level of light reflection and colour

> the level of thermal insulation required. It may be necessary to combine the solar-control coating with an iplus low-e coating to achieve a performance level of $U_g$ = 1.0 W/(m²K) or lower

> the solar factor

> the level of light transmission.

Depending on the above-mentioned product specifications, the table given for each product with the characteristics and the Product Finder tool on www.yourglass.com enables users to choose the most appropriate glass product.

The table includes most of the glass available in the AGC range. The values indicated apply to single glazing and double glazing. The three tables detail respectively the solutions for thermal insulation alone, for solar control alone, and finally for solar control and enhanced thermal insulation combined.

Other performance levels may be achieved by varying the thickness of the glass, primarily in the case of coloured glass. Details of such performance levels are available in the Glass Configurator on the site www.yourglass.com.

| Look (1) | Double glazing | LT | SF | LR | $U_g$ |
|---|---|---|---|---|---|
| **4-16-4 (2)** | | | | | |
| neutral | Clear | 81 | 77 | 15 | 2.7 |
| **4-16 Ar 90% -4 (2)** | | | | | |
| neutral | #3 | 75 | 74 | 17 | 1.5 |
| neutral | ipus Top 1.1$^T$ #3 | 80 | 63 | 12 | 1.1 |
| neutral | iplus Top 1.1 #3 | 76 | 55 | 15 | 1.0 |

(1) Neutral: used to describe a clear glass to which a coating has been applied.
(2) Identical values for 15 or 16 mm spacer.

## Solar control

| Float glass | Look (1) | Double glazing 6-16 Air -4 (2) | LT | SF | LR | $U_g$ |
|---|---|---|---|---|---|---|
| CLEAR | Shiny silver | Stopsol Supersilver Clear #1 | 58 | 59 | 38 | 2.7 |
| | Slightly bluish silver | Stopsol Supersilver Clear #2 | 58 | 59 | 37 | 2.7 |
| | Amber silver | Stopsol Classic Clear #1 | 35 | 45 | 36 | 2.7 |
| | Clear metallic | Stopsol Classic Clear #2 | 35 | 46 | 28 | 2.7 |
| GREY | Grey | Planibel Grey | 40 | 47 | 7 | 2.7 |
| | Silvered steel | Stopsol Supersilver Grey #1 | 27 | 35 | 35 | 2.7 |
| | Metallic steel | Stopsol Supersilver Grey #2 | 27 | 37 | 12 | 2.7 |
| | Silvered | Stopsol Classic Grey #1 | 17 | 29 | 34 | 2.7 |
| | Metallic grey | Stopsol Classic Grey #2 | 17 | 31 | 10 | 2.7 |
| GREEN | Green | Planibel Green | 66 | 46 | 11 | 2.7 |
| | Silver steel | Stopsol Supersilver Green #1 | 47 | 34 | 37 | 2.7 |
| | Shiny green | Stopsol Supersilver Green #2 | 47 | 36 | 26 | 2.7 |
| | Silvered | Stopsol Classic Green #1 | 28 | 26 | 35 | 2.7 |
| | Metallic green | Stopsol Classic Green #2 | 29 | 28 | 20 | 2.7 |
| BRONZE | Bronze | Planibel Bronze | 46 | 51 | 8 | 2.7 |
| | Yellowish silver | Stopsol Classic Bronze #1 | 20 | 31 | 34 | 2.7 |
| | Metallic bronze | Stopsol Classic Bronze #2 | 20 | 33 | 12 | 2.7 |
| AZUR | Light blue | Planibel Azur | 66 | 50 | 11 | 2.7 |
| DARK BLUE | Dark blue | Planibel Dark Blue | 52 | 43 | 9 | 2.7 |
| | Silver blue | Stopsol Supersilver Dark Blue #1 | 37 | 32 | 35 | 2.7 |
| | Shiny blue | Stopsol Supersilver Dark Blue #2 | 37 | 34 | 18 | 2.7 |
| PRIVA-BLUE | Dark blue | Planibel PrivaBlue | 31 | 27 | 6 | 2.7 |
| | Silver blue | Stopsol Silverlight PrivaBlue #1 | 24 | 21 | 25 | 2.7 |
| | Deep blue | Stopsol Silverlight PrivaBlue #2 | 25 | 23 | 8 | 2.7 |

(1) General appearance of the glass (neutral, green, bronze, etc.) to be checked against samples.

(2) Identical values for 15 or 16 mm spacer.

Other factors: apart from the solar and thermal performance levels detailed in this table, the level of acoustic and safety performance of the chosen product can easily be enhanced by including 1 or 2 laminated panes of Stratobel safety glass and/or Stratophone acoustic laminated safety-security glass in the sealed unit.

Note: the performance levels detailed opposite apply to 6 mm thick glass. By varying the thickness of the glass, other performance levels may be achieved.

## Solar control and thermal insulation

| Float glass | Look [1] | Insulating glazing 6-16 Ar 90% -4 [2] | LT | SF | LR | $U_g$ |
|---|---|---|---|---|---|---|
| CLEAR | Neutral | Sunergy Clear #2 | 61 | 52 | 12 | 1.8 |
| | Neutral | Sunergy Clear #2 + iplus Top 1.1 #3 | 61 | 45 | 11 | 1.1 |
| | Neutral | Planibel Clear + iplus Top 1.1 #3 | 79 | 61 | 12 | 1.1 |
| | Neutral | Thermobel Energy$^{NT}$ | 72 | 41 | 12 | 1.0 |
| | Neutral | Thermobel Energy$^{N}$ | 72 | 40 | 12 | 1.0 |
| | Neutral | Stopray Vision-50$^{T}$ #2 | 50 | 30 | 17 | 1.0 |
| | Neutral | Stopray Vision-50 #2 | 50 | 28 | 19 | 1.0 |
| | Silver | Stopray Silver | 43 | 27 | 47 | 1.1 |
| | Shiny silver | Stopsol Supersilver Clear #1 + iplus Top 1.1 #3 | 57 | 46 | 37 | 1.1 |
| | Slightly bluish silver | Stopsol Supersilver Clear #2 + iplus Top 1.1 #3 | 57 | 46 | 36 | 1.1 |
| | Amber silver | Stopsol Classic Clear #1 + iplus Top 1.1 #3 | 34 | 32 | 35 | 1.1 |
| | Clear metallic | Stopsol Classic Clear #2 + iplus Top 1.1 #3 | 34 | 33 | 28 | 1.1 |
| GREY | Grey | Planibel Grey + iplus Top 1.1 #3 | 39 | 36 | 6 | 1.1 |
| | Silver | Stopsol Supersilver Grey #1 + iplus Top 1.1 #3 | 26 | 25 | 35 | 1.1 |
| | Metallic steel | Stopsol Supersilver Grey #2 + iplus Top 1.1 #3 | 27 | 26 | 11 | 1.1 |
| | Dark grey | Stopray Titanium 37$^{T}$ #2 | 36 | 24 | 6 | 1.0 |
| | Grey | Sunergy Grey #2 + iplus Top 1.1 #3 | 30 | 27 | 6 | 1.1 |
| | Silvered | Stopsol Classic Grey #1 + iplus Top 1.1 #3 | 17 | 19 | 34 | 1.1 |
| | Metallic grey | Stopsol Classic Grey #2 + iplus Top 1.1 #3 | 17 | 21 | 10 | 1.1 |
| GREEN | Green | Planibel Green + iplus Top 1.1 #3 | 65 | 39 | 10 | 1.1 |
| | Green | Sunergy Green #2 | 51 | 33 | 10 | 1.8 |
| | Green | Sunergy Green #2 + iplus Top 1.1 #3 | 50 | 30 | 9 | 1.1 |
| | Green | Stopray Lime 61$^{T}$ #2 | 59 | 30 | 10 | 1.1 |
| | Silver steel | Stopsol Supersilver Green #1 + iplus Top 1.1 #3 | 46 | 28 | 36 | 1.1 |
| | Shiny green | Stopsol Supersilver Green #2 + iplus Top 1.1 #3 | 46 | 29 | 26 | 1.1 |
| | Silvered | Stopsol Classic Green #1 + iplus Top 1.1 #3 | 28 | 19 | 35 | 1.1 |
| | Metallic green | Stopsol Classic Green #2 + iplus Top 1.1 #3 | 28 | 20 | 20 | 1.1 |

(Continuation)

| Float glass | Look [1] | Insulating glazing 6-16 Ar 90% -4 [2] | LT | SF | LR | $U_g$ |
|---|---|---|---|---|---|---|
| BRONZE | Bronze | Planibel Bronze + iplus Top 1.1 #3 | 45 | 38 | 7 | 1.1 |
| | Amber silver | Stopsol Classic Bronze #1 + iplus Top 1.1 #3 | 19 | 21 | 34 | 1.1 |
| | Metallic bronze | Stopsol Classic Bronze #2 + iplus Top 1.1 #3 | 20 | 22 | 12 | 1.1 |
| AZUR | Light blue | Planibel Azur + iplus Top 1.1 #3 | 65 | 42 | 10 | 1.1 |
| | Light blue | Sunergy Azur #2 | 50 | 36 | 10 | 1.8 |
| | Light blue | Sunergy Azur #2 + iplus Top 1.1 #3 | 50 | 32 | 9 | 1.1 |
| DARK BLUE | Dark blue | Planibel Dark Blue + iplus Top 1.1 #3 | 52 | 35 | 8 | 1.1 |
| | Silvered blue | Stopsol Supersilver Dark Blue #1 + iplus Top 1.1 #3 | 36 | 25 | 35 | 1.1 |
| | Shiny blue | Stopsol Supersilver Dark Blue #2 + iplus Top 1.1 #3 | 36 | 26 | 18 | 1.1 |
| | Dark blue | Stopray Indigo 48T | 47 | 27 | 8 | 1.1 |
| | Deep blue | Sunergy Dark Blue #2 | 37 | 29 | 8 | 1.8 |
| | Deep blue | Sunergy Dark Blue #2 + iplus Top 1.1 #3 | 36 | 26 | 7 | 1.1 |
| PRIVABLUE | Dark blue | Planibel PrivaBlue + iplus Top 1.1 #3 | 31 | 21 | 6 | 1.1 |
| | Silvered blue | Stopsol Silverlight PrivaBlue #1 + iplus Top 1.1 #3 | 24 | 16 | 25 | 1.1 |
| | Dark blue | Stopsol Silverlight PrivaBlue #2 + iplus Top 1.1 #3 | 24 | 17 | 8 | 1.1 |

(1) General appearance of the glass (neutral, green, bronze, etc.) to be checked against samples.

(2) Identical values for 15 or 16 mm spacer.

Other factors: apart from the solar and thermal performance levels detailed in this table, the level of acoustic and safety performance of the chosen product can easily be enhanced by including 1 or 2 laminated panes of Stratobel safety glass and/or Stratophone acoustic laminated safety-security glass in the sealed unit.

Note: The performance levels detailed opposite apply to 6 mm thick glass. By varying the thickness of the glass, other performance levels may be achieved.

## ▼ Colour

The colour is generally a decisive factor when choosing the appropriate type of glass (coloured glass, coated glass, etc.).

In residential buildings, the general trend is towards the neutral and transparent solutions.

In commercial and public buildings, many colours are available. Samples, mock-ups or the AGC Glass Shuttle can help in making the final decision for a given colour or tint.

In curtain-wall facades, it is important to choose a spandrel which either blends or contrasts with the vision glazing.

## 1.1.4 ENSURING SAFETY

The safety specifications and assessments (risk of injury, protecting people from falling through glass, protection from burglary, firearms, explosions and fire, etc.) need to be examined carefully and the safety glazing should be chosen in compliance with required safety performance.

In such cases, thermally toughened safety glass or laminated safety glass are to be chosen.

The level of safety offered by various types of safety glass is defined by the tests executed to categorise their safety performance for various criteria – impact, burglary, bullet-proof, explosion-proof – and depending on the application:

| | Standard | Thermally toughened safety glass | Laminated safety glass | | Pyrobel EG |
|---|---|---|---|---|---|
| | | | Stratobel | Stratophone | |
| Impact resistance and accident prevention | EN 12600 | ✓ | ✓ | ✓ | ✓ |
| Protection from defenestration | EN 12600 | | ✓ | ✓ | ✓ |
| Burglar-proof | EN 356 | | ✓ | ✓ | |
| Bullet-proof | EN 1063 | | ✓ | | |
| Explosion-proof | EN 13541 | | ✓ | | |

In terms of safety, Stratobel and Stratophone perform to the same level.

(However, in terms of sound insulation, Stratophone performs better than Stratobel when comparing the same glazing composition.)

Depending on the national standard, regulations and building codes, you should assess whether other criteria or specifications require laminated safety glass processed in an insulating glazing

*NB: An insulating glazing unit with one laminated safety glass component only provides protection from shocks and injury on the laminated side of the glass.*

Below are some examples as applied in most countries:

> For roof glazing, laminated safety glass is essential to protect persons beneath the glass opening from injury from loose splinters, particularly if external objects fall onto it.

> For windows, which extend to the floor, there is the risk that a person may fall in the event of a shock or if the glass breaks. Only laminated safety glass provides adequate protection against defenestration.

> For shop windows, depending on the value and size of the goods to be protected, a laminated safety glass should be used, the composition of which should be adapted to provide protection from burglary and theft.

*Note: The performance of the joinery and frame should be equivalent to that of the glass element to achieve an acceptable overall performance level.*

*Classification standards also exist for the joinery and frame and help with selecting the appropriate joining product and frame.*

## 1.1.5 ENSURING FIRE RESISTANCE

The required fire protection rating is specified by the respective national building regulations following a risk assessment based on the building characteristics and the location of the fire rated element (facade, partitioning walls, stairways, etc.)

For certain applications like doors, sidelights, glass located near the floor and other hazardous locations, safety performances according to standard EN 12600 are an additional requirement on fire resistant glass.

Fire-resistant glass is only a part of the overall fire resistant component. The glazier is responsible for ensuring that the fire component as a whole meets the required specifications and standards and/or the approval of the relevant authorities. Official fire test reports owned by AGC are therefore available for this purpose.

AGC is not responsible for fire-resistant glass mounted in systems that do not meet the relevant requirements.

The Product Selector below shows how to choose a fire-resistant glass according to specifications:

Building application — Fire Rating EN 13501-2 — Safety Rating on FR Glass EN 12600 → Approved sizes (1) → Product (2)

- Smoke barrier Single glazing
- Interior doors & screens Single glazing
- Interior screens Butt-Jointed Single glazing
- Outside windows & curtain walls Double glazing
- Horizontal screens & Cellings Single glazing

PYROBEL® FIRE RESISTANT GLASS

PYROPANE® FIRE RESISTANT GLASS

(1) For more information about the approved framing system and size, please refer to the respective Data Sheets.

(2) Pyrobel(ite) in an IGU structure can be either 6 – air – Pyrobel(ite) EG or Laminated glass 33.2 – air – Pyrobel(ite).

As an example, see below how to choose a fire-resistant glass for outside windows & curtain walls with EI rating:

| Building application | Fire Rating EN 13501-2 | Safety Rating on FR Glass EN 12600 | Approved sizes (1) | Product (2) |
|---|---|---|---|---|
| Outside windows & curtain walls Double glazing | EI 15 | 1B1 | Medium | PYROBEL 8 EG IGU |
| | EI 30 | 1B1 | Large | PYROBEL 16 EG IGU |
| | EI 45 | 1B1 | Large | PYROBEL 17N EG IGU |
| | EI 60 | 1B1 | Large | PYROBEL 25 EG IGU |
| | EI 90 | 1B1 | Large | PYROBEL 30 EG IGU |
| | EI 120 | 1B1 | Large | PYROBEL 53N EG IGU |

## 1.1.6 BUILDING-INTEGRATED PHOTOVOLTAICS

Different electrical power levels can be achieved depending on the solar cell coverage density.

The table below gives an overview of the installed power depending on solar cell density and the subsequent light transmission of the glazing.

| Applications | Spandrels | Vision Glass | | |
|---|---|---|---|---|
| Cells per m² | 36 | 28 | 24 | 16 |
| Light transmission (%) | 0 | 25 | 33 | 49 |
| Power (Wp/m²) | 146 | 116 | 99 | 66 |

The light transmission, $U_{glass}$, $U_g$-value and electrical characteristics are calculated for every BIPV glass composition on per-project basis.

## 1.1.7 MULTIFUNCTIONAL GLAZING

Various functions (thermal insulation, solar control, safety, sound insulation, decoration) can be combined in a glass element by integrating various single glass components, each with their particular functions, benefits and characteristics.

### ▼ Introduction

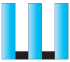
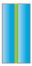
The various functions available (thermal insulation, solar control, sound insulation, safety and security, decoration and aesthetics, etc) can be combined with each other by designing the composition of the glass element.

The following functions are detailed in the tables on the next pages:

| Multifunctionality | Enhanced thermal insulation | Solar control | Sound insulation | Safety & security | Decoration & aesthetics |
|---|---|---|---|---|---|
| Combination 1 | ● | | | | |
| Combination 2 | ● | ● | | | |
| Combination 3 | ● | | ● | | |
| Combination 4 | ● | | | ● | |
| Combination 5 | ● | ● | ● | ● | |
| Combination 6 | ● | | | | ● |
| Combination 7 | ● | ● | ● | ● | ● |

# ▼ Glazing symbols

## Glazing symbols

| | |
|---|---|
|  | Single glazing |
|  | Single glazing thicker than above |
|  | Double glazing |
|  | Triple glazing |
|  | Laminated glass with acoustic PVB or PVB |
|  | Coated glass |
|  | Thermally toughened glass |

## Examples

| | |
|---|---|
|  | Double glazing comprising a coated sheet of glass and a sheet of laminated safety glass with PVB |
|  | Dissymmetrical double glazing in which the thinner glass sheet has a coating in position #2 |

## ▼ How to use and understand the tables?

On the following pages, various tables show the appropriate glass to be used depending on the performance level(s) required.

These tables show:

> Desired performance levels higher than those of standard double glazing are marked with a tick (✓)

> Additional performance levels achieved: in some cases, the glass obtained also enhances other functions which were not necessarily desired (for example, a laminated glass with PVB always enhances acoustic performance even when used to provide safety). These are shown by a bullet (●).

*Note: The tables have been simplified and do not include all information, in particular the thickness of the glass.*

## ▼ Combination n°1: Enhanced thermal insulation

A distinction is made for:

> Thermal insulation, i.e. a $U_g$-value between 1.1 and 1.5 W/(m²K)

- Solution: double glazing with a low-emissivity coating – compulsory in some countries and strongly recommended in terms of energy performance. $U_g$-values below 1.0 W/(m²K) can be achieved using triple glazing.

> Enhanced thermal insulation, i.e. a $U_g$-value less than 1.1 W/(m²K)

- Solution: insulating glazing unit (double glazing or triple glazing) with latest generation of low-e coating iplus Advanced 1.0 or Thermobel Advanced 0.8 or 0.9
- Solution: insulating glazing with iplus low-e coating. Offering optimal $U_g$-values and high solar factor for maximum use of free solar heat.

Today's default insulating glazing is a double glazing with a $U_g$-value of 1.1 W/m²K and there is a clear trend towards double and triple glazing with $U_g$-values between 1.0 and 0.6 W/m²K.

In all the cases below, a low-emissivity coating has to be included in the insulating glazing to enhance the thermal insulation provided.

| Multi-functionality | Enhanced thermal insulation | Solar control | Selective (high LT, low SF) | Sound insulation | Safety & security | Decoration & aesthetics |
|---|---|---|---|---|---|---|
| Standard insulating glazing | | | | | | |
| Insulating glazing with iplus Advanced 1.0 or iplus Top 1.1 | ✓ | | | | | |
| Insulating glazing with iplus Advanced 0.8 or iplus Advanced 0.9 | ✓ | | | | | |
| Insulating glazing (triple glazing) with iplus Top 1.1 or iplus LS | ✓ | | | | | |

## ▼ Combination n°2: Enhanced thermal insulation and solar control

The solar-control glass pane is assembled as the outer pane of the insulating glazing unit. The solar-control coatings are applied in either position 1 (pyrolytic) or 2 (pyrolytic or magnetron).

Solution: solar control glass (coated glass, optionally in combination with body tinted glass).

| Multi-functionality | Enhanced thermal insulation | Solar control | Selective (high LT, low SF) | Sound insulation | Safety & security | Decoration & aesthetics |
|---|---|---|---|---|---|---|
| Insulating glazing DGU with iplus Advanced 1.0 or iplus Top 1.1 | ✓ | | | | | |
| Insulating glazing DGU with iplus Advanced 1.0 or iplus Top 1.1 with Artlite or BIPV | ✓ | ✓ | | | | |
| Insulating glazing DGU with iplus Advanced 1.0 or iplus Top 1.1 with Stopsol | ✓ | ✓ | | | | |
| Insulating glazing DGU with Sunergy with iplus Advanced 1.0 or iplus Top 1.1 | ✓ | ✓ | | | | |
| Insulating glazing DGU with Stopray or ipasol | ✓ | ✓ | ✓ | | | |
| Insulating glazing TGU with iplus Top 1.1 or iplus LS with Stopray or ipasol | ✓ | ✓ | ✓ | | | |

### ▼ Combination n°3: Enhanced thermal insulation and sound insulation

An acoustic insulating glazing has to be chosen in order to increase the acoustic comfort.

The solutions in ascending order of efficiency are:

> an insulating glazing with glass components of different thicknesses

> an insulating glazing with one or two laminated glass panes and a PVB interlayer (this glass is designed for safety purposes but also provides enhanced sound insulation)

> an insulating glazing with one or two laminated glass panes and an acoustic PVB interlayer.

With equal compositions, it is always advisable to widen the spacer within the insulating glazing assembly.

Other functions are possible by altering the glass components. See below.

| Multifunctionality | Enhanced thermal insulation | Solar control | Selective (high LT, low SF) | Sound insulation | Safety & security | Decoration & aesthetics |
|---|---|---|---|---|---|---|
| Dissymmetrical insulating glazing DGU with iplus Advanced 1.0 or iplus Top 1.1 | ✓ | | | ✓ | | |
| Dissymmetrical insulating glazing DGU with iplus Advanced 1.0 or iplus Top 1.1 with Stratobel | ✓ | | | ✓ | ● | |
| Dissymmetrical insulating glazing DGU with iplus Advanced 1.0 or iplus Top 1.1 with Stratophone | ✓ | | | ✓ | ● | |
| Dissymmetrical insulating glazing TGU with iplus Top 1.1 or iplus LS | ✓ | | | ✓ | | |
| Dissymmetrical insulating glazing TGU with iplus Top 1.1 or iplus LS with Stratobel | ✓ | | | ✓ | ● | |
| Dissymmetrical insulating glazing TGU with iplus Top 1.1 or iplus LS with Stratophone | ✓ | | | ✓ | ● | |

### ▼ Combination n°4: Enhanced thermal insulation and safety

There are several levels of safety and different glass products that meet the individual requirements at each of these levels.

#### Protection of individuals from injury (no risk of defenestration)

Solution: thermally toughened safety glass or laminated safety glass.

An insulating glazing unit comprising thermally toughened safety glass and annealed glass provides no protection from the risk of injury if both panes break at the same time. For safety reasons, when a thermally toughened safety glass is used in an insulating unit, the other glass should also be thermally toughened or laminated.

To prevent accidents, the safety glass should be positioned on the side on which the impacts are likely to occur. Where such load impacts are likely to occur on either side of the glass, insulating glazing units comprising two sheets of safety glass (laminated or thermally toughened safety glass) should be used.

#### Protection of individuals from injury (risk of defenestration)

Solution: only laminated safety glass can be used.

#### Roof glazing

Solution: laminated safety glass must be used. It is assembled as a lower glass component to protect individuals from injuries due to glass debris or the impacting body passing through the glass element.

#### Protection from vandalism and burglary in shops, isolated dwellings and homes located in unsafe districts

Solution: laminated safety glass. The relevant type of laminated safety glass according to the desired level of safety should be selected according to building code criteria or recommendations from insurance companies.

#### Protection from firearms, explosions and fires

Solution: special series of laminated safety glass products. Special cases should be assessed individually.

| Multifunctionality | Enhanced thermal insulation | Solar control | Selective (high LT, low SF) | Sound insulation | Safety & security | Decoration & aesthetics |
|---|---|---|---|---|---|---|
| Insulating glazing DGU with iplus Advanced 1.0 or iplus Top 1.1 with 2 thermally toughened safety glass sheets as outer pane | ✓ | | | | ✓ | |
| Insulating glazing DGU with iplus Advanced 1.0 or iplus Top 1.1 with Stratobel or Stratophone | ✓ | | | ● | ✓ | |

### ▼ Combination n°5: Enhanced thermal insulation, solar control, acoustic and safety

Solution: double glazing comprising one (or two) laminated glass sheets with PVB or acoustic PVB and assembled with a Stopsol or Sunergy coating combined with an iplus coating or eventually a single coating Stopray or ipasol having a combined function of solar control and low-e functionality.

| Multifunctionality | Enhanced thermal insulation | Solar control | Selective (high LT, low SF) | Sound insulation | Safety & security | Decoration & aesthetics |
|---|---|---|---|---|---|---|
| Insulating glazing DGU with iplus Advanced 1.0 or iplus Top 1.1 with Stopsol with Stratobel or Stratophone | ✓ | ✓ | | ✓ | ✓ | |
| Insulating glazing DGU with Sunergy with iplus Advanced 1.0 or iplus Top 1.1 with Stratobel or Stratophone | ✓ | ✓ | | ✓ | ✓ | |
| Insulating glazing DGU with Stopray with Stratobel or Stratophone | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Insulating glazing TGU with iplus Top 1.1 or iplus LS with Stopray or ipasol with Stratobel or Stratophone | ✓ | ✓ | ✓ | ✓ | ✓ | |

## ▼ Combination n°6: Enhanced thermal insulation and decoration

Solution: insulating glazing with Artlite

Enhanced thermal insulation may be achieved by using an iplus low-e coating: one iplus low-e coating for a double glazing unit and two iplus low-e coatings for a triple glazing unit.

| Multifunctionality | Enhanced thermal insulation | Solar control | Selective (high LT, low SF) | Sound insulation | Safety & security | Decoration & aesthetics |
|---|---|---|---|---|---|---|
| Insulating glazing DGU with iplus Advanced 1.0 or iplus Top 1.1 with Imagin or Oltreluce | ✓ | | | | | ✓ |
| Insulating glazing DGU with iplus Advanced 1.0 or iplus Top 1.1 with Artlite | ✓ | ● | | | | ✓ |
| Insulating glazing TGU with iplus Top 1.1 or iplus LS with Artlite | ✓ | ● | | | | ✓ |

## ▼ Combination n°7: Enhanced thermal insulation, solar control, acoustic, safety and decoration.

| Multifunctionality | Enhanced thermal insulation | Solar control | Selective (high LT, low SF) | Sound insulation | Safety & security | Decoration & aesthetics |
|---|---|---|---|---|---|---|
| Insulating glazing DGU with iplus Advanced 1.0 or iplus Top 1.1 with Stopsol Artlite with Stratobel or Stratophone | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Insulating glazing DGU with Sunergy Artlite with iplus Advanced 1.0 or iplus Top 1.1 with Stratobel or Stratophone | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Insulating glazing DGU with Stopray[T] Artlite with Stratobel or Stratophone | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Insulating glazing TGU with iplus Top 1.1 or iplus LS with Stopray[T] Artlite with Stratobel or Stratophone | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

## 1.1.8 FIRE PROTECTION

Different performance levels (E, EW, EI) can be achieved using different fire-resistant glass products. The table below gives an overview of the AGC range.

| Performance | Polished wired glass | Pyropane | Pyrobel/Pyrobelite |
|---|---|---|---|
| E | ✓ | ✓ | ✓ |
| EW | | ✓ | ✓ |
| EI | | | ✓ |
| DH | | ✓ | |

## 1.1.9. CHECK FEASIBILITY

Once the type of glass has been chosen (float glass, laminated safety glass or insulating glazing) and the composition determined, check with your AGC contact or AGC factory on the availability of product, the production feasibility and terms of delivery. Or consult the Product Catalogue on www.yourglass.com.

Pay attention to the handling of the glass element in the building (facade, roof or interior wall). Make sure that the size and weight allow safe handling and installation. Check access for cleaning and maintenance purposes, including practicalities for replacing the glass element.

# 1.2 – Facade applications

## 1.2.1 SILICONE STRUCTURAL GLAZING

Silicone Structural Glazing allows to bond glass elements (single glazing or insulating glazing) onto a curtain wall frame by using bonding adhesives and sealants. This results in maximizing the building transparency through the reduction or removal of the mechanical fixation.

A preliminary study is required for SSG projects for which a standard template has to be filled in.

## 1.2.2 SPANDRELS

Spandrel glass hides the opaque sections and supporting structure of facades.

Spandrels can be combined with vision glazing to create all-glass facades.

Depending on the products and colours used, either optimal harmony or contrasting effects can be achieved.

Different functions can be integrated within spandrels such as thermal insulation, sound insulation and fire protection.

The following types of spandrels are available:

> enamelled single glass: where either a pane of clear float glass, body-tinted glass or glass with a pyrolytic coating is used as substrate with an enamel and then thermally toughened or heat-strengthened

> an insulating glazing comprising the same glass as vision glass for the outer glass pane and an enamelled glass as inner pane

> shadow box: a spandrel comprising a vision glazing combined with an opaque background (metal sheet, etc.) to achieve a partially opaque effect in harmony with the building.

Ideally the thickness of the spandrel glass should be the same as the outer glass pane of the vision glazing thus providing a match in terms of colour and aesthetics.

By default, spandrel glass must be heat-treated (toughened safety glass or heat-strengthened glass) to prevent thermal breakage unless a preliminary thermal study concludes differently.

A preliminary study is required for cases where insulating glazing is installed as a spandrel. For each constituent, check for the maximum allowable work temperature for every constituent component as indicated by the manufacturer.

Please refer to the coating product pages for recommended spandrel elements.

The recommendations for harmonising colours for each product are given for information purposes only. They are based on a range of tests designed to identify the best possible solution without the latter necessarily being a perfect match (harmony).

It is not uncommon for an architect to seek to achieve a degree of contrast between vision glazing and spandrels rather than complete harmony.

Some combinations of glass may give rise to more or less marked differences in colour or reflection. Such differences are due to the nature of the glass used, the angle of vision, surroundings, weather conditions, light intensity at a particular time, etc.

For all these reasons, AGC advises clients to build prototypes for each project and to view them on-site during the construction phase to confirm their choice. AGC cannot be held responsible for any differences in harmony, colour or reflection in a facade.

# 2
# DECORATIVE GLASS

Pomme Sucrée - Gijón, Spain - Architect: Francesc Rifé - Lacobel White Pearl & MyColour by Lacobel

# 2.1 – Factors influencing the choice of glass

Both the aesthetic and functional requirements of a design project define the choice of a specific decorative glass. There is an AGC decorative glass solution for every design project.

## 2.1.1 TYPE OF APPLICATION

Glass products can be used in a very large range of applications:

> floors, stairs
> balustrades
> wall cladding
> partitions
> furniture: both in horizontal (tables, shelves, etc.) and vertical (decoration or structural elements) applications
> doors: such as furniture doors, sliding doors, entry doors to buildings
> mirrors
> frames
> others.

The type of application determines the functional and aesthetic requirements of the glass product.

## 2.1.2 SAFETY

AGC can provide different solutions to make the final glass installation safe:

> thermally toughened safety glass
> laminated safety glass
> glass with a SAFE or SAFE+ film
> fire-resistant glass.

Some applications such as floors or balustrades, automatically require laminated glass to be used for safety reasons. For other applications such as furniture, wall cladding, etc., most countries have national regulations requiring safety glass to be used in certain situations.

## 2.1.3 INSTALLATION

Decorative glass products may be installed via bonding, mechanical fixing, pressure gaskets and other methods.

Make sure to follow AGC's installation guidelines for the various AGC decorative glass products. They can be downloaded from www.yourglass.com.

*For more information on AGC's silicone bonding solutions, please refer to the "FIX-IN" section in the Painted Glass chapter.*

## 2.1.4 APPEARANCE

AGC's decorative glass products offer a wide choice in terms of appearance, colour, patterns and surface finishing.

> Transparent glass solutions provide the greatest possible transparency: objects and people are clearly visible through the glass.

> Translucent glass solutions provide a degree of privacy: just the shape of objects and people can be made out through the glass. Depending on the products, the level of light transmission of translucent glass may be just as high as that of transparent glass.

> Opaque glass solutions provide a full coverage: objects and people cannot be seen through the glass.

> Reflective glass solutions provide either a full or partial coverage. Objects and people are reflected by the glass' reflective surface.

## 2.1.5 OTHER OPTIONS

AGC offers additional glass products that meet special requirements:

> AntiBacterial™ glass: thanks to a special layer of silver ions onto the glass surface, the antimicrobial action of the silver eliminates 99.9% of all bacteria that form on its surface and prevents the spread of fungi (available as Lacobel AB, Mirox AB, Planibel AB)

> Stratophone: a laminated safety glass using acoustic PVB interlayers for sound reduction performance.

# 2.2 – Transparent, Translucent or Opaque?

| | Transparent | Translucent | Opaque |
|---|---|---|---|
| Neutral | Planibel Clear, Clearvision, Coloured<br>Stratobel | | |
| Coloured | Planibel Coloured<br>Stratobel Colour | Stratobel Colour (Matelux glass & coloured PVB)<br>Artlite (Digital) | Stratobel with opaque PVB<br>Lacobel, Lacobel T<br>Colorbel |
| Reflective | | ipachrome design<br>Stopsol Supersilver | MNGE<br>Mirox 3G<br>Sanilam Easycut<br>Black Mirox |
| Satin finish | | Matelux<br>Lacomat | Matelac |
| Patterned glass | | Stratobel EVA & Impression<br>Imagin<br>Oltreluce | Oltreluce Silver |
| Specialties | Planibel AB<br>Stratophone | Stratophone | Lacobel and Mirox AB<br>Stratophone |

## 2.2.1 TRANSPARENT GLASS

AGC offers a wide range of transparent glass, in clear, extra-clear and coloured versions. The table below will guide you through its possible major applications and uses.

| Product | Description | Applications | | | | | | Use | |
|---|---|---|---|---|---|---|---|---|---|
| | | Showerglass | Flooring(1) | Balustrade(1) | Partitions(2) | Furniture(2) | Doors(2) | Exterior | Interior |
| Planibel Clear, Clearvision and Linea Azzurra | Clear float glass | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Planibel Coloured | Body-tinted float glass | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Stratobel | Laminated safety glass with transparent PVB interlayer(s) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Stratobel Colour | Laminated safety glass made by either coloured Planibel or coloured PVB | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

(1) These products may only be used in laminated glass.
(2) In most countries, regulations require the use of safety glass (toughened, laminated, with a SAFE film) for certain applications.

