الشركة السعودية الأمريكية للزجاج
SAUDI AMERICAN GLASS

Reflecting your vision

since 1978

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A Subsidiary of زجاج GLASS إحدى شركات

معلوكة بالكامل من دبي للإستثمار Wholly Owned by DUBAI INVESTMENTS

Emirates Float Glass, Abu Dhabi
Primary Float Glass Manufacture

شركة الإمارات لألواح الزجاج المسطوح ذ.م.م
EMIRATES FLOAT GLASS LLC

Saudi American Glass Company, Riyadh
Architectural Flat Glass Processor

الشركة السعودية الأمريكية للزجاج
SAUDI AMERICAN GLASS

Emirates Glass LLC, Dubai
Architectural Flat Glass Processor

الامارات للزجاج
Emirates Glass

Lumiglass Industries LLC, Dubai
Automotive and Architectural Laminated Glass

لومي لصناعة الزجاج ش.ذ.م.م
LUMIGLASS Industries LLC

WHAT IS GLASS?

Glass is a material with remarkable properties of fragility, durability and transparency and is an essential component of civilised life as we know it in the modern world. It protects us from short-term changes in the weather as well as from longer-term changes in the climate and provides us with a view of the world beyond the pane. If undisturbed, glass will continue to perform it's protective role for centuries but, if disturbed by impact, excessive wind-load or other undue forces, it will break into fragments which can be potentially lethal. This unique combination of durability and fragility are enhanced by modern processing methods which provide a wide range of benefits of additional strength and security and allow glass to be used in a vast range of applications in all aspects of modern living.

Saint Chapelle Cathedral, Paris 1248

Granada Mall, Riyadh 2011

COMPOSITION OF COMMERCIAL WINDOW GLASS

SODA-LIME GLASS

ORIGIN	DESCRIPTION		%
Mined or Quarried Materials	Silica	Si	72
	Limestone	$CaCO_3$	9
	Dolomite	$CaMg(CO_3)_2$	4
	Others	incl. iron oxide	1
Manufactured Materials	Soda Ash	Na_2CO_3	14
By - Product material	Clean Scrap	Cullet	Up to 20% by volume

**Note: All commercial window glass contains a residue of iron oxide (Fe_2O_3) which is difficult and expensive to remove and gives the glass it's characteristic green edge-colour which is considered acceptable for most glazing applications, including mirrors. However, to meet the demand for a "whiter" architectural window glass, it is possible to remove most of the residual iron by further processing and additional cost to create "Low-Iron" ("Extra-Clear") glass which is almost perfectly white with no green colour at the edges. The clarity and high light-transmission characteristics of "Low-Iron" glass make it a highly popular glazing-choice for a wide variety of applications in Retail and Commercial buildings.

Let us now introduce you to Saudi American Glass Factory and their superb range of architectural glass products...

MSVD MAGNETIC SPUTTERED VACUUM DEPOSITION COATING LINE FOR K-LITE® HIGH PERFORMANCE GLASS

COMPANY PROFILE

SAUDI AMERICAN GLASS COMPANY

Saudi American Glass Company is a subsidiary of Glass LLC which itself is a holding company set up by Dubai Investments PJSC to create a vertically-integrated flat glass industry in the Gulf Region.

Saudi American Glass was established in Riyadh in 1978 and has, since then, occupied a strategic position as the leading processor of architectural flat glass in Saudi Arabia.

In 1993, in anticipation of a huge increase in demand for energy-efficient high performance glass (Solar Control and Low Emissivity Low-E), SAG commissioned the first MSVD coating line in the Middle East and launched it's highly successful K – LITE range of sputter-coated facade glazing into the Saudi market. Today, after 18 years of outstanding success, K – LITE is still the market leader in this field and SAG can proudly demonstrate a multitude of projects, now approaching 18 years old and which are still presenting a fresh appearance with no reduction in performance.

During its 33 year old history, SAG has consistently followed a programme of progressive capital expansion into all areas of its product range and can truly be described as a state – of – the – art enterprise, administered and operated by a well–proven team of experts at every level of the organisation. In addition to the production of K – LITE sputter-coated high performance glass, SAG employs the latest technology in glass-cutting, tempering and heat strengthening, glass-washing and edge-working, double glazing, silk screen ceramic fritting and lamination: all produced in full conformance with current international standards and backed by an unrivaled record of reliability, durability and performance at least equal to the best in the international market.

SAG is well-placed in terms of capacity, expertise and innovation to serve its growing market as a reliable single source of high performance glass products to meet the most stringent requirements of property developers, architects and engineers.

K-LITE®

MSVD Sputter-Coated Energy-Saving Glass

TECHNICAL DETAILS

The K-LITE range comprises 3 main product-categories:

1. Single Silver (1xAg) Low-E KE 74 Series Double Glazed

- Available pre-tempered only: cut-to-size by SAG.
- Edge deletion required.
- This is a standard Low-E range in which the coating position can be on surface # 2 (KE 742) for cooling-dominated environments or on surface # 3 (KE 743) for heating-dominated environments. Solar resistance varies according to tint of outer pane.

2. Single Silver (1xAg) Optima Multi-Functional Low-E # 2 Double Glazed

- Available pre-tempered only: cut-to-size by SAG.
- Edge-deletion is required.
- Coating position: surface # 2.
- K-LITE Optima series is designed to provide good solar resistance combined with good thermal insulation and is suitable for a cooling-dominated environment where good SHGC and U-value performance are required to ensure lower solar heat gain and optimum efficiency of air-conditioning equipment.

3. Solar Control K-LITE HP Reflective #2: single or double glazed

- SS, CS, AB, KR, DB, AR, ORG, ABILR Series.
- Available pre-tempered only: cut-to-size by SAG.
- Durable coating: Edge-deletion not required.
- Silicone bonding sealants can be applied directly to the coating.
- Can be used as single glazing for spandrel applications.

Product	Coating Type	Coating Position	Coating Ref	Availability			Remarks
				Substrate	Normal Max size mm	Thickness mm	
K-LITE KE 74	Single Silver Standard Low-E	#2	KE742	Clear Tinted	3660 x 2440 3300 x 2440	4,6,8,10, 6,8	
		#3	KE743				
K-LITE Optima Neutral	Single Silver Multi-Functional Low-E	#2	Neutral 43 Neutral 51 Neutral 60	Clear Tinted	3660 x 2440 3300 x 2440	4,6,8,10, 6,8	
K-LITE Optima Silver			Silver 36 Silver 47				
K-LITE Optima Azura			Azura				
K-LITE HP	Solar Control	#2	SS 08 14 20 35	Clear Tinted	3660 x 2440 3300 x 2440	4,6,8,10,12, 6,8	Sterling Silver
			CS 08 14 20 35 CSILR				Chrome Silver
			AB 08 14 20				Azura Blue
			DB 08 14 20 35				Dark Bronze
			ORG				Dark Gold
			KR 1 KR 48 KR HLT				Chrome
			ABILR 12 ABILR 19				Azura Blue Internal Low Reflection


Tonino Lamborghini
CAFE RESTO

K-LITE® KE 74 SERIES

Standard Low-E

Type Single Silver (1xAg) Low-E # 2 or 3, KE 742/743 Series

Availability Non Post-Temperable

K-LITE KE 74 is an MSVD sputtered Low-E glass with a nominal light transmission of 74%. The coating is neutral/low reflective and retains the appearance of clear or body-tinted glass. It is ideal for applications requiring subdued colours, low reflectances and abundant daylight. As a result, K-LITE KE 742/743 is highly effective in blocking the transmission of heat in the near and far infrared (IR) wavebands of the solar spectrum and thus provides excellent resistance to ambient conducted heat-transfer (outdoor-indoor temperature difference). However, K-LITE KE 742/743 Low-E glass is quite transparent to direct solar radiant energy and does not have significant solar control capability in the typical Gulf environment.

K-LITE 742/743 is therefore suitable for glazed openings which require a high degree of visual transparency and low reflectance, but may not meet the current requirements of local and national building codes, or the current requirements of green-building rating systems, such as LEED or ESTIDAMA, for solar energy resistance in hot climatic conditions with minimum cloud-cover.

K-LITE 742/743 is an insulated glass product and cannot be used in single glazing. Edge-deletion of KE 742/743 is necessary prior to fabrication of insulated units.

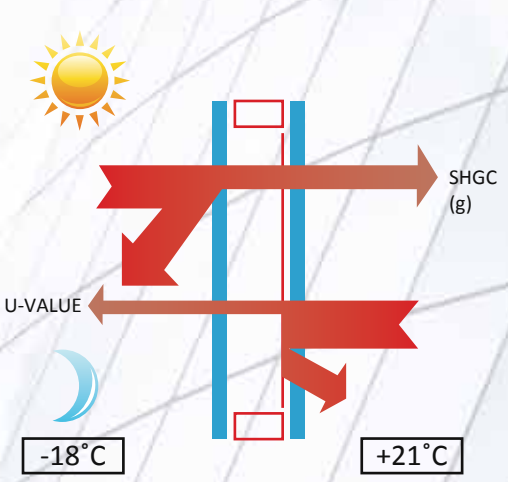
Spandrel Panels

Due to the high light transmission characteristics of the KE 742/743 range, it is recognized that colour-uniformity between vision and non-vision areas of a typical curtainwall design will not be achieved. It is therefore necessary to use a harmonizing or contrasting glass spandrel option. Two spandrel options are available for use with KE 742/743 Low-E vision glass.

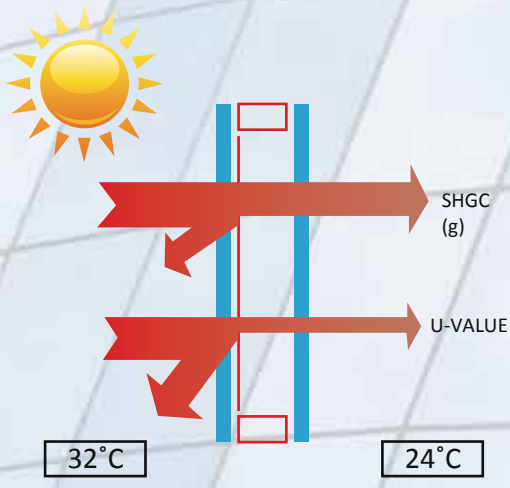
a. A double glazed unit of the same outer pane and coating position as used for the vision glazing. To control “read-through”, an all-over ceramic frit paint, usually white, grey or black, can be applied on surface # 4 or, alternatively, by using a shadow-box comprising an insulated back-pan with a suitably painted finish.

or

b. Single glazed K-LITE reflective high performance solar control glass to complement the appearance of the K-LITE KE 742/743 vision glass, and by using a shadow-box comprising an insulated back-pan with a suitably painted finish.



HEATING-DOMINATED ENVIRONMENT
K-LITE KE 743 TO MINIMISE WINTER HEAT-LOSS



COOLING-DOMINATED ENVIRONMENT
K-LITE KE 742 TO CONTROL TOTAL HEAT-GAIN

For full details of Spectrophotmetric and Thermal Insulation performance data on any K-Lite product, kindly refer to the Technical Advisory Service of Saudi American Glass Factory.

K-LITE® OPTIMA SERIES

Multi-Functional Low-E

Type Single Silver (1xAg) Multi-functional Low-E # 2

Availability Non Post-Temperable

K-LITE Optima has been developed as a range of Low- E coatings which have a neutral silver appearance when applied onto clear glass. The K-LITE Optima range of two coating options – Optima Neutral and Optima Silver – provides a multi-functional capability with good solar resistance and excellent thermal insulation, summer or winter. At the same time, K-LITE Optima allows generous transmission of light with moderate-to-low internal reflection, giving the appearance of clear or tinted glass when viewed from inside.

K-LITE Optima is an insulated glass product with the coating on surface # 2 and cannot be single glazed. Edge-deletion of the Optima coating is necessary prior to fabrication of insulated glass units.

Spandrel Panels

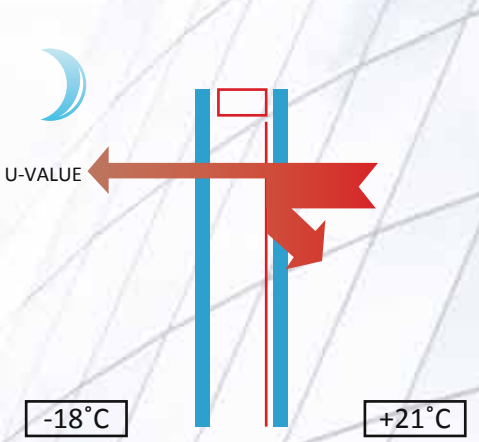
The K-LITE Optima range of multi-functional Low-E glass is characterized by medium-to-high light transmission values. As a result, variable "read-through" of structural elements, blinds, curtains, luminaires etc. may occur in normal daytime conditions and colour-uniformity may not be achieved between vision and non-vision areas in typical curtainwall designs.

It is therefore necessary to consider either a harmonizing, or contrasting spandrel option when using the K-LITE Optima range. Two spandrel options are available for use with K-LITE Optima Low-E vision glass.

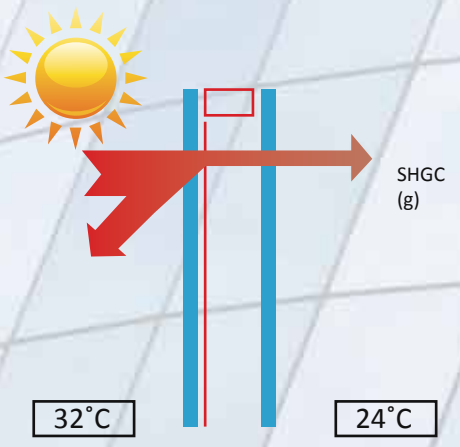
a. A double glazed unit of the same outer pane and coating position as used for the vision glazing to control "read-through", an all-over ceramic frit paint usually white, grey or black, can be applied on surface # 4 or, alternatively by using a shadow-box comprising an insulated back-pan with a suitably painted finish.

or

b. Single glazed K-LITE reflective high performance solar control glass to complement the appearance of the K-LITE Optima vision glass, and by using a shadow-box comprising an insulated back-pan with a suitably painted finish.