# 2.2.2 TRANSLUCENT GLASS

| Product | Description | Applications | | | | | | | Use | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Showerglass | Flooring(1) | Balustrade(1) | Mirrors | Partitions(2) | Furniture(2) | Doors(2) | Exterior | Interior |
| Stratobel, Stratobel Colour | Laminated safety glass, with matt, white, printed or coloured PVB or Matelux glass | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| ipachrome design Stopsol Supersilver | Float glass with a highly reflective coating | ✓ | | | ✓ | ✓ | ✓ | | ✓ | |
| Imagin (wired) | Patterned glass, including wired and anti-glare glass | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Oltreluce | Patterned glass | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Artlite (Digital) | Silk screen-printed and heat-treated glass | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Lacomat | Painted, satin finished glass | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Matelux | Satin finished, acid-etched glass | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |

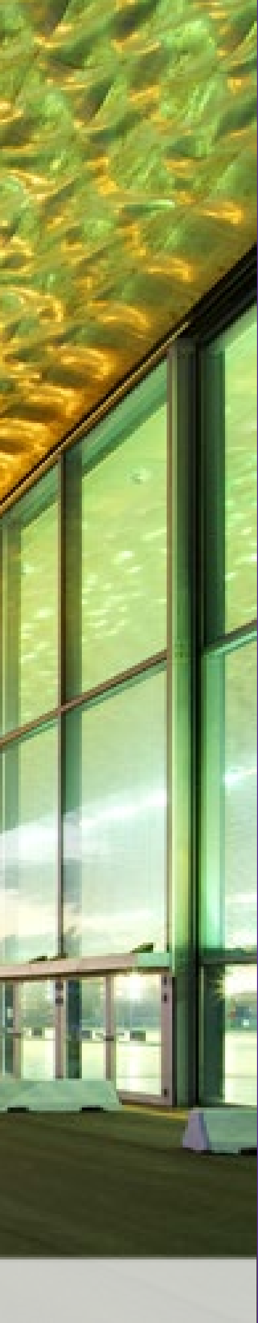
(1) These products may only be used in a safety version.
(2) In most countries, regulations require the use of safety glass (toughened, laminated, with a SAFE film) for certain applications.

## 2.2.3 OPAQUE GLASS

| Product | Description | Applications | | | | | | | | Use | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Showerglass | Flooring(1) | Balustrade(1) | Mirrors | Wall cladding(2) | Partitions(2) | Furniture(2) | Doors(2) | Exterior | Interior |
| Stratobel Colour | Laminated safety glass using fully opaque PVB interlayers | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Lacobel(3) | Painted glass | | ✓ | | | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Lacobel T(3) | Painted toughened glass | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Matelac(3) | Painted or silvered, satin finished (acid-etched) glass | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Mirox MNGE | Copper-free and low-lead environmentally friendly mirror | | | | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| Mirox 3G | Ecological mirror – ROHS | | | | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| Sanilam Easycut | Laminated double sided mirror | | | | ✓ | | | ✓ | | | ✓ |

(1) These products may only be used in a safety version.
(2) In most countries, regulations require the use of safety glass (toughened, laminated, with a SAFE film) for certain applications.
(3) The back of the glass should not be visible.

Blue Pavilion - Fiera Del Mare, Genoa, Italy - Architect: Sandro Carbone - Planibel Clear & Sunergy Clear



# IV
# Brands and products

## 1. Float

# 1.1 – Introduction

IBGE/BIM - Brussels, Belgium - Architect: Cepezed bv / Samyn and Partners - Thermobel Energy$^N$ (laminated) on Planibel Clearvision

Planibel is AGC's high quality range of float glass which can be processed in numerous ways for use in multiple sectors, such as the construction, decoration, automotive and high-tech industries.

Planibel float glass is produced using the float glass manufacturing process mastered by AGC at its European plants. The transparent sheet glass presents a perfectly flat, planar and parallel face with uniform properties across the entire surface. The Planibel range is available in:

> 3 neutral clear colours: clear, extra-clear (Clearvision) and Linea Azzurra

> 7 body tinted colours: Green, Grey, Bronze, Azur, PrivaBlue, Dark Blue, Dark Grey.

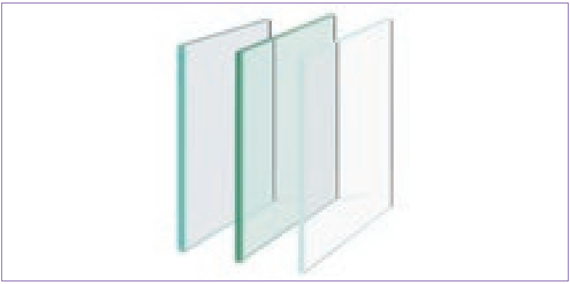
The Planibel range presents certified products complying with all main European standard, such as EN 572-1 and 2 – Glass in building – Basic soda lime silicate glass products – Part 1: Definitions and general physical and mechanical properties and Part 2: Float glass.

All products are CE-marked in compliance with EN 572-9.

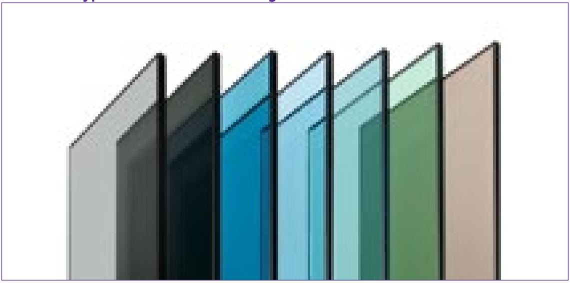
Planibel float glass can be used as single monolithic glazing, insulating double or triple glazing, as well as laminated glass. It is furthermore compatible with almost all types of glass processing.

Planibel float glass is an environmental friendly product which can be fully recycled. All Planibel products are Cradle to Cradle Certified™ Silver.

The three types of Planibel float glass (Linea Azzurra – Clear – Clearvision)



The seven types of Planibel Coloured glass



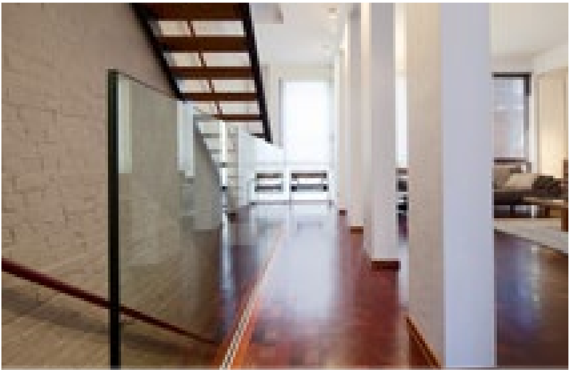
# 1.2 – Float glass ranges

Arca Regler GmbH - Düsseldorf, Germany - Architect: AJF Proiekt GmbH - Planibel Linea Azzurra

# Planibel Clear, Clearvision, Linea Azzurra

## ▼ DESCRIPTION

### Planibel Clear



Private house - Brussels, Belgium - Architect: E. Bouffioux - Planibel Clear

> Planibel Clear is AGC's float glass suitable for multiple applications in the construction, interior decoration and, more broadly, the automotive and high-tech sectors

> Planibel Clear can be processed in every imaginable way:

- insulating glazing, laminated safety glass, thermally toughened glass, enamelled glass, silk-screen printed glass, sandblasted glass, acid-etched glass, bent glass, etc.

## Planibel Clearvision

Torre Iberdrola - Bilbao, Spain - Architect: César Pelli - Planibel Clearvision

> Planibel Clearvision is an extra-clear, low-iron float containing less than < 200 ppm $Fe_2 0_3$ iron oxide. Planibel Clearvision fits in with current architectural trends towards neutrality, purity and luminosity

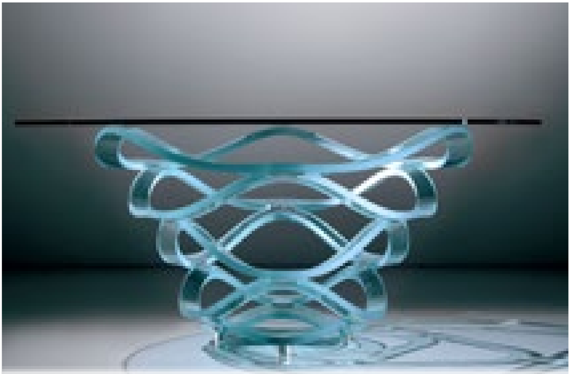
> Its low-iron content gives it an extra-clear appearance (without the dominant green tint seen in ordinary glass), a very high light-transmission rating (92%) and a high level of energy transmission

> An excellent colour rendering index offers a superb appearance. Even in extra-thick versions, the substrate remains perfectly neutral, proof of just how pure this product is

> All processing techniques are suitable: insulating glazing, laminated safety glass, thermally toughened glass, enamelled glass, sandblasted glass, acid-etched glass, bent glass, etc.

> Planibel Clearvision can be used in various decorative applications and in facades, as well as in all applications where maximum solar gain is required.

## Planibel Linea Azzurra



Neolitico - Italy - Planibel Linea Azzurra

> Planibel Linea Azzurra is a clear glass available in large thicknesses and featuring a unique bluish tint

> Ideal for use in large glazed areas and for high-end furniture and decoration

> The high quality of the glass makes processing easy, particularly cutting and bending.

## ▼ BENEFITS

> A large range of neutral clear float glass suitable for a multitude of interior and exterior applications

> All products offer numerous processing options

> All Planibel products are Cradle to Cradle Certified™ Silver.

## ▼ PERFORMANCE

| Planibel | Composition (mm) | Light properties | | Energy properties | | | $U_g$-value W/(m²K) |
|---|---|---|---|---|---|---|---|
| | | LT (%) | LR (%) | Tot EA (%) | SF (%) | SC | |
| Clear | 3 | 90 | 8 | 6 | 88 | 1.01 | 5.8 |
| | 4 | 90 | 8 | 8 | 86 | 0.99 | 5.8 |
| | 5 | 89 | 8 | 10 | 85 | 0.98 | 5.7 |
| | 6 | 89 | 8 | 12 | 84 | 0.97 | 5.7 |
| | 8 | 88 | 8 | 15 | 82 | 0.94 | 5.6 |
| | 10 | 87 | 8 | 18 | 79 | 0.91 | 5.6 |
| | 12 | 86 | 8 | 21 | 77 | 0.89 | 5.5 |
| Clearvision | 3 | 92 | 8 | 1 | 91 | 1.05 | 5.8 |
| | 4 | 92 | 8 | 1 | 91 | 1.05 | 5.8 |
| | 5 | 91 | 8 | 2 | 91 | 1.05 | 5.7 |
| | 6 | 91 | 8 | 2 | 90 | 1.03 | 5.7 |
| | 8 | 91 | 8 | 3 | 90 | 1.03 | 5.6 |
| | 10 | 91 | 8 | 3 | 89 | 1.03 | 5.6 |
| | 12 | 91 | 8 | 4 | 89 | 1.02 | 5.5 |
| Linea Azzurra | 8 | 87 | 8 | 20 | 78 | 0.90 | 5.6 |
| | 10 | 86 | 8 | 24 | 75 | 0.86 | 5.6 |
| | 12 | 85 | 8 | 28 | 72 | 0.83 | 5.5 |
| | 15 | 83 | 8 | 33 | 69 | 0.79 | 5.4 |
| | 19 | 81 | 7 | 38 | 65 | 0.75 | 5.3 |
| | 25 | 78 | 7 | 44 | 60 | 0.69 | 5.2 |

## ▼ STANDARD SIZE AND THICKNESSES (mm)

Planibel Clear, Clearvision and Linea Azzurra are available in a full range of standard sizes and thicknesses.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

Other specific non-standard dimensions (even larger than Jumbo 3,210 mm x 6,000 mm) and thicknesses are available on request with a minimum quantity order.

A special range of extra-thin clear glass specifically for high-tech applications (electronics, frames, displays, etc.) includes thicknesses ranging from 2 mm down to 0.85 mm (contact your local AGC representative for more information).

## ▼ PROCESSING OPTIONS

| Heat treatment | | |
|---|---|---|
| Thermally toughened or heat-strengthened | | Yes |
| Silk-screen printing and enamelling | | Yes |
| Bending | | Yes |
| **Laminated glass** | | |
| PVB | | Yes<br>- For assemblies with safety PVB, see Stratobel<br>- For assemblies with acoustic safety PVB, see Stratophone<br>- For assemblies with decorative safety PVB or with EVA, see Decorative laminated glass |
| EVA | | |

## ▼ USES

| | | |
|---|---|---|
| Monolithic glass | | Yes |
| Insulating glass | | Yes |
| Low-emissivity insulating glass | | Yes – with low-e coating in #3 & #5 (for triple glazing) |

## ▼ APPLICATIONS

| | |
|---|---|
| Interior | Yes |
| Exterior | Yes |

# Planibel Coloured

Private house - Hungary - Designer of sliding doors: Alu-Style Kft - Planibel Bronze

## ▼ DESCRIPTION

> The AGC Planibel Coloured range comprises body-tinted glass which can be used for solar control, decorative, industrial and other applications

> It can be processed in any way for use in numerous sectors, including construction, decoration, automotive, etc.

> Various colours available (Green, Grey, Bronze, Azur, Priva-Blue, Dark Blue, Dark Grey)

> Coloured glass can deliver medium levels of solar control

> Assembled with low-e glass in insulating glazing units, it can furthermore provide thermal insulation performances

> Uses: single glazing, insulating glazing, laminated glass, thermally toughened glass, enamelled glass.

## ▼ BENEFITS

> Can be processed in many different ways: lamination, thermal treatment, bending, etc.

> Wide range of colours, including a unique range of blue colours. Mainly used in facades and interiors

> Low level of light reflection

> Medium level of solar control

> All Planibel products are Cradle to Cradle Certified™ Silver.

## ▼ COMMENTS

> High level of energy absorption. We advise ascertaining whether the glass should be toughened

> Planibel coloured is a body-tinted glass. To secure perfect colour uniformity on the facade, we advise against mixing Planibel coloured glass of various thicknesses since the appearance will be different

> The thicker the Planibel glass, the darker the colour.

## ▼ PERFORMANCE AND COLOUR RANGE

| Planibel | Light properties | | Energy properties | | | $U_g$-value W/(m²K) |
|---|---|---|---|---|---|---|
| | LT (%) | LR (%) | Tot EA (%) | SF (%) | SC | |
| **6 mm Planibel** | | | | | | |
| Green | 73 | 7 | 51 | 56 | 0.64 | 5.7 |
| Bronze | 51 | 6 | 45 | 61 | 0.70 | 5.7 |
| Grey | 44 | 5 | 49 | 58 | 0.67 | 5.7 |
| Azur | 73 | 7 | 45 | 60 | 0.69 | 5.7 |
| PrivaBlue | 35 | 5 | 75 | 38 | 0.44 | 5.7 |
| Dark Blue | 58 | 6 | 54 | 53 | 0.61 | 5.7 |
| Dark Grey | 8 | 4 | 88 | 29 | 0.33 | 5.7 |
| **6 mm Planibel Coloured glass - 16 - 4 mm Planibel Clear (1)** | | | | | | |
| Green | 66 | 11 | 54 | 46 | 0.53 | 2.7 |
| Bronze | 46 | 8 | 50 | 51 | 0.59 | 2.7 |
| Grey | 40 | 7 | 53 | 47 | 0.54 | 2.7 |
| Azur | 66 | 11 | 49 | 50 | 0.57 | 2.7 |
| PrivaBlue | 31 | 6 | 77 | 27 | 0.31 | 2.7 |
| Dark Blue | 52 | 9 | 57 | 43 | 0.49 | 2.7 |
| Dark Grey | 7 | 5 | 89 | 25 | 0.29 | 2.7 |

(1) Identical values for a 15 or 16 mm spacer.

## ▼ STANDARD SIZE AND THICKNESSES (mm)

Planibel Coloured products are available in a wide range of standard sizes and thicknesses.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

Other specific non-standard dimensions and thicknesses are available on request with a minimum quantity order.

## ▼ PROCESSING OPTIONS

| | | |
|---|---|---|
| **Heat-treatment** | | |
| Thermally toughened or heat-strengthened | | Yes |
| Silk-screen printing and enamelling | | Yes |
| Bending | | Yes |
| **Laminated glass** | | |
| PVB | | Yes<br>- For assemblies with safety PVB, see Stratobel<br>- For assemblies with acoustic safety PVB, see Stratophone<br>- For assemblies with decorative safety PVB or with EVA, see Decorative laminated glass |
| EVA | | |

## ▼ USES

| | | |
|---|---|---|
| Monolithic glass | | Yes |
| Insulating glass | | Yes |
| Low-emissivity insulating glass | | Yes – with low-e coating in #3 & #5 (for triple glazing) |

## ▼ APPLICATIONS

| | |
|---|---|
| Interior | Yes |
| Exterior | Yes |

Ambassador Office Building - Warsaw, Poland - Architect: AMC - Andrzej M. Choldzynski Sp. z o. o. - Stopray Vision-50T

# — IV —
# Brands and products

## 2. Exterior glass

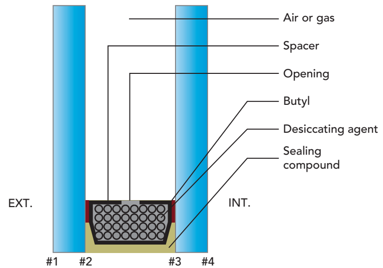
# 2.1 – Introduction

Ex-Sieroterapico - Milan, Italy - Architect: Dante O. Benini & Partners - iplus Energy[NT]

# ▼ INSULATING GLAZING ASSEMBLIES – GENERAL

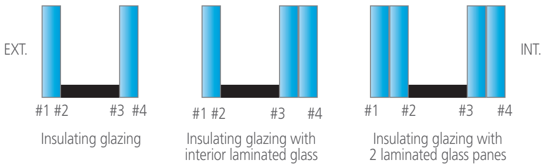
These are sealed units comprising several panes of glass which, having been assembled and sealed in the factory, are separated by hermetically sealed space(s) containing air or an insulating gas. The main aim of such assemblies is to use the insulating properties of the air or gas space to lower the thermal transmittance ($U_g$ value) of the glazing. The latter's insulating properties can be further enhanced in various ways (low-emissivity coatings, gas, etc). The unit may be double- or triple-glazed.

**Insulating glazing: components and numbering of the sides**

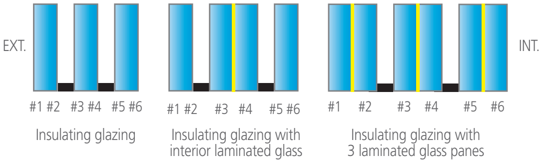



The sides of insulating glazing are generally numbered positions 1 to 4 from the outside in, the outside being on the left in the diagram below.

**Numbering of the sides of a double glazing unit**



**Numbering of the sides of a triple glazing unit**




The composition of a sealed unit is shown by three figures (in mm) representing the following thicknesses:

> The external pane of glass

> The air or gas space

> The internal pane of glass.

Example: 6/12/4 indicates an external 6 mm thick glass pane, a spacer measuring 12 mm and an internal 4 mm thick glass pane.

## ▼ DOUBLE GLAZING COMPONENTS

Double glazing comprises the following elements:

> Two panes of glass

> A spacer to determine the width of the space between the two panes of glass. This may be assembled with corner mechanisms, bent or welded. The spacer may be made of steel or aluminium. Spacers made of synthetic or composite materials ("warm edge") are also available. A synthetic spacer is used for specific applications

> The space between the two panes of glass may be filled with air or with another gas injected during the manufacturing process (argon or krypton)

> An initial waterproof barrier made of butyl and positioned on the side of the spacer which is in contact with the glass. It is designed to prevent moisture from entering the air or gas space

> A second waterproof barrier or seal linking the panes of glass and the spacer. This is designed to ensure that the assembly is mechanically stable. The seal is made of polysulphide, polyurethane or silicone. Only silicone is suitable if the seal is to be exposed to solar radiation or in some specific applications

> A desiccant placed in the spacer to dry out (adsorb) the gas trapped at the point where the glass touches it and to adsorb any steam that enters the unit over time through the outside seal.

The lifespan of a unit will depend on the performance of the desiccant and the waterproof barriers. If the desiccant becomes ineffective or if the seal is no longer hermetic, condensation will form inside the unit and it will have to be replaced.

AGC offers all possible joint technologies (PU, PS, silicone) and spacer bars (aluminium, steel, Warm Edge). AGC also offers the unique possibility of combining silicone with an argon filling or even a warm-edge (Warm-E) spacer.

## ▼ THE AGC GUARANTEE

Insulating glazing supplied by AGC Glass Europe carry the Thermobel brand. The guarantee specifies that vision performance through the insulating glazing will not be affected by condensation or dust on the inside of the unit. This guarantee does not cover breakage or cracks in the glass or replacement windows which have become defective once the guarantee period on the original glazing has expired.

*Please see duration, terms and conditions of the guarantee, available on www.yourglass.com.*

## ▼ ALTITUDE

Insulating glazing units that must travel or be fitted 800 metres higher than the production location will either be levelled out in advance in the workshop or will be fitted with a levelling mechanism. It is important to specify this when placing your order.

## ▼ MULTIPLE FUNCTIONS

By varying Thermobel's components, other functions can be obtained which will complement the glazing's thermal insulation properties: enhanced thermal insulation, solar control, sound insulation, safety and decoration.

# 2.2 – Thermal insulation

Private house - Paris, France - Architect: G. Hamonic & JC Masson - Thermobel Energy[N]

## ▼ INTRODUCTION

Thermal insulation is the ability of a glazing to prevent heat exchanges between the exterior and the interior environments; it is one of the most important properties of a glazing, enabling it to provide protection from the cold in winter, prevent heat losses, save heating energy, and provide thermal comfort inside a building.

The insulating property of a glazing is measured by its $U_g$-value (defined in EN 673). The lower the value, the better. Several techniques are used to enhance a glazing's $U_g$-value.

The first technique is the well-known use of glass assemblies: several glass panes are assembled together to construct double glazing or triple glazing structures. The space between the different panes is filled with noble gas (argon or krypton) that acts as a thermal insulating layer in the assembly. Since triple glazing has two gas-filled cavities, it is nearly twice as effective as double glazing, which has only one gas-filled cavity. The thermal insulation and the $U_g$-value of an insulating glass can be improved by:

> the choice of noble gas used: krypton enables better thermal performance than argon

> optimising the space between the glass panes, typically in the range of 10 mm to 20 mm

> using so-called warm edge spacers to prevent heat conduction between the glass panes.

AGC's registered brand name for double glazing structures is Thermobel. Triple glazing structures bear the name Thermobel TG.

The second technique is the use of neutral[(1)] and transparent coatings applied to the glass. These coatings are called low-e coatings or *high-performance* coatings and are designed to let light and energy into the building, while preventing heat from escaping. Over the years, AGC has developed a full range of low-e coatings providing – in addition to thermal insulation – different functions (compatibility with the tempering process[(2)], solar control, anti-condensation, etc.) for different applications (double glazing, triple glazing, etc.).

AGC's registered brand name for low-e coatings is iplus.

AGC supplies the single glass panes (iplus) to customers making their own insulating glass units, as well as the final insulating glass units (Thermobel) to customers such as window makers and facade glazers.

The following tables summarise the AGC range.

(1) Neutral coatings are coatings that do not affect the color rendering of objects when observed through the glazing. For example, a red object remains red when observed through a neutral coating.

(2) For some applications and markets, coatings need to be toughened to have their mechanical resistance improved relative to thermal shocks or to ensure compliance with certain safety standards.

## Double glazing assemblies

| Single coated pane | Assembled in double glazing | Typical composition | Coating position(s) | $U_g$-value W/(m²K) | LT (%) | LR (%) | g (%) | Key feature |
|---|---|---|---|---|---|---|---|---|
| iplus Top 1.1 | Thermobel Top | 4 - 16 Ar 90% - 4 | #3 | 1.1 | 80 | 12 | 63 | Thermal insulation |
| iplus Top 1.1$^T$ | Thermobel Top$^T$ | 4 - 16 Ar 90% - 4 | #3 | 1.1 | 81 | 12 | 64 | Thermal insulation, toughenability |
| iplus Advanced 1.0 | Thermobel Advanced | 4 - 16 Ar 90% - 4 | #3 | 1.0 | 76 | 15 | 55 | Enhanced thermal insulation |
| iplus Advanced 1.0$^T$ | Thermobel Advanced$^T$ | 4 - 16 Ar 90% - 4 | #3 | 1.0 | 80 | 13 | 60 | Enhanced thermal insulation, toughenability |
| iplus Energy$^N$ | Thermobel Energy$^N$ | 4 - 16 Ar 90% - 4 | #2 | 1.0 | 73 | 12 | 41 | Enhanced thermal insulation, solar control |
| iplus Energy$^{NT}$ | Thermobel Energy$^{NT}$ | 4 - 16 Ar 90% - 4 | #2 | 1.0 | 73 | 12 | 42 | Enhanced thermal insulation, solar control, toughenability |
| iplus AF Top | Thermobel AF Top | 4 - 16 Ar 90% - 4 | #1 and #2 | 1.1 | 76 | 16 | 56 | Thermal insulation, anti-condensation |
| iplus AF Energy$^N$ | Thermobel AF Energy$^N$ | 4 - 16 Ar 90% - 4 | #1 and #2 | 1.0 | 68 | 16 | 39 | Enhanced thermal insulation, solar control, anti-condensation |

## Special AGC assemblies

Thanks to specific developments components other than coatings, AGC has also developed its own special assemblies for double glazing, as described in the table below[1].

| AGC special assemblies | Typical composition | $U_g$-value W/(m²K) | LT (%) | LR (%) | g (%) | Key feature |
|---|---|---|---|---|---|---|
| Thermobel Advanced 0.8 | 4 - 10 AGC gas - 4<br>Coatings in position #2 and #4 | 0.8 | 71 | 19 | 49 | Close to triple glazing performance with double glazing structures |
| Thermobel Green | "Green" is a processing option, compatible with most regular Thermobel structures, including triple glazing. | Depends on the configuration | | | | Safer and cleaner to process, better ecological footprint |

(1) Please note that these special assemblies might not be available on all markets, depending on local requirements and legislations, for example.

## Triple glazing assemblies

| Single coated pane | Assembled in double glazing | Typical composition | Coating positions | $U_g$-value W/(m²K) | LT (%) | LR (%) | g (%) | Key feature |
|---|---|---|---|---|---|---|---|---|
| iplus Top 1.1 | Thermobel TG Top | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4 | #2 and #5 | 0.6 | 72 | 15 | 51 | Thermal insulation |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4 | #2 and #5 | 0.5 | | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4 | #2 and #5 | 0.5 | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| iplus Top 1.1^T | Thermobel TG Top^T | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4 | #2 and #5 | 0.6 | 73 | 15 | 53 | Thermal insulation, toughenability |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4 | #2 and #5 | 0.5 | | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4 | #2 and #5 | 0.5 | | | | |
| iplus LS | Thermobel TG LS | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4 | #2 and #5 | 0.7 | 73 | 17 | 60 | Thermal insulation, enhanced solar gains |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4 | #2 and #5 | 0.6 | | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4 | #2 and #5 | 0.6 | | | | |
| iplus LST | Thermobel TG LST | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4 | #2 and #5 | 0.7 | 73 | 17 | 60 | Thermal insulation, enhanced solar gains, toughenability |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4 | #2 and #5 | 0.6 | | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4 | #2 and #5 | 0.6 | | | | |
| iplus Advanced 1.0 | Thermobel TG Advanced | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4 | #2 and #5 | 0.6 | 64 | 21 | 42 | Enhanced thermal insulation |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4 | #2 and #5 | 0.5 | | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4 | #2 and #5 | 0.4 | | | | |

(Continuation)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| iplus Advanced 1.0$^{T}$ | Thermobel TG Advanced$^{T}$ | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4 | #2 and #5 | 0.6 | 71 | 18 | 49 | Enhanced thermal insulation, toughenability |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4 | #2 and #5 | 0.5 | | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4 | #2 and #5 | 0.4 | | | | |
| iplus Energy$^{N}$ | Thermobel TG Energy$^{N}$ | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4(1) | #2 and #5 | 0.6 | 65 | 15 | 37 | Enhanced thermal insulation, solar control |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4(1) | #2 and #5 | 0.5 | | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4(1) | #2 and #5 | 0.5 | | | | |
| iplus Energy$^{NT}$ | Thermobel TG Energy$^{NT}$ | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4(1) | #2 and #5 | 0.6 | 65 | 15 | 38 | Enhanced thermal insulation, solar control, toughenability |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4(1) | #2 and #5 | 0.5 | | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4(1) | #2 and #5 | 0.5 | | | | |
| iplus AF Top | Thermobel TG AF Top | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4 | #1, #2 and #5 | 0.6 | 68 | 19 | 49 | Thermal insulation, anti-condensation |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4 | #1, #2 and #5 | 0.5 | | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4 | #1, #2 and #5 | 0.5 | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| iplus AF Energy$^{N}$ | Thermobel TG AF Energy$^{N}$ | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4(1) | #1, #2 and #5 | 0.6 | 61 | 18 | 35 | Enhanced thermal insulation, solar control, anti-condensation |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4(1) | #1, #2 and #5 | 0.5 | | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4(1) | #1, #2 and #5 | 0.5 | | | | |

(1) The third glass pane is iplus Top 1.1.

The following pages will describe the low-e coatings of the iplus range, followed by Thermobel characteristics and specialties.

# Low-e coatings - iplus range

## ▼ INTRODUCTION

AGC's iplus range of low-e coatings offers a variety of products for different applications and contexts. However, iplus coatings all share the same set of properties:

> iplus coatings feature **low emissivity**, i.e. they are designed to prevent heat from escaping the building and therefore provide savings in energy consumption and improve thermal comfort

> iplus coatings feature **high light transmission**, i.e. a large amount of light enters the building, providing visual comfort

> iplus coatings are **neutral coatings**, i.e. the colour of an object is not altered by someone observing that object through a window with a neutral coating

> iplus coatings have a **low level of light reflection**, again improving visual comfort by avoiding unwanted reflections

> iplus coatings are **easy-to-process** coatings, i.e. their mechanical resistance allows glass processors to easily cut, grind or assemble these coatings into insulating glass units.

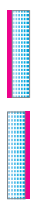
In addition to complying with regulatory and legal requirements, iplus coatings[1] are Cradle to Cradle Certified™ Silver and PassivHaus certified.

(1) Exception made for the iplus AF family of products.

*NB1: The list of low-e coatings described in this chapter is not exhaustive. Depending on the country and local requirements, some specific products are marketed by AGC. For more details, please refer to www.yourglass.com or your local sales representative.*

*NB2: In the following paragraphs, we will detail the key benefits and properties of these coatings. For further information related, for example, to processing and availability, please consult www.yourglass.com.*

## ▼ PROCESSING OPTIONS IPLUS RANGE

| Heat-treatment | | |
|---|---|---|
| Thermal toughening or heat strengthening |  | iplus Top 1.1, iplus Advanced 1.0, iplus LS, iplus Energy$^{N}$, iplus AF Top, iplus AF Energy$^{N}$: No<br>iplus Top 1.1$^{T}$, iplus Advanced 1.0$^{T}$, iplus LST, iplus Energy$^{NT}$: mandatory |
| Silk-screen printing and enamelling |  | iplus Top 1.1$^{T}$, iplus Advanced 1.0$^{T}$, iplus LST, iplus Energy$^{NT}$: yes<br>(see processing guide on www.yourglass.com) |
| Bending |  | iplus Top 1.1$^{T}$, iplus Advanced 1.0$^{T}$, iplus LST, iplus Energy$^{NT}$: yes<br>(see processing guide on www.yourglass.com) |
| **Laminated glass** | | |
| PVB |  | Yes<br>See processing guide on www.yourglass.com |
| EVA | | |

# iplus Top 1.1 & iplus Top 1.1$^T$

Private house - Spain - iplus Top 1.1

## ▼ DESCRIPTION

- Used in double and triple glazing for residential and commercial applications, **iplus Top 1.1** ensures that a high amount of light enters the building thanks to its high light transmission (LT = 80%), low reflection (LR = 12%) and a very neutral colour
- **iplus Top 1.1$^T$** is the toughenable version of iplus Top 1.1 and is, after toughening, five times more resistant, for example to thermal shocks.

## ▼ BENEFITS

- Achieve great visual comfort level of any living space, thanks to generous distribution of natural light
- With a high solar factor (SF = 63%) and good thermal insulation ($U_g$ = 1.1 W/(m$^2$K)), iplus Top 1.1 is meeting today's expectations regarding energy performances of glazings
- iplus Top 1.1$^T$ also features high light transmission (LT = 81%), low reflection (LR = 12%), a high solar factor (SF = 64%) and good thermal insulation ($U_g$ = 1.1 W/(m$^2$K))
- After toughening, iplus Top 1.1$^T$ has exactly the same appearance as iplus Top 1.1 meaning both coatings can be used on the same glazed surface.

## ▼ PERFORMANCE

iplus Top 1.1 and iplus Top 1.1$^T$ performance are described in the table below.

| Single coated pane | Assembled in double glazing | Typical composition | Coating position(s) | $U_g$-value W/(m²K) | LT (%) | LR (%) | g (%) |
|---|---|---|---|---|---|---|---|
| iplus Top 1.1 | Thermobel Top | 4 - 16 Ar 90% - 4 | #3 | 1.1 | 80 | 12 | 63 |
| iplus Top 1.1$^T$ | Thermobel Top$^T$ | 4 - 16 Ar 90% - 4 | #3 | 1.1 | 81 | 12 | 64 |
| **Single coated pane** | **Assembled in triple glazing** | **Typical composition** | | **$U_g$-value W/(m²K)** | **LT (%)** | **LR (%)** | **g (%)** |
| iplus Top 1.1 | Thermobel TG Top | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4 | #2 and #5 | 0.6 | 72 | 15 | 51 |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4 | | 0.5 | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4 | | 0.5 | | | |
| iplus Top 1.1$^T$ | Thermobel TG Top$^T$ | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4 | #2 and #5 | 0.6 | 73 | 15 | 53 |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4 | | 0.5 | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4 | | 0.5 | | | |

# iplus Advanced 1.0 & iplus Advanced 1.0$^T$

Private house - Ireland - iplus Advanced 1.0$^T$

## ▼ DESCRIPTION

- Mainly intended for use in double glazing for residential applications
- **iplus Advanced 1.0** is characterised by its excellent thermal insulation ($U_g$ = 1.0 W/($m^2$K))
- **iplus Advanced 1.0$^T$** is the first low-emissivity coating from AGC to offer a safety function thanks to the toughening process combined with thermal insulation of 1.0 W/($m^2$K).

## ▼ BENEFITS

- iplus Advanced 1.0 maintains high light transmission (LT = 76%) and a good solar factor (SF = 55%)
- Like its counterpart iplus Advanced 1.0, iplus Advanced 1.0$^T$ possesses similar properties to achieve superb visual comfort, plus qualities to meet new energy trends: excellent thermal insulation ($U_g$ = 1.0 W/($m^2$K)) and a high solar factor (SF = 60%)
- Significantly high light transmission and solar factor for this level of thermal insulation, enabling users to also benefit from solar gains.

## ▼ PERFORMANCE

The performance of iplus Advanced 1.0 and iplus Advanced $1.0^{T}$ is described in the table below. You will note the high levels of light transmission and solar factor, especially in double glazing assemblies.

| Single coated pane | Assembled in double glazing | Typical composition | Coating position(s) | $U_g$-value W/(m²K) | LT (%) | LR (%) | g (%) |
|---|---|---|---|---|---|---|---|
| iplus Advanced 1.0 | Thermobel Advanced | 4 - 16 Ar 90% - 4 | #3 | 1.0 | 76 | 15 | 55 |
| iplus Advanced $1.0^{T}$ | Thermobel $Advanced^{T}$ | 4 - 16 Ar 90% - 4 | #3 | 1.0 | 80 | 13 | 60 |
| **Single coated pane** | **Assembled in triple glazing** | **Typical composition** | | **$U_g$-value W/(m²K)** | **LT (%)** | **LR (%)** | **g (%)** |
| iplus Advanced 1.0 | Thermobel TG Advanced | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4 | #2 and #5 | 0.6 | 64 | 21 | 42 |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4 | | 0.5 | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4 | | 0.4 | | | |
| iplus Advanced $1.0^{T}$ | Thermobel TG $Advanced^{T}$ | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4 | #2 and #5 | 0.6 | 71 | 18 | 49 |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4 | | 0.5 | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4 | | 0.4 | | | |

# iplus LS & iplus LST

Private house - Germany - iplus LST

## ▼ DESCRIPTION

> Triple pane structures are known to provide high insulation properties, but generally have the drawback of compromising on light transmission and the amount of free solar energy that the glazing lets through. **iplus LS** is a low-emissivity coating ideal for tackling these points by achieving a higher light transmission and a higher total energy transmittance

> It is the natural choice for consumers who want an energy-efficient home, such as passive houses, where every source (or waste) of energy must be considered

> **iplus LST** is the toughenable version of iplus LS and is, after toughening, five times more resistant, for example to thermal shocks.

## ▼ BENEFITS

> Perfect balance between high thermal insulation ($U_g$ = 0.7 W/(m²K)), high light transmission (LT = 74%) and high solar factor (SF = 63%)

> iplus LST has the same optical properties as iplus LS in terms of light transmission (LT = 73%), solar factor (SF = 63%) and colour, meaning that, after toughening, iplus LST has exactly the same appearance as iplus LS, and both coatings can be used on the same glazed surface.

## ▼ PERFORMANCE

The performance of iplus LS and iplus LST is described in the table below. You will note the high levels of solar factor achieved by these triple glazing structures, as well as the very low $U_g$-values.

| Single coated pane | Assembled in triple glazing | Typical composition | Coating position(s) | $U_g$-value $W/(m^2K)$ | LT (%) | LR (%) | g (%) |
|---|---|---|---|---|---|---|---|
| iplus LS | Thermobel TG LS | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4 | #2 and #5 | 0.7 | 73 | 17 | 60 |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4 | | 0.6 | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4 | | 0.6 | | | |
| iplus LST | Thermobel TG LST | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4 | #2 and #5 | 0.7 | 73 | 17 | 60 |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4 | | 0.6 | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4 | | 0.6 | | | |

# iplus Energy$^{N}$ & iplus Energy$^{NT}$

Private house - Switzerland - iplus Energy$^{N}$

## ▼ DESCRIPTION

> In residential applications with large south-oriented glazing or in commercial buildings with glass-based facades, solar radiation often needs to be controlled to avoid overheating

> **iplus Energy$^{N}$** keeps the sun's excessive energy out (SF = 41%) so users can comfortably enjoy sunny days and save on air-conditioning costs

> **iplus Energy$^{NT}$** is the toughenable version of iplus Energy$^{N}$ and is, after toughening, five times safer.

## ▼ BENEFITS

> iplus Energy$^{N}$ has a neutral colour and a high level of thermal insulation ($U_g$ = 1.0 W/(m²K)), while achieving high light transmission (LT = 73%) and low light reflection (LR = 12%)

> iplus Energy$^{NT}$ has similar properties to iplus Energy$^{N}$, with the same neutral colour and a high level of thermal insulation ($U_g$ = 1.0 W/(m²K)) and low light reflection (LR = 13%), high light transmission (LT = 75%) and low total energy transmittance (SF = 45%).

## ▼ PERFORMANCE

The performance of iplus Energy$^{N}$ and iplus Energy$^{NT}$ is described in the table below. You will note the low solar factor, while maintaining a high light transmission.

| Single coated pane | Assembled in double glazing | Typical composition | Coating position(s) | $U_g$-value W/(m$^2$K) | LT (%) | LR (%) | g (%) |
|---|---|---|---|---|---|---|---|
| iplus Energy$^{N}$ | Thermobel Energy$^{N}$ | 4 - 16 Ar 90% - 4 | #3 | 1.0 | 73 | 12 | 41 |
| iplus Energy$^{NT}$ | Thermobel Energy$^{NT}$ | 4 - 16 Ar 90% - 4 | #3 | 1.0 | 73 | 12 | 42 |
| **Single coated pane** | **Assembled in triple glazing** | **Typical composition** | | **$U_g$-value W/(m$^2$K)** | **LT (%)** | **LR (%)** | **g (%)** |
| iplus Energy$^{N}$ | Thermobel TG Energy$^{N}$ | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4[1] | #2 and #5 | 0.6 | 65 | 15 | 37 |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4[1] | | 0.5 | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4[1] | | 0.5 | | | |
| iplus Energy$^{NT}$ | Thermobel TG Energy$^{NT}$ | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4[1] | #2 and #5 | 0.6 | 65 | 15 | 38 |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4[1] | | 0.5 | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4[1] | | 0.5 | | | |

(1) The third glass pane is iplus Top 1.1.

# iplus AF, iplus AF Top & iplus AF Energy$^N$


Private house - Czech Republic - iplus AF Top

## ▼ DESCRIPTION

> While highly insulated windows provide comfort and energy savings, the more we insulate our windows, the greater the possibility of an external condensation problem occurs

> **iplus AF** is a pyrolytic hard coating specifically developed to be used on the outer surface of the glazing in order to prevent condensation by increasing the temperature of the pane

> As well as ensuring a clear view of the outside world, iplus AF will make your living space more comfortable, reduce your energy bills and protect the environment

> **iplus AF Top**, being a double coating (meaning one coating on each side of the glass, in this case iplus AF and iplus Top 1.1), is a two-in-one solution combining the thermal insulation performance of iplus Top 1.1 with the anti-condensation properties of iplus AF in a single glass pane

> **iplus AF Energy$^N$**, being a double coating (meaning one coating on each side of the glass, in this case iplus AF and iplus Energy$^N$), is a two-in-one solution combining the thermal insulation and solar control performance of iplus Energy$^N$ with the anti-condensation properties of iplus AF in a single glass pane.

## ▼ BENEFITS

> The iplus AF coating prevents condensation by increasing the temperature of the pane

> Used in conjunction with other low-e coatings, one single glass pane will offer anti-condensation properties and thermal insulation, with or without solar control.

## ▼ PERFORMANCE

| Single coated pane | Assembled in double glazing | Typical composition | Coating position(s) | $U_g$-value W/(m²K) | LT (%) | LR (%) | g (%) |
|---|---|---|---|---|---|---|---|
| iplus AF and iplus Top 1.1 | Thermobel AF/Top | 4 - 16 Ar 90% - 4 | #1 and #3 | 1.1 | 75 | 16 | 59 |
| iplus AF Top | Thermobel AF Top | 4 - 16 Ar 90% - 4 | #1 and #2 | 1.1 | 76 | 16 | 56 |
| iplus AF Energy$^{N}$ | Thermobel AF Energy$^{N}$ | 4 - 16 Ar 90% - 4 | #1 and #2 | 1.0 | 68 | 16 | 39 |
| **Single coated pane** | **Assembled in triple glazing** | **Typical composition** | | **$U_g$-value W/(m²K)** | **LT (%)** | **LR (%)** | **g (%)** |
| iplus AF Top | Thermobel TG AF Top | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4(1) | #1, #2 and #5 | 0.6 | 68 | 19 | 49 |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4(1) | | 0.5 | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4(1) | | 0.5 | | | |
| iplus AF Energy$^{N}$ | Thermobel TG AF Energy$^{N}$ | 4 - 14 Ar 90% - 4 - 14 Ar 90% - 4(1) | #1, #2 and #5 | 0.6 | 61 | 18 | 35 |
| | | 4 - 18 Ar 90% - 4 - 18 Ar 90% - 4(1) | | 0.5 | | | |
| | | 4 - 12 Kr 90% - 4 - 12 Kr 90% - 4(1) | | 0.5 | | | |

(1) The third glass pane is iplus Top 1.1.

# Special low-e coatings: Planibel G, Planibel G fasT & Isocomfort

Industrial appliance - Fridge door supermarket - Planibel G fasT

## ▼ INTRODUCTION

Thanks to a highly resistant surface, certain low-e coatings are especially suitable for industrial applications, such as home appliance, commercial refrigeration, heated glass, touch screens, etc.

## ▼ DESCRIPTION

> **Planibel G, Planibel G fasT** and **Isocomfort** are pyrolytic hard coatings that can be toughened and do not require any edge deletion

> Thanks to their durability and resistance, Planibel G, Planibel G fasT and Isocomfort are especially suitable for above mentioned industrial applications, as well as in construction insulating glass exposed to severe climatic conditions.

## Special low-e coatings: Planibel G, Planibel G fasT & Isocomfort



## ▼ BENEFITS

- **Planibel G** and **Planibel G fasT** have a very neutral aspect, offering a high level of light transmission and low level of reflection
- **Planibel G, Planibel G fasT** and **Isocomfort** can be processed in various ways, including toughening and bending.
- **Planibel G fasT** and **Isocomfort** benefit of further surface treatments, allowing it to be toughened in all types of furnaces with a faster toughening cycle
- Thanks to an online surface treatment, **Planibel G fasT** and **Isocomfort** present an even higher level of scratch resistance, as well as reduced maintenance.

## ▼ PERFORMANCE

| Single coated pane (4 mm) | Position of coating | $U_g$-value W/(m²K) | LT (%) | LR (%) | g (%) | Emissivity ε |
|---|---|---|---|---|---|---|
| Planibel G | #2 | 3.7 | 82 | 10 | 75 | 0.14 |
| Planibel G fasT | #2 | 3.7 | 82 | 10 | 75 | 0.14 |
| Isocomfort | #2 | 3.6 | 77 | 15 | 69 | 0.11 |
| **Double glazing 4 - 15 Ar 90% - 4** | **Position of coating** | **$U_g$-value W/(m²K)** | **LT (%)** | **LR (%)** | **g (%)** | **Emissivity ε** |
| Planibel G | #3 | 1.5 | 75 | 17 | 74 | - |
| Planibel G fasT | #3 | 1.5 | 75 | 17 | 74 | - |
| Isocomfort | #3 | 1.4 | 70 | 21 | 71 | - |

# Insulating glass - Thermobel range

Over the years, AGC has developed in-depth industrial and technical expertise in insulating glass production through its Europe-wide network of glass processors operating more than 70 lines manufacturing double and triple glazing.

Thermobel, the AGC brand name for insulating glass, is therefore a synonym for quality and reliability, as each of the components in AGC's insulating glass has been selected to satisfy rigorous internal specifications, usually exceeding market norms and standards, for example in the selection of components and raw materials.

Of course, Thermobel products are based on the use of AGC's broad range of coatings, but they also leverage AGC's ability to innovate, resulting in some AGC specialties related to the way the insulating glass itself is built. These innovations range from specific processing techniques resulting in glazings that are cleaner and safer to manipulate while featuring a smaller ecological footprint (Thermobel Green), to multi-coating assemblies that enhance thermal insulation (Thermobel Advanced 0.8).

*NB1: The list of insulating glass products described in this chapter is not exhaustive. Depending on the country and local requirements, certain products are marketed by AGC. For more details, please refer to www.yourglass.com or your local sales representative.*

*NB2: In the following paragraphs, we will detail the key benefits and properties of the Thermobel range. For further information related, for example, to processing and availability, please consult www.yourglass.com.*

## ▼ THE TG FAMILY

Thermobel TG is AGC's brand name for its family of triple glazing. Increasingly popular, triple glazing provides a level of thermal insulation significantly higher than that of standard double glazing, and therefore energy savings and improved thermal comfort. To tackle common pitfalls encountered with triple glazing, AGC has developed specific products dedicated to such assemblies, such as Thermobel TG LS which features the thermal insulation of triple glazing without negatively impacting light and free solar heat gain.

## ▼ THE *WARM EDGE* OPTION

The ultimate thermal performance of a window depends not only on the thermal insulation obtained thanks to the glass (characterised by its $U_g$-value), but also on the performance of the spacers used on the edge of the insulating glass.

In its *Warm Edge* version, Thermobel uses special spacers, whose design and materials disrupt the thermal bridge and therefore improve the thermal insulation of the window (up to 7%), decrease condensation risks on the edge of the glazing and ensure a uniform temperature across the entire glazing.

The *Warm Edge* option is compatible with other Thermobel products.

## ▼ THE *LATTICE* OPTION

In its *Lattice* version, lattices (also called Georgian bars) are integrated within the Thermobel glazing, yielding countless aesthetic options. Indeed, several materials, textures (e.g. wood-like), widths or colours (even in two-sided versions) are offered. Different lattices can even be combined in a given glazing.

In addition to the aesthetic effect obtained, the benefits of integrating lattices within the insulating glass include easy maintenance and improved thermal insulation.

The *Lattice* option is compatible with other Thermobel products.

## ▼ THE *GREEN* OPTION

The *Green* option pertains to a specific method of manufacturing insulating glass focused on optimizing the quantity of sealant used to glue the glass panes to the edges of insulating glass. Thermobel Green is an AGC-exclusive innovation which, in addition to streamlining the environmental footprint of the insulating glass, also results in cleaner products that are easier to process by the window maker but which do not impact the aesthetics of the final window as seen by the end consumer. In an effort to improve window makers' industrial operations, Thermobel Green comes with arrised edges resulting in glazing that is safer to manipulate and less sensitive to thermal shocks.

The *Green* option is compatible with other Thermobel products.

# Thermobel Advanced 0.8[1]

Private house - Belgium - Thermobel Advanced 0.8

## ▼ DESCRIPTION

> Specially engineered for applications where triple glazing is not an option but where the most optimal use of energy is sought

> Thermobel Advanced 0.8 is a double glazing which provides a very high level of thermal insulation ($U_g$ = 0.8 W/(m$^2$K)).

## ▼ BENEFITS

> Perfect for renovations, it offers triple glazing insulation with double glazing thickness (18 mm thick in standard configurations) and a low weight of 20 kg/m² (1.5 to 2 times lighter than triple glazing)

> This highly insulating glass solution features good light transmission (LT = 71%) while benefitting from solar energy gains due to its high solar factor (SF = 49%).

(1) This product may not be available on all European markets.

## ▼ PERFORMANCE

The performance of Thermobel Advanced 0.8 is described in the table below. You will note the extremely low $U_g$-value (the lowest achievable by double glazing) combined with good light transmission and total energy transmittance.

| AGC special assemblies | Typical composition | $U_g$-value $W/(m^2K)$ | LT (%) | LR (%) | g (%) |
|---|---|---|---|---|---|
| Thermobel Advanced 0.8 | 4 - 10 AGC gas - 4 | 0.8 | 71 | 19 | 49 |

# 2.3 – Solar control

Covent Garden - Brussels, Belgium - Architect: Montois&Partners and Art&Build - Stopsol Supersilver Dark Blue

## ▼ INTRODUCTION

As its name suggests, solar control glass helps to control the amount of solar energy that enters a building. It allows sunlight to pass through a window or facade while reflecting away a large degree of the sun's heat.

As a consequence, the indoor space stays bright and much cooler than it would if normal glass was used.

Hence, using solar control glazing will save large amounts of energy (reduction of energy needed to air-condition the building).

Solar control glass is not necessarily coloured or mirrored glass, although such finishes can be applied for aesthetic purposes, if desired. The potential lies in the coating technology: in a complex process, multi-layer coatings are applied to the surface of float glass, which will have the dual effect of allowing sunlight in, while repelling solar heat. Solar control glass units are typically double-glazed.

AGC offers a wide range of solar control glass, available in single, double or triple glazings. Different aesthetics are available – neutral or coloured, with a variety of light and reflection levels.

Solar control performance, as expressed by the Solar Factor (SF), will vary according to:

> the use of body-tinted float glass (Planibel coloured glass): the most economical solution, but medium performance

> the use of glass with pyrolytic coatings (Stopsol or Sunergy): easy to process, unlimited creativity and good performance

> the use of glass with magnetron coatings (Stopray or ipasol): top light and energy performance.

# Planibel Coloured

Poslovni Centar Heinzelova 70 - Zagreb, Croatia -
Architect: Krešimir Crnkovic dipl. ing. arh. - Planibel Coloured Azur

The Planibel Coloured range comprises body tinted glass which can be used for solar control applications.

*See the Float chapter for detailed information on this range.*

## ▼ PERFORMANCE AND COLOUR RANGE

| Composition | Light properties | | Energy properties | | | $U_g$-value W/(m²K) |
|---|---|---|---|---|---|---|
| | LT (%) | LR (%) | Tot EA (%) | SF (%) | SC | |
| **6 mm Planibel** | | | | | | |
| Green | 73 | 7 | 51 | 56 | 0.64 | 5.7 |
| Bronze | 51 | 6 | 45 | 61 | 0.70 | 5.7 |
| Grey | 44 | 5 | 49 | 58 | 0.67 | 5.7 |
| Azur | 73 | 7 | 45 | 60 | 0.69 | 5.7 |
| PrivaBlue | 35 | 5 | 75 | 38 | 0.44 | 5.7 |
| Dark Blue | 58 | 6 | 54 | 53 | 0.61 | 5.7 |
| Dark Grey | 8 | 4 | 88 | 29 | 0.33 | 5.7 |
| **6 mm Planibel Coloured glass - 16 - 4 mm Planibel Clear (1)** | | | | | | |
| Green | 66 | 11 | 54 | 46 | 0.53 | 2.7 |
| Bronze | 46 | 8 | 50 | 51 | 0.59 | 2.7 |
| Grey | 40 | 7 | 53 | 47 | 0.54 | 2.7 |
| Azur | 66 | 11 | 49 | 50 | 0.57 | 2.7 |
| PrivaBlue | 31 | 6 | 77 | 27 | 0.31 | 2.7 |
| Dark Blue | 52 | 9 | 57 | 43 | 0.49 | 2.7 |
| Dark Grey | 7 | 5 | 89 | 25 | 0.29 | 2.7 |

(1) Identical values for a 15 or 16 mm spacer.

# Stopsol

Torre Gas Natural - Barcelona, Spain - Architect: Enric Miralles & Benedetta Tagliabue - Stopsol Supersilver Grey & Classic Clear

## ▼ DESCRIPTION

> Stopsol is a solar control glass with a reflective pyrolytic coating (pyrolytic coatings are Class A according to EN 1096-1). Thanks to its very hard coating, Stopsol can be easily used for a large variety of processing options including toughening, laminating, bending and silk-screen printing

> The Stopsol brand comprises three types of coatings: Classic (amber appearance), Supersilver (silver appearance) and Silverlight (bluish appearance). These coatings are generally available on clear glass, as well as some coloured glass

> The coating may be applied in position 1 or 2 . This will affect how the glass looks, especially when used with coloured glass

> Stopsol can be assembled in insulating glazing with iplus low-emissivity glass

> Range of spandrels available in monolithic glass and double glazing.

## ▼ BENEFITS

> Coated glass with good solar control and unique reflective aesthetics

> Stopsol range provides full visual privacy through its reflective coating

> The large range of Stopsol allows several combinations of solar control, light transmission levels and colours

> Stopsol glass offers architects unlimited creativity: one product can be used for various applications.

## ▼ COMMENTS

<table>
<tr><th></th><th>Coating #1</th><th>Coating #2</th></tr>
<tr><td rowspan="3">Aestetics exterior</td><td colspan="2">On clear glass: always reflective</td></tr>
<tr><td>On coloured glass: very reflective</td><td>On coloured glass: less reflective</td></tr>
<tr><td colspan="2">In #1 for heat-strengthened, toughened or enamelled Stopsol, optical distortions due to thermal treatment are more visible than would be the case with non-reflective glass</td></tr>
<tr><td>Aestetics interior</td><td colspan="2">The reflection of the glass and its “mirror” aestetics are important when the coating is in #2</td></tr>
<tr><td>Look</td><td>Appearance of the coating stands out</td><td>Colour of the float glass stands out</td></tr>
<tr><td>Absorption</td><td colspan="2">Higher if the coating is applied in #2 and if the float glass is coloured.<br>Can be toughened.</td></tr>
</table>

> Stopsol coatings are not low-emissivity coatings

> We recommend using the same thickness of glass throughout the entire facade, especially when the Stopsol coatings are applied in position 2.

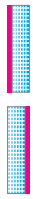
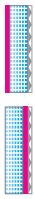
## ▼ PERFORMANCE AND COLOUR RANGES

| Composition [1] | Look | Light properties | | Energy properties | | | $U_g$-value W/(m²K) |
|---|---|---|---|---|---|---|---|
| | | LT (%) | LR (%) | Tot EA (%) | SF (%) | SC | |
| **6 mm Stopsol #1 or #2 [1]** | | | | | | | |
| Classic Clear #1 | Yellowish silver | 38 | 34 | 25 | 52 | 0.60 | 5.7 |
| Classic Clear #2 | Clear metallic | 38 | 27 | 33 | 54 | 0.62 | 5.7 |
| Classic Bronze #1 | Yellowish silver | 22 | 34 | 43 | 39 | 0.45 | 5.7 |
| Classic Bronze #2 | Metallic bronze | 22 | 12 | 60 | 45 | 0.52 | 5.7 |
| Classic Green #1 | Silvered | 31 | 34 | 50 | 34 | 0.39 | 5.7 |
| Classic Green #2 | Metallic green | 31 | 20 | 67 | 38 | 0.44 | 5.7 |
| Classic Grey #1 | Silvered | 19 | 34 | 45 | 37 | 0.43 | 5.7 |
| Classic Grey #2 | Metallic grey | 19 | 10 | 63 | 42 | 0.48 | 5.7 |
| Supersilver Clear #1 | Brilliant silver | 63 | 35 | 9 | 65 | 0.75 | 5.7 |
| Supersilver Clear #2 | Slightly bluish silver | 63 | 34 | 13 | 66 | 0.76 | 5.7 |
| Supersilver Green #1 | Steel silver | 51 | 35 | 42 | 42 | 0.48 | 5.7 |
| Supersilver Green #2 | Brilliant green | 51 | 24 | 55 | 45 | 0.52 | 5.7 |
| Supersilver Grey #1 | Steel silvered | 29 | 34 | 39 | 43 | 0.49 | 5.7 |
| Supersilver Grey #2 | Metallic steel | 29 | 11 | 56 | 47 | 0.54 | 5.7 |
| Supersilver Dark Blue #1 | Silvered blue | 40 | 34 | 45 | 40 | 0.46 | 5.7 |
| Supersilver Dark Blue #2 | Brilliant blue | 40 | 17 | 59 | 43 | 0.54 | 5.7 |
| Silverlight PrivaBlue #1 | Silvered blue | 27 | 24 | 64 | 31 | 0.396 | 5.7 |
| Silverlight PrivaBlue #2 | Intense blue | 27 | 8 | 77 | 34 | 0.39 | 5.7 |
| **6 mm Stopsol #1 or #2 - 16 Ar 90% - 4 mm Iplus Top1.1 #3 [1]** | | | | | | | |
| Classic Clear #1 | Yellowish silver | 34 | 35 | 33 | 32 | 0.37 | 1.1 |
| Classic Clear #2 | Metallic clear | 34 | 28 | 41 | 33 | 0.38 | 1.1 |
| Classic Bronze #1 | Yellowish silver | 19 | 34 | 51 | 21 | 0.24 | 1.1 |
| Classic Bronze #2 | Metallic bronze | 20 | 12 | 67 | 22 | 0.25 | 1.1 |
| Classic Green #1 | Silvered | 28 | 35 | 56 | 19 | 0.22 | 1.1 |
| Classic Green #2 | Metallic green | 28 | 20 | 73 | 20 | 0.23 | 1.1 |
| Classic Grey #1 | Silvered | 17 | 34 | 53 | 19 | 0.22 | 1.1 |
| Classic Grey #2 | Metallic grey | 17 | 10 | 71 | 21 | 0.24 | 1.1 |
| Supersilver Clear #1 | Brilliant silver | 57 | 37 | 19 | 46 | 0.53 | 1.1 |
| Supersilver Clear #2 | Slightly bluish silver | 57 | 36 | 21 | 46 | 0.53 | 1.1 |
| Supersilver Green #1 | Steel silver | 46 | 36 | 48 | 28 | 0.32 | 1.1 |
| Supersilver Green #2 | Brilliant green | 46 | 26 | 60 | 29 | 0.33 | 1.1 |
| Supersilver Grey #1 | Steel silvered | 26 | 35 | 49 | 25 | 0.29 | 1.1 |
| Supersilver Grey #2 | Metallic steel | 27 | 11 | 65 | 26 | 0.30 | 1.1 |
| Supersilver Dark Blue #1 | Silvered blue | 36 | 35 | 51 | 25 | 0.29 | 1.1 |
| Supersilver Dark Blue #2 | Brilliant blue | 36 | 18 | 65 | 26 | 0.30 | 1.1 |
| Silverlight PrivaBlue #1 | Silvered blue | 24 | 25 | 68 | 16 | 0.18 | 1.1 |
| Silverlight PrivaBlue #2 | Intense blue | 24 | 8 | 81 | 17 | 0.20 | 1.1 |

(1) Identical values with 15 or 16 mm spacer.

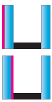
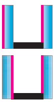
*For further details on performance, visit www.yourglass.com.*

## ▼ PROCESSING OPTIONS

| | | |
|---|---|---|
| **Heat treatment** | | |
| Thermal toughening or heat-strengthening |  | Yes |
| Silk-screen printing and enamelling |  | Yes – no silk-screen printing or enamelling on Supersilver coating |
| Bending |  | Yes |
| **Laminated glass** | | |
| PVB |  | Yes<br>- for assemblies with safety PVB, see Stratobel<br>- for assemblies with safety and acoustic PVB, see Stratophone<br>- for assemblies with safety or decorative PVB see Stratobel Color, see Decorative laminated glass |
| EVA | | |

*See "Matelux Stopsol" for glass with a satin-finish coating (cfr chapter 3.4).*

## ▼ USES

| | | |
|---|---|---|
| Monolithic glass |  | Yes |
| Insulating glass |  | Yes – Coating does not need to be edge-stripped. The Stopsol coating is applied in #1 or #2 |
| Insulating glass with low-emissivity coating |  | The Stopsol coating is applied in #1 or #2<br>The low-emissivity coating is applied in #3 |

## ▼ APPLICATIONS

| | |
|---|---|
| Interior | Yes |
| Exterior | Yes |

## ▼ STANDARD THICKNESSES (mm)

Available in different thicknesses, depending on the colour.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

# Sunergy

Blue Pavilion - Fiera Del Mare - Genoa, Italy - Architect: Sandro Carbone - Sunergy Clear

## ▼ DESCRIPTION

> Sunergy is a solar control glass with a pyrolytic coating (pyrolytic coating are Class A according to EN 1096-1). It is suitable for a large variety of processing options, including toughening, laminating, bending and silk-screen printing

> Available in five colours: Clear, Green, Grey, Blue and Dark Blue

> Can be assembled into double and triple glazing units with a low-e glass to provide higher levels of thermal insulation and solar control

> Optimal $U_g$ values up to 1.0 W/(m²K) (in combination with low-e glass)

> Recommended for use in position 2.

## ▼ BENEFITS

> Superb appearance and visual comfort, thanks to a high level of light transmission and low reflection

> An extremely neutral appearance for Sunergy Clear

> Interior comfort: good thermal insulation combined with solar control

> Can be processed very easily

> Unlimited creativity for architects: one type of glass can be used for various applications.

## ▼ COMMENTS

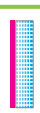
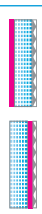
- > The coating does not affect the natural colour of the base glass
- > Absorption: the glass should be toughened if the absorption level is high. Pyrolytic coatings are easier to toughen
- > We recommend using the same thickness of glazing throughout the entire facade.

## ▼ PERFORMANCE AND COLOUR RANGES

| Composition | Look | Light properties | | Energy properties | | | $U_g$-value W/(m²K) |
|---|---|---|---|---|---|---|---|
| | | LT (%) | LR (%) | Tot EA (%) | SF (%) | SC | |
| **6 mm Sunergy #2** | | | | | | | |
| Clear #2 | clear | 68 | 9 | 37 | 60 | 0.69 | 4.1 |
| Green #2 | green | 56 | 7 | 63 | 41 | 0.47 | 4.1 |
| Azur #2 | azur | 56 | 7 | 60 | 44 | 0.52 | 4.1 |
| Dark Blue #2 | dark blue | 40 | 6 | 68 | 37 | 0.44 | 4.1 |
| Grey #2 | grey | 34 | 5 | 64 | 41 | 0.48 | 4.1 |
| **6 mm Sunergy #2 - 16 Ar (90%) - 4 mm with iplus Top #3** (1) | | | | | | | |
| Clear #2 | clear | 61 | 11 | 47 | 45 | 0.52 | 1.1 |
| Green #2 | green | 50 | 9 | 68 | 30 | 0.34 | 1.1 |
| Azur #2 | azur | 50 | 9 | 65 | 32 | 0.37 | 1.1 |
| Dark Blue #2 | dark blue | 36 | 7 | 73 | 26 | 0.30 | 1.1 |
| Grey #2 | grey | 30 | 6 | 71 | 27 | 0.31 | 1.1 |

(1) Identical values with 15 or 16 mm spacer.

## ▼ PROCESSING OPTIONS

| Heat treatment | | |
|---|---|---|
| Thermal toughening or heat-strengthening |  | Yes |
| Silk-screen printing and enamelling |  | Yes – under certain conditions – Please contact us to discuss further details |
| Bending |  | Yes |

| Laminated glass | | |
|---|---|---|
| PVB |  | Yes, but the coating is not low-emissivity if placed next to PVB.<br>- For assemblies with safety PVB, see Stratobel.<br>- For assemblies with safety and acoustic PVB, see Stratophone. |
| EVA | | Yes |

## ▼ USES

| | | |
|---|---|---|
| Monolithic glass |  | Yes |
| Insulating glass |  | Yes – see Thermobel – General introduction<br>The coating does not need to be edge-stripped.<br>The Sunergy coating is in #2. |
| Insulating glass with low-emissivity coating |  | The Sunergy coating is in #2.<br>The low-emissivity coating is in #3. |

## ▼ APPLICATIONS

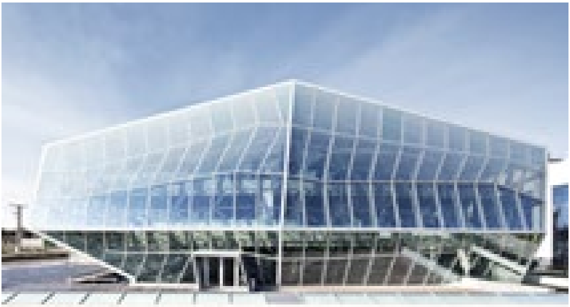
| | |
|---|---|
| Interior | No |
| Exterior | Yes |

## ▼ STANDARD THICKNESSES (mm)

Available in different thicknesses, depending on the colour.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

# Stopray & ipasol


Sede Ámbar - Santander, Spain - Architect: Sobrellano Arquitectos - Stropray Vision-50$^{T}$

## ▼ DESCRIPTION

> Stopray and ipasol are solar control glass ranges with a magnetron coating (Stopray and ipasol coatings are Class C according to EN 1096-1). Thanks to their magnetron coating, Stopray and ipasol can provide the best performance in terms of solar control and thermal insulation, offering a large range of different aesthetics. The solar control function is achieved by applying a C class metallic coating (EN 1096-1) to the glass.

> Various performance levels and colours available, including a large range of neutral and low light-reflection glass

> Some products of the Stopray range can be toughened after the coating has been applied (see Stopray$^{T}$ and Stopray Smart)(1)

> Use: always in double glazing or in triple glazing (position 2) – single glass panes available for glass processors

(1) Slight aesthetic difference in transmission between Stopray Vision-50 and Stopray-50 T.

> Stopray and ipasol products are Cradle to Cradle Certified™ Silver. For more information, please refer to www.yourglass.com.

## ▼ NEW RANGE: STOPRAY SMART

Stopray Smart presents two major innovations within AGC's Stopray range of magnetron-coated solar-control glass:

> It can be used in toughened or non-toughened versions

> Depending on the type of sealant used, edge-deletion is no longer necessary. For more information, follow the processing instructions in the Stopray Smart Structural Glazing Sealant Compatibility Guide available on www.yourglass.com.

## ▼ BENEFITS OF THE STOPRAY & IPASOL RANGES

> High level of light transmission and low level of internal solar heat throughput

> High selectivity (relationship between LT and SF), excellent for the range of neutral colours. In particular, the new products Stopray Ultra and ipasol ultraselect, provide a very high level of selectivity (LT/SF > 2), thanks to their special "triple silver coating"

> Suitable for use in all climates: combines solar control in summer with thermal insulation in winter. Particularly well suited to tertiary buildings with air conditioning to maintain a comfortable temperature while at the same time minimising energy costs

> Finish: wide range of light-reflection and light-transmission levels

> Look: different colours – extensive range of neutral colours.

## ▼ COMMENTS

> Coating always applied in position 2

> Absorption: variable. A thermal shock analysis should be conducted.