K-LITE OPTIMA MULTI-FUNCTIONAL LOW-E
REDUCED HEAT-LOSS IN WINTER



K-LITE OPTIMA MULTI-FUNCTIONAL LOW-E
REDUCED HEAT-GAIN IN SUMMER

For full details of Spectrophotmetric and Thermal Insulation performance data on any K-Lite product, kindly refer to the Technical Advisory Service of Saudi American Glass Factory.

K-LITE® REFLECTIVE

High Performance Solar Control Glass

Type Durable, Sputtered Solar Control # 2

Availability Non Post-Temperable

K-LITE solar reflective coatings consist of thin layers of metal, typically stainless steel, nickel, chromium, titanium and tin, sequentially applied in various combinations by magnetically sputtered vacuum deposition technology on SAGF's state-of-the-art coating line. Excellent facade-colour, uniformity and superior solar resistance, these are the outstanding features of K-LITE high performance glass which provides superb control of solar heat gain in the typical Gulf environment and are vital in optimizing the capacity of air-conditioning equipment to reduce energy consumption.

K-LITE HP coatings are durable and can be incorporated into sealed insulated units for vision glazing or as single glass for spandrel panels.

The facade colour-uniformity and stability of K-LITE HP coatings makes them the natural choice for structural silicone curtainwall systems in which the structural silicone can be applied directly to the K-LITE HP coating. Fabrication of insulated glass units as well as structural bonding of single glazed spandrel panels do not require edge-deletion of the coating.

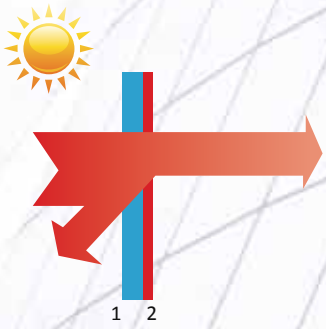
Spandrel Panels

K-LITE HP glass can be used in single glazed form as spandrel glass in all types of curtainwall construction. Colour-uniformity between vision and non-vision areas is assured when the light transmission of the selected K-LITE HP glass does not exceed 14%. From 14%-20% LT, the colour change is marginal, depending on the tint and external reflectance of the vision pane and its adjacent spandrel pane.

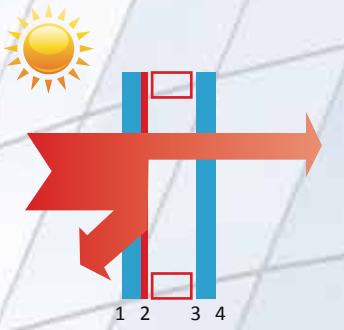
K-LITE HP Glass With Low Indoor Reflectance

Many architects and property owners are becoming increasingly interested in the lowest possible indoor reflectance (LRin) of their selected glass when seen at night under normal artificial lighting conditions.

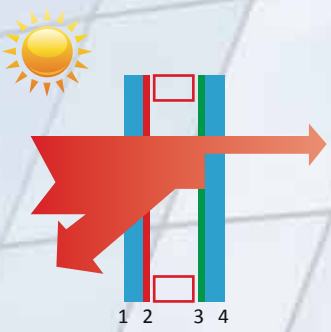
To meet this growing desire, SAGF have developed a range of K-LITE HP glass options which combine excellent solar resistance (SHGC) and low indoor reflectance (LRin). This range includes K-LITE KR1, AR, CSILR and ABILR coatings on a full selection of clear and tinted float glass substrates giving SHGC values ≤ 20 and LRin values ≤ 17%.



6mm K-LITE HP GLASS #2
Typical SHGC/g 13-28
Typical U-VALUE 5.10 W/m^{2}K



24mm 1G UNIT (6+12+6mm)
K-LITE HP COATING #2
Typical SHGC/g 11-23
Typical U-VALUE 2.60 W/m^{2}K



24mm 1G UNIT (6+12+6mm)
K-LITE HP COATING #2
K-LITE KE 743 LOW-E #3
Typical SHGC/g 9-19
Typical U-VALUE 1.90 W/m^{2}K

For full details of Spectrophotmetric and Thermal Insulation performance data on any K-Lite product, kindly refer to the Technical Advisory Service of Saudi American Glass Factory.

THE CONTRIBUTION OF K-LITE HP GLASS TO SUSTAINABLE GREEN BUILDING

Throughout the Gulf region there is now a rapidly growing appreciation of, and conformance to, the latest concepts of green-building principles notably the USGBC/LEED (Leadership in Energy and Environmental Design) and the ESTIDAMA (Abu Dhabi) Green Building rating systems which are now being strongly adopted as standard references for Sustainable Architectural Design and Construction.

It is a well-known and very serious fact, that the Gulf States have the highest per-capital carbon footprints in the world and that urgent attention must be given, starting now, to address this problem. It is equally well-known, that the majority of heat-gain into a building is through the glazing. In the typical Gulf Summer Conditions, over 70% of peak electrical generating capacity is for cooling.

Therefore it follows that glass-selection and specification can have a potentially large effect on the capacity and operational efficiency of air-conditioning systems.

From its extensive product range of K-LITE High Performance Glass, Saudi American Glass Company are able to offer many insulated glass types which provide SHGC/g values ≤ 25 and U- values ≤ 2.20 W/m^2k in order to comply with LEED and ESTIDAMA requirements for energy-saving glass. In addition, most of these products give excellent visible light transmission (VLT), thus providing good interior daylight factors whilst maintaining excellent views of the world outside the building.

K-LITE High Performance Glass provides optimum indoor comfort-levels in terms of solar control, thermal insulation, good daylight, factors, and reduction of glare and preservation of views.

In terms of Regional Sourcing, The Glass LLC Group of Companies is well-located to meet Green Building Criteria for local supply. A substantial proportion of SAG's product range is manufactured using raw float glass (clear, bronze, and grey) from sister company, Emirates Float Glass in Abu Dhabi whose main source of raw materials is Saudi Arabia, and using UAE and Qatar-derived gas the prime energy source. Many of SAG products can therefore be considered to be up to 90% (by value) of Gulf-origin from raw material through to finished product. Re-cycling of glass at pre-consumer and post-consumer stages of manufacture and use is done within the limits of available national facilities at the present time.

SAG are proud to be able to make a substantial contribution to sustainable architectural design in the Kingdom of Saudi Arabia and throughout the Gulf, based on the operational efficiency of their superb manufacturing facilities and the dependable performance of the K-LITE range of High Performance Glass.

SAG TECHNICAL SERVICES

Design Criteria

Saudi American Glass, together with Emirates Glass Laboratory, are able to provide a comprehensive support service to our customers and specifiers, covering all aspects of the specification, manufacture and installation of K-LITE sputtered high performance glass.

SAG are able to review perspectives, concept-drawings, detailed drawings and glass specifications to give professional advice on a wide range of matters concerning the use of glass in buildings, including:

- Colour.
- Reflectance. Indoor/Outdoor
- Solar Resistance. SHGC to NFRC 301.2009 Standard
  g – value to EN 410 Standard
- Thermal Insulation. U – value to NFRC 100.2009 Standard
  U – value to EN 673 Standard
- Visible Light Transmission.
- Centre-Of-Glass-Deflection.
- Optimisation of glazing modules to minimize waste.
- Acoustic Insulation.
- Conformance with Green Building Guidelines (LEED, ESTIDAMA etc.).

Note:
SAG are not able to undertake calculation of the capacity of heating or cooling systems based on any specific glass type for any specific project. Such calculation must be made by qualified HVAC Engineers, using the spectrophotometric and thermal insulation performance data for K-LITE glass provided by SAG.

Specification Of Glass Thickness

SAG Technical Services Department can undertake glass thickness and center-of-glass deflection studies provided that the following information is supplied.

- Design wind load in kPa.
- Height of building.
- Dimensions of the glass.
- Fixing system: 4-side or 2-side supported.
- Type and condition of the glass e.g. Annealed, Heat Strengthened, Fully Tempered, single or double glazing.
- Slope of glazing in deg. from horizontal.

Selection

Selection of the right K-LITE glass product for a particular building requires careful consideration of colour and performance to achieve the desired appearance with optimum energy consumption and performance.

The Actual Colour

This is a precise value which is determined by the body tint of the glass substrate, and the visible light transmission and reflectance of the chosen K-LITE coating. Generally, the low VLT coatings (K-LITE HP Reflective Glass) produce the strongest colours. As the VLT increases, so also does the transparency of the glass, and thus the colours become more subdued. Many combinations of K-LITE HP Reflective, Optima and KE Low-E coatings are available to create a huge palette of colours.

Colour Rendering Index (CRI)

Is the ratio of the perceived colours of the spectrum viewed through a specific glass , compared to the perception of the same colours in normal daylight with no glass (compare a fixed window and an adjacent open window which is showing “white light”). The CRI scale is from 1 – 100. Glass with lower CRI causes colours to appear relatively faded, whereas the higher the CRI, the more vibrant the colours. Colour rendering indices above 90 are very good and from 80 - 90 are good.

The Observed Colour

When viewing K-LITE HP glass on a completed building, the human eye and brain are influenced by a number of extremely important environmental factors, including:

- The time of the day.
- The sky conditions.
- The distance of the observer from the building.

SAG TECHNICAL SERVICES
Design Criteria

- The colours and reflectance of surrounding buildings and landscapes.
- The colour of the other materials in the exterior of the building.
- The difference between the internal and external light intensity.

Furthermore, the colour and reflectance of many K-LITE glass types will be affected by the blue colour of the sky when the weather conditions are clear and bright, and when there are no reflected adjacent landscapes or buildings.

When the sky is partially cloudy or overcast, or when shaded from the sun, the reduced light intensity produces a darkening of glass colour.

The Daily Cycle

While the building itself is static, the combined effect of a mobile sky, a mobile sun and a mobile observer, creates an ever-changing aspect which is an inherent and beautiful characteristic of K-LITE high performance glass.

Distortion

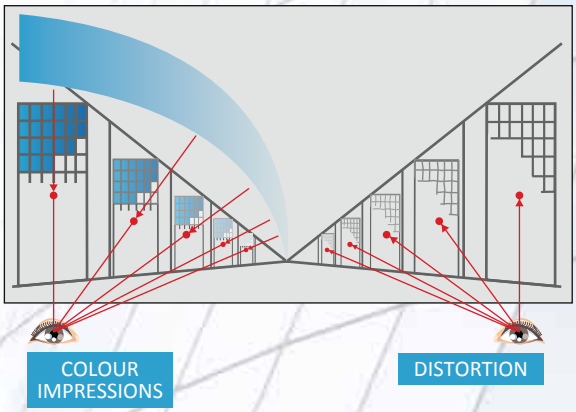
Due to the nature of the horizontal roller technology in the production of Heat-Treated glass (HS or FT), the final product will never be as flat as the original annealed float glass. The visible effect of flatness-irregularity is known as distortion. When glass is further treated with a reflective coating, the degree of distortion becomes more noticeable. This is, however, an inherent feature of heat-treated reflective glass and is not a quality problem.

All SAGF heat-treated glass types (HS and FT) are produced within the tolerances of American Standard ASTM C 1048, current version. Distortion may be accentuated in sealed insulated glass units due to changes in barometric air pressure and changes of temperature acting on a fixed volume of air hermetically sealed between two glass-lites.

Accuracy of installation of framing members and correct tightness of fixing screws also have a vital effect on the planarity of the glass-surfaces. Even small deviations in tolerance in the installation of frames can produce substantial visible distortion in the glass itself.

Distortion can also be minimized by ensuring that the heat-treated glass is manufactured and installed with the characteristic roller wave pattern parallel to the W – dimension.

Distortion is only visible when an image is reflected. Depending on the proximity of the observer to the glazed surface, the amount of distortion will vary. When standing close to the glass, the degree of distortion is very small, but increases as the observer moves away from the facade.



Strain Patterns

Slight variations of stress across the surface of a Heat-Treated (mainly FT) glass may become visible to the eye due to the effect of polarized light at certain times of day, especially near to sun-down when the glass is shaded. Strain patterns (commonly known as “Quench-Marks”) are an anisotropic phenomenon which can occur in all Heat-Treated glass types, and are sometimes more noticeable in tinted glass and reflective coated glass. Anisotropic strain-patterns are not considered to be a defect in the Heat-Treated glass.

Mock-up Samples

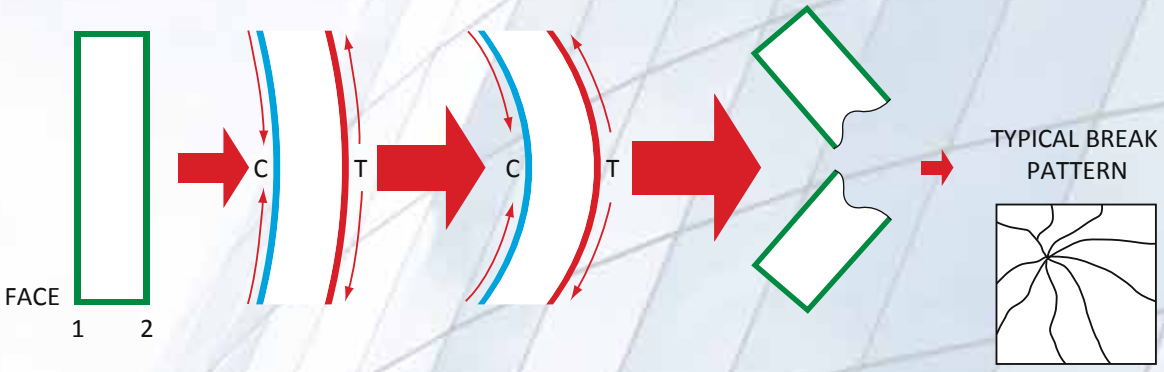
Distortion, colour and reflectance of K-LITE high performance glass are important design considerations that architects and owners should evaluate in a full-size mock-up frame erected on site, including a shadow-box, prior to final selection and approval of the desired product.