## ▼ PERFORMANCE AND COLOUR RANGES

| Thermobel Stopray or Thermobel ipasol | Look | Light properties | | Energy properties | | | $U_g$-value W/(m²K) |
|---|---|---|---|---|---|---|---|
| | | LT (%) | LR (%) | Tot EA (%) | SF (%) | SC | |
| Stopray Vision-60$^T$ | neutral | 60 | 14 | 38 | 37 | 0,43 | 1,0 |
| Stopray Lime 61$^T$ | green | 59 | 10 | 64 | 30 | 0,34 | 1,0 |
| Stopray Vision-50$^{T(1)}$ | neutral | 50 | 17 | 40 | 30 | 0,34 | 1,0 |
| Stopray Indigo 48$^T$ | dark blue | 47 | 8 | 67 | 27 | 0,31 | 1,0 |
| Stopray Vision-36$^T$ | neutral | 36 | 31 | 40 | 21 | 0,24 | 1,0 |
| Stopray Titanium 37$^T$ | grey | 36 | 6 | 64 | 24 | 0,28 | 1,0 |
| ipasol neutral 70/39 | neutral | 70 | 12 | 34 | 38 | 0,44 | 1,0 |
| ipasol neutral 69/37 | neutral | 69 | 12 | 33 | 37 | 0,43 | 1,0 |
| ipasol ultraselect 62/29 | neutral | 62 | 10 | 33 | 29 | 0,33 | 1,0 |
| Stopray Vision-60 | neutral | 61 | 15 | 37 | 35 | 0,40 | 1,0 |
| Stopray Ultra-60 | neutral | 60 | 13 | 38 | 28 | 0,32 | 1,0 |
| ipasol neutral 60/33 | neutral | 60 | 11 | 41 | 33 | 0,38 | 1,0 |
| Stopray Vision-50$^{(1)}$ | neutral | 50 | 19 | 42 | 28 | 0,32 | 1,0 |
| ipasol neutral 50/27 | neutral | 50 | 9 | 49 | 27 | 0,31 | 1,1 |
| Stopray Ultra-50 on Clearvision | neutral | 49 | 18 | 33 | 23 | 0,26 | 1,0 |
| ipasol platin 47/29 | silver | 47 | 40 | 30 | 29 | 0,33 | 1,1 |
| Stopray Silver 43/25 | silver | 43 | 47 | 27 | 26 | 0,30 | 1,0 |
| ipasol shine 40/22 | blue | 40 | 16 | 54 | 22 | 0,25 | 1,1 |
| ipasol sky 30/17 | blue | 30 | 18 | 63 | 17 | 0,20 | 1,1 |
| ipasol platin 25/17 | silver | 25 | 64 | 20 | 17 | 0,20 | 1,1 |
| Stopray Smart 51/33 | neutral | 51 | 25 | 39 | 33 | 0,38 | 1,1 |
| Stopray Smart 30/20 | neutral bluish | 30 | 28 | 52 | 20 | 0,23 | 1,1 |
| ipasol bright white | neutral | 59 | 36 | 11 | 51 | 0,59 | 1,1 |
| ipasol bright neutral | neutral | 57 | 35 | 23 | 47 | 0,54 | 1,1 |
| Silverlight PrivaBlue #2 | intense blue | 24 | 8 | 81 | 17 | 0.20 | 1.1 |

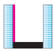
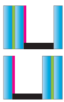
(1) Slight aesthetic difference in transmission between Stopray Vision-50 and Stopray-50$^T$.

## ▼ COMPONENTS IN INSULATING GLAZING

The components of Stopray in DGUs and TGUs may be varied to achieve different sound and safety functions.

The Stopray coating is always in position 2, facing the cavity of the insulating glazing.

## ▼ PROCESSING OPTIONS

| Heat treatment | | |
|---|---|---|
| Heat-strengthening or thermal toughening |  | Yes – before the coating is applied for non-toughenable Stopray and ipasol glazings.<br>Stopray T(2) and Stopray Smart glass have a toughenable coating. In this case, the glass may be toughened after the coating has been applied. |
| Enamelled or silk-screen printed glass | | Yes – under certain conditions |
| **Laminated glass** | | |
| PVB |  | Yes – the coating must not come into contact with the PVB (only exception: Stopray LamiSmart).<br>- For assemblies with safety PVB, see Stratobel.<br>- For assemblies with acoustic safety PVB, see Stratophone.<br>- For assemblies with decorative safety PVB see Decorative laminated glass. |
| EVA | | |

(2) Stopray T glass must be toughened to achieve the stated performance.

## ▼ APPLICATIONS

| | |
|---|---|
| Interior | No |
| Exterior | Yes |

## ▼ STANDARD THICKNESSES (mm)

Available in different thicknesses, depending on the colour.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

# 2.4 – Acoustic glass

Porta Nuova - Milan, Italy - Architect: Piuarch - Stratobel & Stratophone

## ▼ INTRODUCTION

Acoustic insulation is a glazing's ability to prevent noise from passing through it, for example between a noisy external environment and a quiet room inside a building. The higher the acoustic insulation of a glazing, the greater the comfort, with a resulting positive impact on well-being and health.

The acoustic properties of a glazing are measured by the values $R_w$ ($C$, $C_{tr}$), defined in EN ISO 717-1, and all measured in decibels (dB). From these values, two sums can be computed:

> The value obtained via "$R_w + C$" represents acoustic insulation against higher frequency noises, such as high-speed traffic, children playing, radio or TV

> The value obtained via "$R_w + C_{tr}$" represents acoustic insulation against lower frequency noises, such as low-speed traffic or nightclub music.

AGC holds acoustic certificates for a large range of products, and is continuously extending this database.

Several techniques can be used to improve the acoustic insulation of a glazing, depending on the type of glazing structure (monolithic or assembled in insulating glazing unit):

> For monolithic glass, the use of laminated glass improves the acoustic insulation. One key element for improving acoustic insulation is the nature of the interlayer used in the assembly. AGC's brand name for laminated glass using interlayers specifically dedicated to acoustics is Stratophone

> For insulating glazing units, acoustic insulation can be improved by using a wider spacer between the panes, using asymmetric assemblies or using (acoustic) laminated glass in the assembly. AGC's brand name for insulating glazing is Thermobel, available as Thermobel Stratobel and Thermobel Stratophone if laminated glass is used within the assembly.

AGC supplies the single glass panes (Stratophone) to customers making their own insulating glass units, as well as the final insulating glass units (Thermobel) to customers such as window makers or facade glazers.

# Stratophone

Prague Ruzyne Airport - Prague, Czech Republic - Stratophone

## ▼ DESCRIPTION

> AGC's Stratophone products, built with two (or more) panes of glass with one (or more) acoustic PVB[1] interlayers, are laminated glass products designed to address both acoustic and safety challenges

> Additional functions, such as solar control, thermal insulation and decoration can also be achieved when assembled with the various glass substrates (clear, extra-clear or coloured float, etc.) and coatings (iplus, Stopray, etc.)

> Stratophone products are Cradle to Cradle Certified™ Silver. For more information, please refer to www.yourglass.com.

(1) Polyvinyl butyral.

## ▼ BENEFITS

- Stratophone products provide better acoustic performance than regular laminated glass (about 3 dB for comparable structures) while achieving a similar level of safety performance
- Stratophone can be used as a standalone product as laminated glass, as well as part of an insulating glazing assembly
- Can be used in a wide range of applications: insulating glazing for commercial buildings or private homes laminated glass for office partitions, etc

## ▼ PERFORMANCE

The composition of Stratophone can be identified by a code comprising:

> A series of numbers indicating the nominal thickness of each glass pane

> The final figure indicates the number of PVB films 0.38 mm thick.

Example: 44.2 is a laminated glass comprising two 4-mm panes of glass separated by a 0.76 mm thick PVB film.

Performance figures are given in the table below. One can note $R_w$ values ranging from 35 dB to 41 dB, improving as the glass gets thicker. For comparison purposes, a 10 dB difference in the acoustic value means half as much noise.

| Composition | Acoustic values (EN ISO 717-1) (dB) | | | Thickness (mm) | Weight/m² (kg) |
|---|---|---|---|---|---|
| | $R_w$ | $R_w+C$ | $R_w+C_{tr}$ | | |
| **Planibel** | | | | | |
| 6 mm | 31 | 29 | 28 | 6 | 15 |
| 8 mm | 32 | 31 | 30 | 8 | 20 |
| **Stratobel** | | | | | |
| 44.2 | 35 | 34 | 32 | 9 | 21 |
| 66.2 | 36 | 35 | 33 | 13 | 31 |
| **Stratophone** | | | | | |
| 33.2 st | 36 | 36 | 33 | 7 | 16 |
| 44.2 st | 37 | 37 | 35 | 9 | 21 |
| 55.2 st | 39 | 38 | 36 | 11 | 26 |
| 66.2 st | 40 | 39 | 37 | 13 | 31 |
| 88.2 st | 41 | 40 | 39 | 17 | 41 |

*NB: For compositions not in this list, please refer to www.yourglass.com and its online tools, or contact your local sales representative.*

# Thermobel, Thermobel Stratobel & Thermobel Stratophone

Private house - Belgium - Thermobel Stratophone

## ▼ DESCRIPTION

Thermobel – AGC's brand name for insulating glazing units – can be designed to provide high acoustic insulation through a careful selection of structures and components. Different techniques are used for this purpose:

> The acoustic value of a regular Thermobel assembly, comprising two (three) sheets of float glass, is drastically improved when the thicknesses of the two (three) panes are different, resulting in asymmetric structures

> In Thermobel Stratobel, at least one sheet is made of Stratobel laminated glass, further boosting acoustic performance

> The best performance is achieved by Thermobel Stratophone, based on the use of Stratophone acoustic laminated glass.

## ▼ BENEFITS

> High acoustic insulation achieved

> As acoustic performance is not modified by the use of coatings (low-e, solar control, etc.) on one or more glass panes, or by the nature of the glass pane (clear, coloured, extra-clear, etc.), acoustic Thermobel structures are fully compatible with the other functions expected of insulating glazing, such as thermal insulation, safety, solar control and aesthetics.

## ▼ PERFORMANCE

The acoustic performance of the Thermobel range is detailed in the table below. For comparison purposes, a 10 dB difference in the acoustic value means half as much noise.

Please note the following:

> The full range of acoustic performance is very broad: from 30dB to 52dB

> Asymmetric double glazing delivers about 5dB performance boost compared to symmetric double glazing

> The use of Stratobel, or even better Stratophone, leads to significantly better values

> There is no significant difference in the acoustic performance of Thermobel (double glazing) and Thermobel TG (triple glazing).

| Composition | Acoustic values (EN ISO 717-1) (dB) | | | Thickness (mm) | Weight/m² (kg) |
|---|---|---|---|---|---|
| | $R_w$ | $R_w+C$ | $R_w+C_{tr}$ | | |
| **Thermobel** | | | | | |
| 4 - 16 - 4 | 30 | 29 | 26 | 24 | 20 |
| 6 - 15 - 6 | 32 | 31 | 29 | 27 | 30 |
| 6 - 15 - 4 | 36 | 35 | 31 | 25 | 25 |
| 8 - 16 - 4 | 37 | 35 | 32 | 28 | 30 |
| 10 - 15 - 6 | 38 | 37 | 34 | 31 | 40 |
| **Thermobel Stratobel** | | | | | |
| 4 - 16 - 44.2 | 37 | 35 | 31 | 29 | 31 |
| 44.2 - 16 - 33.2 | 39 | 38 | 34 | 32 | 37 |
| 6 - 15 - 55.2 | 39 | 38 | 35 | 32 | 41 |
| 8 - 15 - 55.2 | 41 | 39 | 37 | 34 | 46 |
| 66.2 - 16 - 55.2 | 42 | 41 | 38 | 40 | 57 |
| 88.2 - 15 - 66.2 | 46 | 45 | 41 | 45 | 72 |
| **Thermobel Stratophone** | | | | | |
| 4 - 15 - 44.2 st | 39 | 37 | 34 | 28 | 31 |
| 6 - 16 - 44.2 st | 41 | 39 | 35 | 31 | 36 |
| 8 - 16 - 44.2 st | 42 | 40 | 36 | 33 | 41 |
| 6 - 15 - 66.2 st | 42 | 41 | 37 | 34 | 46 |
| 8 - 15 - 66.2 st | 43 | 41 | 39 | 36 | 51 |
| 10 - 16 - 44.2 st | 45 | 43 | 39 | 35 | 46 |
| 10 - 16 - 55.2 st | 46 | 44 | 40 | 37 | 51 |
| 10 - 16 - 66.2 st | 46 | 44 | 41 | 39 | 56 |
| 66.2 st - 16 - 44.2 st | 49 | 46 | 41 | 38 | 52 |
| 88.2 st - 15 - 44.2 st | 50 | 48 | 43 | 41 | 62 |
| 66.2 st - 16 - 66.2 st | 50 | 48 | 43 | 42 | 62 |
| 88.2 st - 16 - 66.2 st | 52 | 51 | 47 | 46 | 72 |

| | | | | | |
|---|---|---|---|---|---|
| Thermobel TG | | | | | |
| 4 - 12 - 4 - 12 - 4 | 33 | 31 | 27 | 36 | 30 |
| 6 - 12 - 6 - 12 - 6 | 35 | 33 | 29 | 42 | 45 |
| 4 - 15 - 4 - 15 - 6 | 36 | 34 | 29 | 44 | 35 |
| 4 - 12 - 4 - 12 - 8 | 37 | 36 | 31 | 40 | 40 |
| 6 - 12 - 4 - 12 - 8 | 39 | 37 | 34 | 42 | 45 |
| Thermobel TG Stratobel | | | | | |
| 4 - 12 - 4 - 12 - 33.2 | 36 | 35 | 30 | 39 | 36 |
| 6 - 16 - 4 - 16 - 44.2 | 39 | 37 | 32 | 51 | 46 |
| 8 - 16 - 6 - 16 - 33.2 | 39 | 38 | 33 | 53 | 51 |
| 44.2 - 12 - 6 - 12 - 44.2 | 41 | 39 | 33 | 48 | 57 |
| 8 - 16 - 4 - 16 - 55.2 | 41 | 39 | 37 | 55 | 56 |
| 8 - 16 - 6 - 16 - 55.2 | 43 | 41 | 39 | 57 | 61 |
| 66.2 - 16 - 6 - 16 - 44.2 | 44 | 43 | 39 | 60 | 67 |
| Thermobel TG Stratophone | | | | | |
| 4 - 12 - 4 - 12 - 44.2st | 39 | 37 | 32 | 41 | 41 |
| 6 - 12 - 4 - 12 - 44.2 st | 41 | 39 | 33 | 43 | 46 |
| 8 - 12 - 4 - 12 - 44.2 st | 42 | 40 | 35 | 45 | 51 |
| 44.2 - 12 - 4 - 12 - 44.2 st | 43 | 41 | 36 | 46 | 52 |
| 10 - 12 - 4 - 12 - 44.2 st | 44 | 42 | 37 | 47 | 56 |
| 8 - 16 - 6 - 16 - 55.2 st | 45 | 44 | 40 | 57 | 61 |
| 10 - 16 - 6 - 16 - 55.2 st | 46 | 44 | 41 | 59 | 66 |
| 10 - 16 - 6 - 16 - 66.2 st | 47 | 46 | 43 | 61 | 71 |
| 44.2 st - 10 - 4 - 10 - 66.2st | 47 | 46 | 40 | 46 | 62 |
| 44.2 st - 12 - 6 - 12 - 66.2st | 48 | 46 | 41 | 52 | 67 |
| 88.2 st - 12 - 6 - 12 - 66.2 st | 51 | 50 | 46 | 60 | 87 |

*NB: Each individual configuration of an insulating glass unit has its own acoustic performance figures. Consequently, the above table is a summary of the countless possibilities offered by the Thermobel range. For other structures not listed above, more information and dedicated tools can be found on www.yourglass.com or can be obtained from your local sales representative.*

# 2.5 – Laminated safety glass

Railway Station Liège Guillemins - Liège, Belgium - Architect: S. Calatrava - Stratobel

## ▼ INTRODUCTION

Glass facades, windows for homes, office partitions and sliding doors are all examples of the countless applications where the safety aspect of glass needs to be considered and suitable products, complying with dedicated regulations and norms, must be used.

Along with thermal treated glass, the Stratobel range of laminated glass is AGC's answer to these concerns. This pertains to safety issues (protection of people and property from injury, damage, falls and vandalism) with the Stratobel range, as well as to more advanced security functions, with a view to providing protection against burglary, firearm attacks or explosion via Stratobel Security (single pane) or Thermobel Stratobel Security (insulating glazing unit).

Both Stratobel and Stratobel Security are tested and certified according to the relevant standards, and both are ideal for use in insulating glazing units (generally, the laminated glass pane faces the inside of the building), that inherit from these certificated safety and security levels. Depending on the structure of the assembly (number of glass panes and their thickness) and the thickness and nature of the plastic interlayers (PVB[1] or EVA[2] being the most common), different levels of safety can be achieved and an appropriate product can be offered for different needs.

By its nature and the materials used in its construction, Stratobel also provides protection from ultraviolet radiation, as well as better acoustic performance than a non-laminated glass pane. Advanced acoustic performance can even be obtained with special interlayers (see the "Acoustic" section).

Lastly, Stratobel laminated glass can be combined with a vast range of AGC glass products, coatings and specific interlayers to offer solar control, enhanced thermal insulation and decorative functions.

AGC supplies the single glass panes either in large sheet formats for processing and cutting by a glass processor, or at the right size via its glass processing operations, depending on customer preferences and product complexity.

(1) Polyvinyl butyral.
(2) Ethylene vinyl acetate.

# Stratobel

Railway Station Liège Guillemins - Liège, Belgium - Architect: S. Calatrava - Stratobel

## ▼ DESCRIPTION

Stratobel products are built with two (or more) glass panes assembled with a polymer interlayer that holds the glass panes together in the event of breakage.

Usually, Stratobel products are tested according to:

> standard EN 12600, level 2B2, corresponding to prevention of cuts and injury due to accidental impact, while level 1B1 prevents persons from falling through the glass in the event of accidental breakage

> standard EN 356 and its various levels:

- basic protection against vandalism (P1A-P2A), achieved by structures with at least 2 PVB interlayers
- medium-level protection against small-scale crime (P3A-P4A), achieved by structures with at least 4 PVB interlayers
- enhanced protection against attacks of limited duration (P5A), achieved by structures with at least 6 PVB interlayers.

> Stratobel products are Cradle to Cradle Certified™ Silver. For more information, please refer to www.yourglass.com.

## ▼ BENEFITS

> Stratobel products are an effective solution for protecting individuals from injuries caused by broken glass and for preventing falls and defenestration

> As Stratobel products are harder to break, they also offer an effective solution against vandalism for homes, shops and offices.

## ▼ PERFORMANCE

The performance figures for certain Stratobel products are detailed in the table below. The level of protection increases with glass thickness and the number of PVB interlayers.

| Composition | Class EN 12600 | Class EN 356 | Thickness (mm) | Weight/m² (kg) |
|---|---|---|---|---|
| Stratobel 33.1 | 2B2 | NPD | 6 | 15 |
| Stratobel 44.1 | 2B2 | NPD | 8 | 20 |
| Stratobel 66.1 | 1B1 | NPD | 12 | 30 |
| Stratobel 33.2 | 1B1 | P2A | 7 | 16 |
| Stratobel 44.2 | 1B1 | P2A | 9 | 21 |
| Stratobel 66.2 | 1B1 | P2A | 13 | 31 |
| Stratobel 33.4 | 1B1 | P4A | 8 | 17 |
| Stratobel 44.4 | 1B1 | P4A | 10 | 22 |
| Stratobel 66.4 | 1B1 | P4A | 14 | 32 |
| Stratobel 44.6 | 1B1 | P5A | 10 | 22 |
| Stratobel 66.6 | 1B1 | P5A | 14 | 32 |

*NB: Not all possible Stratobel compositions are described in the above table. More details on other possible compositions can be found on www.yourglass.com or obtained from your local sales representative.*

# (Thermobel) Stratobel Security

Factory Office Center - Prague, Czech Republic - Architect: Ing.Arch. Vojtechovsky - Stratobel Explosion proof

## ▼ DESCRIPTION

> Stratobel Security is used when a high level of security is required (e.g. to protect people or a property from theft, attacks, firearms or explosions)

> Security products are often more complex than the regular Stratobel range (multi-laminated assemblies)

> Security products are tested according to the following standards:

- Stratobel Security Burglary refers to laminated glass complying with EN 356 (levels P6B, P7B and P8B), ensuring protection against organised theft and attacks using hand-held tools
- Stratobel Security Bullet refers to laminated glass complying with EN 1063. Thermobel Stratobel Security Bullet refers to insulating glass complying with EN 1063. Levels BR1-S to BR7-NS[1] ensure protection from various kinds of weapons and ammunition
- Stratobel Security Explosion refers to laminated glass complying with EN 13541, with levels ranging from ER1-S to ER4-NS.

(1) NS stands for "no splitting".

> AGC has developed specific solutions to facilitate the use of these glazings, which are often heavy and thick
  - Using chemically tempered glass (Stratobel Security Thin family) results in thinner and lighter structures delivering the same level of performance
  - Using polycarbonate as a component of laminated glass (Stratobel Security XThin PC family) results in even thinner and lighter structures
  - The certification of Thermobel Stratobel Security double glazing itself (not just the laminated component) results in reduced total thickness (and weight) because the mechanical resistance of both glass panes is taken into account, not just the contribution by the laminated glass.

*NB: Specific rules need to be followed during installation. For example, there is generally a direction in which the faces of the glazing should be positioned, and a specific positioning within the insulating glazing unit. More information can be found on www.yourglass.com or obtained from your local sales representative.*

## ▼ BENEFITS

> Multitude of glazing solutions offering high levels of security

> AGC offers specific solutions making it possible to use thinner and lighter structures while maintaining the same levels of performance

> Wide range of products available for different applications.

## ▼ PERFORMANCE

The tables on the next double pages detail AGC's (Thermobel) Stratobel Security range. This list is not exhaustive and more information can be found on www.yourglass.com or obtained from your local sales representative.

| Stratobel Safety: Protection from injuries and falls | | | | |
|---|---|---|---|---|
| | Norms | | Total thickness (mm) | Weight (kg/m²) |
| | Impact EN 12600 | Break-in EN 356 | | |
| 22.1 | 2B2 | NPD | 4 | 10 |
| 33.1 | 2B2 | NPD | 6 | 15 |
| 44.1 | 2B2 | NPD | 8 | 20 |
| 22.2 | 1B1 | P2A | 5 | 11 |
| 55.1 | 1B1 | NPD | 10 | 25 |
| 66.1 | 1B1 | NPD | 12 | 30 |
| 88.1 | 1B1 | NPD | 16 | 40 |
| 33.2 | 1B1 | P2A | 7 | 16 |
| 44.2 | 1B1 | P2A | 9 | 21 |
| 55.2 | 1B1 | P2A | 11 | 26 |
| 66.2 | 1B1 | P2A | 13 | 31 |
| 88.2 | 1B1 | P2A | 17 | 41 |
| 1010.2 | 1B1 | P2A | 21 | 51 |
| 1212.2 | 1B1 | P2A | 25 | 61 |
| 33.4 | 1B1 | P4A | 8 | 17 |
| 44.4 | 1B1 | P4A | 10 | 22 |
| 55.4 | 1B1 | P4A | 12 | 27 |
| 66.4 | 1B1 | P4A | 14 | 32 |
| 88.4 | 1B1 | P4A | 18 | 42 |
| 1010.4 | 1B1 | P4A | 22 | 52 |
| 44.6 | 1B1 | P5A | 10 | 22 |
| 66.6 | 1B1 | P5A | 14 | 32 |

| Stratobel Security Burglar: Protection from break-ins | | | | |
|---|---|---|---|---|
| | Norms | | Total thickness (mm) | Weight (kg/m²) |
| | Impact EN 12600 | Break-in EN 356 | | |
| 502-2 | 1B1 | P6B | 15 | 32 |
| 603-9 | 1B1 | P7B | 26 | 56 |
| 204-9 | 1B1 | P8B | 32 | 68 |
| XThin PC version: for ultra-thin and ultra-light solutions | | | | |
| 214.541 PC | 1B1 | P6B | 15 | 28 |
| 216.541 PC | 1B1 | P7B | 17 | 30 |
| 219.841 PC | 1B1 | P8B | 20 | 34 |

| Max size availability | Light & Energy properties | | Acoustics | |
|---|---|---|---|---|
| | LT (%) | EA (%) | $R_w$ ($C$; $C_{tr}$) (dB) | |
| 600 x 321 | 90 | 14 | NPD | |
| 600 x 321 | 90 | 17 | 32 (-1 ; -3) | |
| 600 x 321 | 89 | 20 | 34 (-1 ; -2) | |
| 600 x 321 | 90 | 46 | NPD | |
| 600 x 321 | 87 | 23 | 35 (-1 ; -3) | |
| 600 x 321 | 86 | 25 | NPD | |
| 600 x 321 | 84 | 31 | NPD | |
| 600 x 321 | 89 | 19 | 33 (-1 ; -4) | |
| 600 x 321 | 88 | 21 | 35 (-1 ; -3) | |
| 600 x 321 | 87 | 24 | NPD | |
| 600 x 321 | 86 | 27 | 36 (-1 ; -3) | |
| 600 x 321 | 84 | 32 | 39 (-1 ; -3) | |
| 600 x 321 | 82 | 36 | 40 (-1 ; -3) | |
| 600 x 321 | 80 | 40 | 42 (-0 ; -3) | |
| 600 x 321 | 89 | 21 | NPD | |
| 600 x 321 | 88 | 23 | NPD | |
| 600 x 321 | 87 | 26 | 36 (-1 ; -4) | |
| 600 x 321 | 86 | 29 | 37 (-1 ; -4) | |
| 600 x 321 | 84 | 34 | NPD | |
| 600 x 321 | 80 | 38 | NPD | |
| 600 x 321 | 88 | 23 | NPD | |
| 600 x 321 | 86 | 30 | NPD | |

| Max size availability | Light & Energy properties | | | |
|---|---|---|---|---|
| | LT (%) | EA (%) | | |
| 600 x 321 | 86 | 31 | | |
| 600 x 321 | 82 | 41 | | |
| 600 x 321 | 80 | 45 | | |
| | | | | |
| Cut size | 85 | 27 | | |
| Cut size | 83 | 29 | | |
| Cut size | 81 | 31 | | |

| Stratobel Security Bullet: Resistance to bullet attacks | | | | |
|---|---|---|---|---|
| | Norms | | Total thickness (mm) | Weight (kg/m²) |
| | Break-in EN 356 | Bullets EN 1063 | | |
| 402-1-B | P4A | BR1-S | 13 | 31 |
| 802-5-B | P2A | BR1-NS | 18 | 42 |
| 902-7-B | NPD | BR2-S | 19 | 43 |
| 104-1-B | P6B | BR2-NS | 31 | 73 |
| 403-5-B | NPD | BR3-S | 24 | 54 |
| 704-3-B | P6B | BR3-NS | 37 | 89 |
| 004-8-B | NPD | BR4-S | 30 | 66 |
| 304-6-B | P6B | BR4-S / SG1-S | 33 | 80 |
| 106-1-B | NPD | BR4-NS | 51 | 123 |
| 504-4-B | P8B | BR5-S / SG2-S | 35 | 81 |
| 806-2-B | P7B | BR5-NS | 58 | 141 |
| 347-2-B | NPD | BR5-NS | 63 | 151 |
| 905-9-B | NPD | BR6-S | 49 | 116 |
| 148-1-B | NPD | BR6-NS | 71 | 170 |
| 408-1-B | P8B | BR6-NS | 74 | 179 |
| 009-1-B | P8B | BR7-NS | 80 | 188 |
| Thin version: for thin and light solutions | | | | |
| STOPX13 | NPD | BR1-NS | 13 | 31 |
| STOPX22 | NPD | BR2-NS | 22 | 52 |
| STOPX26 | NPD | BR3-NS | 26 | 63 |
| STOPX35 | NPD | BR4-NS | 35 | 83 |
| STOPX44 | NPD | BR5-NS / SG1-NS | 44 | 104 |
| PK52-CT | NPD | BR6-S | 52 | 124 |
| STOPX57 | NPD | BR6-NS / SG2-NS | 57 | 135 |
| PK65-CT | NPD | BR7-S | 65 | 157 |
| STOPX74 | NPD | BR7-NS | 74 | 179 |
| XThin PC version: for ultra-thin and ultra-light solutions | | | | |
| 810.361 PC | NPD | BR1-NS | 14 | 25 |
| 815.051 PC | NPD | BR2-NS | 15 | 31 |
| 819.070 PC | NPD | BR3-NS | 19 | 41 |
| 823.860 PC | P7B | BR4-NS / SG1-NS | 24 | 51 |
| 835.800 PC | P7B | BR5-NS / SG2-NS | 36 | 81 |
| 841.370 PC | P7B | BR6-NS | 42 | 93 |
| 886.820 PC | P7B | BR7-NS | 87 | 205 |

| Stratobel Security Explosion: Resistance to explosion | | | | |
|---|---|---|---|---|
| | Norms | | | Total thickness (mm) |
| | Impact EN 12600 | Break-in EN 356 | Explosion EN 13541 | |
| 002-2-EX | 1B1 | P5A | ER1-S | 10 |
| 902-2-EX | 1B1 | P6B | ER2-S | 19 |
| XThin PC version: for ultra-thin and ultra-light solutions | | | | |
| 823.860-EX PC | 1B1 | P7B | ER3-NS | 24 |

| | Max size availability | Light & Energy properties | | | |
|---|---|---|---|---|---|
| | | LT (%) | EA (%) | | |
| | 600 x 321 | 86 | 27 | | |
| | 225/255x321 | 84 | 33 | | |
| | Cut size | 84 | 35 | | |
| | 225/255x321 | 78 | 46 | | |
| | Cut size | 82 | 40 | | |
| | 225/255x321 | 76 | 50 | | |
| | Cut size | 80 | 44 | | |
| | 225/255x321 | 78 | 47 | | |
| | Cut size | 70 | 58 | | |
| | 255 x 321 | 77 | 49 | | |
| | Cut size | 67 | 61 | | |
| | Cut size | 66 | 63 | | |
| | Cut size | 72 | 57 | | |
| | Cut size | 63 | 66 | | |
| | Cut size | 62 | 66 | | |
| | Cut size | 62 | 67 | | |
| | | | | | |
| | Cut size | 86 | 27 | | |
| | Cut size | 82 | 37 | | |
| | Cut size | 80 | 42 | | |
| | Cut size | 77 | 48 | | |
| | Cut size | 73 | 54 | | |
| | Cut size | 70 | 58 | | |
| | Cut size | 69 | 60 | | |
| | Cut size | 65 | 63 | | |
| | Cut size | 62 | 67 | | |
| | | | | | |
| | Cut size | 84 | 28 | | |
| | Cut size | 84 | 29 | | |
| | Cut size | 82 | 34 | | |
| | Cut size | 81 | 39 | | |
| | Cut size | 75 | 49 | | |
| | Cut size | 74 | 52 | | |
| | Cut size | 58 | 70 | | |

| | Weight (kg/m²) | Max size availability | Light & Energy properties | | |
|---|---|---|---|---|---|
| | | | LT (%) | EA (%) | |
| | 22 | 600x321 | 88 | 25 | |
| | 43 | 600x321 | 84 | 35 | |
| | | | | | |
| | 51 | Cut size | 81 | 27 | |

| Thermobel Stratobel Security Bullet: Resistance to bullet attacks | | | | |
|---|---|---|---|---|
| | Norms<br>Bullets<br>EN 1063 | Total thickness (mm) | Weight (kg/m²) | Max size availability |
| 9205-1-B | BR3-NS | 49 | 93 | Cut Size |
| 1205-1-B | BR4-S | 41 | 70 | Cut Size |
| 2207-1-B | BR4-S / SG1-S | 62 | 113 | Cut Size |
| 7206-1-B | BR4-NS | 57 | 113 | Cut Size |
| 1207-1-B | BR4-NS / BR6-S | 61 | 125 | Cut Size |
| 4207-1-B | BR5-NS | 64 | 127 | Cut Size |
| 7207-1-B | BR5-NS / SG1-NS | 67 | 124 | Cut Size |
| 3206-1-B | BR6-S | 53 | 100 | Cut Size |
| 3209-1-B | BR6-NS | 83 | 176 | Cut Size |
| 6208-1-B | BR7-S | 76 | 157 | Cut Size |
| 8209-1-B | BR7-NS | 88 | 188 | Cut Size |
| 9207-1-B | SG1-NS | 69 | 145 | Cut Size |
| 9208-1-B | SG2-NS | 79 | 162 | Cut Size |
| Thin version: for thin and light solutions | | | | |
| VIX55 | BR4-NS / SG1-NS | 55 | 98 | Cut Size |
| VIX61 | BR5-NS / SG2-NS | 61 | 109 | Cut Size |
| VIX66 | BR6-NS / SG2-NS | 66 | 119 | Cut Size |
| XThin PC version: for ultra-thin and ultra-light solutions | | | | |
| 848i560 PC | BR6-NS | 49 | 82 | Cut Size |
| 890i100 PC | BR7-NS | 90 | 185 | Cut Size |
| 851i560 PC | SG2-NS | 51 | 82 | Cut Size |

(1) Values are given when clear uncoated glass is used for all panes of the assembly. Light and energy properties of most of the assemblies can be tuned by using coated glass, for example to improve thermal insulation (leading to lower $U_g$ values).

| | Light properties[1] | | Energy properties[1] | | |
|---|---|---|---|---|---|
| | LT (%) | LR (%) | EA (%) | $U_g$ (W/(m²K)) | SF (%) |
| | 69 | 12 | 52 | 2.5 | 49 |
| | 73 | 14 | 45 | 2.5 | 61 |
| | 66 | 13 | 55 | 2.4 | 58 |
| | 66 | 12 | 57 | 2.4 | 46 |
| | 65 | 12 | 59 | 2.6 | 49 |
| | 65 | 12 | 60 | 2.5 | 45 |
| | 65 | 13 | 57 | 2.0 | 58 |
| | 68 | 13 | 53 | 2.4 | 55 |
| | 58 | 11 | 67 | 2.4 | 43 |
| | 61 | 11 | 64 | 2.4 | 46 |
| | 57 | 10 | 68 | 2.3 | 40 |
| | 62 | 12 | 62 | 2.5 | 46 |
| | 62 | 12 | 82 | 2.3 | 32 |
| | | | | | |
| | 68 | 13 | 51 | 2.5 | 59 |
| | 67 | 13 | 54 | 2.4 | 60 |
| | 66 | 13 | 25 | 2.4 | 57 |
| | | | | | |
| | 70 | 13 | 48 | 2.6 | 59 |
| | 53 | 11 | 70 | 2.3 | 44 |
| | 70 | 13 | 48 | 2.5 | 59 |

# 2.6 – Heat-treated glass

Conseil Géneral des Pyrénées Atlantiques - Pau, France -
Architect: Philippe Ch. Dubois et Associés - Heat-treated glass

## ▼ INTRODUCTION

Various AGC glass products can be heat-treated for the specific purpose of enhancing their resistance to mechanical and thermal loads

> There are three types of glass after heat-treatment:
  - heat-strengthened glass
  - thermally toughened safety glass
  - heat-soaked thermally toughened safety glass.