SAG HEAT TREATED GLASS

INTRODUCTION TO S.A.G. HEAT-TREATED FULLY TEMPERED (FT) AND HEAT-STRENGTHENED (HS) GLASS

Primary float glass, as manufactured, is a glass which is totally free from stress which is known as “Annealed“condition. This allows it to be easily cut, drilled and edge-worked. However, annealed glass cannot be used as a structural material and has extremely limited resistance to high wind-load, dead load or extreme solar exposure. Furthermore, when broken, annealed glass is a lethal material which can cause severe or fatal injury. **Question:** how can these limitations are overcome? **Answer:** by heat-treatment in a modern gas-fired horizontal roller furnace to induce additional properties into the annealed glass which will make it suitable for use in contemporary designs including structural silicone curtain wall systems and all forms of bolted frameless glazing. **How is this done?**

Impact Behavior of Annealed Glass



When loaded in any circumstance, annealed glass will deflect causing the Face # 1 to develop a level of compressive stress while Face # 2 is now in tension. As the load increases, the tensile stress in Face # 2 also increases. Since glass is very strong in compression, but weak in tension, the Face # 2 surface will soon reach its tensile stress – limit and the glass will break. All stress-forces will be relieved, and the result is a potentially dangerous fragmentation. Annealed glass cannot, therefore, be used for frameless glazing and is restricted for use in areas which have no legal requirement for safety glass. **How can this situation be resolved to allow for safe glazing design?**

Heat-Treated Glass: HS and FT

Saudi American Glass offers both Heat-Strengthened (HS) and Fully Tempered (FT) glass for applications requiring added strength or resistance to stresses caused by absorption of solar energy and to resist the forces of deflection under wind-load. Both glass types are produced on the most modern horizontal roller type of furnace which, nevertheless, causes the float glass surfaces to develop roller-wave distortion which is a normal characteristic of heat-treated glass and is controlled well within the parameters of current American Standard ASTM C 1048.

Tempered glass may occasionally break due to the presence of inclusions, typically nickel sulphide, which can occur from time-to-time during production of raw float glass. Although the extent of spontaneous breakage is statistically minimal, many designers and contractors will frequently prefer to use Heat Strengthened (HS) glass, in which spontaneous breakage is virtually unknown.

In instances where there is a legal requirement to satisfy the safety aspect of local and / or international building codes or where frameless glazing is involved, or to resist extreme wind-loads or dead loads in sloped areas, then Fully Tempered (FT) glass or laminated Heat-Strengthened glass must be used.

Fully Tempered (FT) Glass

FT glass is produced by Saudi American Glass in horizontal roller furnaces in which the glass is heated to around 700 degC at which temperature it is red-hot and in a “plastic” condition. Since the pitch of the support-rollers is 120 mm, the soft glass is constantly oscillated forwards and backwards during the entire process in order to minimise any tendency to sag between the rollers. On reaching the peak temperature, the glass is quickly moved to the quenching zone where it is rapidly cooled, simultaneously on both surfaces, by a force of cold air which causes the outer surfaces (including the edges) to contract, thus creating a total “envelope” of compressive stresses in Faces # 1 and 2.

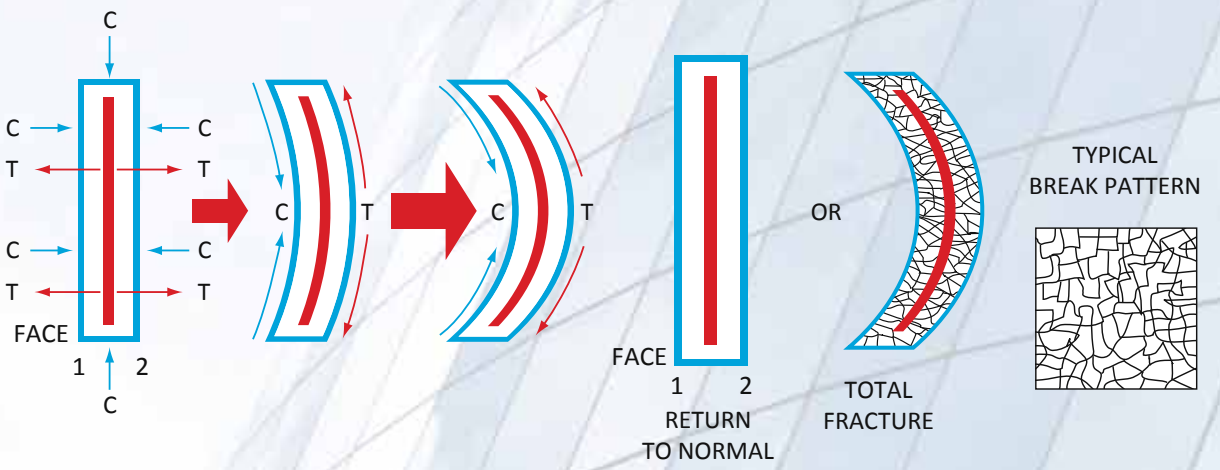
However, this rapid cooling of the surfaces is not immediately conducted to the hot centre of the glass which remains in a state of expansion but then cools, after a short delay, to a greater degree of contraction than the surfaces. As a result, the centre-zone of the glass is now placed in tension entirely within the compression-envelope, thus creating a perfect balance of forces in a stable Fully Tempered condition.

Clearly, if the FT glass is now subjected to a load, the compressive stress in Face # 2 will allow the glass to absorb a much greater force without breaking and, on removal of the force, the glass (being a perfectly elastic material) will return to its original flat condition.

SAG HEAT TREATED GLASS

INTRODUCTION TO S.A.G. HEAT-TREATED FULLY TEMPERED (FT) AND HEAT-STRENGTHENED (HS) GLASS

Impact Behaviour of Fully Tempered Glass



Breakage of FT glass will occur when the deflection exceeds the capacity of the compressive envelope to resist the tensile force ultimately created in Face # 2. Alternatively, if hit by a sharp or very hard object, on the face or on the edge of the pane, which penetrates through to the tensile zone, then the sudden release of energy stored in the tensile zone will cause total disintegration of the glass into small fragments which are classed as “non-injurious“. This important feature of FT glass means that it is considered by all major international standards to be a “true safety glass“ for use in all glazing situations where impact-resistance and thermal safety are required.

Summary of S.A.G. Fully Tempered (FT) Glass

- Is 4 – 5 times stronger than annealed glass of the same thickness.
- Has much greater resistance to thermally-induced stress than annealed glass.
- Tempered properties are stable within a temperature-range from -100 degC to 290 degC and can withstand severe temperature down-shocks.
- Typically breaks into small particles which can be handled safely.
- Suitable for use as a safety glass as defined by:
  European Standard EN 12600 2002
  British Standards BS EN 6206 / 6262

Conforms to European Production Standard EN 12150-1 2000 and current American Standard ASTM C 1048.

Applications

- All types of clear, tinted and Post-Temperable sputter-coated glass are available in FT condition.
- FT glass can be used in any window or curtain wall system
- FT glass is a structural glass which can be used for frameless glass facades, frameless glass doors, glass balustrades and many types of furniture and oven appliances.
- FT glass is widely used in private and public transport vehicles.
- FT glass can be laminated with a suitable number of PVB interlayers.
- FT glass can be produced with silk-screened and digital printed ceramic frit designs.
- FT glass CANNOT be cut or drilled after tempering. Any post-tempering operations such as edge-grinding, cutting, sand-blasting etc may cause sudden, or premature, failure.
- Edge-Working: FT glass is normally supplied with standard arrised edges for general glazing purposes. Where glass-edges are exposed, a variety of smooth or polished edge-finishes are available on rectangular, shaped or complex-shaped glass lites.
- All K-LITE HP, OPTIMA and KE-74 Low-E coatings are available on FT glass which is tempered prior to the coating process.

SAG HEAT TREATED GLASS

INTRODUCTION TO S.A.G. HEAT-TREATED FULLY TEMPERED (FT)
AND HEAT-STRENGTHENED (HS) GLASS

Heat-Strengthened (HS) Glass

HS glass is a “semi-tempered“ glass in which the hot glass is cooled similarly to tempered glass, but for a longer period which results in much lower compressive stress in the “external envelope’ and a much weaker tensile zone. HS glass is therefore not a safety glass and cannot be used for frameless bolted glazing. When broken, the fragmentation is into large pieces which, however, tend to remain in situ, especially when used in sealed insulated units where the perimeter sealant is able to retain the glass with minimum “fall-out “. Due to the minimal tensile zone, the risk of spontaneous breakage from Nickel Sulphide inclusions is almost “zero”.

Summary of HS Glass

Picture Framing Impact Dicing

Typical Heat Strengthened Fracture

- Is 2 – times stronger than Annealed glass of the same thickness.
- Has much greater resistance to thermal stress than Annealed glass.
- Typically breaks edge-to-edge in large pieces.
- Is not a safety glass.
- Conforms to European Production Standard EN 1863 and current American Standard ASTM C 1048.

Applications

- HS glass is not a structural glass and must be glazed on all four edges in conventional or structural silicone curtain wall systems.
- Not suitable for frameless bolted glazing.
- HS glass is the ideal choice for high-rise buildings where added resistance to wind-load and thermal stresses is required.
- HS glass can be laminated with a suitable number of PVB interlayers.
- HS glass can be produced with silk-screened and digital printed ceramic frit designs.
- All K-LITE, OPTIMA AND KE-74 Low – E coatings are available on HS glass which is Heat-Strengthened prior to the coating process.

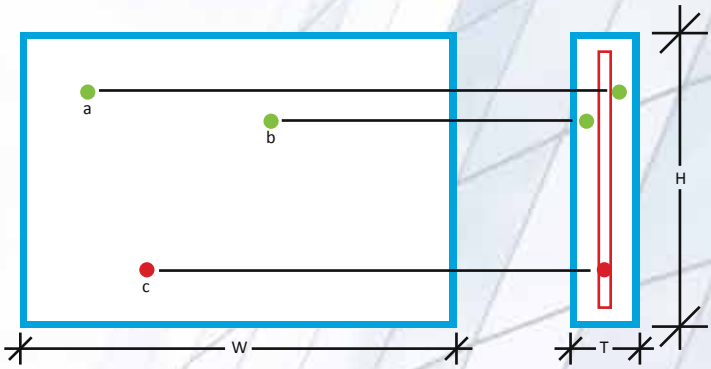
SAG HEAT SOAK TESTING

In its original state, float glass is produced as a primary raw material in the form of large stocksheets which are intended for downstream processing to create the finished glass product, as installed. The Float Glass Process ensures that the glass is cooled gradually to achieve a stress-free condition which is described as Annealed glass. This process of annealing allows the glass to be cut, edge-worked and drilled safely and accurately without risk of uncontrolled breakage.

Saudi American Glass sources its raw float glass requirements from reputable manufacturers which conform to best international standards including American Standard ASTM C 1036 in terms of flatness, surface quality and minimal internal impurities, bubbles, and seeds within the body of the glass.

Although float glass manufacturers take extreme precautions to ensure maximum purity of the raw materials, it is possible from time-to-time, for Nickel Sulphide (NiS) inclusions (which are invisible to the human eye and also to electronic QC procedures) to occur in the glass. Their extremely small size, typically from 0.076 – 0.38mm, means that they are undetected by all practical detection methods, and so they may be present, randomly, in the float pane which has been cut and prepared for tempering.

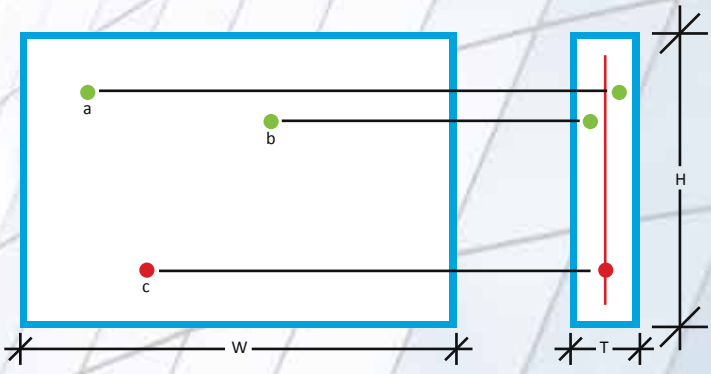
Distribution of NiS inclusions in FT Glass



From this random distribution of inclusions in the FT glass pane, it can be seen that (a) and (b) are located within the compression envelope where they will remain dormant indefinitely and cause no risk to the integrity of the FT glass.

Inclusion (c) is located within the tensile zone where it will commence to undergo changes to its crystalline structure, causing it to expand. Ultimately, after a period of time, which may be from 6 – 36 months, from date of production, the expansion of the NiS inclusion, although only from 2 – 4% in volume, can result in internal stress up to 500,000 psi which will cause “spontaneous” breakage through total release of the latent energy contained in the tensile zone.

Distribution of NiS inclusions in HS Glass



From the same random distribution in Heat Strengthened glass, the critical inclusion (c) is not affected by the much weaker forces of the tensile zone and it will therefore remain dormant indefinitely. HS glass has minimal risk of spontaneous breakage due to the presence of inclusions (including Nickel Sulphide) in the raw float glass substrate.

SAG HEAT SOAK TESTING

Heat Soak Testing. Note that on a worldwide basis, FT glass is not warranted against spontaneous breakage due to NiS or other impurities, and replacement glass will be supplied at Owner's expense. **Heat Soak Testing (HST)** is not a guarantee that the FT glass will not fail at a future date, but Saudi American Glass advises it's Clients to take the option of HST as an **assurance of minimal risk** for all glazed areas which may present difficult and costly access (out of proportion to the cost of any replacement glass) with great disruption to occupants.

Test-Programme: At Buyer's discretion, the FT glass supplied by Saudi American Glass may be subject to partial, or random, Heat Soak Testing, or may be 100% tested.

NOTE: The cost of HST is determined by the thickness of the glass which affects the cycle-time in the HST oven.

NOTE: Spontaneous breakage may not always be due to Nickel Sulphide inclusions, and can also occur as a result of edge-damage, surface scratches, glass-to-metal contact etc, all of which can contribute to weakness and premature failure of the FT glass.

Availability

Saudi American Glass have installed HST facilities to conduct Heat Soak Testing in accordance with European Standard EN 14179 in which the "holding time" is 2 hours at 290 deg C.

HST Oven Capacity is 5000 x 2400mm and daily output is 10 tons.

COMPARISON OF TEMPERED GLASS AND HEAT STRENGTHENED GLASS

Characteristic	Tempered Glass	Heat Strengthened Glass
Surface Compressive Stress	80N/mm2 to 150N/mm2 but ≥100N/mm2 for safety glazing quality.	25N/mm2 to 52N/mm2
Mechanical Strength	≥ 4 times that of annealed glass. Can be used with bolted fixings.	≥ 2 times that of annealed glass
Resistance to Thermal Stress	≥ 6 times that for annealed glass.	≥ 2 times that of annealed glass. Sufficient for most glazing applications.
Maximum Operating Temperature	300˚C Can withstand thermal down-shock of 200 Centigrade degrees.	150˚C
Fracture Characteristics	Breaks into small, relatively harmless fragments. For safety glazing needs ≥ 40 particles in 50mm square when tested to ASTM C 1048.	Fracture similar to annealed glass. Should not be regarded as a safety glass.
Optical Distortion	Some optical distortion may be expected within limits set by ASTM C 1048.	Can be less than for tempered glass.
Bow	Some bow may be expected within limits set by ASTM C 1048.	Can be less than for tempered glass.
Thickness Available	4mm to 19mm	4mm to 10mm
Nickel Sulphide Inclusions	A very small proportion of panels contain critical Nickel Sulphide (NiS) inclusions. Most of these can be eliminated by heat soaking.	Not generally regarded as a source of fracture. Heat Soak Testing not applicable.

SAG SAFE-T-LAM LAMINATED ARCHITECTURAL GLASS

Introduction

Modern architectural design continues with growing emphasis to depend on the beauty and durability of glass to perform an increasing multitude of tasks.

Versatile and indispensable, glass is used worldwide to enhance facades with colour and reflectance, to illuminate interiors, and to protect occupants from the weather, from fire, from noise and from criminals. If properly used, it can keep us warm, or cool, with optimum consumption of energy, but it has one fault: it is fragile and breaks easily and then no longer acts as a protective barrier.

SAFE-T-LAM laminated glass provides a comprehensive solution to all of these problems at every level of criminal threat or environmental danger.

What is Laminated Glass?

SAFE-T-LAM laminated glass is formed by creating a sandwich of two, or more, sheets of glass bonded to each other under heat and pressure, using a plastic interlayer of PVB (PolyVinylButyral) which has optical qualities almost equal to the glass itself. Standard PVB interlayer is 0.38mm (.015 inch) thick, and can be used in single or multiple interlayer-combinations depending on the desired level of strength required. SAFE-T-LAM laminated glass cannot be visually distinguished from standard clear glass when both are used in different locations on the same building elevation.

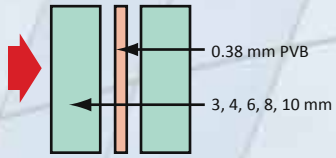
SAG SAFE-T-LAM LAMINATED ARCHITECTURAL GLASS

SAFE-T-LAM laminated glass provides optimum levels of protection in terms of

SAFETY **SECURITY** **SOUND CONTROL** **SOLAR CONTROL** **UV LIGHT PROTECTION**

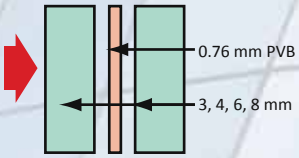
Safety (Normal Strength: NS) Annealed glass only

The safety of glazing in buildings is now a matter of universal concern. Annealed SAFE-T-LAM (NS) with a 0.38mm PVB Interlayer is a true safety glass conforming to all major international standards, for use in residential or public buildings where any glazed opening is at risk from accidental human impact. When broken, SAFE-T-LAM NS remains in the frame and continues to perform safely, resisting penetration by the impacting person, and preventing injury.



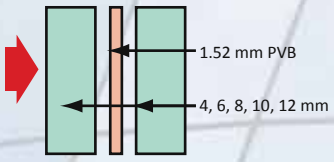
Security a (High Penetration Resistance: HPR) Annealed glass only

Robbery and violence are growing aspects of modern life and glazing systems have to be designed to withstand smash-and-grab attacks on any premises which store or display valuable commodities. SAFE-T-LAM HPR laminated glass with 0.76mm PVB interlayer, provides all the safety features of an NS laminate plus substantially increased resistance to physical attack in residential and commercial buildings. Also suitable for sloped glazing where it is essential to prevent fall-out in the event of breakage.



Security b (High Impact: HI) Annealed, Heat – Strengthened and Fully Tempered

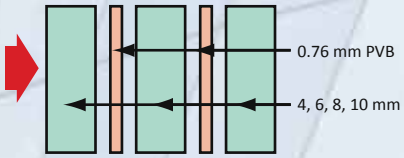
SAFE-T-LAM HI is an annealed glass laminate with a 1.52mm PVB interlayer and is considered to be “Anti-Bandit“ or “Burglar-Resistant“ quality. SAFE-T-LAM HI is sufficiently tough to resist penetration when attacked with bricks, sledge-hammers, or crow-bars. In most cases, the Attackers are deterred by the laminated glass and will run away to look for easier targets. Can also be supplied in Fully Tempered or Heat-Strengthened condition for additional structural strength and / or enhanced thermal safety when exposed to high temperatures.



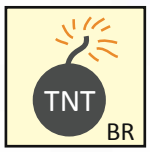
SAG SAFE-T-LAM LAMINATED ARCHITECTURAL GLASS

Security c (Heavy Duty: HD)

SAFE-T-LAM HD laminated glass is designed for use in areas where additional protection is required. A minimum of three glass sheets combined with multiple layers of PVB offers a high level of deterrence and prolonged resistance to violent attack



Security d (Blast Resistance)

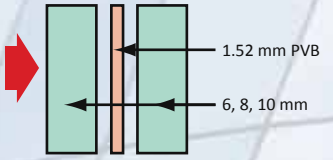


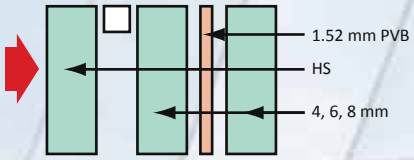
In buildings subjected to extreme blast-forces, the majority of deaths and injuries are caused by broken glass, especially where windows are installed with m1onolithic annealed glass.

SAFE-T-LAM HI laminated glass, correctly installed in suitable framing systems, will mitigate, or totally prevent, the penetration of glass fragments into the building. However, whereas the velocity and impact-force of bullets can be calculated with great accuracy, blast-forces are much more unpredictable and can vary according to:

- Distance of glazing from the explosion.
- Height of glazing above the explosion.
- Weight and chemical composition of the explosive material.

Generally, a 3-ply SAFE-T-LAM HI Annealed laminated glass with a 1.52mm PVB interlayer will provide a high level of protection with minimum glass fall-out, even under severe blast exposure. In the case of double glazing, the Outer Pane should be monolithic (non-laminated) Heat-Strengthened glass and the Inner Pane SAFE-T-LAM HI annealed laminated glass. Edges of the laminated glass should be flat-polished for improved mechanical strength and resistance to thermal stress.





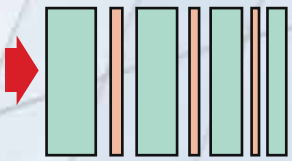
SAG SAFE-T-LAM LAMINATED ARCHITECTURAL GLASS

Security e (Bullet Resistance: BRG)

SAFE-T-LAM BRG is composed of multiple layers of glass and PVB which form an effective barrier to ballistic attacks from small, medium and high-velocity weapons. Configurations of the glass and PVB (and, hence, the thickness and total mass of the BRG glass) depends on the “threat-level“ according to:

- The type of weapon.
- The type of ammunition.
- The velocity of the ammunition.
- The firing distance.

SAFE-T-LAM BRG provides improved security in a variety of commercial, institutional and government buildings where there is a high risk of ballistic attack. BRG is designed to provide a safety barrier from bullet penetration and flying fragmentation. Testing of BRG to recognized ballistics test standard is required to demonstrate ballistics performance. Proper specification of bullet resistant glazing will include the “threat-level“ to which the glazing has been tested.



Actual combination of Glass and PVB are proprietory information of Saudi American Glass.

Saudi American Glass Factory has successfully tested SAFE-T-LAM BRG at a full range of threat-levels and will be pleased to supply details of test results on request to SAG Technical Advisory Department.

Note: Production Size limits. BRG glass is very heavy: large BRG units may create severe problems in manufacture, transportation and installation and these factors must be carefully considered when specifying BRG. For example, 37mm (nominal) thick BRG for ballistic level # BR2 has a total mass of 92 kg/m2, and 79mm (nominal) thick BRG for ballistic level # BR7 has a total mass of 197 kg/m2. Total mass should not exceed 500 kg / pc. Please submit enquiries to the Technical Advisory Service Department at Saudi American Glass Factory for review.

Installation of SAFE-T-LAM

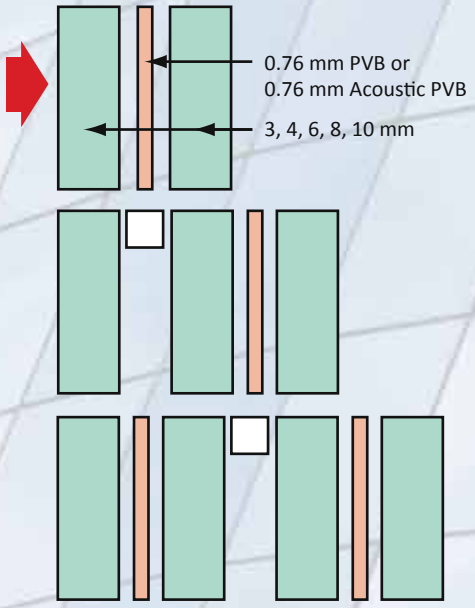
SAFE-T-LAM NS, HPR, HI and BRG laminated glass will perform at maximum levels of protection only if installed into suitably designed frames which, themselves, are able to withstand the forces transmitted through the glass. Full protection therefore depends on a total combination of glass, frame and fixing-method in structural openings which have also been designed to contain the anticipated forces under worst conditions.

SAG SAFE-T-LAM LAMINATED ARCHITECTURAL GLASS

Sound Control

SAFE-T-LAM HPR laminated glass with a 0.76mm PVB interlayer greatly improves Transmission Loss (T/L) over the audible sound frequency waveband from 100 – 5000 Hz, especially in the higher frequency range =< 800 Hz. Acoustic performance depends on the thickness of the glass while retaining the 0.76mm PVB interlayer. Furthermore, when the SAFE-T-LAM HPR laminated glass is used as one, or both, panes of a SAG Insulated Glass Unit, the T/L performance is even more dramatically improved over a larger portion of the audible waveband and with virtual cancellation of Coincidence Dip (see page 39).

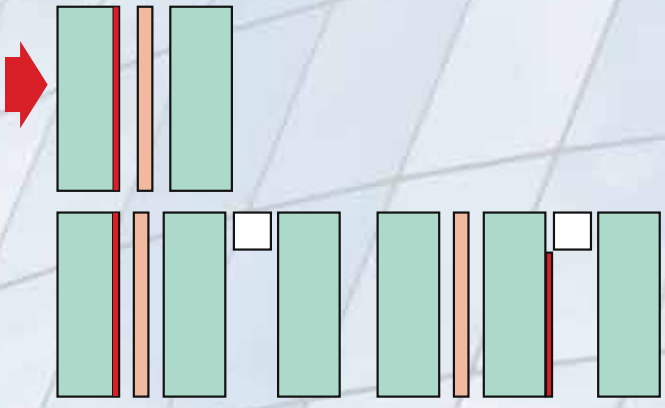
For applications requiring even better acoustic insulation, SAFE-T-LAM HPR is offered with acoustic-grade PVB which has greater sound-attenuating properties, and in which the average T/L improvement is 3 – 4 dB depending on overall glass thickness and whether symmetrical (panes of equal thickness) or asymmetrical (panes of different thickness) glass combinations are used in the laminated construction.