> There also are different breakage patterns:
  - into small blunt pieces:
    - for thermally toughened safety glass
    - for heat-soaked thermally toughened safety glass.

    means that it may be considered safety glass
  - into large sharp pieces:
    - for heat-strengthened glass, meaning that it cannot be considered safety glass.

# Heat-strengthened glass

Typical breakage pattern of heat-strenghened glass

## ▼ DESCRIPTION

> Heat-strengthened glass is heat-treated using a method of controlled heating and cooling which places the outer glass surface under compression and the inner glass surface under tension

> This heat-treatment method delivers a glass with a bending strength greater than annealed glass but less than thermally toughened safety glass. Heat-strengthened glass does not require heat soaking

> Most of AGC glass products can be heat-strengthened: clear and coloured Planibel, Stopsol, Sunergy, some Imagin products and the toughenable versions of the Stopray and iplus low-e ranges

> Some coated glass (eg. in the iplus and Stopray ranges) or painted glass (eg. Lacobel T) can or must be heat-strengthened... Heat-treating these glass products require a specific parameter setting on the furnace

> Silk-screened and enamelled glass need to be at least heat-strengthened. The supplier must undertake a feasibility test if silk-screening or enamelling is applied to coated substrates.

## ▼ COMMENTS

### Mechanical properties

> Use of heat-strengthened glass: single glazing, laminated glazing, insulating glazing. The main goals are:
  - to avoid thermal glass breakage in applications where glass is subject to high energy absorption and / or severe shading
  - to increase bending strength to a maximum of 70 $N/mm^2$ (not taking into account the individual partial factors for the structural design).

> Heat-strengthened glass:
  - has a higher resistance to thermal stress than annealed glass. It can withstand differences in temperature of approximately 100°C
  - has a higher breakage resistance to bending (70 $N/mm^2$) than annealed glass (not considering the individual partial factors for the structural design)
  - breaks into large sharp pieces which can cause injury.

  Accordingly, heat-strengthened glass is not a safety glass.

> Once the heat-strengthening has been executed, no further processing (cutting, drilling holes, edge working, etc.) is possible. Heat-strengthened glass must comply with the standard EN 1863

> Heat-strengthened glass is not subject to breakage caused by nickel sulphide inclusions, also known as ‘spontaneous’ breakage. Therefore no heat soak test is required.

### Optical performance

- The heat-strengthening process causes inherent optical distortion due to surface waviness. Waviness can be measured and evaluated for the overall deformation and local deformation
- The light and energy characteristics of heat-strengthened glass are identical to the announced values for annealed uncoated glass products. For products with heat treatable coatings or enamels, the final light- and energy characteristics are only obtained after the toughening process. Note for coated glass products: compliance with AGC's heat-treatment guidelines is mandatory.

## ▼ FINISHING AND ADDITIONAL PROCESSING

### Edge finishing

The following edge finishings are allowed for heat-strengthened glass:

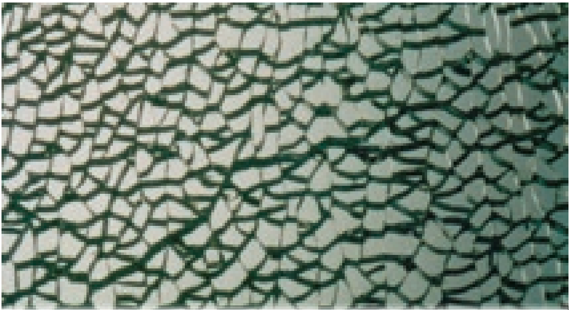
- Arrissed edge (with blank spots)
- Ground edge (with blank spots)
- Ground edge (without blank spots)
- Polished edge.

For building applications, heat-strengthened glass is supplied by default with arrissed edges. Other edge finishings are possible upon request by the customer and subject to a feasibility study.

### Other finishing options

- Drilled (chamfered) holes
- Notches.

# Thermally toughened safety glass



Typical breakage pattern of thermally toughened glass

## ▼ DESCRIPTION

> Thermally toughened safety glass is heat-treated using a method of controlled heating and cooling which puts the outer glass surface under compression and the inner glass part under tension. Such stresses cause the glass, when impacted, to break into small granular particles instead of splintering into jagged shards. The granular particles are less likely to injure occupants or damage objects

> This heat-treatment method delivers a glass with a bending strength greater than heat-strengthened glass. In addition, heat-soak test is required in certain applications or by national standards, building codes or good practice guidelines

> Most of AGC glass products can be toughened: clear and coloured Planibel, Stopsol, Sunergy and some Imagin products

> Some coated glass (eg. in the iplus and Stopray ranges) or painted glass (eg. Lacobel T) can or must be toughened... Heat-treating these glass products requires a specific parameter setting on the furnace

> Silk-screened and enamelled glass can be toughened. The supplier must undertage a feasibility test if silk-screening or enamelling is applied onto coated substrates

> Use of thermally toughened safety glass: single glazing, laminated glazing, insulating glazing. The main goals are:
  - to deliver a safety glass, thus reducing the risk of personal injury
  - to avoid thermal glass breakage in applications where glass is subject to high energy absorption and / or severe shading
  - to increase bending strength to a maximum of 120 N/mm² (not taking into account the individual partial factors for the structural design).

> Once the toughening has been executed, no further processing (cutting, drilling holes, edge working, etc.) is possible

> Thermally toughened safety glass must comply with standard EN 12150.

## ▼ COMMENTS

### Spontaneous breakage

Toughened glass can be subject to breakage caused by nickel sulphide inclusions, also known as 'spontaneous' breakage. The heat soak test can be executed upon request by the customer or if required by national standards, building codes or good practice guidelines. The heat-soak test is not a 100% guarantee that spontaneous breakage will not occur.

### Optical performance

The thermal toughening process causes the surface of the glass to distort in two ways:

> Overall bend of 3 mm/m(1)

> Localised bend of 0.5 mm/300 mm(1).

This phenomenon may be more visible in coated glass.

(1) Values for Planibel heat-strengthened glass using the horizontal process.

### Anisotropy

Depending on the angle of light incidence, the amount of light hitting the glass, the time of observation and the position of the observer with respect to the glass, the inherent phenomenon of heat treatment anisotropy can be observed. Anisotropy is caused by compression of the surface of the thermally toughened glass. Under natural lighting conditions, the reflection characteristics vary from one point to another and differently coloured patterns known as "leopard spots" may be seen on the glass.

## ▼ PERFORMANCE

Thermally toughened safety glass:

> is highly resistant to thermal stress. It can withstand differences in temperature of approximately 200°C

> has a much higher level of mechanical strength and is more resistant to shocks than annealed glass. Thermally toughened glass is resistant to breakage due to bending of at least 120 N/mm². For certain types of glass, these values can be different (patterned glass 90 N/mm² and enamelled glass 75 N/mm²) (not taking into account the individual partial factors for the structural design)

> breaks into small, blunt pieces. Consequently, thermally toughened glass is always a safety glass (conforming to EN 12150) in certain applications. Its usage always depends on the application and national standards, building codes or good practice guidelines

> toughenable magnetron coatings must be toughened to achieve the desired performance (fragmentation, optical, $U_g$ value).

The light and energy characteristics of thermally toughened safety glass are identical to the announced values for annealed uncoated glass products. Note for coated glass products: compliance with AGC's heat-treatment guidelines is mandatory. For heat treatable coatings the final light and energy characteristics are only obtained after the toughening process.

## ▼ FINISHING AND ADDITIONAL PROCESSING

### Edge finishing

The following edge finishing's are allowed for heat-strengthened glass:

> Arrissed edge (with blank spots)

> Ground edge (with blank spots)

> Ground edge (with no blank spots)

> Polished edge.

For building applications, the heat-strengthened glass is supplied by default with arrissed edges Other edge finishings are possible upon request by the customer and subject to a feasibility study.

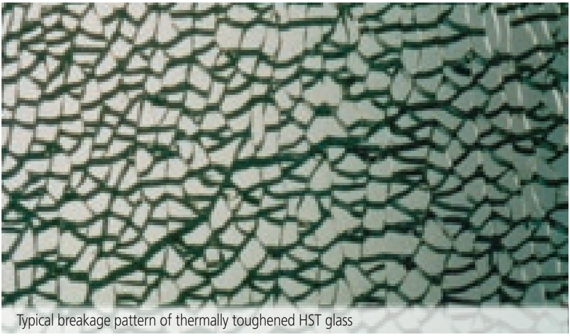
### Other finishing options

> Drilled (chamfered) holes

> Notches.

Certain restrictions (dimensions, positioning with respect to the edges, etc.) are defined in standard EN 12150-1.

# Thermally toughened HST glass



Typical breakage pattern of thermally toughened HST glass

## ▼ DESCRIPTION

> The same as for thermally toughened safety glass

> Heat-soaked thermally toughened safety glass must comply with EN 14179.

## ▼ WHY CHOOSE HEAT-SOAKED THERMALLY TOUGHENED SAFETY GLASS?

The glass product may contain nickel sulphide (NiS) inclusions which can vary in size from a few microns to a few millimetres. These inclusions have a special crystalline structure which is different at low (larger volume) and high (smaller volume) temperatures. In the case of a thermally toughened glass, the inclusions acquire their stable structure at a high temperature when the glass is heated to approximately 650°C. The rapid cooling involved in the toughening process does not give the NiS inclusions time to acquire their stable low-temperature structure before the glass solidifies. The glass is therefore processed at its operating temperature. During this time, the increase in the volume of the NiS inclusions can cause the sheet of glass to break spontaneously once it has been installed.

To limit the risk of breakage, thermally toughened glass can be heat-soaked. This entails placing the glass in a furnace at a constant temperature for a specific period to process the NiS. Any breakage caused by critical NiS crystals will therefore occur during heat-soak test.

## ▼ COMMENTS

*Refer to the section 'Thermally toughened safety glass'.*

## ▼ PERFORMANCE

*Refer to the section 'Thermally toughened safety glass'.*

## ▼ FINISHING

*Refer to the section 'Thermally toughened safety glass'.*

Certain restrictions (dimensions, positioning with respect to the edges, etc.) are defined in standard EN 14179-1.

# 2.7 – Bent glass

"Bolle" - Nardini Distiliries - Research and event center -
Bassano del Grappa, Italy - Architect: M. Fuksas - Sunergy Clear with Planibel Green

## ▼ DESCRIPTION

There are three ways to manufacture bent glass:

1. Gravitational bending: bending process in which the glass sheet is gradually heated above its softening point and where gravity forces the glass sheet to bend under its own weight onto a concave or convex mould placed horizontally in a bending furnace. Once the shaping process is completed, the sheet is cooled in a controlled manner to either annealed glass or thermally toughened safety glass. This is the most common process of producing bent glass for architectural applications
2. Mechanical bending: bending process in which the glass sheet is gradually heated above its softening point while external mechanical forces are extended on the sheet, bending it onto a concave or convex mould in a bending furnace. Once the shaping process is completed, the sheet is cooled in a controlled manner to either annealed glass or thermally toughened safety glass. This is the most common process for producing bent glass for automotive applications
3. Cold bending: process where the glass is bent by exerting an external mechanical force onto the glass sheet onto a concave or convex shaped frame or supporting structure. This is not a common process for producing bent glass for architectural applications. It is only used in special cases.

Gravitational bending is detailed below.

## ▼ MANUFACTURING OPTIONS

### Glass products

Many basic products with a thickness between 3 and 8 mm can be bent. Even products up to 19 mm can be bent if that thickness is available for a given product: Planibel Clear, Planibel Clearvision (extra-clear), Planibel Coloured; Stopsol Classic Supersilver and Supersilver reflective glass; Sunergy; some Imagin patterned products.

If special precautions are taken and the necessary feasibility tests are carried out, heat treatable iplus low-e and Stopray coatings can also be processed into bent glass.

## Types of bent glass

> Bent monolithic glass

> Bent laminated glass (Stratobel): two or more glass sheets – simultaneously moulded, bent and annealed – are then assembled into laminated glass using PVB interlayers

> Bent insulating glazing (Thermobel): insulating glazing whose components are bent and separated by means of a metal spacer. The components can be bent monolithic or laminated annealed glass panes

> Bent thermally toughened safety glass: bent monolithic glass for which a specific cooling profile is applied to conform with EN 12150. Manufacturing bent thermally toughened safety glass is a highly complex process, requiring the creation of special tools for each form requested.

## ▼ PROCESSING OPTIONS

Each constituent glass component is cut, shaped and edge-finished prior to bending and further processing.

Bent glass can be delivered with:

> Arrissed edge (with blank spots)

> Ground edge (with blank spots)

> Ground edge (without blank spots)

> Polished edge

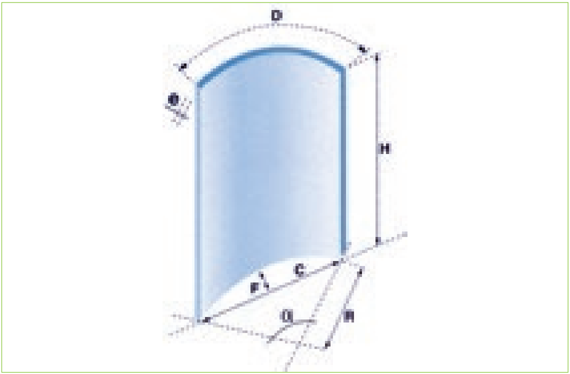
> Dubbed corners

> Holes and notches.

## ▼ DECORATIVE OPTIONS

Decorative surface treatments such as silk-screen printing and enamelling can be applied to bent glass and toughened bent glass prior to bending on the side that is not in contact with the mould. A decorative film can be incorporated into laminated bent glass. Please contact AGC for more information. Usually, a feasibility study is required for these products.

## ▼ SPECIFICATIONS FOR BENT GLASS WITH REGULAR CURVE




Three types of information must be specified.

### Information 1

Glass product (type and thickness) and composition for laminated or insulating glazing.

For laminated bent glass, it is advisable to describe, in the stack order, the nature, coating orientation (if any) and thickness of each glass component and PVB interlayer.

### Information 2

Height of the cylinder generatrix (H).

### Information 3

The curved line is defined by:

> D = developped length
> C = chord length
> F = deflection
> R = curve radius
> $\alpha$ = centre angle.

Two of these parameters are enough to determine the others. By default, the various parameters will always be counted from the inner side (concave part).

Examples of common shapes for bent glass are described in the figure below. Configurations 2 and 3 are possible only in annealed version. Please contact AGC for other options.


## ▼ HANDLING AND STORAGE

Care must be taken when handling and installing bent glass to reduce the risk of breakage. The sheets must be handled by their straight edge and by the middle of the curve.

We recommend storing the glass vertically. For short term storage, it may be preferable to store sheets in their original packaging.

# 2.8 – Enamelled glass & spandrels

CalypSO - Rotterdam, The Netherlands - Architect: William Alsop - Colorbel

## ▼ INTRODUCTION

### Enamelled glass

Enamelled glass is made by applying enamel to glass, followed by drying and heat treatment.

AGC offers different ranges of enamelled glass:

> **Colorbel:** made by uniformly applying enamel to the entire surface of the glass

> **Artlite:** made using a silk-screen printing process and partial application of enamel through screens having the desired patterns

> **Artlite Digital:** made using a digital printing process.

### Spandrels

Spandrels are used to mask opaque sections and the structural elements of facades.

Depending on the products and colours used, either complete harmony or contrasting effects can be achieved.

Different types of spandrels are available:

> single-pane, enamelled glass: this is clear or coloured glass or glass which is covered with enamel and then thermally toughened or heat-strengthened (Colorbel – availability depending on countries)

> an insulating glazing made of the same glass as the vision glass used in the window (external glass)

> an insulating glazing enamelled in position 4 (Colorbel – availability depending on countries – or Lacobel T)

> a shadow-box: this is a spandrel made of vision glazing combined with an opaque background (e.g. metal sheet) to produce an opaque section in harmony with the building.

# Colorbel

Le Carrefour - Leiden, The Netherlands - Architect: VVKU architecten - Colorbel

## ▼ DESCRIPTION

> Colorbel is heat-strengthened, thermally toughened or HST toughened glass, one side of which is coated with an opaque vitrified enamel during the heat treatment process

> Colorbel presents a standard range of 30 colours, including metallic colours. Specific colours can be developed on request

> The perfect match with AGC's range of solar control glazing: Colorbel CM products are designed to ensure that the glazed spandrel part of a facade is in aesthetic harmony with the vision part

> Depending on the type of heat treatment, these products conform to standards EN 1863, EN 12150 and EN 14179

*See the section on Heat-treated glass.*

> Enamelling is possible on various glass substrates (Planibel Clear, Planibel Coloured, Planibel Clearvision, etc.), thus expanding the range of creative possibilities

> Since Colorbel products are opaque and absorb solar radiation, specific precautions – such as a dedicated heat study and the correct selection of components for use in the insulating glazing – should be taken when using it due to the high temperatures it might reach. See our recommendations on www.yourglass.com.

## ▼ BENEFITS

- > Various applications: spandrels, wall cladding, column cladding, etc.
- > Unlimited colour options: choose from RAL, metallic shades and matt light-diffusing enamels. Or create your own
- > Complies with safety glass standards: depending on the type of heat treatment, these products conform to standards EN 1863, EN 12150 and EN 14179
- > Highly resistant to extreme temperature differences, UV, scratches and stains.

# Artlite & Artlite Digital

Fox Vakanties - Hoofddorp, The Netherlands - Architect: Edward van Dongen - Artlite Digital

## ▼ DESCRIPTION

> The Artlite range offers multiple options for meeting changing market demands: from design freedom in terms of colours, patterns and applications to production processes

> With one side featuring permanent decorative or functional designs, this toughened glass is safe, resistant to aging and UVs

> Designs are created by depositing enamel on the glass using a silk-screen printed process or digital printing

> Large design flexibility, ranging from simple geometrical patterns to customised images.

### Artlite

The traditional Artlite products use a silk-screen printing technique offering countless possibilities in terms of graphical design; it is ideal for repetitive series using the same pattern. Fixed costs are absorbed as more volume is produced in the long run, making this a very cost-effective option.

## Artlite Digital

Customisation and precision are the key benefits of printing on glass by depositing enamel-based ink. Artlite Digital is perfect for creating one-off designs, images and landscapes geared to specific needs or for limited production runs. It offers unlimited options and a shorter deployment process.

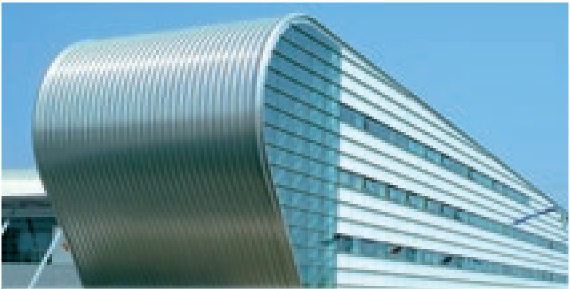
## ▼ BENEFITS

- Unlimited colour options: Choose from RAL, metallic shades and matt light-diffusing enamels. Specific colours can even be developed upon request
- Adjustable light and energy performance to avoid over-heating, cooling and glare, while cutting energy costs
- Compliant with safety glass standards (EN 12150 and EN 14179 for thermally toughened glass and EN 12600 when used in laminated glass).

## ▼ APPLICATIONS

- Facade design: curtain walls, structural glazing, canopies, balustrades
- Protection from the sun: external blinds
- Internal design: partitions, wall panels and cladding
- Privacy: partition, room decoration
- Urban furniture and transportation shelters (train, bus, coach, etc.).

# Thermobel VIP



Wurth Den Bosch - Den Bosch, The Netherlands - Architect: De Twee Snoeken - Thermobel VIP can be installed as a spandrel

## ▼ DESCRIPTION

Thermobel VIP is double glazing for spandrels, presenting the following features:

> an external pane which can be enamelled using a wide variety of colours

> an internal pane which can also be enamelled, or even assembled with a metallic cladding material, depending on requirements

> a vacuum insulation panel (VIP) located in the cavity between the two panes and adjusted in line with the exterior pane

> a warm edge spacer (with UV-resistant silicone).

Combined with high-performance vision glazing, Thermobel VIP spandrels improve the overall insulation of a glass facade.

Thermobel VIP bears the CE marking in line with standard EN 1279-5.

## BENEFITS

- High insulation value (U-value down to 0.3 $W/(m^2K)$)
- The VIP is extremely thin (thickness from 14 mm to 20 mm) versus other solutions available on the market (up to 150 mm thick)
- Gain in ground surface area in relation to conventional solutions
- The spandrel can be integrated into the same facade system as the vision glazing (using the same installation technique)
- The VIP comprises 100% recyclable items.

## SPECIAL FEATURES

- Maximum dimensions: 1,500 x 2,600 mm (larger sizes upon request)
- External appearance: available in various colours (combined or contrasted)
- Internal appearance: selected colours and materials.

## USE

- Thermobel VIP is for use in spandrels
- Available in various colours.

## APPLICATIONS

| | |
|---|---|
| Interior | Yes – selected colours and materials. |
| Exterior | Yes – available in various colours (combined or contrasted). |

## ▼ ENERGY PERFORMANCE

### Energy characteristics in line with EN 674

| Glass | Spacer | VIP | Glass | $U_g$-value of the glazing |
|---|---|---|---|---|
| 6 mm | 22 mm | 20 mm | 4 mm | 0.3 |
| 6 mm | 16 mm | 14 mm | 4 mm | 0.4 |

## ▼ SOUND PERFORMANCE

### Sound insulation in line with EN ISO 717-1

| Glass | Spacer | VIP | Glass | Steel cladding | $R_w$ ($C$; $C_{tr}$) |
|---|---|---|---|---|---|
| 6 mm | 22 mm | 20 mm | 6 mm | - | 35 (-1; -3) dB |
| 6 mm | 22 mm | 20 mm | 4 mm | 0.75 mm | 38 (-2; -5) dB |
| 6 mm | 22 mm | 20 mm | 6 mm | 2.00 mm | 42 (-2; -5) dB |

# 2.9 – Systems (Structura)

Conseil national Principauté de Monaco - Monaco - Architect: ArchiStudio Monaco - Jean-Michel UGHES Architecte - Structura

# Structura

Museum of Polish Jews History - Warsaw, Poland - Architect: Rainer Mahlamäki - Structura Duo+

## ▼ DESCRIPTION

> The Structura range consists of pre-drilled glass held in place by a system of metal fixing points

> The range comprises multiple products:

- Structura Vision: for single or laminated glass
- Structura Duo: for insulating glass with monolithic or laminated components
- Structura Duo+: for insulating glass with monolithic or laminated components. This system eliminates thermal bridging
- Structura Support: for glass fins or glass beams
- Structura Decor: alternative to cladding in single, laminated, enamelled or silk-screen printed glazings.

> The Structura systems can be used for various applications: exterior and/or interior vertical and/or inclined walls, double-skin facades, entryways, galleries, atriums, corridors, canopies etc.

Several Technical Approvals from the CSTB (product) have been granted to the Structura products.

## ▼ BENEFITS

- Ideal for large areas requiring maximum light and transparency
- This system provides a broad view of the surrounding environment
- Perfectly smooth surface on the outside.

## ▼ STRUCTAFLEX GLAZINGS

The different systems within the Structura range are supplied with Structaflex glazing which are specially manufactured for this purpose:

- Thermally toughened Structaflex
- Thermally toughened Structaflex laminated with PVB or EVA
- Double-glazed units with heat-strengthened Structaflex or heat-strengthened and laminated Structaflex components.

The various glass products may be:

- In single glazing: Planibel Clear, Linea Azzurra, Clearvision or Coloured, reflective Stopsol or Sunergy. These products may be enamelled or silk-screen printed
- In double glazing: the same products as with single glazing as well as glazing with low-emissivity or solar protection (Stopray, Stopsol, Sunergy) coatings.

## ▼ TECHNICAL FEATURES

| | |
|---|---|
| Holes | - Countersunk holes with one recess<br>- Cylindrical holes with two recesses<br>- Tolerances:<br>· on diameter -0, +1 mm<br>· in position ± 1.0 mm |
| Edges | Smooth ground edge, nipped corners |
| Dimensional tole-rances | +0; -2 mm |
| Thermal toughening | - Controlled thermal toughening following Heat Soak Treatment<br>- Structaflex and CE marking |
| Heat Soak Treatment | On all sheets |
| Laminating | - Assembly with 4 x 0.38 mm PVB or EVA<br>- Plain or tinted interlayers |
| Double glazing units | Integrated factory-sealed insert.<br>Option: silicone profile between the glazings assembled at the factory |

## ▼ STRUCTURA VISION

Structura Vision is a system of single, monolithic or laminated glazing allowing maximum light transmission and a low level of exterior light reflection. Very large sheets of glass can be used safely and securely depending on external constraints.

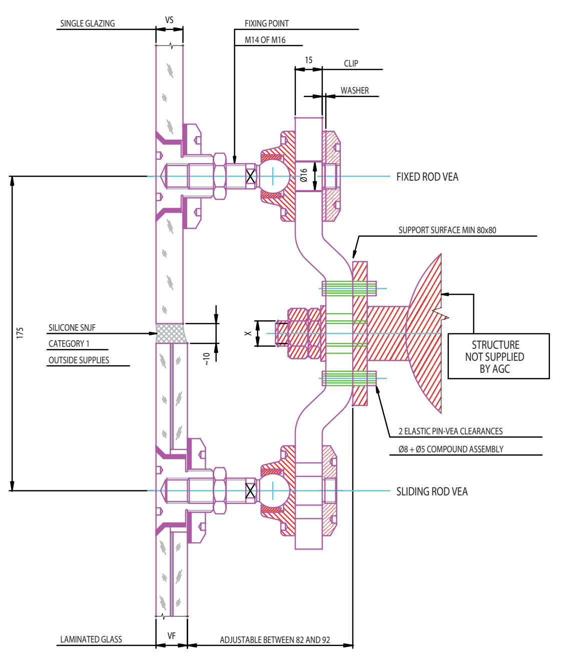
Structura Vision has three variants:

> Vision G: knee-joint system: capable of bearing heavy weights and stresses and significant differential movements – for facades and roofs

> Vision R: knee-joint system: capable of bearing average stresses – for roofs and facades

> Vision V: simplified system: capable of bearing light stresses – mainly for interior vertical partitions.

## Structura Vision diagram



## ▼ STRUCTURA DUO

Structura Duo is an insulating double-glazing system with monolithic or laminated components. It is recommended when a high level of thermal and solar performance is required.

AGC offers a full manufacturing process to ensure optimum quality.

## ▼ STRUCTURA DUO+

Structura Duo+ features new composite materials to replace the steel insert body and aluminium ring spacer, thus improving insulation (by eliminating the thermal bridge) and enhancing the appearance of the installed system. This solution is especially well-suited to facades with double glazing, laminated glass or monolithic glass for use in temperate and cold climates in Central and North European countries. This system has best $U_W$ = 1.3 W/($m^2$K) for structural glazing. Naturally, it complies with the legislation of those countries(1). Last but not least, on top of handling the full manufacturing process, AGC also provides support in the technical design and computations at the early stage of the facade design.

## ▼ STRUCTURA SUPPORT

Structura Support is the logical back-up for Structura Vision and Duo point-fixed structural glazing. The metal and opaque structures are replaced with transparent ones: Structura Support allows glass fins and beams to be incorporated safely and securely into structural glass.

This can be used to create real “all-glass” facades.

(1) Structura Duo+ is not available in France

# 2.10 – All-glass facades

Veresine - Milan, Italy - Architect: Studio KPF - Stopray Vision-50

# Structural glazing

GDF Suez Headquarters - Brussels, Belgium - Architect: M&J-M Jaspers - J. Eyers & Partners - Thermobel Stopray

## ▼ DESCRIPTION

This technique can be used to create an all-glass facade in which the actual structure is hidden behind the glass.

The silicone seal is designed to transfer stresses and to be resistant to UV radiation since there is no rebate on the edges.

The structural glazing facade technique can be used with single panes of glass, coated or non-coated double glazing, enamelled glass, etc.

## ▼ BENEFITS

Structural glazing can be used to create all-glass facades.

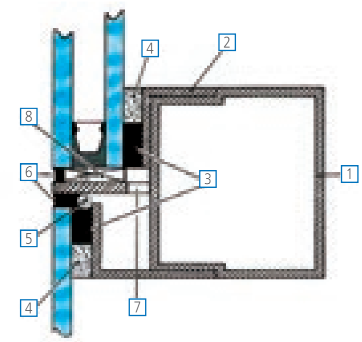
Due to its design, structural glazing also provides:

> good waterproofing
> excellent sound insulation
> an easy-to-clean surface
> protection for the load-bearing structure.

## ▼ PRINCIPLES OF A STRUCTURAL GLAZING FACADE

Glazings (single panes or insulating glazing) will generally be factory-bonded on a metal frame. The glass and frame unit 290290is then transported to the site and fixed to the load-bearing structure.

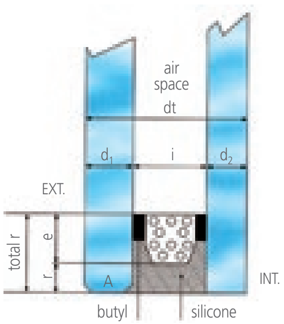
### Structural Glazing Façade diagram




1. Framework
2. Gluing frame support
3. Structural gluing
4. Spacer also backer rod
5. Backer rod
6. Seal
7. Weephole
8. Setting block

## ▼ DESCRIPTION OF STRUCTURAL GLAZING

### Structural Glazing diagram




| | |
|---|---|
| d1: | thickness of the exterior glass: min. 6 mm, max. 17 mm (max. 11 mm in Stopray) |
| i: | air space: 8, 10, 12, 15 mm |
| d2: | thickness of interior glass: max. 17 mm |
| dt: | total thickness of double glazing S: 52 mm max. (max 32 mm in Stopray) |
| e: | height of interlayer |
| r total: | glue and interlayer (according to calculation) |
| r: | interlayer shrinkage (according to calculation) |
| A: | the edge of the exterior pane will always be treated; the edge of the interior pane will generally be as cut; this edge will only be treated upon request. |

## ▼ GLASS COMPONENTS

We generally recommend using glass with a minimum thickness of 6 mm. The glass used is either single or double glazing in which at least one edge remains visible and exposed to radiation. For this reason, the seal must be made of silicone.

| | |
|---|---|
| Float glass – single glazing | Yes – See Planibel and Planibel Coloured. |
| Coated float glass – single glazing | Yes – See solar control glass with a pyrolytic coating which can be used in single glazing units: Stopsol – Sunergy.<br>Edge stripping is not necessary. |
| Insulating glazing | - The height of the silicone seal is higher than that of ordinary insulating glazing and will be calculated to resist wind pressure on the glass<br>- For safety reasons, the interior glass must never be toughened. This is to prevent the second pane of glass from disintegrating if the interior pane breaks<br>- Where necessary, the interior glass will be strengthened<br>- When using magnetron coatings (Stopray, ipasol, iplus), the coating must be edge-stripped to a higher level than that of a traditional glazing since the silicone structural glazing seal is positioned higher than a normal seal. This will cause a larger dark edge to be visible from the outside<br>- When dealing with "stepped" glass, the visible height must be edge-stripped.<br>Stopray Smart does not require any edge deletion (check the mandatory processign requirements) |
| Spandrel/enamelled glass | Yes – Check with the silicone supplier that the structural seal adheres to the enamel. |
| Laminated safety glass | Yes – See Stratobel |

Torre Gas Natural - Barcelona, Spain - Architect: Enric Miralles & Benedetta Tagliabue -
Stopsol Supersilver Grey & Stopsol Classic Clear

Office Building - France - Lacobel T Burgundy Red (wall cladding)

# — IV —
# Brands and products

## 3. Interior glass

# 3.1 – Introduction

IMOBA II - Prague, Czech Republic - Architect: A 32 spol. s r. o. - Lacobel Black Classic

AGC Glass Europe was the first glass manufacturer to offer a wide range of decorative glass products for interior applications. The well-known AGC Mirox brand has even become a synonym for high-quality Belgian mirrors in most regions of the world.

Another highlight in AGC's interior glass range is Lacobel: a registered trademark for painted glass, presenting a large palette of trendsetting colours.

The interior glass product range is supplemented by a variety of other glass solutions offering customers unlimited design options. Over the years, AGC has become a preferred partner for interior architects and designers around the globe.

## ▼ DESIGNING WITH GLASS

AGC provides glass products in line with design trends, as well as customised solutions.

Various options for different colours, transparencies, surface structures, reflectivity and opacity levels are available. Ranging from clear and coloured float glass (see Planibel), mirrors (see Mirox), painted glass (see Lacobel, Matelac, Lacobel T), patterned glass (see Imagin, Oltreluce), up to and including glass with a satin touch or optical features (see Matelux, Matelac, Lacomat), AGC's interior glass ranges provide a solution for all needs.

Individual design requests about colour or printed layouts can be answered with customised products such as Artlite and Colorbel.

## ▼ ADDED VALUE WITH GLASS

In addition to design, several other glass characteristics can be chosen to benefit from the advantages of this unique and noble material.

For environments which request special safety, AGC offers a variety of glass products that can be toughened, laminated or backed by a safety film (SAFE and SAFE+).

As a special option in applications having advanced health care or hygiene requirements, AGC offers an AntiBacterial™ finishing for float glass, mirrors and painted glass.

Various other characteristics can be added to the raw glass by choosing specific coatings or acid etching, just to mention a few options.

## ▼ GLASS PROCESSING AND INSTALLATION

Besides all optical and functional benefits of glass, AGC cares about the processing, installation and maintenance of the glass. All products are developed to allow safe, fast and efficient processing.

Special processing, installation and maintenance guides are available for each product on www.yourglass.com.

## ▼ UNLIMITED CREATIVITY

Architects and designers now have a free hand in using glass creatively: for structural purposes, for protective applications, for presentation and work situations, or in a purely decorative role.

The applications are endless, including wall cladding in bathrooms and kitchens, shower screens, sliding doors, fixed doors, wardrobes, tables, shelves, balustrades, ceilings and partitions, and many more.