SAG SAFE-T-LAM LAMINATED ARCHITECTURAL GLASS

Solar Control

SAFE-T-LAM laminated glass can be produced with K-LITE high performance glass in various combinations to reduce solar energy transmission, to control glare and to screen-out UV radiation. K-LITE High performance reflective coatings can be laminated with the coating on Surface # 2 of the laminate and can be used in single glazing or as the Outer Pane of an insulated glass unit. The K-LITE range of Optima and KE74 Low-E coatings cannot be used in single glazing and must be double glazed. In this case, the low-E coating is applied on surface # 4 of the laminate (facing the sealed air-space of the insulated unit). Normally, when used for solar control with a tinted or K-LITE composition, the glass will be either Heat-Strengthened (minimum PVB thickness = 1.14mm) or Fully Tempered (minimum PVB thickness = 1.52mm) in order to withstand thermal stresses caused by energy absorption and, potentially, partial shading.



K-LITE Reflective

K-LITE KE 74 Optima and K-LITE OPTIMA Low - E Series

Ultra Violet Light (UV) Protection

UV light is one of the most serious causes of fading in goods and materials exposed to direct sunlight through glass. The cost of losses due to fading can be substantial.

SAFE-T-LAM laminated glass is virtually opaque to UV radiation which occurs in a waveband from 310 – 380 nm (nanometres) in the Solar Spectrum, whereas 6mm clear float glass transmits 55% UV at 350 nm. As a further example, UV radiation at 350 nm has a damage-potential 50 times greater than that of Visible Light at 500 nm.

Note: Although UV radiation is the primary cause of fading other environmental factors such as oxygen, moisture, air-pollution, elevated temperatures (in display-windows), visible light and normal wear will also contribute to colour degradation.

UV radiation protection of PVB is stable over time. All clear and tinted PVB interlayers have been shown to provide original levels of UV protection after tests equivalent to more than five years of continuous exposure in full desert conditions.

ULTRA VIOLET SCREENING PROPERTIES	
PVB Thickness mm	Total UV Radiation Filtration (cut-off at 380 nm)
0.38	98%
0.76	99%
⩾ 1.14	99%
6mm Clear Float	55% at 350 nm

Results are for clear PVB only. Pigmented PVB will have equal or greater screening performance. The data shown above are based on specific test samples and are not guaranteed for all samples or applications.

SAG SAFE-T-LAM ONE-WAY MIRROR

Guide to Optimum One-Way Vision

SAFE-T-LAM K-LITE high performance glass is capable of giving first class one-way vision in shops, supermarkets, banks, airports, police stations and other security locations where discreet observation is required. In order to maintain the privacy of the observer-side and also to ensure maximum visibility of the non-private side, the following environmental conditions must be provided.

Private Side

Recommended
Light-Ratio ≤ 1:8

Walls, floors and
furniture to be in
dark, subdued colours

Observer to avoid
wearing white or
light coloured clothing

Single Glazing

10.76 mm

OR

Double Glazing

32 mm

Non-Private Side

Recommended
Light-Ratio ≥ 8:1

Walls, floors and
furniture to be as light possible

Avoid direct lighting on the glass

All glass to be installed with the
coated surface facing the non-private side

S.A.G. INSULATED GLASS UNITS

Why Double Glazing?

Ambient heat-transfer through glass (outdoor-indoor-outdoor) can occur via three mechanisms: Absorption, Conductions and Radiation. Because of its transparency, glass can allow potentially large amounts of conducted and directly-transmitted heat to enter a room-space, and is the "weakest" material in the building- envelope in terms of heat-loss or heat-gain, depending on the climate. This gain, or loss, can be substantially reduced through the use of insulated double glazed units .

S.A.G. double glazed units create a dead (non-convective) air-space between two panes of glass, thus slowing down the rate of heat-exchange between ambient warm and cool air-masses on either side of the unit. The reduction of heat-transfer through glazing in modern building design is of vital importance in minimising the capital cost, and subsequent running cost, of heating or cooling equipment over the entire life-cycle of the building. Room interior comfort levels are also significantly improved, in both summer and winter, through the use of insulated glass units.

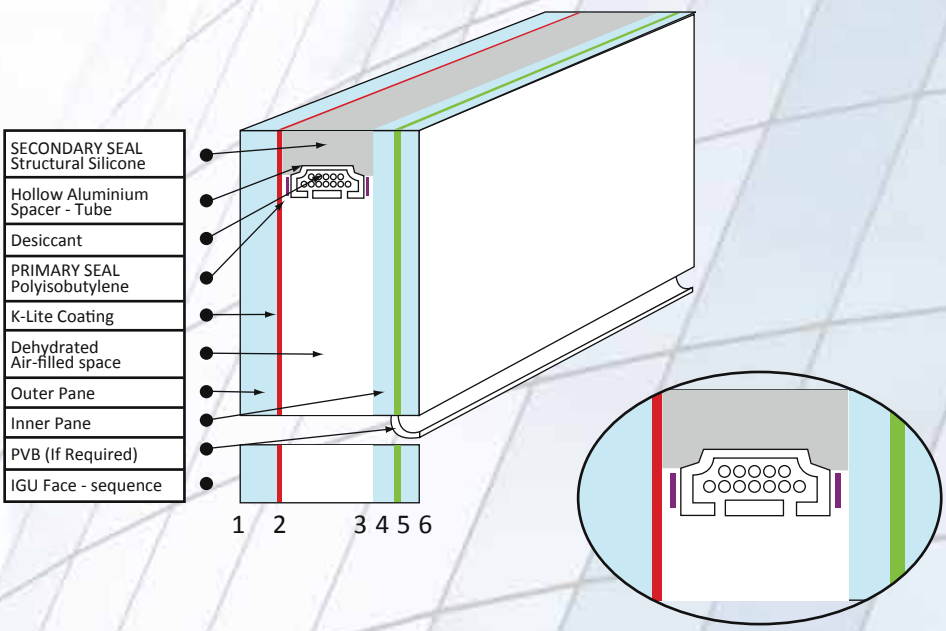
The "Dual - Seal" Fabrication of Insulated Glass Units

Saudi American Glass factory is equipped with the most up-to-date LISEC lines for the manufacture of Sealed Insulated Glass Units (IGU) using mill-finish (silver) or black-painted hollow aluminium spacer tubes filled with a desiccant material to ensure elimination of residual moisture in the air-space and to prevent internal condensation. The inter-space between the two glass panes is thus hermetically sealed and contains de-hydrated air at factory ambient barometric pressure.

Perimeter spacer tubes are of bendable type and sealing is done with a PRIMARY butyl (polyisobutylene) sealant applied to the glass-facing surfaces of the spacer tube to create an impervious vapour-barrier, followed by a structural silicone SECONDARY sealant to bond the two glass panes around the perimeter of the unit. This is known as the "dual-seal" system for production of durable, reliable, sealed double glazed units to last for the life of the building.

Saudi American Glass factory has the capacity to produce up to 50,000 sqm of dual-seal IGU's per month.

Typical SAG Insulated Glass Unit Construction



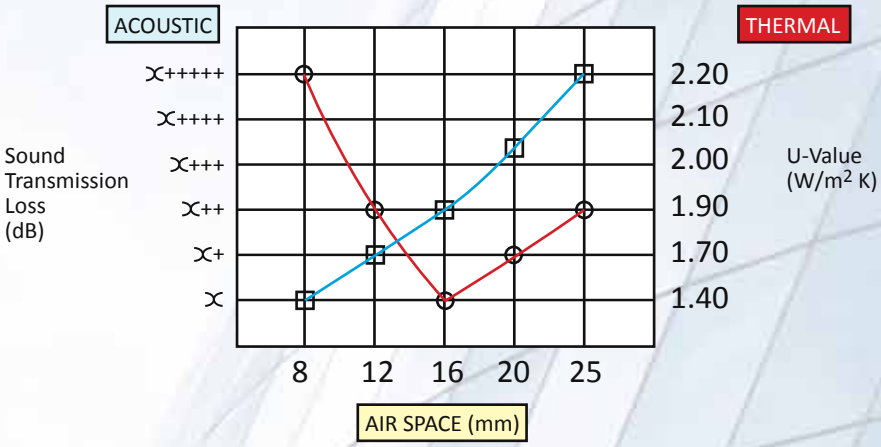
Framing Materials

The efficiency of Insulated Glass Units is seriously affected by the quality and design of the framing systems. Frame materials, such as steel or aluminium are capable of transmitting excessive amounts of heat to the edges of insulated glass units in hot weather. Equally, it is possible for the frame to create a serious lowering of temperature around the edges in cold weather. In each case, only the centre of the glass will perform according to its true thermal resistance (U-Value) with serious effect on its efficiency and cost-benefit to owners and occupants. For this reason, it is strongly recommended that metal framing systems should incorporate a thermal break in the design. Timber and UPVC frames offer better thermal resistance with minimum effect on the overall U-Value of the glass.

S.A.G. INSULATED GLASS UNITS

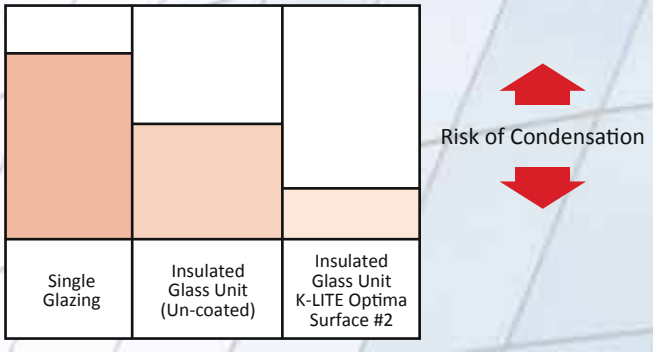
Acoustic Insulation

In addition to the thermal insulation benefits of sealed insulated glass units, there is also an additional significant benefit in terms of acoustic insulation. The combination of two panes of glass and an inter-pane air space provides an effective barrier to sound transmission, especially at sound-frequencies => 500Hz. Transmission Loss (TL) in dB varies according to width of air-space and thickness-combinations of the two glass panes. Every increase in width of air-space improves the TL-performance of the sealed unit. However, thermal insulation (U-Value) reaches an optimum level at 16mm air-space.



Condensation

Sealed insulated glass units play a major part in the reduction of condensation by raising the “Dew-Point“ the relevant glass surface (Outer or Inner, depending on whether the building is heated or air-conditioned) when the Relative Humidity (RH) is high. Optimum air-space width is 16 mm and, for maximum protection, a K-LITE Low-E coating should be applied on Face # 2 for air-conditioned buildings, and Face # 3 for heated buildings.



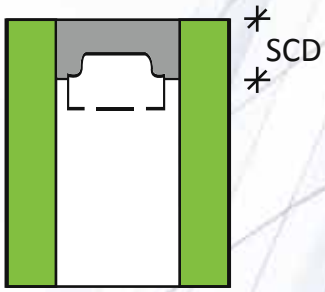
S.A.G. INSULATED GLASS UNITS

Pressure Equalisation

Distortion and bow can be exaggerated in sealed insulated glass units due to changes in barometric pressure and temperature acting on a fixed volume of air hermetically sealed between two glass panes. Large differential in air pressure between site and the sealed air-space can cause excessive stress on the perimeter seals of the unit, leading to potential early failure. Where sealed insulated units have to be transported over high altitudes, or installed in locations where there is a substantial altitude-difference between factory and site, then pressure-equalisation devices (removable at point-of-installation) can be supplied. The small void in the sealant must be filled with a compatible "Neutral-Curing Type "silicone sealant prior to glazing.

Structural Contact Depth

Structural Contact Depth (SCD) of the Secondary Seal is typically 6.4mm, but for very large units and also for sealed insulated units installed in bolted glass facades, it may be necessary to increase the SCD to take account of wind-load, dead load and shear stresses. Note to Window and Curtain wall Contractors; any structural bonding, or any on-site application of silicone sealant to, or around, SAG insulated units MUST be done with "Neutral-Curing Type" structural silicone. The use of "acetoxy-curing" (acetic acid based) silicones is strictly not allowed. For further details, please consult SAG Technical Advisory Service Department.



Structural Contact Depth
(SCD)

Availability

Saudi American Glass insulated glass units are produced in accordance with American Standard ASTM 2190 and European Standard EN 1279 within the manufacturing limitations shown below.

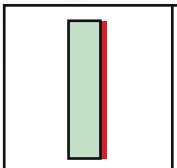
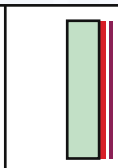
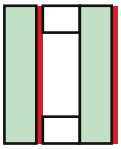
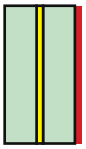
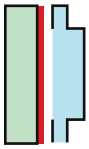
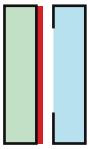
AIR SPACE (mm)	NORMAL MAX. SIZE (mm)	MACHINE LIMITATIONS (mm)
6 8 10 12 16 20	2400 x 3660	2400 x 5000 (Submit Enquiries)

SAG-CERAM CERAMIC FRITTED GLASS

SAG-CERAM from Saudi American Glass is an enamel-painted Fully Toughened or Heat-Strengthened glass in which the paint is ceramic-based and is fire-fused into the glass surface at 700 deg C in a tempering furnace. The resulting ceramic-enamel finish is extremely durable and will never chip or peel even when exposed to maximum solar heat absorption, The Sag-Ceram paint system is also UV-stabilised and is thus resistant to fading in any prolonged exposure to sunlight.

SAG-CERAM is a glass cladding-material which can be fixed to concrete walls using a combination of structural silicone sealants and / or aluminium framing, clips and brackets. It is widely used in conventional and structural silicone curtain wall systems as a harmonizing or contrasting spandrel panel which can be structurally bonded directly onto the ceramic paint on surface # 2 of the panel. Some typical spandrel-applications are shown below

SAG - CERAM Spandrel Design Options

					
SAG - CERAM SURFACE #2	SAG - CERAM ON SURFACE #2 WITH K-LITE HP COATING SUPER - IMPOSED	SAG - CERAM SURFACE #2 OR SURFACE #4	SAFE - T - LAM WITH SAG - CERAM SURFACE #4	SAG - CERAM WITH INSULATED FOLDED METAL BACK - PAN	SAG - CERAM WITH INSULATED FOLDED METAL BACK - PAN

SAG-CERAM “Opaque” involves 100% coverage of paint which is applied by a “squee-gee” roller through a silk-screen. Due to operational reasons, the thickness of the paint-application may be variable so that, if exposed to light on both sides, there may be a dis-uniform appearance. SAG-CERAM “Opaque” is therefore not recommended for any “back-lit” application but, in a typical spandrel or cladding location, will give a smart uniform effect.

SAG-CERAM printed designs are also produced by means of silk screens in an infinite variety of customised patterns including dot-matrix (holes or dots), lines, circles and many other custom-designs typically as shown below.

LINE SERIES

DOT / HOLE SERIES

When used in any location where the printed ceramic paint application is exposed, e.g. in frameless doors, balustrades, partitions etc, the finish is smooth, easy-to-clean and provides a permanent, non-aging, crisp appearance.

SAG-CERAM CERAMIC FRITTED GLASS

SAG-CERAM with K-LITE: Combining the superb performance of K-Lite High Performance Solar Control coatings and the decorative potential of SAG-CERAM printed designs, Saudi American Glass can offer K-Lite HP glass in which the K-LITE coating is applied on top of the ceramic painted design, both applications on surface # 2, to produce a decorative solar control K-Lite product which can be either single or double glazed.

Colours: Regular SAG-CERAM colours in stock include white, black and grey. Custom colours can be made available on request and will be surcharged on quantities =< 400 m2.

Availability

SUBSTRATE	T mm	MANUFACTURING LIMITS	
		MAX mm	MIN mm
CLEAR	4, 6, 8 , 10, 12, 15	2000 x 4000	300 x 300
TINTED GREY BRONZE GREEN BLUE	6, 8, 10	2000 x 3660	300 x 300

Drilling and Edge-Working: SAG-CERAM is a heat-treated (FT or HS) glass product which cannot be cut or worked after heat treatment. All work of this nature must be done prior to heat treatment.

THERMAL MOVEMENT CHARACTERISTICS OF WINDOW GLASS

Commercial-quality (soda-lime) glass has a moderate Coefficient of Linear Expansion compared to many other construction materials. Nevertheless, the unique brittle and fragile nature of glass requires us to understand the implications of good or bad glass-selection and glazing design on the resistance of glass to thermal expansion when exposed to the sun.

Linear expansion is expressed by a coefficient which measures how much the glass will stretch over a temperature difference of one (1) centigrade degree. This coefficient is generally given for a temperature range of 20 – 300 deg C.

The coefficient of linear expansion for normal commercial quality window glass is 9×10^{-6} m/mk, and the following example demonstrates this effect :-

Length of glass = 2000 mm.
Increase in temperature is 30 Centigrade degrees.
Therefore, increase in length = $2000 \times 9 \times 10^{-6} \times 30 = 0.54$ mm.

In other words, an increase of 100 Centigrade degrees in the body of the glass will cause 1 metre of glass to expand by approximately 1.0 mm

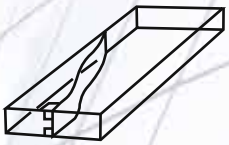
Coefficient of Linear Expansion	(m/mk)	Approximate Ratio
Wood	4×10^{-6}	0.5
Brick	5×10^{-6}	0.5
Limestone	5×10^{-6}	0.5
Glass	9×10^{-6}	1.0
Steel	12×10^{-6}	1.4
Cement (mortar)	14×10^{-6}	1.5
Aluminium	23×10^{-6}	2.5
Polyvinyl Chloride (PVC)	70×10^{-6}	8.0

GLASSTYPE	SOLAR ABSORPTANCE (%)	RISK OF THERMAL BREAKAGE	GLASS CONDITION
Clear	18	Low	Annealed acceptable
Tinted	30 – 40	Medium	Tempered advisved
Reflective on Clear	60 – 70	High	Tempered advised
Reflective on Tinted	70 – 85	Very High	Tempered essential

Thermal Stress and Partial Shading
When glass is exposed to sunlight, solar energy is absorbed, causing the glass-temperature to rise in the center of the pane while the edges which are shaded by the framing system, remain cool. Rapid expansion of the heated center is offset by a slower expansion of the cooler edges, thus creating stresses which may cause the glass to crack.

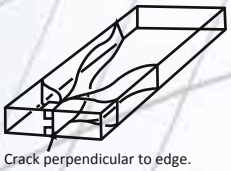
The solar absorptance and corresponding thermal safety risk of various glasstypes is shown below:

Evaluation of Thermal Crack.



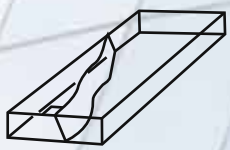
Crack perpendicular to edge.

Thermal Break
Low Stress
Below 10 343 kPa
(Below 1 500 psi.)

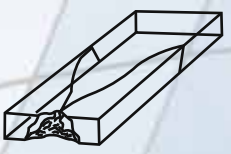


Crack perpendicular to edge.

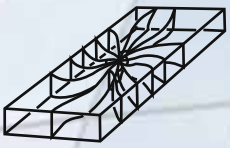
Thermal Break
High Stress



Not A Thermal Break
Low Stress
Below 10 343 kPa
(Below 1 500 psi.)
Tension break
from bending



Impact Damage
Edge of glass



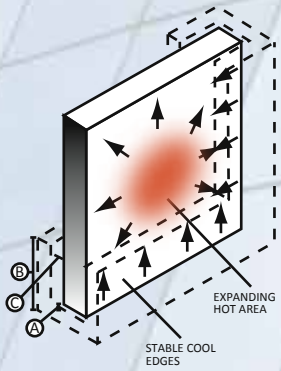
Impact Damage
Face of Glass

Crack perpendicular to edge.

THERMAL MOVEMENT CHARACTERISTICS OF WINDOW GLASS

Factors which affect the thermal safety of glass are:
< Thickness and type of glass: absorptance increases in proportion to thickness
< Glass-to-metal contact caused by:

• Lack of edge-clearance (A)
• Excessive glass-bite (edge-cover) (B)
• Lack of face-clearance (C)



< Condition of glass edges

• Annealed glass with clean-cut or polished edges has best resistance to thermal movement.
• Glass with edges damaged during handling or installation have much higher risk of thermal breakage.

< Colour of Frames: lighter colours (low absorptance) have a higher risk –factor than dark colours (high absorptance) which reduce the temperature differential between the edge and center of the pane.

< Time of day / Time of year: Cold, sunny mornings at Sunrise are more dangerous than hot sunny mornings.

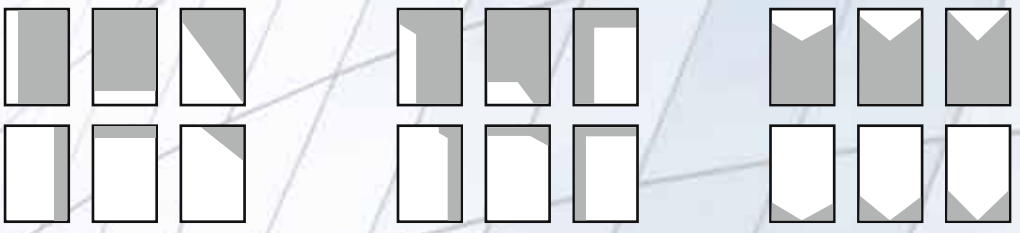
< Drapes, blinds or curtains close to the rear surface of the glass may create interior "heat-traps" with excessive localised heat-gain and thermal stress Retrofit films for improved solar control on clear or tinted annealed glass may cause excessive absorptance of solar energy.

< Partial shading (see diagram below). Shadows cast by building-overhangs, surrounding structures, scaffolding, trees and shrubbery can create a variety of exterior shading patterns on glass in a building. This exterior partial shading can create varying degrees of thermal edge-stress in the glass.

The following diagram shows some typical shading patterns that can be created on glazing. These are noted as "acceptable", "marginal" or "harmful". The drawings can serve as a guide to the severity of thermal stresses created by various exterior shading patterns and will assist in the selection of heat-treated glass, or otherwise, in certain conditions.

The maximum thermal stress occurs when 25%, or less, of an individual glass lite is shaded and when the shaded area includes more than 25% of the lite's perimeter.

Generally, horizontal, vertical or diagonal patterns are not as critical as shading that includes combinations of these patterns. Double-diagonal shading that creates a "V"-shaped patterns with the center of the "V" located at the center of a glass-edge is considered the most critical shading pattern.



Clear glass	Acceptable
Tinted and coated glass	Marginal

Clear glass	Marginal
Tinted and coated glass	Harmful unlesss FT or HS

All glasstypes should be HS or FT

In applications where thermal stress may be a concern, the glass should be Toughened.
Edges of annealed glass should be polished to remove any damage and to improve the mechanical strength of the glass.
Further enquiries concerning the thermal safety of solar control, or any other kind of glass should be directed to the Technical Department at Saudi American Glass Factory.

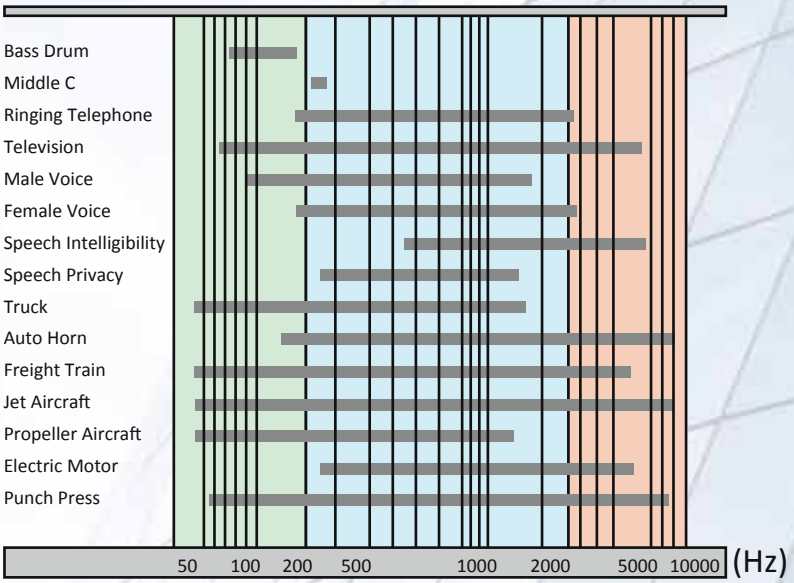
ACOUSTIC INSULATION – DEFINITIONS

Audible Frequency Waveband

All sound waves have a frequency which is measured in Herz (Hz). A sound wave with a frequency of 500 Hz means that there are 500 vibrations per second emanating from the source. The human ear is able to detect frequencies ranging from 20 – 8000Hz, but most acoustic testing on glass is done within the range of 100 – 5000Hz to allow for average human hearing ability.

Acoustic Insulation Definitions

Frequency Distribution of Typical Sounds



Frequency in Cycles Per Second
(with grateful acknowledgement to VIRACON)

The Speed of Sound

Sound vibrations travel at a constant speed of 344 m/sec at 20degC at Mean Sea Level and is known as the **speed of sound.** At higher temperatures (or higher altitudes) the speed of sound increases due to lower air-density. The more the air is disturbed, the louder the sound, but with increasing distance from source, there will be a gradual decrease in the energy of the sound waves. This phenomenon is known as "noise decay".

ACOUSTIC INSULATION – DEFINITIONS

Sound Pressure Level: SPL (Sound Pressure Intensity) is the sound-power of the source and will vary according to the distance of the listener from the source. For example, a jet aircraft on a runway at 1000m distance would have an SPL roughly equivalent to a vacuum cleaner at 3m. SPL is measured in decibels (dB) and employs a non-linear, logarithmic (compressed) scale which means that it cannot be used to compare the loudness of particular sounds in linear fashion. For example, an 80dB SPL is not twice as loud as a 40dB SPL. In fact, any change in sound intensity (SPL) multiplies or divides ten-fold for every 10dB increment or decrease. In the above example, a 40dB increase, the noise has 10,000 times more sound-power.

Perceived loudness, however, relates to the ability of the human ear to detect changes in SPL and doubles with every 10dB change in measured SPL.

Comparison of Sound Intensity and Sound Pressure Level

Sound Intensity or Pressure	Sound Pressure Level in dB	Typical Sounds
1,000,000,000,000	120	Thunder Clap
100,000,000,000	110	Nearby Riveter
10,000,000,000	100	Boiler Factory/Subway
1,000,000,000	90	Loud Street Noise/Noisy Factory
100,000,000	80	Noisy Office
10,000,000	70	Average Street Noise
1,000,000	60	Average Radio/Average Office
100,000	50	Average Conversation
10,000	40	Quiet Radio/Private Office
1,000	30	Average Auditorium
100	20	Quiet Conversation/Whisper
10	10	Soundproof Room
1	0	Threshold of Audibility

(with grateful acknowledgement to VIRACON)

Sound Transmission Loss (TL) measures the insulation-effectiveness of a particular glass as a barrier to noise transmission. The actual Transmission Loss of a specific glass is the difference in Decibels (dB) between the sound pressure striking the glass and the quantity of sound transmitted through the glass over a range of audible frequencies from 100 – 5000Hz. Please refer to the example shown on page # 40
Two generally-accepted methods are used to enable designers to compare the acoustic performance of specific glass types:

• In accordance with American Standards ASTM E-90 & ASTM E 413, the T/L's (in Decibels, dB) of incoming sound over the audible frequency range of 100 – 5000Hz are mathematically integrated to produce a sound-reduction coefficient known as the Sound Transmission Class (STC).