# 3.2 – Mirrors & reflective glass

Tour Oxygène - Lyon, France - Lacobel Orange Classic & Mirox 3G

## ▼ INTRODUCTION

AGC offers a wide range of reflective glass products which can be divided into two families depending on the production process and aesthetic/functional characteristics:

> Mirrors: silver-based mirrors under the globally renowned Mirox brand:
  - MNGE: two-layer mirror
  - 3G: single-layer mirror.

> Decorative reflective glazings:
  - chromium-based mirrored panes under the ipachrome brand
  - pyrolytic-coated reflective glazings under the Stopsol Supersilver brand.

Furthermore, AGC offers different solutions for special applications:

> Advanced requirements for safety:
  - tempering: processing solution applicable to ipachrome glazings
  - safety backing: use of high performance safety foils SAFE and SAFE+.

> Special requirements for design:
  - Mirold Morena: oxidised mirrors with an antique appearance
  - Sanilam EasyCut: two-sided Mirox mirror
  - Black Mirox: dark mirror on Dark Grey Planibel Float
  - Stopsol Supersilver: reflective glazing without backlight and transparent glazing with backlight.

> Advanced requirements for health care and hygiene:
  - AntiBacterial™: silver ion finishing available for Mirox mirrors.

# Mirox New Generation Ecological (MNGE)

Sofitel - Vienna, Austria - MNGE Black Mirox

## ▼ DESCRIPTION

> Mirox New Generation Ecological mirrors stand out for their:
- copper-free metal coating
- low-level lead paints
- resistance to corrosion.

> Whatever the AGC production site, the patented manufacturing process ensures that MNGE is always a high-quality, highly resistant mirror according to international standards

> MNGE shows close to zero indoor emissions of volatile organic compounds (VOCs), including formaldehyde

> MNGE products are Cradle to Cradle Certified™ Silver.

## ▼ BENEFITS

> Unrivalled anti-corrosion properties and protection against ageing
> Excellent resistance to aggressive agents such as the ammonia and acetic acid found in certain cleaning products
> No pitting or clouding damage with age
> Available on Dark Grey Planibel Float (Black Mirox)
> Environmentally friendly mirrors.

## ▼ RANGE

Colour: clear, extra-clear (Clearvision), grey, bronze, green and black versions.

## ▼ STANDARD THICKNESSES (mm)

Available in standard thicknesses from 3 to 10 mm.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

## ▼ APPLICATIONS

| | |
|---|---|
| Interior | - Mirror panes<br>- Furniture: partitions, tables, shelves, fixed doors, sliding doors, display cases and glass bases<br>- Wall cladding |
| Exterior | No |

## ▼ PROCESSING OPTIONS

| | | |
|---|---|---|
| **Safety options** | | |
| With SAFE or SAFE+ film | Yes – Complies with standard EN 12600 class 2B2 for safety of individuals. Applying a SAFE(+) film also makes the silvering resistant to scratches when the back of the glass is exposed. | |
| **Surface treatments** | | |
| Sandblasting | Yes | |
| Acid-etching | Yes – On the non-silvered side. | |
| **Cutting and processing** | | |
| Rectangles, circles | Yes | |
| Edge-grinding, drilling, notches | | |
| **Stress resistance** | | |
| Heat resistance | The silvering can withstand temperatures up to 80°C. | |
| Moisture resistance | Yes – Can be used in applications such as kitchens or bathrooms with normal humidity levels and ventilation. Should not be immersed in water. | |
| UV resistance | Yes | |
| Reaction to fire | Mirox MNGE and 3G<br>Mirox MNGE and 3G SAFE/SAFE+<br>Mirox MNGE and 3G (SAFE/SAFE+) silicone glued (AGC FIX-IN range) | A1<br>A2 s1 d0<br>B s1 d0 |

*For more details, please refer to the processing and installation guides available on www.yourglass.com – Mirox MNGE and Mirox 3G.*

## ▼ SAFETY LEVELS

When impacted on the glass side, the Mirox SAFE or SAFE+ complies with the requirements of standard EN 12600.

### Safety performance

The tests performed by an independent institute in respect of standard EN 12600 clearly demonstrate that as from a thickness of 3 mm, the SAFE and SAFE+ versions of Mirox and Mirold have a breakage pattern similar to a laminated glass. Accordingly, Mirox and Mirold SAFE/SAFE+ can be used in broad glass walls.

| Thickness | Mirox and Mirold SAFE/SAFE+<br>Impact resistance as per EN 12600 |
|---|---|
| 3 mm | 3B3 |
| 4 mm | 2B2 |
| 5 mm | 2B2 |
| 6 mm | 2B2 |

### Cutting

For Mirox and Mirold glass with a SAFE or SAFE+ film the cut is made directly through the film and the glass using a special double-angled cutting wheel.

*For more details, please refer to the processing and installation guides available on www.yourglass.com - Mirox MNGE and Mirox 3G.*

# Mirox 3G

Sofitel - Vienna, Austria - Mirox 3G

## ▼ DESCRIPTION

> Mirox 3G is the most eco-friendly mirror in the AGC range, presenting no copper, no formaldehydes and a close to zero level of lead (< 0,1%)

> Distinctive marking: Mirox 3G Ecological is printed on the back

> Complies with the EU's Restriction of Hazardous Substances (RoHS) Directive, which aims to reduce the use of certain hazardous substances, including lead, in industrial production processes

> Mirox 3G shows close to zero indoor emissions of volatile organic compounds (VOCs), including formaldehyde

> Mirox 3G products are Cradle to Cradle Certified™ Silver.

CERTIFIED cradletocradle CM

SILVER

## ▼ BENEFITS

> 3 times more resistant to scratches than standard mirrors thanks to its protective epoxy paint coating

> 10 times more resistant to corrosion than standard EN 1036, meaning less risk of corrosion in the long term due to oxidation of the silver layer at the edges or around scratches

> Highly resistant to corrosion caused by the natural atmosphere and humidity

> Very resistant to chemical corrosion caused by cleaning products: Mirox 3G is resistant to virtually all existing cleaning products.

## ▼ RANGE

Colour: clear, extra-clear (Clearvision), grey, bronze, green and black versions.

## ▼ STANDARD THICKNESSES (mm)

Available in standard thicknesses from 1.9 to 10 mm

*See the AGC Product Catalogue on www.yourglass.com for more details.*

## ▼ APPLICATIONS

| | |
|---|---|
| Interior | - Mirror panes<br>- Furniture: partitions, tables, shelves, fixed doors, sliding doors, display cases and glass bases<br>- Wall cladding |
| Exterior | No |

## ▼ PROCESSING OPTIONS

*See on page 303.*

## ▼ SAFETY LEVELS

*See on page 304.*

# Mirold Morena

Mirold Morena mirror

## ▼ DESCRIPTION

> Mirold Morena is a mirror on clear float glass, offering a unique antique look

> The special appearance is achieved through controlled oxidation of the silver coating.

## ▼ BENEFITS

Unique antique appearance.

## ▼ STANDARD THICKNESSES (mm)

Available in standard thicknesses 4 and 6 mm.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

## ▼ APPLICATIONS

| | |
|---|---|
| Interior | - Mirror panes<br>- Furniture: partitions, horizontal surfaces, fixed and sliding doors and glass bases<br>- Wall cladding |
| Exterior | No |

## ▼ PROCESSING OPTIONS

*See on page 303.*

## ▼ SAFETY LEVELS

*See on page 304.*

# Sanilam Easycut

Double sided Sanilam mirror for bathroom cupboard

## ▼ DESCRIPTION

Sanilam Easycut consists of two Mirox mirrors assembled using an adhesive coating to ensure mirroring on both sides.

Sanilam Easycut presents:

> a copper-free metal coating

> low level lead paints

> high resistance to corrosion.

## ▼ BENEFITS

> Mirror appearance on both sides

> The whole surface and edges of the silver coatings are protected against corrosion

> Guaranteed against corrosion for 10 years when cut and processed by AGC or by an approved processor (list of approved processors available from your local AGC representative).

## ▼ PROCESSING OPTIONS

| | |
|---|---|
| **Surface treatments** | |
| Sandblasting | Yes |
| Acid-etching | Yes |
| **Cutting and processing** | |
| Rectangles, circles | Yes |
| Edge-grinding, drilling, notches | |
| **Stress resistance** | |
| Heat resistance | The silvering can withstand temperatures up to 80°C. |
| Moisture resistance | Yes – Can be used in applications such as kitchens or bathrooms with normal humidity levels and ventilation. Should not be immersed in water. |
| UV resistance | Yes |

## ▼ STANDARD THICKNESS (mm)

Available in a standard thickness of 6 mm (3+3).

*See the AGC Product Catalogue on www.yourglass.com for more details.*

## ▼ APPLICATIONS

| | |
|---|---|
| Interior | Yes – Cabinet doors with or without framing |
| Exterior | No |

# ipachrome design

John Lewis Department Store - Leicester, UK - Partial ipachrome design

## ▼ INTRODUCTION

ipachrome design features a multilayer coating containing chrome. With a light reflectance of more than 50%, ipachrome design reflects like a conventional silver mirror but is much more durable.

ipachrome design can be tempered and processed into laminated safety glass or further processed into insulating glazing units.

Furthermore, the possibility to apply partial coating offers many design and application possibilities, both outdoors and indoors. Simple motives and complex photorealistic images can be transferred by masking onto the glass surface. The chrome coating is then applied, followed by removal of the mask. The final result is a detailed mirrored pane with high contrasts, transforming the glazing into an eye-catching design object without loosing any functionality.

## ▼ BENEFITS

> Multiple processing options (thermally toughenable and processable into laminated safety glass), combining attractive and eye-catching design without compromising functionality.

> Coating can be partially applied for design purposes.

# ▼ PROCESSING OPTIONS

| Heat treatment and lamination | |
|---|---|
| Thermal toughening | Yes |
| Heat strengthening | Yes |
| Bent glass | On request |
| Lamination | Yes |
| **Surface treatments** | |
| Silk screen-printing and enamelling | Yes – Frit needs to be applied before the coating |
| **Safety options** | |
| ipachrome design T is a safety glass when thermally toughened or processed into a laminated safety glass | |
| **Cutting and processing** | |
| Rectangles, circles | Yes |
| Edge-grinding, drilling, notches | |
| **Stress resistance** | |
| Heat resistance | Non heat treated it can withstand temperatures up to 40 °C. Thermally toughened it can withstand temperatures up to 200 °C. Heat strengthened it can withstand temperatures up to 100 °C. |
| Moisture resistance | Yes |
| UV resistance | Yes |

# ▼ STANDARD THICKNESSES (mm)

Available in standard thicknesses of 6, 8, 10 and 12mm.

*For other thicknesses or sizes, special substrates etc, please contact AGC Interpane.*

*See the AGC Product Catalogue on www.yourglass.com for more details.*

# ▼ APPLICATIONS

| | |
|---|---|
| Interior | Yes |
| Exterior | Yes – Position 2 |

# Stopsol Supersilver

Private house - Poland - Sliding door by Alu-Style Kft. with Stopsol Supersilver

## ▼ DESCRIPTION

> Stopsol Supersilver is a pyrolytic-coated reflective glazing offering privacy and visual comfort

> Its coating delivers outstanding reflection, uniformity and hard scratchproof performance

> Stopsol Supersilver is highly reflective without backlight and becomes transparent when backlit

> Processors particularly appreciate its pyrolytic coating, which is easy to toughen, bend and use in single or double glazing. Stopsol Supersilver is available in five colours.

## ▼ BENEFITS

> It switches from reflective to transparent glazing if a backlight is turned on

> Perfect uniformity and very hard scratchproof coating

> Easy to process

> Wide range of colours: clear, grey, green, dark blue, Priva-Blue.

## PROCESSING OPTIONS

| | |
|---|---|
| **Heat treatment and lamination** | |
| Heat treatment | Yes |
| Bending | Yes |
| Lamination | Yes |
| **Surface treatments** | |
| Silk screen-printing and enamelling | Yes – Feasibility test to be performed by the processor if a silkscreen is applied onto the Stopsol coating |
| **Safety options** | |
| Stopsol Supersilver is a safety glass when heat treated | |
| **Cutting and processing** | |
| Rectangles, circles | Yes |
| Edge-grinding, drilling, notches | |
| **Stress resistance** | |
| Heat resistance | Thermally toughened it can withstand temperatures up to 200 °C.<br>Heat strengthened it can withstand temperatures up to 100 °C. |
| Moisture resistance | Yes |
| UV resistance | Yes |

## RANGE

Colour: clear, grey, green, dark blue, PrivaBlue.

## STANDARD THICKNESSES (mm)

Available in standard thicknesses from 4 to 10 mm, depending on the colour.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

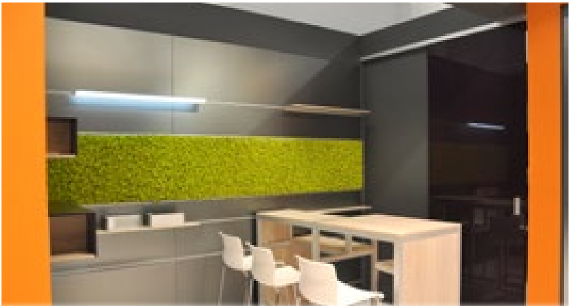
## APPLICATIONS

| | |
|---|---|
| Interior | Yes |
| Exterior | Yes |

# 3.3 – Painted glass

High-end furniture design - Lacobel Blue Petrol

# Lacobel & Matelac



Private house - Hungary - Application by Alu-Style Kft., using Matelac Silver Grey

## ▼ INTRODUCTION

Lacobel and Matelac have a long-standing reputation as top-quality painted decorative glass products offering endless design opportunities to enhance any interior design project.

Their opaque appearance is achieved by applying a high-quality paint to the back of the glass.

The paints used are environmentally friendly and both ranges are Cradle to Cradle Certified™ since 2013.

## ▼ DESCRIPTION

> While Lacobel offers a reflective and shiny appearance (paint + float glass), the Matelac range shows a smooth satin look (paint + acid-etched float glass)

> Both types of glass are used in a wide variety of furniture and interior design applications

> They are also available in a SAFE or SAFE+ version

*To know more about safety backing films, see the chapter on SAFE/SAFE+.*

> Lacobel and Matelac products are Cradle to Cradle Certified™ Silver. For more information, please refer to www.yourglass.com.

## ▼ BENEFITS

> High-quality finishing: the unique manufacturing process, based on a curtain coater system, guarantees a uniform finish and the paint to adhere flawlessly to the glass

> Easy to clean and maintain due to its large smooth surface

> Lacobel and Matelac products show very little indoor emissions of Volatile Organic Compounds (VOCs), including very low levels of formaldehyde.

## ▼ COLOUR RANGE

> Lacobel: 25 standard colours

> Matelac: 12 standard colours

## ▼ STANDARD THICKNESSES (mm)

> Lacobel: from 3 to 10 mm

> Matelac: from 4 to 10 mm.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

## ▼ PROCESSING OPTIONS

| | |
|---|---|
| **Safety glass** | |
| With SAFE or SAFE+ film | Yes – Complies with standard EN 12600 for safety of individuals.<br>See section on SAFE and SAFE + safety backing. |
| **Surface treatments** | |
| Sandblasting | Yes – Lacobel on the non-painted side. Matelac is by definition an acid-etched glass. |
| Acid-etching | Yes – Lacobel on the non-painted side.<br>Matelac is by definition an acid-etched glass. |
| **Cutting and processing** | |
| Rectangles, circles | Yes – Like traditional mirror glass. |
| Edge-grinding, drilling, notches | |
| **Stress resistance** | |
| Heat resistance | Lacobel and Matelac paints can withstand temperatures up to 80°C and temperature difference of 30°C on the same sheet of glass. |
| Moisture resistance | - All Lacobel and Matelac colours can be used in humid environments (bathrooms and kitchens), but should not be immersed in water.<br>- The metallic colours (Metal Grey, Metal Taupe, Rich Aluminium and Starlight Black) require a SAFE or SAFE+ film to be applied in such locations.<br>- Lacobel and Matelac should be protected from any water leakage on the back of the glass (silicone should be used for seals). |
| UV resistance | Yes |

*For more details, please refer to the installation and processing guides available on www.yourglass.com – Lacobel and Matelac.*

## ▼ APPLICATIONS

| | |
|---|---|
| Interior | - Furniture: partitions, tables, shelves, fixed and sliding doors, display cases and glass bases<br>- Wall coverings |
| Exterior | No |

# Lacobel T

Private loft - Belgium - Lacobel T Petrol Green

## ▼ DESCRIPTION

Lacobel T is the first high-quality painted glass that processors can immediately cut and heat-treat at their plant. This simplifies the production process and accelerates the delivery times, ultimately resulting in both lower costs and faster response to market needs.

To achieve this, a toughenable coloured paint is applied to the back of the float glass prior to the heat treatment which fixes it to the glass surface.

To avoid any damage to the paint and subsequent risks of aesthetic defects, Lacobel T must be heat-treated by tempering furnaces equipped with at least upper convection.

Available in 15 trendsetting colours, this glass is strong, safe and highly resistant to heat, thermal shock and UV, making it suitable for indoor and outdoor use.

## ▼ BENEFITS

After heat-treatment Lacobel T is a true enamelled glass which:

> presents a uniform and glossy appearance over time
> can be classified as safety glass as per EN 12150
> offers high resistance to impacts, thermal shocks and scratches
> is light and UV resistant, no discolouring
> has high resistance to moisture
> can be used indoors (wall cladding, furniture) and outdoors (facades, IGU, garden furniture)
> offers nearly zero indoor emissions of volatile organic compounds (VOCs).

## ▼ BENEFITS FOR PROCESSORS

> More flexible management of production and inventory
> Significant time saving, shorter delivery times
> Impeccable appearance thanks to industrial paint application process
> Colour stability after toughening
> Scratch-resistant paint prevents damage during shipping
> Can also be used outdoors, e.g. in facades and spandrels.

## ▼ RANGE

> Colours: 15 standard colours.

## ▼ STANDARD THICKNESSES (mm)

Standard: 4, 6, 8, 10 mm. Non-standard: 3[(1)], 5, 12 mm

*See the AGC Product Catalogue on www.yourglass.com for more details.*

(1) Special tempering quench needed.

## ▼ PROCESSING OPTIONS

| | |
|---|---|
| **Safety glass** | |
| Toughening | Yes – Convection furnace mandatory |
| Lamination | Yes – With PVB, on both painted and glass sides |
| SAFE film | No longer necessary |
| **Surface treatments** | |
| Sandblasting | Yes – On glass side before or after heat treatment and on painted side before |
| Etching | On glass side after heat treatment |
| Silk-screen printing | No – With the exception of cold screen-printing on the glass side after heat treatment |
| Bending | Painted side opposite to mould/furnace rollers |
| **Cutting and processing** | |
| Rectangles, circles | Yes |
| Edge-grinding, drilling, notches | |
| **Stress resistance** | |
| Heat resistance | Yes – Resistant to thermal shock after heat-treatment. Up to 200°C temperature difference within the glass surface. |
| Moisture resistance | Yes – Can be used in applications such as kitchens or bathrooms with normal humidity levels and ventilation. Should not be immersed in water. |
| UV resistance | Yes – The colour is fixed during the tempering process (no discolouration). |
| Reaction to fire | EN 13501-1:A1 |

*For more details, please refer to the installation and processing guides available on www.yourglass.com – Lacobel T.*

## ▼ APPLICATIONS

| | |
|---|---|
| Interior | - Furniture: doors, table tops, shelves, writing boards<br>- Wall cladding (especially near heat sources)<br>- Display units<br>- Retail stands<br>- Kitchen splashbacks |
| Exterior | Outdoor furniture, facade cladding, shop fronts, spandrels |

# MyColour by Lacobel

Pomme Sucrée - Gijón, Spain - MyColour by Lacobel

## ▼ DESCRIPTION

MyColour by Lacobel is a service providing the option of designing your own Lacobel colour. With this unique tool you can order Lacobel glass in the colour of your choice (minimum order of 200 m² required), matching your design requirements or corporate identity. This service is available online for registered clients.

## ▼ BENEFITS

> Service based on customer requirements

> Quick delivery times:

- one week for receiving an initial test sample
- three to four weeks for delivery of the order.

> A tracking system allows you to see the status of your order (manufacture, delivery, etc.).

## ▼ HOW TO ORDER

> Go to www.yourglass.com

> Click on “MyColour by Lacobel” in the “Tools” section

> Enter your login and password (please ask your local AGC representative for these codes)

The system will then give you two possibilities:

- you can either type in the RAL or Pantone colour reference (if you already know it)
- you can send a sample (a piece of fabric, paper or any other item) to the address given on the site and you will receive a sample of painted glass in the colour you wish to reproduce. If the test is conclusive, you can place your order using the paint reference you received. Orders will be delivered within 3 to 4 weeks.

# SAFE and SAFE+

Door by Alu-Style Kft., with Lacobel SAFE

## ▼ DESCRIPTION

SAFE is a polymer film applied to the painted side of the glass. It has two functions:

> If the glass breaks, the splinters adhere to the film thereby preventing injury and damage

> The film protects the paint from scratches.

SAFE exists in two versions: SAFE and SAFE+.

> SAFE: this film is available from AGC on glass in cut sizes only.

  The glass can be bonded with silicone as long as a primer is applied beforehand on the film side.

> SAFE+: the SAFE+ film is designed for use with DLF glass formats. Compared to the traditional SAFE film, the SAFE+ film presents no overlap of the foil: it is applied to the entire sheet making the cutting process easier (special cutting recommendations available from your local agent).

  The glass can be bonded with silicone as long as a primer is applied beforehand on the film side.

## ▼ SAFETY LEVELS

> When impacted on the glass side, the SAFE or SAFE+ film complies with the requirements set out in standard EN 12600

> The tests performed by an independent institute in respect of standard EN 12600 clearly demonstrate that as of a thickness of 3 mm, Mirox and Lacobel/Matelac featuring SAFE or SAFE+ have a breakage pattern similar to laminated glass (type B). As such, Mirox and Lacobel/Matelac SAFE/SAFE+ can be used in wide glass walls.

### Soft body impact resistance per EN 12600

| Thickness | Lacobel SAFE/SAFE+ | Matelac SAFE/SAFE+ |
|---|---|---|
| 3 mm | 3B3 | N/A* |
| 4 mm | 2B2 | 3B3 |
| 5 mm | 2B2 | N/A* |
| 6 mm | 2B2 | 3B3 |

* The actual "Product Catalogue" does not offer these products.

## ▼ CUTTING

Cutting glass coated with a SAFE or SAFE+ film: the cut is made directly through the film and the glass using a double-angled cutting wheel.

*For more details, please refer to the installation and processing guides available on www.yourglass.com - Lacobel, Matelac, Mirox.*

# FIX-IN: Bonding solution for design glass

Gluing is the most common method for bonding glass sheets to a substrate (such as walls, furniture and other structures).

Unlike many other fitting methods (using screws, clips, etc.), bonding systems ensure that there is no visible means of fixation to interrupt the smooth appearance of the flat glass wall.

AGC has many years of successful experience in this field and provides its own advanced solution for the many different bonding and fitting necessities of its customers: the FIX-IN glass bonding solution for design glass.

The FIX-IN range is a solution for interior applications that includes the silicone adhesive and the appropriate primer and surface activator. Professionals can buy the components online at www.agc-store.com or from their glass processors.

The FIX-IN product range is ideal for Mirox, Lacobel, Lacobel T and Matelac. The unique compatibility between the various FIX-IN components and AGC paints prevent them from corrosive damages on the back of decorative glass, guaranteeing colour uniformity and stability.

AGC also offers a 5-year warranty(1) against paint discoloration, peeling or cracking on the back of the glass. To assist with application, an extensive installation guide and technical data sheets

(1) This warranty is subject to specific terms and conditions. See www.yourglass.com for more details.

for FIX-IN products are available on www.yourglass.com. There is also a 3D animation showing the main installation steps.

The full FIX-IN system consists of five products:

> FIX-IN PR: wall primer for use on porous surfaces prior to applying FIX-IN SL

> FIX-IN SA: surface activator, to be used on AGC's SAFE(+) film prior to applying FIX-IN SL

> FIX-IN AT: double-sided adhesive foam tape, as spacer and for initial tack

> FIX-IN SL: interior application silicone adhesive

> FIX-IN TU: touch-up paint for small scratches on painted Lacobel and Matelac glass that might occur during installation or processing of the glass.

All products have been tested with various substrates, including tiles in case of refurbishment (see table).

| Product | FIX-IN PR Primer | FIX-IN SL Silicone adhesive |
|---|---|---|
| MDF, Medium Density Fibreboard (EN 316) | No | Yes |
| OSB, Oriented Strand Board (EN 300) | No | Yes |
| Particle board, not fire retardant treated (EN 312) | No | Yes |
| Gypsum plasterboard (EN 520) | Yes | Yes |
| Plywood, not fire retardant treated (EN 312) | No | Yes |
| Calcium silicate board (prEN 14306) | Yes | Yes |
| Fibre cement board (ISO 390) | Yes | Yes |
| Gypsum plaster | Yes | Yes |
| Cement plaster | Yes | Yes |
| Concrete | Yes | Yes |
| Brick masonry | Yes | Yes |
| Tiles, existing | Not needed if the bonding surface is clean and adherent | Yes |

Important: All FIX-IN products must be stored and handled in compliance with the latest version of the AGC Installation Guide for interior glass as well as the product's technical data sheets. These can be found on www.yourglass.com. Any local requirements and regulations must also be followed.

# 3.4 – Satin-finish glass

Door "Wave" by Fratelli Longhi - Italy - Matelux Dark Grey

## ▼ INTRODUCTION

Translucent glass sheets with a satin finish are often chosen in interior decoration for their smooth and noble appearance and for their capacity to provide a certain degree of privacy by filtering light softly or by diffusing reflections

AGC uses several techniques to create a satin finish:

> satin painting (Lacomat)

> acid-etching (Matelux, Matelac).

The choice of the technique will depend on the type of application, the degree of translucency or reflective light diffusion and the level of safety required.

Depending on the technique used, the level of light transmission of a translucent glass can be very close to that of clear glass.

# Matelux

Sofitel - Vienna, Austria - Sliding door with Matelux Grey

## ▼ DESCRIPTION

> Matelux is a float glass with a high-quality, acid-etched finish, either on one or on both sides

> Available in an antislip version for steps and floors

> Ideal for interior (furniture, etc.) and exterior (facades and roofs, etc.) applications

> Matelux products are Cradle to Cradle Certified™ Silver. For more information, please refer to www.yourglass.com.

CERTIFIED cradletocradle™ SILVER

## ▼ BENEFITS

- Translucent, neutral satin-finish glass: more transparent than Lacomat or sandblasted glass
- Multiple processing options: may be toughened, laminated (with a clear or coloured interlayer), assembled in double glazing, etc. Easy to maintain, highly resistant to stains
- Acid-etching is highly appreciated for its fine and uniform grain
- High level of light transmission: at the same thickness, Matelux can offer the same level of light transmission as float glass.

## ▼ SPECIFIC APPLICATIONS: MATELUX STOPSOL

### Description

Matelux Stopsol is a float glass with a Stopsol reflective coating on one side and an acid-etched finish on the other side. The side with the reflective coating is positioned against the supporting structure.

### Aesthetic benefits

- Combines seamlessly with corresponding Stopsol vision glass
- Contrasting aesthetic effect of vision glass (neutral or reflecting) and satin-finished spandrels
- Dynamic appearance: In rainy weather, the wet Matelux Stopsol spandrel is shiny and reflective, while in sunny weather the glass has a satin metallic look.

## ▼ SPECIFIC APPLICATIONS: MATELUX ANTISLIP

- The special etching – patented by AGC Glass Europe – gives this glass antislip properties (in accordance with German standard DIN 51130, classified R10)
- Available as standard on Planibel Clear and Planibel Clearvision.

## ▼ PROCESSING OPTIONS

| | |
|---|---|
| **Heat treatment** | |
| Heat strengthening and thermal toughening | Yes |
| Bending | Yes |
| **Lamination** | |
| PVB | Yes – The acid-treated side should not be positioned against the PVB layer (to retain the unique matt appearance of Matelux). |
| EVA | Yes |
| **Surface treatments** | |
| Silk-screen printing and enamelling | Yes – On both sides |
| Painting and varnishing | Yes – On the non-etched side. See the Matelac range on www.yourglass.com. |
| Silvering | Yes – On the non-etched side. See the Matelac Silver range on www.yourglass.com. |
| **Cutting and processing** | |
| Rectangles, circles | Yes – Cuts like traditional float glass. |
| Edge-grinding, drilling, notches | |
| **Stress resistance** | |
| Heat resistance | Same as float glass |
| Moisture resistance | Yes – Where the etched side of the Matelux glass is exposed to water, the etching becomes less visible. It recovers its uniform appearance when dry. |
| UV resistance | Yes – May be exposed to the sun and artificial light. |
| Reaction to fire | A1 |
| Bending resistance | Matelux offers the same bending resistance as Planibel float glass (tested against standard EN 1288-3). |

## ▼ RANGE

There are three types of etching and several types of float glass depending on the required level of translucency and colour.

| Glass substrate | Type of etching | | |
|---|---|---|---|
| | Classic etching on one side | Light etching on one side | Etching on both sides |
| **Clear float glass** | | | |
| Clear (light green edge) | ✓ | ✓ | ✓ |
| Clearvision (clear edge) | ✓ | | |
| Linea Azzurra (light blue edge) | ✓ | | |
| **Coloured float glass** | | | |
| Bronze | ✓ | | |
| Green | ✓ | | |
| Grey | ✓ | | |
| Dark Grey | ✓ | | |
| **Glass with a Stopsol coating** | | | |
| Supersilver clear | ✓ | | |

## ▼ STANDARD THICKNESSES (mm)

Available in thicknesses from 3 to 19 mm.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

## ▼ APPLICATIONS

| | |
|---|---|
| Interior | - Furniture: partitions, tables, shelves, fixed doors, sliding doors, display cases and glass bases<br>- Specific applications:<br>. Matelux Double Sided: doors<br>. Matelux Linea Azzurra: tables, shelves, basin units, floors and staircases due to the wide range of thicknesses available<br>. Matelux antislip: for stairs and floors |
| Exterior | Yes<br>Matelux Stopsol glass suits spandrel panels.<br>When used in double glazing, it is advisable to ensure that the etched side faces into the double glazing unit. |

# Lacomat

Private house - Czech Republic - Sliding door by Alu-Style Kft., with Lacomat

## ▼ DESCRIPTION

Lacomat is a clear Planibel float glass painted on one side with a satin-finish opalescent paint

There are two versions of Lacomat:

> Lacomat White: pronounced matt appearance, white colour

> Lacomat Classic: matt appearance, more diffused than Lacomat White.

## ▼ BENEFITS

> Neutral, light translucent appearance offering more privacy than acid-etched Matelux

> High resistance to stains on the painted side, especially fingerprints

> High level of light transmission (over 80%).

## ▼ PROCESSING OPTIONS

| | |
|---|---|
| **Surface treatments** | |
| Sandblasting | Yes – On the non-painted side |
| Acid-etching | |
| **Cutting and processing** | |
| Rectangles, circles | Yes – Can be cut like conventional float glass. |
| Edge-grinding, drilling, notches | |
| Bonding to metal | Yes – With UV glues |
| **Stress resistance** | |
| Heat resistance | Lacomat can withstand temperatures up to 120 °C |
| Moisture resistance | Lacomat can be used in humid environments (bathrooms and kitchens), but should never be immersed in water. |
| UV resistance | Yes |

## ▼ COLOUR RANGE

> Lacomat Classic, diffused opalescent and matt appearance

> Lacomat White, pronounced opalescent appearance, whiter look.

## ▼ STANDARD THICKNESSES (mm)

Available in thicknesses from 3 to 6 mm.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

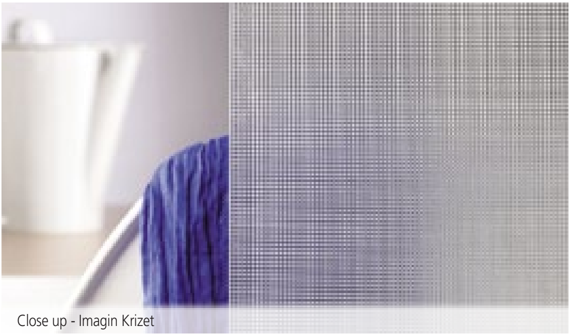
## ▼ APPLICATIONS

| | |
|---|---|
| Interior | - Furniture: partitions, tables, shelves, fixed doors, sliding doors, etc.<br>- Wall covering |
| Exterior | Double glazing with Lacomat painted side only in position 2 or 3 |

# 3.5 – Patterned glass

Close up - Imagin Flutes

# Imagin


Close up - Imagin Krizet

## ▼ DESCRIPTION

> The Imagin range consists of decorative clear or coloured glass with a pattern applied to one or both sides

> It offers over 20 geometric, stylish, classical or contemporary designs, with or without metal mesh (see Imagin wired glass).

## ▼ BENEFITS

> Wide range of patterns

> Translucency determined by the structure and the design

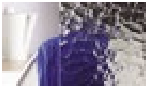
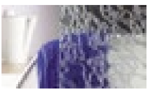
> Ideal for decorative architectural applications requiring a certain degree of privacy

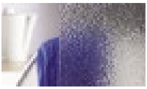
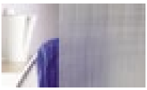
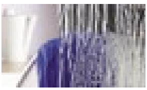
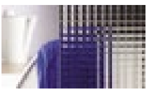
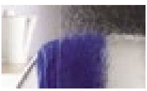
> Can be thermally toughened, laminated, sandblasted or fitted in double glazing depending on the design and thickness.