• **Sound Transmission Class (STC)** is a single number rating system (based on the all the T/L's from 100 – 5000 Hz) to categorize the acoustic-attenuating properties of glass when used for interior applications such as partitions, ceilings and walls. Although not intended for use in selecting glass for window applications, STC ratings are often specified as a means of comparison for such purpose. The higher the STC value, the better the overall acoustic insulation properties of the glass.

• Alternatively, a European-based system similarly expresses the sound control performance of a specific glass with a weighted sound reduction (T/L) rating , also measured in Decibels, and denoted as "Rw"

ACOUSTIC INSULATION – DEFINITIONS

Mass, Stiffness and Resonance

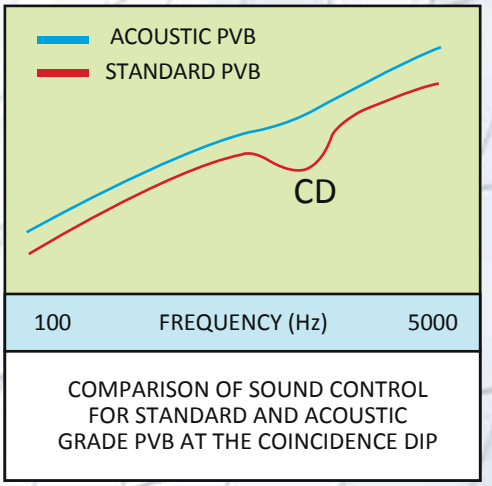
In common with any building material, the T/L – performance of glass is dependent on its mass, stiffness and damping characteristics. In a single monolithic glass, the only effective way to improve its acoustic performance is to increase the thickness, because stiffness and damping cannot be changed. Therefore, the T/L's for a single monolithic glass, measured over 18 different audible frequencies between 100 and 5000 Hz, varies only according to thickness.

Thicker glass tends to provide better sound reduction even although it may actually transmit more sound at some critical frequencies. As a general rule, glass is more transparent to noise at lower frequencies (approx. 100 – 500 Hz) and more opaque to noise in the higher frequency-range (500 – 5000 Hz). Where the performance of a thick monolithic glass is considered insufficient, it will be necessary to look for improvements in resonance (damping) and stiffness which means that multiple plies of glass, laminated and / or double glazing, will have to be used. And even with these enhanced make-ups, there will always be critical frequencies (fewer, of course) at which they begin to vibrate and permit the transmission of sound.

By reviewing and evaluating the T/L's of various tested products, one can attain optimum glass performance by selecting a product that provides the highest T/L's at the range of frequencies most critical to the location of the building and the type of environmental noise.

Commercial buildings use a wide variety of glass types to provide enhanced solar, acoustic and safety performance. Monolithic glass generally gives the lowest acoustical performance levels. Laminated glass can give higher acoustical performance levels than monolithic glass due to the sound-damping characteristics of the polyvinyl butyral (PVB) interlayer which, itself, can be further improved by the use of special acoustic-grade PVB products. Insulating glass also has an excellent potential to provide excellent T/L – performance due the fact that, in addition to the acoustical benefit of the air-space, the glass-combinations can be expanded to make use of different thicknesses of glass, and laminated glass, so that all the benefits of **Mass, Stiffness and Resonance** can be obtained.

Coincidence Dip; relates to the dip, or loss, in insulating properties of the glass which occurs when the glass is vibrating at the same frequency as the sound that is being transmitted.



COMPARISON OF SOUND CONTROL FOR STANDARD AND ACOUSTIC GRADE PVB AT THE COINCIDENCE DIP

CD can be substantially reduced by using

a) thicker glass with greater mass and stiffness, b) laminated glass in which the viscoelastic PVB interlayer provides a damping effect, c) Laminated glass with Acoustic Quality PVB which improves TL's by up to 3 dB compared to normal PVB, d) double glazing with panes of different thickness and e) double glazing with one, or both panes laminated. Furthermore, in all of these cases there will be a progressive improvement in STC Values. However, overall acoustic performance is affected not only by the glass itself but also by the quality and air-tightness of the glazing system; efficient sealing of open able windows is therefore essential in order to achieve optimum glass performance.

All of these solutions for improvement of acoustic insulation of glazed openings are available from Saudi American Glass Factory. Kindly submit enquiries to SAG Technical Advisory Service Department for review.

ACOUSTIC INSULATION – DEFINITIONS

The acoustic data shown below are the measurements of the sound-insulation performance of various specific glass types of Monolithic, SIG Units and Laminated constructions in accordance with ASTM E-90-83 at Riverbank Acoustical laboratories, Illinois, USA.

SOUND TRANSMISSION LOSS (TL), dB From 100-5000 Hz

	Frequency in HZ	100	125	160	200	250	315	400	500	530	800	1000	1250	1600	2000	2500	3150	4000	5000	STC
MONOLITHIC	6mm RAL-TL85-169	23	25	25	24	26	26	29	31	33	34	34	35	34	30	37	32	37	41	31
MONOLITHIC	12mm RAL-TL85-198	26	30	26	30	33	33	34	36	37	35	32	32	36	40	43	46	50	51	36
	Frequency in HZ	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	STC
INSULATING	3-16AS' • 3mm RAL-TL85-212	26	21	23	23	26	21	19	24	27	30	33	36	40	44	46	30	34	45	28
INSULATING	3-10AS' • 5mm RAL-TL85-213	26	23	23	20	23	19	23	27	29	32	35	39	44	47	48	41	36	43	31
INSULATING	6-12AS* • 6mm RAL -TL85-298	29	22	26	18	25	25	31	32	34	36	39	40	39	35	36	46	52	56	35
INSULATING	6-Lam.-12AS' - 4mm RAL-TL85-189	27	27	26	24	22	28	32	35	38	38	39	40	42	43	41	45	52	57	37
INSULATING	6-Lam-12AS*-4mm RAL-TL85-236	26	23	25	23	27	31	34	36	36	39	41	43	45	46	43	49	55	55	39
INSULATING	6-Lam-12AS*-6mm RAL-TL85-235	28	20	29	24	26	30	34	36	39	42	43	44	44	41	40	47	52	56	39
INSULATING	10-Lam-12AS*-6mm RAL-TL85-192	28	17	28	29	33	34	36	40	40	41	41	41	41	40	43	49	54	58	40
INSULATING	6-Lam-12AS*-6mm Lam RAL-TL85-172	26	21	29	28	30	34	36	40	42	44	44	44	45	46	47	52	57	58	42
	Frequency in HZ	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	STC
LAMINATED	5-0.76-5mm RAL-TL85-170	25	26	28	27	29	29	30	32	34	35	35	36	36	35	35	38	43	46	35
LAMINATED	4-0.76-4mm RAL-TL85-200	27	27	27	30	31	31	33	34	35	36	36	35	34	37	41	45	49	52	36
LAMINATED	4-1.52-6mm RAL-TL85-228	26	29	28	30	33	33	35	36	37	38	38	37	38	41	44	47	51	54	39
LAMINATED	10-0.76-6mm RAL-TL85-222	29	30	28	32	34	35	36	38	38	38	36	38	42	46	49	52	55	57	40
LAMINATED	12-1.52-6mm RAL-TL85-230	29	30	27	32	35	35	37	38	38	38	37	41	44	48	50	52	56	56	41

The data and information shown above are based on samples tested and are not guaranteed for all samples or applications.
Riverbank Acoustical Laboratories, Inc.
*AS = air space (sealed)

ACOUSTIC INSULATION – DEFINITIONS

Examples of T/L Performance of Laminated Glass at Different Locations.
Glass Sample: 16.76mm (10 6.2) SAFE-T-LAM HPR in Single Glazing.

Location # 1 : Close to airport runway
Sound Pressure Level (SPL) = 90 dB

Frequency (Hz)	T/L (dB)	SPL minus T/L (90 minus T/L)	Environment
100	29	61	Average Street
125	30	60	Average Office
160	28	62	
200	32	58	
250	34	56	
315	35	55	
400	36	54	
500	38	52	
630	38	52	
800	38	52	
1000	36 (CD)	54 (CD)	
1250	38	52	
1600	42	48	Average Conversation
2000	46	44	
2500	49	41	
3150	52	38	Private Office
4000	55	35	
5000	57	33	

STC / RW = 40

CD = Coincidence-Dip (Coincidence Frequency)

Location # 2 : Within 10m from busy street
Sound Pressure Level (SPL) = 72 dB

SPL minus T/L (72 minus T/L)	Environment	Remarks
43	Average Conversation	
42		
44		
40	Private Office	All data subject to Standard Tolerance of plus/minus 1 Unit
38		
37		
36		
34		
34		
34		
36		
34		
30	Quiet Conversation	
26		
23		
20		
17	Whisper	
15		

STC / RW = 40

DEFINITIONS OF PERFORMANCE

For Visible Light, Solar Transmittance and Thermal Insulation

PERFORMANCE CRITERIA STANDARDS

The performance characteristics of all glasstypes, including K-LITE High Performance and K-LITE Low-E glass, are measured according to a complex and important set of criteria which can be rationalized into three main categories:

1. VISIBLE LIGHT
2. SOLAR ENERGY
3. THERMAL INSULATION

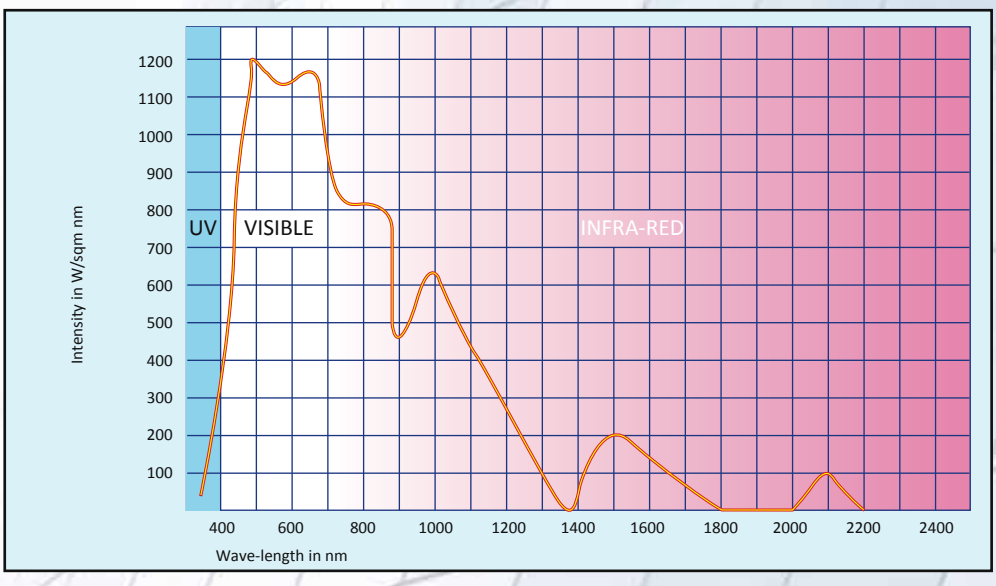
Definition of Terms

1. VISIBLE LIGHT TRANSMISSION (19% of the Solar Spectrum)

(LT) The Light Transmission (LT) and Reflectance (LR) values of a given glass type are of ratios of the quantity of light which is transmitted or reflected compared to the total quantity of light which reaches the glass at an angle of 90˚.

The luminous sensation experienced in the brain, through the eye, is due solely to electromagnetic radiation at wavelengths between 380 and 780 nanometers within the solar spectrum (See diagram).

This luminous efficiency has been standardized by the International Lighting Committee using the D65 illuminant described in ISO DP 9050, on which all standard measurements of light transmission through glass are based. The D65 illuminant has a spectral composition which corresponds to natural daylight in the 380-780nm waveband.



THE SOLAR SPECTRUM

(LR) The Visible Light Reflectance of a glasstype occurs on the inner (IN) and outer (OUT) surfaces of the glass.

LR (in) : Is the percentage of visible light reflected away from the interior surface of the glass.

LR (out) : Is the percentage of visible light reflected by a given glass surface.
in accordance with standard criteria formulated in ISO 9050 : 1990.
The higher the LR (out) value (%), the stronger the “mirror appearance”
of the glass.

DEFINITIONS OF PERFORMANCE

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2. SOLAR ENERGY

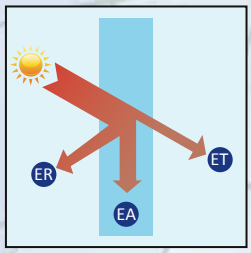
Solar Energy is made up of many different wavelengths of energy within the solar spectrum and these can be grouped into three categories:

Ultraviolet light (UV)	-	300 – 380 nm (4%)
Visible light (LT)	-	380 – 780 nm (19%)
Infrared radiation (IR)	-	780 – 2150 nm (63%)
Others	-	(various) 14%

Energy wavelengths from 300-2150nm in the solar spectrum, with the sun at 42˚ above the horizon, and a clear sky, are the standard ASHRAE parameters for the calculation of energy transmission values for all glasstypes.

Note: Solar Altitude of 42˚ corresponds to Air Mass (AM) = 1.50

As the sun strikes a glass surface, the incident energy will be REFLECTED (ER), ABSORBED (EA) and TRANSMITTED (ET). The values for ER, EA and ET are expressed as a % of total incident solar energy.