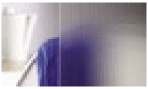
# Imagin

## ▼ PROCESSING OPTIONS

| Symbols used | |
|---|---|
| T | Toughenable |
| L | Can be laminated (patterned 4 mm clear and PVB >=0.76 mm) |
| II | Can be assembled into a double glazing unit |
| E | Can be enamelled |

| | | | | | |
|---|---|---|---|---|---|
| 33/33 |  | T | L | II | E |
| Atlantic |  | T | | II | |
| Bamboo |  | | | II | |
| Chinchilla |  | T | L | II | E |
| Crepi |  | T | L | II | |
| Delta |  | T | | II | E |
| Diamante 9 |  | T | | II | E |

| | | | | | |
|---|---|---|---|---|---|
| Flutes |  | T | | | E |
| Gothic |  | T | | | E |
| Kathedral Gross |  | | | | |
| Kathedral Klein |  | T | | | E |
| Konfeta |  | T | | | E |
| Krizet |  | T | L | | E |
| Kura |  | T | | | E |
| Niagara |  | | | | |
| Patterned 130 |  | T | | | |
| Polar |  | T | | | E |

| | | | | | |
|---|---|---|---|---|---|
| Satinbel |  | T | L | I | E |
| Screen |  | T | L | I | E |

*For further details on heat-strengthening or enamelling options, please contact AGC.*

## ▼ STANDARD THICKNESSES (mm)

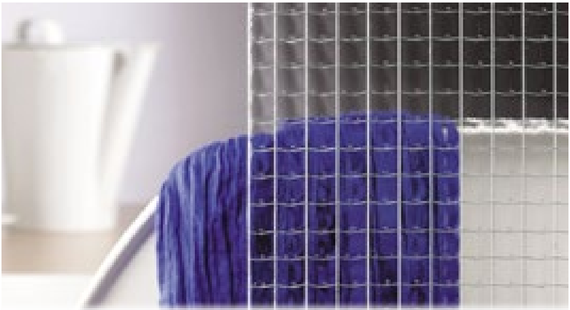
Available in thicknesses from 3 to 15 mm.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

## ▼ APPLICATIONS

| | |
|---|---|
| Interior | Yes – All furniture, partitions, shower screens, shelves, tables, counters, doors, etc. |
| Exterior | Yes – Windows, facades, atrium, roofs, doors, etc. |

# Imagin wired glass



Close up - Imagin wired glass

## ▼ DESCRIPTION

> Imagin Wired is the fire-resistant version in the Imagin range

> The integrated metal mesh provides advanced safety and security

> The range also includes clear polished wired glass.

## ▼ BENEFITS

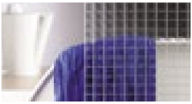
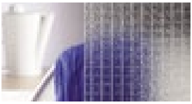
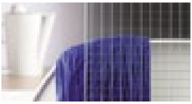
Fire-resistant properties:

> Polished wired glass P (E30/E60)

> Polished wired glass J (E30).

# Wired Imagin glass

## ▼ RANGE

| | |
|---|---|
| Wired "O" 1/2 |  |
| Wired "S" 1/2 |  |
| Wired Polished |  |

## ▼ PROCESSING OPTIONS

| **Heat treatment** | |
|---|---|
| Heat-strengthened and thermally toughened | No |
| Silk-screen printed and enamelled | No |
| Bending | No |
| **Laminated glass** | |
| PVB | No |
| EVA | No |

## ▼ APPLICATIONS

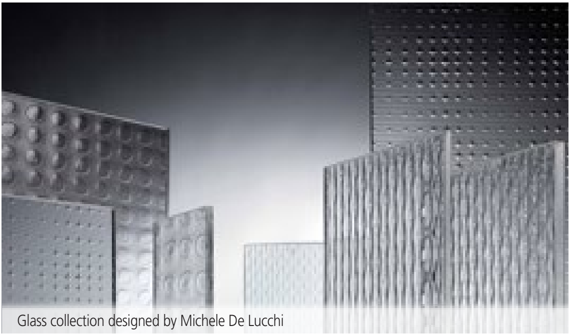
| | |
|---|---|
| Interior | Yes – All furniture doors, partitions, etc. |
| Exterior | Yes – Wired glass is not considered a safety glass.<br>Please refer to current standards. |

## ▼ STANDARD THICKNESSES (mm)

Available in thicknesses from 3 to 15 mm.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

# Oltreluce



Glass collection designed by Michele De Lucchi

## ▼ DESCRIPTION

> Oltreluce is an exclusive patterned glass collection designed by the Italian designer Michele De Lucchi

> It presents contemporary patterns that play with light, available in clear, and silvered versions

> Three exclusive patterns: Oltreluce Circles, Oltreluce Waves, Oltreluce Space.

## ▼ BENEFITS

> Surfaces that delicately filter light offering new architectural options

> Silvered version adds unexpected perspectives to the pattern, creating unique reflections

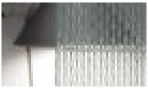
> Unique, modern design for decorative applications

> Can be toughened, laminated or assembled into double glazing units depending on the design and thickness.

# Oltreluce

## ▼ PROCESSING OPTIONS

| Symbols used | |
|---|---|
| T | Toughenable |
| L | Can be laminated<br>(patterned 4 mm clear and PVB >=0.76 mm) |
| I | Can be assembled into a double glazing unit |
| E | Can be enamelled |

| | | | | | |
|---|---|---|---|---|---|
| Oltreluce Waves Clear |  | | L | I | E |
| Oltreluce Circles Clear |  | T | L | I | E |
| Oltreluce Space Clear |  | T | L | I | E |

*For further details on heat-strengthening or enamelling options, please contact AGC.*

## ▼ STANDARD THICKNESSES (mm)

Available in thicknesses from 4 to 8mm.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

## ▼ APPLICATIONS

| | |
|---|---|
| Interior | Yes – All furniture, partitions, shower screens, shelves, doors, etc. |
| Exterior | Yes – windows, doors, glass facades. |

# 3.6 – Decorative laminated glass

Hôpital Niort - Niort, France - Stratobel Coloured

## ▼ INTRODUCTION

AGC's Stratobel laminated glass products are made via different assembly techniques with a view to creating specific looks for both interior and exterior design.

The technique used will influence both the appearance of the glass – transparent, coloured, translucent/opalescent or opaque – and its level of safety, which, when PVB is used, is determined by the amount of PVB layers in the application.

*See also Stratobel in the "Brands and Products" section.*

# Stratobel Clear, White, Black, Coloured

Private house - Czech Republic - Stratobel Coloured

## ▼ DESCRIPTION

The laminated assembly includes one or more clear, coloured, matt or opaque PVB interlayers. The glass substrates are clear, coloured or satin-finished.

> Wide range of colours

> Translucent, transparent or opaque appearance

> Original look for your facades, conservatories, balconies, walls, partitions, doors, interior design applications

> Stratobel products are Cradle to Cradle Certified™ Silver.

CERTIFIED cradletocradle ™ SILVER

## ▼ RANGE

| Stratobel range | Appearance | Glass substrate | Interlayer |
|---|---|---|---|
| Clear | Clear | Planibel (Clear, Clearvision, Linea Azzurra) | Clear |
| White | White (transparent, translucent, opaque) | Planibel (Clear, Clearvision, Linea Azzurra) Matelux (Clear, Clearvision, Antislip) | Clear, white (matt or opaque) |
| Black | Black opaque | Planibel (Clear, Clearvision, Linea Azzurra) | Black opaque |
| Coloured | Coloured | Planibel Coloured, Matelux (on clear or on coloured Planibel) | Clear, matt, coloured |

### Stratobel Clear

> Laminated safety glass with transparent appearance

> The assemblies consist of glass substrates and PVB interlayers reproducing a perfectly transparent appearance

- Glass substrates: Planibel (Clear, Clearvision, Linea Azzurra)
- PVB interlayers: transparent PVB interlayers.

### Stratobel White

> Laminated safety glass with white opalescent or opaque appearance

> The assemblies consist of glass substrates or PVB interlayers producing an opalescent (milky) appearance, with the level of privacy increasing up to full white opaque (similar to painted glass)

- Glass substrates: Planibel (Clear, Clearvision, Linea Azzurra) or Matelux satin-finish glass (Clear, Clearvision, Antislip)
- PVB interlayers (numbers indicate the level of light transmission): Mat 65, Mat 80, Opaque 07.

> A special version with acoustic performance similar to Stratophone is also available.

*See Stratophone in the "Brands and products" section.*

## Stratobel Black

> Laminated safety glass with black opaque appearance

> The assemblies consist of glass substrates and PVB interlayers delivering a full black opaque appearance (similar to painted glass)

- Glass substrates: Planibel (Clear, Clearvision, Linea Azzurra)
- PVB interlayer: pure opaque black aesthetic with no light transmission.

## Stratobel Colour

> Laminated assembly with coloured aesthetics

> The assemblies consist of glass substrates and/or PVB interlayers that deliver a coloured appearance

- Glass substrates: Planibel coloured float or Matelux satin-finish glass (on Planibel Clear or on Planibel Coloured)
- PVB interlayers: coloured (see table below).

| | |
|---|---|
| Grey | 6544 |
| Bronze | 6452 |
| Blue Green | 3773 |
| Cool Blue | 6376 |
| Dark Yellow | 4 |
| Dark Red | 5 |
| Dark Blue | 6 |

> Other coloured PVB interlayers are available upon request. Several coloured PVB interlayers can be mixed to create new colours (subject to certain technical constraints).

*For more information, please contact your local AGC representative.*

## ▼ STANDARD THICKNESSES (mm)

AGC offers a wide range of standard thicknesses for Stratobel products.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

## ▼ BENEFITS

> The Stratobel range offers numerous applications for decoration and and can be used for solar control (subject to specific conditions)

> High mechanical performance (depending on Stratobel structure)

> Laminated glass with safety function

> Range of contemporary standard colours with "colour on demand" option

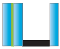
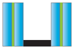
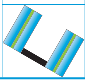
> Stratobel Black and White opaque can be combined in the same product to have one side black and one side white.

## ▼ PROCESSING OPTIONS

| | |
|---|---|
| **Safety** | |
| Lamination | Yes – Stratobel, by definition, is a laminated safety glass. |
| **Surface treatment** | |
| Sandblasting | Yes |
| Enamelling | |
| Acid-etching | |
| **Cutting and processing** | |
| Rectangles, circles | Yes |
| Edge-grinding, grinding, drilling, notches | |
| **Heat treatment** | |
| Heat-strengthening | Yes – Please contact us for advice on individual cases. |
| Thermal toughening | |
| Silk-screen printing | |
| **Stress resistance** | |
| Moisture resistance | Stratobel can be used in humid environments (bathrooms and kitchens) but should not be immersed in water. |

*For more information, please refer to the installation and processing guides available on www.yourglass.com - Stratobel.*

## ▼ USES

| | | |
|---|---|---|
| Monolithic glass |  | Yes |
| Insulating glass |   | - Stratobel should be positioned so that it faces the exterior for aesthetic reasons and to reduce the risk of breakage due to thermal shock.<br>- In cases where a safety solution is required on both the inside and outside: double glazing with two sheets of Stratobel laminated glass. |
| |  | - In roof applications: Stratobel laminated glass.<br>- Please contact us for thermal shock calculations. |

## ▼ APPLICATIONS

| | |
|---|---|
| Interior | Yes – Furniture, partitions, glass floors, etc. |
| Exterior | Yes – All architectural, construction and renovation applications. |

# 3.7 – AntiBacterial™ glass


Public bathroom - Czech Republic - Lacobel AB Green Pastel

## ▼ INTRODUCTION

In its ongoing quest to develop innovative products that improve peoples' lives, AGC has engineered an AntiBacterial™ glass, a major innovation in the world of glass design. The process developed and patented by AGC involves diffusing silver ions into the upper layers of the glass. The ions interact with bacteria and destroy them by disabling their metabolism and disrupting their ability to reproduce. The antibacterial effect of the glass is ongoing, particularly in the moist and temperate conditions that favour the development of bacteria and mould.

## ▼ DESCRIPTION

> AntiBacterial™ glass is perfect for places where strict hygiene is a must (hospitals, laboratories, pharmacies, sport centres, showers, bathrooms)

> The antimicrobial action of the silver ions inside the glass eliminates 99.9% of all bacteria that form on its surface and prevents the spread of fungi

> The bacteria tested on AB glass are found mainly in hospitals and are particularly responsible for nosocomial infections.

## ▼ BENEFITS

> Eliminates 99.9% of bacteria that accumulate on vertical and horizontal surfaces

> Prevents spread of fungi

> Easy to install

> Easy to clean: resistant to cleaning products, including those used in hospitals.

## ▼ PERFORMANCE

To evaluate the performance of AntiBacterial™ glass, tests have been conducted on a representative range of bacteria and fungi.

| | |
|---|---|
| **Bacteria** | |
| Staphylococcus Aureus | 99.9% fewer bacteria |
| Escherichia Coli | 99.99% fewer bacteria |
| Pseudomonas Aeruginosa | 99.99% fewer bacteria |
| **Fungi** | |
| Aspergillus Niger | 90% fewer fungi |
| Candida Albicans | 90% fewer fungi |

The antibacterial properties of the silver ions on AB glass last for very long and are guaranteed by AGC for a period of 10 years(1).

## ▼ RANGE

> Lacobel AB - painted glass

> Planibel AB - clear or coloured glass

> Mirox AB - mirror.

## ▼ PROCESSING OPTIONS

*See the Planibel, Lacobel and Mirox (3G and MNGE) chapters in this document, as well as the processing guides available on www.yourglass.com.*

## ▼ APPLICATIONS

| | |
|---|---|
| Interior | Yes |
| Exterior | No |

(1) This warranty is subject to specific terms and conditions. See www.yourglass.com for more details.

# 3.8 – Framing glass

Framing glass

# Glamatt

Glamatt framing glass

## ▼ DESCRIPTION

- Glamatt is clear glass for picture frames that can be used to reduce the negative effect of incident light by diffusing reflections
- The framed item can be seen clearly
- Excellent reproduction of contrasts and colours.

## ▼ BENEFITS

- Less glare
- Good colour diffusion
- Excellent reproduction of contrasts
- Easy to cut and clean.

## ▼ APPLICATIONS

Can be used to frame photographs, posters, adverts, maps, documents, degrees and other certificates.

## ▼ STANDARD THICKNESSES (mm)

Available in a standard thickness of 2 mm.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

# Matobel One Side

Kandinsky reproduction - Matobel One Side framing glass

## ▼ DESCRIPTION

> Matobel is float glass which has been treated with a non-glare coating on one side

> The “matt” side should be installed facing the outside of the frame

> Clear glass for picture frames that can be used to reduce the negative effect of incident light by diffusing reflections

> The framed item can be seen clearly.

## ▼ BENEFITS

- > Anti-glare and accurate colour reproduction: the perfect balance(1)
- > With a clarity rating of 50.9%, a gloss factor of 70(2) and a haze value of 4.12%, Matobel One Side not only offers perfect optical properties by reducing the level of light reflection but also excellent colour reproduction thanks to its neutral appearance. This combination of properties presents users with a perfectly reproduced image of any picture, photograph or painting
- > Easy to cut and clean.

## ▼ APPLICATIONS

Can be used to frame photographs, posters, advertisements, maps, documents, degrees and other certificates.

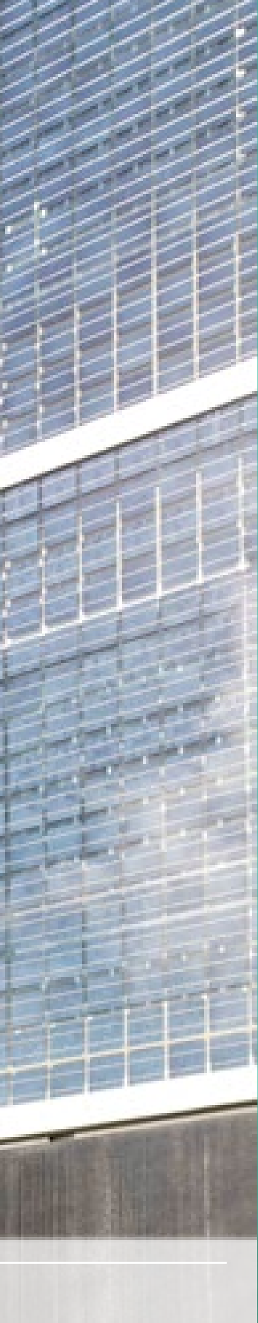
## ▼ STANDARD THICKNESSES (mm)

Available in standard thicknesses of 1.9 and 2.9 mm.

*See the AGC Product Catalogue on www.yourglass.com for more details.*

(1) Values calculated by AGC for 1.9-mm thick Matobel One Side.
(2) Gloss: 70±5 in accordance with the relevant US standard (BYK Gardner, Micromaster 60° angle).

IUT Michel de Montaigne - Bordeaux, France - Owner: Conseil régional d'Aquitaine - Company: T2B Aluminium - Architects: Atelier des architectes Mazières, et associé Daniel De Marco - SunEwat XL



# — IV —
# Brands and products

## 4. Building-Integrated Photovoltaics

SunEwat

# SunEwat

Ecole René Clair - Villeneuve d'Ascq, France - Architect: Faouzi - SunEwat XL

## ▼ DESCRIPTION

- > AGC's SunEwat is a special range of products capable of actively generating power
- > This range of laminated safety glass products features photovoltaic cells embedded between two sheets of glass, enabling the building to produce the same amount of energy as it consumes in context of nearly Zero Energy Buildings
- > The modules combine design and functionality, allowing customers to benefit from limitless aesthetic options for achieving a high level of energy supply and seamless integration into buildings
- > SunEwat allows multiple opportunities to combine electricity generation with facades, canopies, sunshades, balustrades, louvers, spandrels and more.

## ▼ BENEFITS

- > The entire facade can be used as an active element to provide electricity
- > SunEwat modules are custom-made and can be tailored specifically to each project
- > Light transmission can be adjusted easily by changing the distance between the cells
- > Large size (2 x 4 m) is available, offering many applications.
- > SunEwat performs at high temperatures, even in non-ventilated spandrels
- > It can be assembled into an insulating glazing unit (Thermobel, double or triple glazing) to provide the required level of thermal insulation
- > All glass panes used are 100% heat soak tested.

## ▼ SUNEWAT RANGE: SUNEWAT XL

| | |
|---|---|
| Minimum size of module | 400 mm x 400 mm |
| Maximum size of module | 2,000 mm × 4,000 mm |
| Shape | Highly flexible, within minimum and maximum module size |
| Space between cells | Minimum: 4 mm<br>Maximum: 50 mm |
| Outside glass | Toughened HST Clearvision |
| Inside glass | Toughened HST Clearvision, clear, coloured, painted, silk screened, etc. |
| Glass thickness | Depending on structural requirements |
| Photovoltaic cells | Mono or Polycrystalline 156 mm (6 inch), high performance up to 20% |

*For further information on this product and the entire range, please refer to www.yourglass.com.*

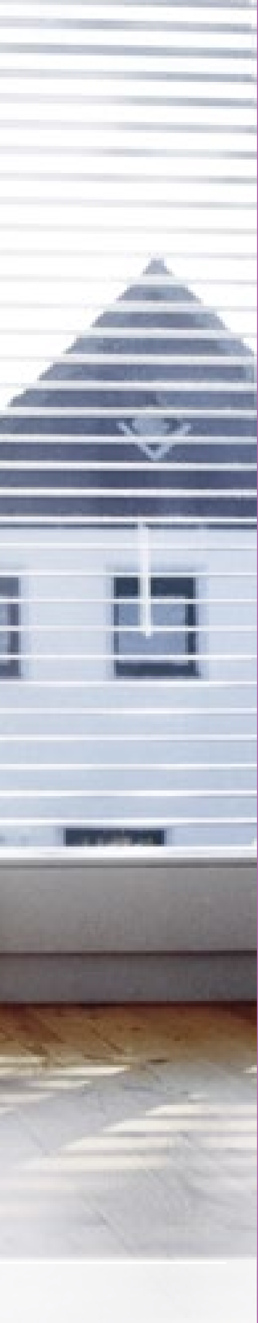
## ▼ ELECTRICAL PERFORMANCE

> SunEwat uses standard electrical components and is designed to be interconnected to form an array. It must be installed by specialised companies having the necessary expertise and must comply with the standards and regulations applicable to PV installations

> Different electrical characteristics can be achieved depending on the type of solar cell used (i.e. mono or polycrystalline) and coverage density. The following table provides examples of electrical product performance. The product characteristics are determined for each project.

| Module description | 4 m² / High opacity | 4 m² / Low opacity |
|---|---|---|
| Module dimensions | 2,000 x 2,000 mm | 2,000 x 2,000 mm |
| Quantity of cells | 144 (12x12) | 72 (9x8) |
| Module thickness | 13.6 mm (6+1.6+6) | 13.6 mm (6+1.6+6) |
| Opacity (cells) | 88% | 44% |
| Typical power Pmax | 633 Wp | 316 Wp |
| Operating voltage Vpm | 78.2 V | 39.1 V |
| Current at operating voltage Ipm | 8.1 A | 8.1 A |
| Short-circuit current Isc | 9.31 A | 8.6 A |
| Open-circuit voltage Voc | 93.31 V | 46.7 V |
| Minimum power Pmin | 570 Wp | 285 Wp |
| Maximum system voltage | 1,000 VDC | 1,000 VDC |
| Maximum modules in series | 8 modules | 16 modules |
| Maximum reverse current | 16 A | 16 A |
| Maximum series fuse | 12 A | 12 A |
| Application class to IEC/EN 61730 | Class A | Class A |
| Module weight | 120 kg | 120 kg |
| Current temperature coefficient | +0.06%/°C | +0.06%/°C |
| Voltage temperature coefficient | -0.36%/°C | -0.36%/°C |
| Power temperature coefficient | -0.4%/°C | -0.4%/°C |

Private house - The Netherlands - Thermobel Store



# IV
# Brands and products

## 5. Integrated blinds

Thermobel Store

# Thermobel Store

Integrated blinds - Thermobel Store

## ▼ DESCRIPTION

> Thermobel Store® is an insulating glazing with blinds integrated between two sheets of glass

> Light entering the building can be controlled at all times via the built-in blinds, ensuring solar control and privacy

> Thermobel Store® comes with a variety of blinds and control functionalities (manual or automatic) and can be customised to any project

> A range of low-e, solar control, acoustic glass products can also be used with the system, which is available in double or triple glazing with Technical Approval

> Thermobel Store® is ideal for any vertical exterior or interior application in buildings: tertiary buildings, work rooms, hospitals, laboratories or interior partitions.

## ▼ BENEFITS

Thermobel Store® combines all the benefits of insulating glazing and blinds:

> Very durable, no cleaning required

> Light and heat from the outside can be adjusted (solar control)

> Privacy.

*For more information on this product and the entire range, please refer to www.yourglass.com.*


Design Hub - Singapore - Pyrobel 25

# IV
# Brands and products

## 6. Fire-resistant glass

# 6.1 – Introduction

Ghelamco Arena - Ghent, Belgium - Architect: Bontick - Pyrobel 25 & Pyrobel 25 Vision Line

Fire-resistant properties in a glass construction element determine how far that element can limit the spread of fire by restricting it to a specific area.

The fire resistance of a glass construction element is measured against a number of criteria:

> Stability: the glass stays in place

> Integrity against flames, hot gases and smoke: the glass prevents flames, smoke and hot gases (but not heat) from passing through. The fire remains contained

> Limited radiation: the glass restricts the amount of heat passing through the glass to the protected side

> Thermal insulation: the average temperature of the glass on the protected side remains below 140°C which eliminates the risk of ignition of exposed materials, either due to radiation or convection. The building can therefore be evacuated safely and calmly.

The European classification standards for glass use the following abbreviations:

> R: Stability

> E: Integrity = the time during which the flames do not pass

> W: Radiation limitation = the time during which radiation does not exceed a specific level

> I: Thermal insulation = the time during which the temperature does not rise above a certain thermal threshold on the unexposed side.

The fire resistance of each element is determined by the time (in minutes) during which the element has simultaneously met one or more of the relevant criteria.

Example: a door which remains fire resistant for half an hour in terms of integrity will be classified as E30. A wall which is fire resistant for one hour in terms of limited radiation will be classified EW60. A wall which is fire resistant for one hour in terms of thermal insulation will be classified EI60.

The fire resistance rating applies to the entire construction element, i.e. the glass + the frame.

## ▼ BRANDS OF FIRE-RESISTANT GLASS

AGC offers a range of thermally toughened and thermally toughened coated products (Pyropane*) and a range of laminated glass with an intumescent interlayer (Pyrobelite and Pyrobel) covering the various performance levels of fire resistant glass.

| | Thermally toughened and thermally toughened coated glass | Laminated glass with intumescent interlayers |
|---|---|---|
| E | Pyropane[1] | Pyrobelite |
| EW | Pyropane[1] | Pyrobelite |
| EI | | Pyrobel |

(1) Availability depends on market.

## ▼ INSTALLING PRODUCTS

In all cases, fire resistance test reports concern construction elements as a whole and not the individual glazing. Projects should be conducted in accordance with all aspects of the test report. No components may be altered without first obtaining an assessment report, a site report or similar documentation from an official laboratory.

The desired level of classification will only be achieved if the limits regarding size and installation indicated in the reports are respected.

# 6.2 – Fire-resistant glass ranges

IMOBA II - Prague, Czech Republic - Architect: A 32 spol. s r. o. - Pyrobel-Pyrobelite

# Pyrobel & Pyrobelite

A2 Groeninge - Kortrijk, Belgium - Pyrobel

## ▼ DESCRIPTION

Pyrobel and Pyrobelite are made of clear Planibel glass and transparent interlayers. In the event of fire the glass sheets transform into opaque screens that stop the flames and limit heat transmission:

> Pyrobelite EW glass – Integrity and limited radiation – limit heat radiation through the glazing for 30 or 60 minutes

> Pyrobel EI glass – Integrity and Insulation – strongly limit heat transmission for 15, 20, 30, 45, 60, 90 or 120 minutes.

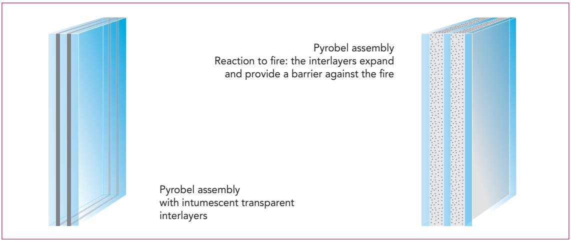
The choice depends on:

> the level of fire resistance required by national regulations

> the type of application

> the approvals available for frames and sizes.

# Pyrobel & Pyrobelite




## ▼ RANGE

### The Pyrobel and Pyrobelite range

| Products | Fire resistance |
|---|---|
| **Internal grade** | |
| Pyrobelite 7 | EW30 |
| Pyrobelite 10 | EW30 |
| Pyrobelite 12 | EI20/EW60 |
| Pyrobel 8 | EI15/EW30 |
| Pyrobel 16 | EI30/EW60 |
| Pyrobel 17 N | EI45/EW60 |
| Pyrobel 25 | EI60 |
| Pyrobel 30 | EI90 |
| Pyrobel 53N | EI120 |
| **External grade** | |
| Pyrobelite 9 EG | EI20/EW30 |
| Pyrobelite 12 EG | EI20/EW30 |
| Pyrobel 8 EG | EI15/EW30 |
| Pyrobel 16 EG | EI30/EW60 |
| Pyrobel 17N EG | EI45/EW60 |
| Pyrobel 25 EG | EI60 |
| Pyrobel 30 EG | EI90 |
| Pyrobel 53N EG | EI120 |
| **Horizontal grade** | |
| Pyrobel 19H | EI30 |
| Pyrobel 23H | EI45 |
| Pyrobel 28H | EI60 |

## ▼ BENEFITS

### Transparency

> No metallic mesh

> Light transmission equivalent to that of float glass of the same thickness.

### Safety

> Safety rated from 3B3 to 1B1 (EN 12600)

> Can be reinforced into anti-bandit, anti-burglar and bullet-proof versions

> It is possible to combine Pyrobel with accident prevention and anti-burglary functions.

### Sound reduction

Higher level than traditional laminated glass.

### Sizes

Approved for large sizes.

### Installation

Easy to install in traditional wooden, steel or aluminium frames or as Pyrobel Vision Line (butt-joint glazing).

## ▼ PERFORMANCE

| Products | Nominal thickness (mm) | Thickness tolerance (mm) | Weight (kg/m²) | Resistance to fire | Impact resistance EN 12600 | Acoustic EN 12758: $R_w$ ($C;C_{tr}$) (dB) | $U_g$ (W/(m²K)) EN 673 | TL-EN 410 $\tau_v/\rho_v$ (%) | FS-EN 410 $\tau_e/\rho_e$ (%) |
|---|---|---|---|---|---|---|---|---|---|
| **Internal grade** | | | | | | | | | |
| Pyrobelite 7 | 7.9 | ± 0.9 | 17 | EW30 | 3B3 | 34 (0; -3) | 5.7 | 89/8 | 73/7 |
| Pyrobelite 10 | 11 | ± 1 | 26 | EW30 | 2B2 | 37 (-1; -3) | 5.6 | 86/8 | 68/7 |
| Pyrobelite 12 | 12.3 | ± 1 | 27 | EI20/EW60 | 2B2 | 36 (-1; -3) | 5.6 | 86/8 | 65/7 |
| Pyrobel 8 | 9.3 | ± 1 | 20 | EI15/EW30 | NPD | 34 (-1; -3) | 5.6 | 88/8 | 70/7 |
| Pyrobel 16 | 17.3 | ± 1 | 40 | EI30/EW60 | 2B2 | 39 (-1; -3) | 5.4 | 84/8 | 60/6 |
| Pyrobel 17N | 17.8 | ± 1.6 | 40 | EI45/EW60 | 1B1 | 39 (0; -3) | 5.4 | 86/8 | 67/7 |
| Pyrobel 25 | 26.6 | ± 2 | 60 | EI60 | 1B1 | 40 (-1; -3) | 5.2 | 81/7 | 53/6 |
| Pyrobel 30 | 30 | ± 2.5 | 69 | EI90 | 1B1 | 42 (-1; -4) | 5.1 | 83/8 | 59/7 |
| Pyrobel 53N | 52.7 | ± 3 | 122 | EI120 | 1B1 | 48 (-2; -7) | 4.5 | 75/6 | 42/5 |
| **External grade** | | | | | | | | | |
| Pyrobelite 9 EG | 12.06 | ± 1.5 | 28 | EI20/EW30 | 1B1 | 37 (-1; -2) | 5.5 | 86/8 | 63/6 |
| Pyrobelite 12 EG | 16.1 | ± 1 | 35 | EI20/EW60 | 1B1 | 38 (-1; -3) | 5.4 | 85/8 | 58/6 |
| Pyrobel 8 EG | 13.1 | ± 1.3 | 28 | EI15/EW30 | 1B1 | 36 (-1; -3) | 5.4 | 86/8 | 62/6 |

(Continuation)

| Products | Nominal thickness (mm) | Thickness tolerance (mm) | Weight (kg/m$^2$) | Resistance to fire | Impact resistance EN 12600 | Acoustic EN 12758: $R_w$ ($C$;$C_{tr}$) (dB) | $U_g$ (W/(m$^2$K)) EN673 | TL-EN410 $\tau_v/\rho_v$ (%) | FS-EN 410 $\tau_e/\rho_e$ (%) |
|---|---|---|---|---|---|---|---|---|---|
| Pyrobel 16 EG | 21.1 | ± 1.5 | 48 | EI30/EW60 | 1B1 | 39 (-1; -3) | 5.2 | 83/7 | 54/6 |
| Pyrobel 17N EG | 21.6 | ± 1.8 | 48 | EI45/EW60 | 1B1 | 40 (-1; -3) | 5.2 | 85/8 | 60/7 |
| Pyrobel 25 EG | 30.4 | ± 2 | 68 | EI60 | 1B1 | 43 (-1; -4) | 5.0 | 80/7 | 48/6 |
| Pyrobel 30 EG | 33.7 | ± 2.8 | 77 | EI90 | 1B1 | 43 (-1; -4) | 4.9 | 81/8 | 53/6 |
| Pyrobel 53N EG | 56.5 | ± 3 | 130 | EI120 | 1B1 | 49 (-2; -7) | 4.4 | 73/7 | 40/5 |
| **Horizontal grade** | | | | | | | | | |
| Pyrobel 19H | 19.1 | ± 1.5 | 43 | EI30 | 1B1 | 38 (-1; -3) | 5.2 | 81/7 | 53/6 |
| Pyrobel 23H | 23.7 | ± 1.8 | 54 | EI45 | 1B1 | 39 (0; -3) | 5.0 | 80/7 | 49/6 |
| Pyrobel 28H | 28.4 | ± 2 | 63 | EI60 | 1B1 | 41 (0;-3) | 4.9 | 78/7 | 47/6 |

Light properties in accordance with EN 410:
- $\tau_v$: light transmission
- $\rho_v$: light reflectance.

Solar energy properties in accordance with EN 410:
- $\tau_e$: solar direct transmittance
- $\rho_e$: solar direct reflectance.

# ▼ USES

| | |
|---|---|
| Monolithic glass | Yes |
| Insulating glazing | Yes |

# ▼ APPLICATIONS

| | |
|---|---|
| Interior | Yes |
| Exterior | Yes |

# ▼ INSTALLATION INSTRUCTIONS

## General instructions

> Pyrobel glass is supplied in ready-to-mount units and cannot be cut or processed

> The outer edge of the glass is protected and this protection should not be damaged or removed

> The glass should not be exposed to temperatures below -40°C or above 50°C or to local heat sources

> The edges of the glass should not come into contact with water

> Pyrobel and Pyrobelite glass must be installed in an approved frame. All details included in the test report must be respected.

## Instructions for external applications

> When exposed to solar radiation, Pyrobel glass should be of the "External Grade" (EG) type. Pyrobel EG must be fitted correctly, with the PVB side facing the radiation source. The glass type mark is applied generally on the non-PVB side

> The glass should be fitted in a drained and ventilated frame to prevent any water stagnation in the frame

> Pyrobel glass fitted in a facade should not be exposed to temperatures above 50 °C. The location of the building and the orientation of the facade should be taken into consideration. Incorporating a solar-control glass into Pyrobel double glazing will lower its temperature.

*Please contact AGC for further details.*

# 6.3 – Toughened fire-resistant glass

Motorway tunnel - Vchynice, Czech Republic - Pyropane

# Pyropane

Aéroports de Lyon - Lyon, France - Architect: Xavier Mancourt - Pyropane

## ▼ DESCRIPTION

> Pyropane is AGC's range of toughened fire resistant glass

> The range includes products obtained by treating and toughening glass which may or may not be coated with a special metallic coating

> They comply with specific European standards and are classified according to tests in appropriate frames. Multiple applications:

- Fire resistant insulating double glazing (E/EW 30 and E/EW 60) for facades
- Interior fire resistant glazing for partitions and doors (E 30/ EW 20)
- Smoke barrier (DH 30).

As toughened glass, Pyropane offers all the usual safety benefits in terms of protection from injury.

## ▼ BENEFITS

### Facades: solar and thermal protection

In the EW60 double glazing version, Pyropane's performance in terms of thermal insulation (U value) and solar control (solar factor) is unparalleled among fire protection glazings.

### Safety

> Pyropane fire-resistant single and double glazings are made from toughened glass

> If broken, the risk of injury is considerably reduced because the glass fractures into small, blunt pieces. Pyropane is a toughened safety glass, classified 1C1 under standard EN 12600.

### Vision

Pyropane fire-resistant glass provides perfect vision. It remains clear under all circumstances. It is neither wired nor fibre-reinforced, and has a high light transmission rating.

## ▼ PERFORMANCE

| | Pyropane 100<br>E30 | Pyropane SB 100<br>DH 30 | Pyropane 211-44<br>E30/60 - EW30/60 | Pyropane 231-28<br>E30/60 - EW30/60 |
|---|---|---|---|---|
| Type of glazing | Single glazing | Single glazing | Double glazing | Double glazing |
| Use | Interior/exterior | Interior | Exterior, facade | Exterior, facade |
| Fire protection | Bi-directional | Bi-directional | Mono-directional | Mono-directional |
| Glass thickness | 6 mm | 6 mm | 27 mm in 6/15/6 | 27 mm in 6/15/6 |
| Weight | 15 kg/m² | 15 kg/m² | 30 kg/m² | 30 kg/m² |
| Tolerance (thickness) | +/- 0.2 mm | +/- 0.2 mm | -0.8 +1 mm | -0.8 +1 mm |
| Tolerance (dimensions) | +0 - 2 mm | +0 - 2 mm | +2 - 2 mm | +2 - 2 mm |
| Light transmission – LT% (EN 410) | 89 | 89 | 73 | 50 |
| Light reflection – LR% (EN 410) | 8 | 8 | 13 | 20 |

| | | | | |
|---|---|---|---|---|
| Solar factor – SF% (EN 410) | 84 | 84 | 44 | 31 |
| $U_g$ coefficient (EN 673) | 5.7 W/(m$^2$K) | | 1.0 W/(m$^2$K) with Ar 90% 15 mm | 1.0 W/(m$^2$K) with Ar 90% 15 mm |
| Acoustic insulation $R_w$ (C; $C_{tr}$) (EN ISO 717-1) | 31 (-2; -3) dB | | 31 (-1; -4) dB | 31 (-1; -4) dB |
| Impact resistance – class EN 12600 | 1C1 | 1C1 | 1C1 / 1C3 | 1C1 / 1C3 |
| Fire reaction – class EN 13501 | A1 | A1 | | |
| UV resistance | Yes | Yes | Yes | Yes |
| Transparency | Yes: No mesh – remains clear in case of fire | | | |
| CE marking | Conforms to EN 14179-2 | Conforms to EN 12101-1 and EN 14179-2 | Conforms to EN 1279-5 | Conforms to EN 1279-5 |
| Fire resistance | E30 according to EN 13501-2 | DH 30 according to EN 12101-1 | E30/60 – EW30/60 according to EN 13501-2 | E30/60 – EW30/60 according to EN 13501-2 |

## ▼ USES

| | |
|---|---|
| Monolithic glass | Yes |
| Double glazing | Yes |

## ▼ APPLICATIONS

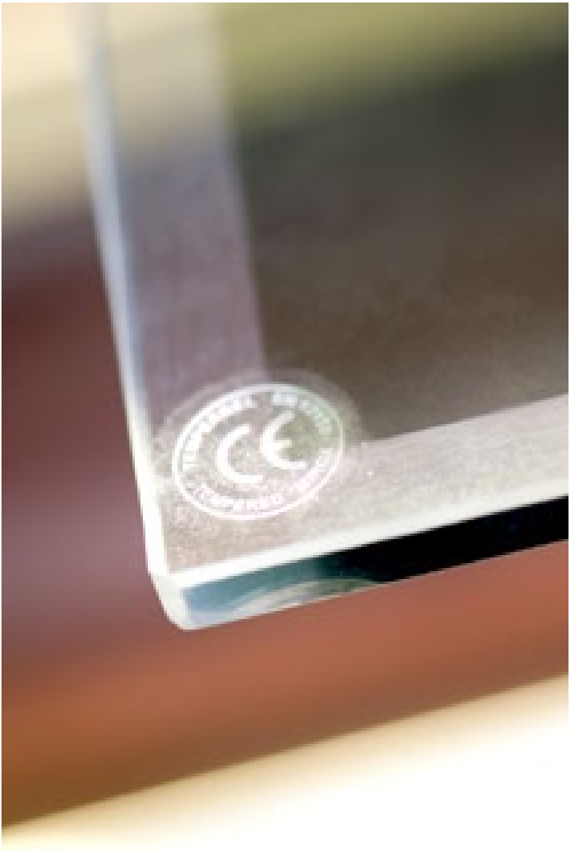
| | |
|---|---|
| Interior | Yes |
| Exterior | Yes |

Umicore - Hoboken, Belgium - Architect: Conix Architects - Thermobel Stopray Vision-50 and Vision-50T

# — V — Technical annexes & regulations

1

# C€ MARKING AND STANDARDS



CE marking

# 1.1 – CE marking

*For further information on CE marking, please consult the Glass for Europe website at http://www.glassforeurope.com/en/issues/ce-marking.php.*

## 1.1.1 WHAT IS THE CE MARKING?

Construction products bearing the CE marking indicate that they meet the following six basic requirements for construction works:

> Mechanical resistance and stability

> Safety in case of fire

> Hygiene, health and environment

> Safety and accessibility in use

> Protection against noise

> Energy economy and heat retention.

These requirements are evaluated according to European standards (EN standards). Other product characteristics, such as appearance and colour, are not covered by the CE marking.

## 1.1.2 PURPOSE OF THE CE MARKING

The CE marking is not merely a matter of applying the CE marking to products, but is also about implementing a single European market. Construction products circulate freely within the EU, without any restrictions imposed by individual countries. Their only mandatory assessment is via the CE marking procedure based on European standards (EN).

No country will be allowed to impose additional requirements covering the same aspects as the CE marking, either de facto or through national legislation.

The CE marking is the only way to show that a product regulated by a European standard can be sold on the European market.

Applying EN standards ensures that all products are evaluated in the same way in all EU countries. EN standards take precedence over all national standards.

The CE marking demonstrates that the product conforms to EN standards and that it is suitable for sale on the European market but it does not impose the product on any national market. Individual countries may pass regulations governing the use of the product.

### 1.1.3 WHEN DID THE CE MARKING COME INTO FORCE?

The date on which manufacturers of glass products must begin applying the mark to their products is indicated in the product standard. Prior to that date, it is illegal to affix marks to those products.

For standard products (e.g. float glass, patterned glass, etc.), thermal toughened safety glass and coated glass, the start date is 1 September 2005. For laminated glass, insulating glazing and thermally toughened heat-soaked glass the date is 1 March 2006.

However, after these dates there will be a one-year transition period during which the old system and the new CE marking system will run concurrently. During this time, manufacturers will be able to choose whether to mark their products or to wait. At the end of this transition period, CE marking will become mandatory.

The table below gives details of the standards, corresponding products and launch dates for CE marking.

| Standard | Relevant AGC products | Dates |
|---|---|---|
| EN 572-9 –<br>Glass in building: basic soda lime silicate glass | Planibel float glass and<br>Planibel coloured float glass<br>Imagin wired glass<br>Imagin patterned glass<br>Polished wired glass | Start of mandatory<br>CE marking:<br>1 September 2006 |
| EN 1096-4 –<br>Coated glass | Planibel G / Planibel A<br>Planibel GfasT<br>Planibel Isocomfort<br>Planibel Hortiplus<br>iplus Top 1.1 / iplus Advanced 1.0 / iplus Energy $^{N}$ / iplus LS<br>iplus Top 1.1$^{T}$ / iplus Advanced 1.0$^{T}$ / iplus Energy $^{NT}$ / iplus LS T<br>iplus I-Top<br>iplus Light<br>iplus AF<br>iplus AF Top / iplus AF Energy$^{N}$<br>iplus Twin Top<br>Stopsol Classic, Supersilver<br>Sunergy, Stopray, ipasol | |
| EN 12150-2 –<br>Thermally toughened soda lime silicate safety glass | All thermal-toughened safety glass products | |
| EN 1863-2 –<br>Heat-strengthened soda lime silicate glass | All heat-strengthened products | |
| EN 12337-2 –<br>Chemically strengthened soda lime silicate glass | All chemically toughened products | |
| EN 14449 –<br>Laminated glass and laminated safety glass | Stratobel<br>Stratobel EVA<br>Stratophone<br>Pyrobel and Pyrobelite | Start of mandatory<br>CE marking:<br>1 March 2007 |
| EN 1279-5 –<br>Insulating glass units | Thermobel | |
| EN 14179-2 –<br>Heat-soak tested, thermally toughened soda lime silicate safety glass | All thermally toughened and heat-soaked products, Pyropane[1] | |
| EN 1036-2 –<br>Mirrors | Mirox 3G<br>Mirox MNGE | Start of mandatory<br>CE marking:<br>1 February 2010 |

(1) Availability of Pyropane depending on markets.

# 1.2 – AGC & CE marking

## 1.2.1 WHAT INFORMATION IS REQUIRED FOR THE CE MARKING?

Each individual product qualifying for the mark must bear the logo, but some additional information must also be passed on to the client:

### ▼ General information

> name and address of manufacturer
> reference to the relevant European standard
> unique identification code of the product type
> intended use as laid down in the harmonised technical specification applied
> identification number of the notified body (if applicable)
> the last two digits of the year in which it was first affixed.

### ▼ Technical data

18 technical product features (fire resistance, impact resistance, thermal properties, etc.) including the durability must be stated .

*See the example below for float glass Planibel clear 4mm.*

| Declaration of performance | | |
|---|---|---|
| CE<br>AGC Glass Europe<br>Avenue Jean Monnet, 4<br>1348 Louvain-La-Neuve<br>Belgium<br>Certificate number: N/A<br>Notified body: N/A<br>EN 572-9:2004 | | |
| 4 mm Planibel Clear | | |
| Basic soda lime silicate glass intended to be used in buildings and construction work. | | |
| **Essential characteristics** | **AVCP systems** | **Performance** |
| Safety in the case of fire | | |
| Resistance to fire | 1 | NPD |
| Reaction to fire | 3, 4 | A1 |
| External fire performance | 3, 4 | NPD |
| Safety in use | | |
| Bullet resistance | 1 | NPD |
| Explosion resistance | 1 | NPD |
| Burglar resistance | 3 | NPD |
| Pendulum body impact resistance | 3 | NPD |
| Resistance against sudden temperature changes and temperature differentials | 4 | NPD |
| Wind, snow, permanent and imposed load resistance | 4 | NPD |
| Protection against noise | | |
| Direct airborne sound insulation (EN 12758) – $R_w$ $(C;C_{tr})$: dB | 3 | 30 (-2;-4) |
| Thermal properties | | |
| Declared emissivity | 3 | NPD |
| Thermal properties (EN 673) | 3 | 5, 8 |
| Radiation properties | | |
| Light Transmission | 3 | 90 |
| Light Reflection | 3 | 8 |
| Solar energy characteristics | | |
| Solar energy Transmission | 3 | 84 |
| Solar energy reflection | 3 | 8 |
| Solar factor | 3 | 86 |
| Durability | 3 | PASS |

NPD = No Performance Determined.

## 1.2.2 INFORMATION ABOUT THE CE MARKING ON AGC'S WEBSITE WWW.YOURGLASS.COM

The CE markings are provided in various formats on www.yourglass.com.

### ▼ PDF files

For products to which the CE marking already applies, click on the "CE marking" button on your screen to download a PDF file containing the tables applying to all usual products.

### ▼ Product finder

Two tools are available in the Toolbox: Product Finder and Glass Configurator. You can use this to search for a specific brand, product, structure or look or enter the appropriate technical values.

You can also print out a CE marking data sheet for a specific product in the appropriate language by clicking on the "CE marking" button.

### ▼ Glass Configurator

You can use the "CE marking" module in the Glass Configurator to obtain the product declaration in the appropriate language.

# 1.3 – European glass standards

## 1.3.1 INTRODUCTION

The tables below detail the standards published in CEN TC 129 "Glass in building". Officially published standards are indicated as EN. Draft standards in the process of being drawn up are indicated as prEN. These standards are published in the different countries of the European Union (NBN EN in Belgium, NF EN in France, etc.) and are available from national standardisation bodies (NBN in Belgium, AFNOR in France, NEN in the Netherlands, etc.).

Several tables give details of the standards according to the following classification system:

> Harmonised standards for the CE marking

> Standards for basic glass products

> Standards for processed glass products

> Standards for testing and calculation methods.

## 1.3.2 HARMONISED STANDARDS FOR THE CE MARKING (TC 129)

| | |
|---|---|
| EN 572-9:2004 | Basic soda lime silicate glass products – Evaluation of conformity |
| EN 1036-2:2008 | Mirrors from silver coated float glass for internal use – Evaluation of conformity: product standard |
| EN 1051-2:2007 | Glass blocks and glass pavers – Evaluation of conformity: product standard |
| EN 1096-4:2005 | Coated glass – Evaluation of conformity |
| EN 1748-1-2:2005 | Special basic products – Borosilicate glasses – Evaluation of conformity |
| EN 1748-2-2:2005 | Special basic products – Glass ceramics – Evaluation of conformity |
| EN 1279-5:2008+A1 | Insulating glass units – Evaluation of conformity |
| EN 1863-2:2004 | Heat strengthened soda lime silicate glass – Evaluation of conformity |
| EN 12150-2:2000 | Thermally toughened soda lime silicate safety glass – Evaluation of conformity |
| EN 12337-2:2005 | Heat-strengthened soda lime silicate glass – Evaluation of conformity |

(Continuation)

| | |
|---|---|
| EN 13024-2:2005 | Toughened borosilicate safety glass – Evaluation of conformity |
| EN 14178-2:2005 | Glass in building – Basic alkaline earth silicate glass products – Evaluation of conformity |
| EN 14179-2:2005 | Heat soaked thermally toughened soda lime silicate safety glass – Definition and description |
| EN 14321-2:2005 | Thermally toughened alkaline earth silicate safety glass |
| EN 14449:2005 | Laminated glass and laminated safety glass – Evaluation of conformity |

## 1.3.3 STANDARDS FOR TC 129 CONCERNING BASIC GLASS PRODUCTS

| Reference | Title |
|---|---|
| EN 572-1:2012 | Basic soda lime silicate glass products – Definitions and general physical and mechanical |
| EN 572-2:2012 | Basic soda lime silicate glass products – Float |
| EN 572-3:2012 | Basic soda lime silicate glass products – Polished wired glass |
| EN 572-4:2012 | Basic soda lime silicate glass products – Drawn glass |
| EN 572-5:2012 | Basic soda lime silicate glass products – Patterned glass |
| EN 572-6:2012 | Basic soda lime silicate glass products – Wired patterned glass |
| EN 572-7:2012 | Basic soda lime silicate glass products – Wired or unwired channel shaped |
| EN 572-8:2012 | Basic soda lime silicate glass products – Supplied and final cut sizes |
| EN 1748-1-1:2004 | Special basic products – Borosilicate glasses |
| EN 1748-2-1:2001 | Special basic products – Glass ceramics |
| EN 14178-1:2005 | Basic alkaline earth silicate glass products – Part 1: Float glass |

## 1.3.4 STANDARDS FOR TC 129 CONCERNING PROCESSED GLASS PRODUCTS

| Reference | Title |
|---|---|
| EN 1036-1:2007 | Mirrors from silver coated float glass for internal use. Definitions, requirements and test methods. |
| EN 1051-1:2003 | Glass blocks and glass pavers – Definitions, requirements, testing method and checks |
| EN 1096-1:2012 | Coated glass – Definition and classification |
| EN 1096-2:2012 | Coated glass – Requirements and test methods for class A, B and S coatings |
| EN 1096-3:2012 | Coated glass – Requirements and test methods for class C and D coatings |
| EN 1279-1:2004 | Insulating glass units – Generalities, dimensional tolerances and rules for the system description |
| EN 1279-2:2003 | Insulating glass units – Long term test method and requirements for moisture penetration |
| EN 1279–3:2003 | Insulating glass units – Long-term test method, requirements for gas leakage rate and for gas concentration tolerances |
| EN 1279-4:2002 | Insulating glass units – Methods of testing for the physical attributes of edge seals |
| EN 1279-6:2002 | Glass units – Factory production control and periodic tests |
| EN 1863-1:2000 | Heat-strengthened soda lime silicate glass – Definition and description |
| pr EN 1863-1:2011 | Heat-strengthened soda lime silicate glass – Definition and description |
| EN 12150-1:2000 | Thermally toughened soda-lime silicate safety glass – Definition and description |
| EN 12337-1:2000 | Chemically strengthened soda lime silicate glass – Definition and description |
| EN ISO 12543-1:2011 | Laminated glass and laminated safety glass – Definitions and description of component parts |
| EN ISO 12543-2:2011 | Laminated glass and laminated safety glass – Laminated safety glass |

(Continuation)

| | |
|---|---|
| EN ISO 12543-2:2011 | Laminated glass and laminated safety glass |
| EN ISO 12543-3:2011 | Laminated glass and laminated safety glass – Laminated glass |
| EN ISO 12543-4:2011 | Laminated glass and laminated safety glass – Test methods for durability |
| EN ISO 12543-5:2011 | Laminated glass and laminated safety glass – Dimensions and edge finishing |
| EN ISO 12543-6:2011/ AC:2012 | Laminated glass and laminated safety glass – Appearance |
| EN 13022-1:2006+ A1:2010 | Structural sealant glazing – Glass products for structural sealant glazing systems – Supported and unsupported monolithic and multiple glazing |
| EN 13022-2:2006+ A1:2010 | Structural sealant glazing – Assembly rules |
| EN 13024-1:2002 | Thermally toughened borosilicate safety glass – Definition and description |
| EN 14179-1:2005 | Heat-soaked thermally-toughened soda-lime silicate safety glass – Definition and description |
| EN 14321-1:2005 | Thermally toughened alkaline earth silicate safety glass |

## 1.3.5 STANDARDS FOR TC 129 CONCERNING TESTING AND CALCULATION METHODS

| Reference | Title |
|---|---|
| EN 356:1999 | Security glazing – Testing and classification of resistance against manual attack |
| EN 357:2005 | Fire-resistant glazed elements with transparent or translucent glass products – Classification of fire resistance |
| EN 410:2011 | Determination of luminous and solar characteristics of glazing |
| EN 673:2011 | Determination of thermal transmittance (U value) – Calculation |
| EN 674:2011 | Determination of the thermal transmittance (U value) – Guarded hot plate method |
| EN 675:2011 | Determination of thermal transmittance (U value) – Heat flow meter method |
| EN 1063:1999 | Security glazing – Testing and classification of resistance against bullet attack |
| EN 1288-1:2000 | Determination of the bending strength of glass – Fundamentals of testing glass |

(Continuation)

| | |
|---|---|
| EN 1288-2:2000 | Determination of the bending strength of glass – Coaxial double ring test on flat specimens with large surface areas |
| EN 1288-3:2000 | Determination of the bending strength of glass – Test with specimen supported at two points (four point bending) |
| EN 1288-4:2000 | Determination of the bending strength of glass – Testing of channel shaped glass |
| EN 1288-5:2000 | Determination of the bending strength of glass – Part 5: Coaxial double ring test on flat specimens with small test surface areas |
| EN 12600:2003 | Pendulum test – Impact test method and classification for flat glass |
| EN 12603:2003 | Procedures for goodness of fit and confidence intervals for Weibull distributed glass strength data |
| EN 12758:2011 | Glazing and airborne sound insulation – Product descriptions and determination of properties |
| EN 12898:2001 | Determination of emissivity |
| prEN 16612 | Design of glass panes |
| EN 13541:2000 | Testing and classification of resistance against explosion pressure |
| EN ISO 14438:2002 | Determination of energy balance value – Calculation method |

## 1.3.6 STANDARDS FOR TC 129 CONCERNING INSTALLATION

| | |
|---|---|
| pr EN 12488 | Assembly rules – Glazing requirements |

# 1.4 – Other European standards & documents

## 1.4.1 SOUND RELATED

> EN ISO 717-1:1996 – Acoustics. Rating of sound insulation in buildings and of building elements

> EN ISO 140-3:1995 – Measurement of sound insulation in buildings and of building elements. Part 3: Laboratory measurement of airborne sound insulation of building elements

## 1.4.2 THERMAL RELATED

> EN ISO 10077-1:2006 – Thermal performance of windows, doors and shutters. Calculation of thermal transmittance – Part 1: General

> EN ISO 10077-2:2003 – Thermal performance of windows, doors and shutters. Calculation of thermal transmittance – Part 2: Numerical method for frames

> EN 13947:2006 – Technical performances of facades – Calculation of thermal transmittance coefficient

> EN ISO 13788:2001 – Hygrothermal performance of building components and building elements – Internal surface temperature to avoid critical surface humidity and interstitial condensation – Calculation methods (ISO 13788/2001)

## 1.4.3 SOLAR RELATED

> EN 13363-1 + A1:2007 – Solar protection devices combined with glazing – Calculation of solar and light transmittance – Part 1: Simplified method

> EN 13363-2 + A1:2005 – Solar protection devices combined with glazing – Calculation of total solar energy transmittance and light transmittance – Part 2: Detailed calculation method

## 1.4.4 STRUCTURAL GLAZING RELATED

> ETAG 002:1999 – Structural sealant glazing systems (SGGS) – Part 1: Supported and non supported system

> ETAG 002:1999 – Structural sealant glazing systems (SGGS) – Part 2: Coated aluminium systems

> ETAG 002:2002 – Structural sealant glazing systems (SGGS) – Part 3: Systems incorporating profiles with thermal barrier

## 1.4.5 POINT-FIXED GLAZING RELATED

> 1998 – UEAtc technical report for the assessment of installation using point-fixed glazing systems

## 1.4.6 COATINGS RELATED

> UEAtc technical guide: 2001 – Coated glass

> GEPVP code of practice for in-situ measurement and evaluation of the colour of coated glass used in facades

## 1.4.7 FIRE RELATED

- EN 13501-1:2007 – Classification of construction products and building elements. Part 1: Classification using test data from reaction to fire tests
- EN 13501-2:2009 – Fire classification of construction products and building elements – Part 2: Classification using data from fire resistance tests, excluding ventilation services
- EN 1363-1:1999 – Fire resistance tests. Part 1: General requirements
- EN 1363-2:1999 – Fire Resistance Tests-Part 2: Alternative and Additional Procedures
- EN 1364-1:1999 – Fire resistance tests for non-load bearing elements – Part 1: Walls
- EN 1364-2:1999 – Fire resistance tests for non-load bearing elements – Part 2: Ceilings
- EN 1364-3:2007 – Fire resistance tests for non-load bearing elements in buildings – Part 3: Curtain walls – Full configuration (complete assembly)
- EN ISO 1716:2002 – Reaction to Fire Tests for Building Products – Determination of the Heat of Combustion (ISO 1716:2002)
- EN ISO 1182:2002 – Reaction to fire tests for building products – Non-combustibility test (ISO 1182:2002)
- EN 13823:2002 – Reaction to fire tests for building products – Building products excluding floorings exposed to the thermal attack by a single burning item
- EN ISO 11925-2:2002 – Reaction to fire tests – Ignitability of building products subjected to direct impingement of flame – Part 2: Single-flame source test (ISO 11925-2:2002)

## 1.4.8 EUROCODES RELATED

- EN 1990:2002 – Eurocodes – Basis for structural designs
- EN 1991-1-1:2002 – Eurocode 1. Actions On Structures – Part 1-1:General Actions – Densities, Self-weight, Imposed Loads For Buildings
- EN 1991-1-3:2003 – Eurocode 1 – Actions on structures – Part 1-3:General actions. Snow loads
- EN 1991-1-4:2005 – Eurocode 1 – Actions on structures – Part 1-4:General actions. Wind actions

## 1.4.9 SHOWERS, LIFTS, FURNITURE AND GREENHOUSES

- EN 14428:2005 – Shower partitions – Functional details and testing methods
- EN 81-1:2000 – Safety rules for the construction and installation of lifts – Part 1: Electric lifts
- EN 14072:2004 – Glass in furniture – Test methods
- EN 13031-1:2002 – Greenhouses – Design and Construction – Part 1:Commercial-production greenhouses

## 1.4.10 JOINERY AND CURTAIN-WALL FACADES

The TC 33 of CEN applies to joinery and curtain-wall facades. Several standards are detailed below but there are many more besides.

> EN 14351-1:2006 – Windows and doors – Product standard, performance characteristics – Part 1: Windows and external pedestrian doorsets without resistance to fire and/or smoke leakage characteristics

> EN 13830:2003 – Curtain walling. Product standard

> EN 13049:2003 – Windows. Soft and heavy body impact. Test method, safety requirements and classification

> EN 14019:2004 – Curtain walling. Impact resistance. Performance requirements

> ENV 1627:1999 – Windows, doors, shutters. Burglar resistance. Requirements and classification

> ENV 1628:1999 – Windows, doors, shutters. Burglar resistance. Test method for the determination of resistance under static loading

> ENV 1629:1999 – Windows, doors, shutters. Burglar resistance. Test method for determination of resistance under dynamic loading

> ENV 1630:1999 – Windows, doors, shutters. Burglar resistance. Test method for the determination of resistance to manual burglary attempts

> EN 13123-1:2001 – Window, doors and shutters – Explosion resistance; Requirements and classification – Part 1: Shock tube

> EN 13123-2:2004 – Windows, doors, and shutters – Explosion resistance – Requirements and classification – Part 2: Range test

> EN 13124-1:2001 – Windows, doors and shutters – Explosion resistance; Test method – Part 1: Shock tube

> EN 13124-2:2004 – Windows, doors and shutters. Explosion resistance. Test method – Part 2: Range test

> EN 1522:1999 – Windows, doors, shutters and blinds. Bullet resistance. Requirements and classification
> EN 1523:1988 – Windows, doors, shutters and blinds. Bullet resistance. Test method
> EN 1026:2000 – Windows and doors. Air permeability. Test method
> EN 12207:2000 – Windows and doors. Air permeability. Classification
> EN 12211:2000 – Windows and doors. Resistance to wind load. Test method
> EN 12210:2000 – Windows and doors. Resistance to wind load. Classification
> EN 1027:2000 – Windows and doors. Watertightness. Test method
> EN 12208:2000 – Windows and doors. Watertightness. Classification
> EN 12152 – Curtain walling. Air permeability. Performance requirements and classification
> EN 12179:2000 – Curtain walling. Resistance to wind load. Test method
> EN 13116:2001 – Curtain walling. Resistance to wind load. Performance requirements
> EN 12155:2000 – Curtain walling. Watertightness. Laboratory test under static pressure
> EN 12154:2000 – Curtain walling. Watertightness. Performance requirements and classification

# — 2 —
# GLASS INSTALLATION

Ghelamco Arena - Ghent, Belgium - Architect: Bontick - Lacobel Black Classic

## INTRODUCTION

This chapter sets out the fundamental principles for installing glazing elements.

More detailed brochures on the following subjects are available at www.yourglass.com:

> traditional glazing in rebates

> structural glazing

> specific installation purposes (floors, balustrades, portholes, etc.)

> point-fixed glazing (Structura)

> decorative glass products.

In all cases, any relevant national standards and regulations must be applied in addition to these requirements.

# 2.1 – Installation guideline for traditional rebate glazing

*Find below the main attention points. For detailed installation guidelines, please visit www.yourglass.com for a given product.*

## 2.1.1 KEY POINTS

When installing glass elements in rebates (single glazing, laminated glass, insulating glazing, etc.) you should adhere to certain rules to ensure that the project remains durable and continues to provide high levels of performance, while at the same time limiting any alteration:

> the correct sizes of glass should be used

> the glazing should be of high quality

> the frame should be of high quality

> there should be no contact between the glass and the frame.

The glass should be installed on setting blocks and there should be sufficient clearance between the frame and the glazing.

> the area between the frame and glazing should be watertight and the rebate should be drained

> materials should be compatible

> insulating glazing joints should be protected from UV radiation (exception made for silicone joint insulating glazing)

> thermal and mechanical stresses within the glazing should be limited

> the unit should be properly maintained.

## 2.1.2 EDGE QUALITY

The edges of the glass elements to be installed must have, at a minimum, an arrised edge with a good finishing (no chips, dents, etc.). Glass sheets with visually detectable edge damage should not be used.

## 2.1.3 FRAME QUALITY AND FINISHING

The overall performance of the window is determined by three constituent materials: the glass element, the frame and the sealant material. Consequently, attention must be paid in the design stage to choosing the correct frame and to the actual installation in the facade.

Various degrees of performance can be chosen depending on the frame: wind- and water-tightness, efficiency in water drainage, structural behaviour, performance required in terms of countering burglary, bullets, explosions, fire, etc.

Distortions in frames must be limited so as not to exceed the permitted mechanical stresses in the glass and in the insulating glazing seal.

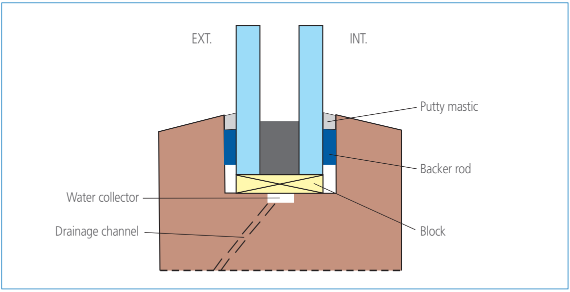
## 2.1.4 SETTING BLOCKS AND REBATE DIMENSIONS

No mechanical contact is allowed between the glass elements and the frame or with any other hard material. Setting blocks:

- are positioned in the rebate in order to prevent any direct mechanical contact
- ensure that the glazing is positioned correctly in the frame (height, width, thickness) and that there is a minimum clearance between the glazing and the frame
- transfer the weight of the glass and the load(s) applied to the frame through the setting blocks
- should be dimensioned according to the glass weight and application (depending the environmental conditions, e.g. swimming pools)
- maintain the squareness of the frame when opening it or using it.

The rebate and the glazing beads must be large enough to ensure that blocks can be set correctly. It is therefore important to adhere to the minimum clearances between the glazing and the frame, both in the same plane as the glass (i.e. between the glazing and the rebate platform) and perpendicular to the plane of the glass (i.e. between the insulating glazing and the height of the insulating glazing bead or rebate upstand).

**Fitting a DGU into a frame:**
**example of fitting with putty mastic in a wooden frame**




## 2.1.5 WATER DRAINAGE FEATURES

The joint between the frame and the glass element must be both watertight and airtight. No water should be allowed to stagnate in the rebate platform in order to prevent damage to the glass element's seal or deterioration of the laminated glass interlayer.

Seals (putty mastic, waterproof seals) are used to keep areas watertight and airtight. These seals also absorb different expansion levels between the frame and the insulating glazing while remaining watertight and airtight. They should retain these properties over time.

Drainage keeps a rebate as dry as possible, even under unfavourable conditions, by draining away any water that accidentally penetrates into the rebate (condensation, infiltration due to the failure of a waterproof seal, etc.) via drainage channels or outlets.

## 2.1.6 CHEMICAL COMPATIBILITY OF MATERIALS

Once the glass elements have been fitted, adjacent or nearby materials should be compatible, i.e. they may not, following chemical or physical interaction, impact on each other in such a way that their performance level is reduced.

## 2.1.7 PROTECTION FROM UV RADIATION

Some types of sealants used in insulating glazing are vulnerable to chemical deterioration when exposed to ultraviolet radiation, leading to deterioration in product performance. Check the manufacturer's processing and utilisation guidelines.

These constituent materials must be protected from UV radiation.

## 2.1.8 LIMIT THE RISK OF THERMAL STRESS IN THE GLASS ELEMENT

Glass is inherently a brittle material and subject to thermal breakage if a temperature gradient of more than 30 °C is present.

AGC can make the assessment of the risk of thermal breakage. For glass elements where a high risk of thermal breakage is present, a thermally treated glass (thermally toughened safety glass or heat-strengthened glass) must be chosen.

Where there is a risk of this occurring (insulating glazings set back from the facade, shadows cast by blinds, etc.) the risk of thermal breakage should be assessed and, where necessary, heat-strengthened or thermally toughened safety glass products should be used.

For roof glazing, the thermal load is significantly increased.

## 2.1.9 PRECAUTIONS DURING INSTALLATION AND MAINTENANCE

During construction work, the glass should be protected from damage.

The glass elements must be protected so as to avoid any risk of thermal breakage or irreparable surface damage to the glass surface or deterioration of the glass edge.

# 2.2 – Specific installation guidelines

AGC has drawn up a series of specific installation guidelines that can be consulted on and downloaded from www.yourglass.com:

> Structural Glazing
> Point-Fixed Glazing - Structura
> Bent Glass
> Glass Balustrades
> Glass Floors and Stair Treads.

# 2.3 – Decorative products

AGC offers a series of specific installation guidelines for decorative products.

These can be found on www.yourglass.com in the specific brands or products sections.

Cubic Center - Bucharest, Romania - Designer: Design Unit, Gabriel Carstea - Lacobel Black Classic & Grey Metal

Main Point Karlin Building - Prague, Czech Republic - Architect: DaM Architects - iplus

# VI
# yourglass.com

# 1
# INTRODUCTION

Launched in late 2002, www.yourglass.com has become the reference site and source of key information for all architectural and renovation construction projects incorporating facade, roof and interior glazings.

In order to structure the vast amount of information available on the site more efficiently, the sections below detail the structure of the site and how best to use it.

The site is available in nine languages: German, English, Spanish, French, Italian, Dutch, Polish, Russian and Czech.

Users can also choose their country. The information varies from one country to another since the various ranges and products available are not necessarily the same on all markets.

For registered users, the language and country details are recorded and the site will automatically launch in the correct language and country environment.

# 2
# YOUR GLASS TOOLS

Your Glass Tools provides access to several modules and calculation tools.

### ▼ Brochure Finder

The Brochure finder module can be used to download information brochures in pdf format.

### ▼ E-photolibrary

The Reference finder module can be used to locate examples of how a given range of products has been used in buildings. You can search by country, city, building, architect or product.

### ▼ Product Finder

The Product Finder module can be used to quickly determine which glazing meets a particular set of specifications by entering details of the solar factor, light transmission, thermal transmittance and glazing colour.

Three options are available:

> a detailed product description

> product specifications

> the product's CE Marking document.

### ▼ Glass Configurator

The Glass Configurator module can be used to calculate light and energy performance (LT, DET, SF, etc.) of single, laminated and insulating glazing.

A calculation report comprising light values in accordance with standards EN 410, energy values in accordance with standards EN 410 and ISO 9050, and thermal transmittance in accordance with standard EN 673 can be printed out or saved in electronic form.

## ▼ Calculation Programmes

The Calculation Programmes module provides access to several calculation sheets, for example:

> the thickness of facade glazings (according to the relevant Belgian standard)

> $U_g$ values for windows (according to the relevant European standard)

> energy performance for combined solar-protection glazings (according to the relevant European standard).

New modules will be added on a regular basis.

Each calculation is based on a national or European standard (clearly stated) and is valid only in the relevant country(ies).

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See www.yourglass.com for further addresses.