ER + EA + ET = 100%

(ER) **Direct Solar Energy Reflectance**
The percentage of solar energy reflected away from the exterior surface of the glass.

(EA) **Energy Absorption**
The percentage of solar energy absorbed by the glass or the sheets forming the glass.

(ET) **Direct Solar Energy Transmittance**
The percentage of solar energy (UV, Visible and near-IR) directly transmitted through the glass.

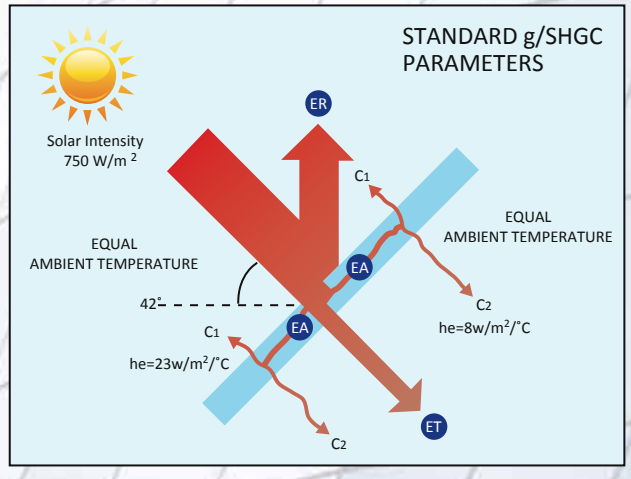
(SGHC) **Solar Heat Gain Coefficient**
Is the Total Energy Transfer of solar energy, by direct transmission and re-radiation, with equal ambient temperature on both sides of the glass, occurring at Solar Altitude = 42 degrees corresponding to Air-Mass = 1.50 as defined by ASHRAE / NFRC 200 – 300. 2001 .

The Total Energy Transfer of 3mm clear float glass, which is the thinnest commercial window glass, is 87% (0.87). Thus, the Solar Heat gain Coefficient (SHGC) of 3mm clear glass is 87 (written as a whole number). All other glasstypes eg thicker, tinted, reflective, SIG etc will have lower SHGC. The lower the SHGC the better the solar resistance of the product.

Note: SHGC has now superseded SC as the dominant parameter for assessment of glass-performance.

g-value European Standard EN 410	=	(SGHC) (Solar Heat Gain Coefficient) American Standard ASHRAE/NFRC 200/300

g/SHGC is denoted by (ET + C2) in the following diagram.



DEFINITIONS OF PERFORMANCE

For Visible Light, Solar Transmittance and Thermal Insulation

(UV) Ultra Violet Light (4% of Solar Spectrum)

Up to 60% of the fading and deterioration of interior furnishing and fabrics is caused by UV radiation. K-LITE High Performance coatings generally give less than 2% UV transmission and are thus highly effective in preventing damage from this source.

(SC) Shading Coefficient

Is the ratio of the quantity of solar heat entering a room through a specific glasstype compared to the quantity of heat which would enter the room through a single 3mm thick clear glass under the same environmental conditions.

3mm clear glass is the thinnest commercial quality glass used in buildings and has a Total Energy Transfer (Solar Heat Gain Coefficient) of 87% (0.87)

The Shading Coefficient of 3mm Clear glass is therefore denoted as 1.00, based on an SHGC of 87.

Although SC has, for many years, been a highly effective means of comparing the solar heat resistance of any glass type with another glass type, it is now being superseded by Solar Heat Gain Coefficient which is the Actual percentage of heat being transmitted (not a ratio).

The Shading Coefficient (SC) is a highly effective means of comparing the solar heat resistance of any glass type with any other glass type. The lower the (SC) number, the better the solar heat resistance of the glass, typically:

Uncoated clear double glazing	SC = 0.87
Clear double glazing with K-LITE Low-E	SC = 0.67
Clear double glazing with K-LITE Optima	SC = 0.23 – 0.55
Clear double glazing with K-LITE High Perfomance Glass	SC = 0.15 – 0.42

RHG Relative Heat Gain

RHG is a very useful means of comparing the total energy transmittance of all glass types, based on a set of standard conditions formulated by ASHRAE, namely:

SOLAR INTENSITY	230Btu/Hr/Sqft
OUTDOOR/INDOOR TEMPERATURE DIFFERENCE	14˚F
SUMMER U-VALUE	Btu/Hr/Sqft/Deg F from the data sheet
g/SHGC	
RHG = (SHGC x 230) + (Summer-U X 14) Expressed as Btu/Hr/Sqft To obtain metric RHG, multiply by 3.154	

The RHG takes account of all the mechanisms of heat transfer under daytime conditions, in full sun, and is an excellent reference criteria for the comparison of all glass types, where air-conditioning is being used.

DEFINITIONS OF PERFORMANCE

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3. THERMAL INSULATION

U-VALUES

The thermal resistance of a glass, denoted by the U-value, indicates the quantity of heat passing through the glass by means of conduction, convection (in an air space) and radiation, due to difference in temperature between the indoor and outdoor air.

North America

North American practice, as formulated by ASHRAE (American Society for Heating Refrigerating and Air-conditioning Engineers) is to recognize the difference in the thermal conductivity of glass under hot summer conditions in daytime, and cold winter conditions at night time (the two climatic extremes), that is to say when the building is air conditioned or heated.

ASHRAE U – values are calculated according to the following environment conditions, published in the 'Fundamentals Handbook 1989' as follows:

ENVIRONMENTAL CONDITIONS	ASHRAE STANDARD (NFRC 100)		
	SUMMER DAYTIME "U"		WINTER NIGHTTIME "U"
OUTDOOR TEMPERATURE	˚F	89	0
	˚C	32	-18
INDOOR TEMPERATURE	˚F	75	70
	˚C	24	21
WIND VELOCITY	mph	7.5	15
	kph	12	24
SOLAR INTENSITY	$Btu/Hr/ft^2$	248	NO SUN
	W/m^2	788	

U-values denoted by ASHRAE are expressed as Btu/Hr/Sqft/°F (Eng) or (metric).
To convert Eng to metric, multiply by 5.678.

EUROPEAN U-value (previously K)

The European U-value is expressed as $W/m^2/K$ and is based on ISO-DP 10292 draft standard conditions, confirmed in European Standard EN 673, with a wind speed of 4.4m/sec at 0°C and an indoor temperature of 20°C.

The European U-value corresponds to the American ASHRAE winter U-value, that is to say, there is no allowance for solar intensity. Any attempt to use the European U-value of a particular glass type to calculate the size of an air conditioning system may result in a shortfall in the installed capacity.

All U-values shown in the data pages are based on center-of-glass calculations. The use of thermal-break aluminum profiles, PVC or timber frames will result in optimum overall thermal performance of the glass, whereas non-thermal break metal frames will give the least favourable performance due to conductivity of the glass edges.

DUAL - SEAL
INSULATED
GLASS LINE

DRILLING AND
EDGE - WORKING

GLASS CUTTING

LAMINATING WITH
PVB INTERLAYERS

PERFORMANCE TESTING AND QA/QC PROCEDURES

Performance Testing

Saudi American Glass Company have submitted their full K-LITE range to the Oxford Brookes University in the UK for physical performance testing and analysis according to European Standard EN 673 (Thermal Insulation Properties) and EN410 (Spectrophotometric Properties).

Furthermore, SAG has full access to the Spectrophotometers at Emirates Glass LLC in Dubai, with software installed and commissioned by the renowned TNO Institute of Applied Physics in the Netherlands (Recently Re-Established as OMT Solutions).

Emirates Glass is now able to produce full Performance Data Analysis Reports with a comprehensive data-review based on European (EN 410/673) and American (NFRC 100, 200, 300/301/302) standards, as well as ISO 9001:200 and including the same Air Mass boundary conditions for (g) and SHGC values.

Quality Assurance & Quality Control

To ensure full compliance with adopted standards, and to maintain accreditation to ISO 9001, 2008. SAG has a well-established QA/QC organisation with extensive supervision and education on the factory floor.

As a strong testimonial to the technical excellence of SAG, the company can point to innumerable projects throughout Saudi Arabia where IG units are still in perfect condition after 30 years of service, and K-LITE coated glass still fresh and bright after 17 years. This record is unmatched by any other company in the region.

Incoming raw materials and consumable items, as well as any glass processed by 3rd parties, are subjected to detailed checking procedures using, when necessary, appropriate instrumentation to ensure “Fitness-for-purpose” of all K-LITE glass products within the parameters set by major international standards. These processes are also implemented at every stage of production through to finished goods prior to dispatch.

QA/QC personnel are available at any time to deal with any quality issues that may arise at customers’ premises, or on site, following delivery or installation of K-Lite glass.

QA/QC Standards & Conformances

SAG have established their superb reputation for quality at every level on relevant British/European Standards for the Flat Glass Industry. From this very large range of standards, covering the manufacture and use of glass in buildings, the principal items are shown in the following table:

EN 356 : 2000	Glass in building. Security glazing. Testing and classification of resistance against manual attack.
EN 410 : 1998	Glass in building. Determination of luminous and solar characteristic of glazing.
EN 572 : 2004	Glass in building. Basic soda-lime silicate glass products. Part1 Definitions and general physical and mechanical properties. Part2 Float Glass. Part3 Supplied and final cut sizes. Part9 Evaluation of conformity/product standard.
EN 673 : 1997	Thermal performance of windows & doors.
EN 1063 : 2000	Glass in building: Security glazing. Testing and classification of resistance to bullet attack.
EN 1096 – 1	Glass in building. Coated glass. Part1 Definitions and classifications. Part2 --- A,B & S coatings. Part3 --- C&D coatings. Part4 Evaluation of conformity.
EN 1279	Glass in Buildings. Insulated glass units. Part1 2004 : Generalities, Dimensional tolerances and rules for the system description. Part2 2005 : Long-term test method and requirements for moisture penetration. Part3 2005 : Long-term test method and requirements for gas leakage rate and for gas concentration tolerances. Part4 2002 : Methods of test for physical attributes of edge seals. Part5 2005 : Evaluation of conformity. Part6 2002 : Factory production control and periodic tests.
EN 1863	Glass in building. Heat strengthened soda lime silicate glass. Part1 Definition and description. Part2 Evaluation of conformity / product standard.
EN 12150 -1	Glass in building. Thermally tempered soda lime silicate safety glass. Part1 Definition and description. Part2 Evaluation of conformity / product standard.
EN ISO 12543 – 1	Glass in building. Laminated glass. Part1 Definition and description of component parts. Part2 Laminated safety glass. Part3 Laminated glass. Part4 Test methods for durability. Part5 Dimensions and edge finishing. Part6 Appearance.
EN 12600	Glass in building. Pendulum test. Impact test method and classification for flat safety glass.
EN 14179	Glass in building. Heat soaked thermally tempered soda lime silicate safety glass. Part1 Definition and description. Part2 Evaluation of conformity / product standard.
EN 14449	Glass in building. Laminated glass and laminated safety glass. Evaluation of conformity / product standard.

Our Mission

From raw primary float glass through all the manufacturing processes of cutting, edge-working, heat-treatment (FT/HS), sputter coating, double glazing and laminating, SAG's entire QA/QC efforts on behalf of its customers is aligned to these well-developed and trusted standards which set the highest benchmarks for quality in the architectural flat glass industry and ensure that glass-constructions and installations are sound, energy-efficient and, as far as possible, environmentally sustainable in manufacture and use.

Product Warranties

SAG Provide standard product warranties in respect of:

- SAFE – T – LAM Laminated Glass : 5 years
- K-LITE Sputter Coated Glass : 10 years
- Dual-Sealed Insulated Glass Units : 10 years

Copies of the above are available from SAG upon request.

PRODUCTION: MANUFACTURING LIMITATIONS

INSULATED UNITS

All dual-seal insulated glass units are produced with mill finish aluminum or black painted bendable spacer tubes. Other finishes must be specified. Stepped units can be produced with 1 to 4 sides stepped.

Standard sealants in use are:
Encapsulated glazing : 2-part polyurethane
Structural glazing : 2-part Structural IG Silicone

All primary sealant is composed of Polyisobutylene (P.I.B)

Maximum manufacturing limitation

2400 x 3660 mm (subject to substrate availability)	2400 x 5000 mm (submit enquiries for review)

HEAT TREATMENT

All glass-types are available in Heat-Strengthened (type'HS') and Fully Tempered (type 'FT') condition. HS and FT processing is done in accordance with American Standards ASTM C – 1048 – 04, EN1863 and EN 12150-1.

Manufacturing limitations of heat treated glass (subject to substrate availability)

Dimensional (mm)	2400 x 6000 (Max)		300 x 300 (Min)				
Thickness (mm)	HS	4	6	8	10		
	FT		6	8	10	12	15

SAFE-T-LAM LAMINATED GLASS

Manufacturing limitations

Make - up (T) mm	MAX mm	MIN mm
3+3 and 4+4	2400 x 3660	300 x 300
6+6, 8+8, 10+10, 12+12	2400 x 4300	300 x 300

SAFE-T-LAM Laminated Glass is produced in accordance with European standards EN ISO 12543-1 and EN 14449.

K-LITE SPUTTER COATED HIGH PERFORMANCE GLASS

SAG produces magnetic-sputtered coatings in accordance with American Standard ASTM C1376 – 10, EN 1096-1.
Manufacturing limitations of K-LITE range of sputter-coated glass.

Product	Condition			
	ANN		HS/FT	
	Min	Max	Min	Max
K-Lite 742/743	300 x 300	2440 x 3660	400 x 700	2400 x 5000
K-Lite Optima	300 x 300	2440 x 3660	400 x 700	2400 x 5000
K-Lite HP	300 x 300	3000 x 6000	400 x 700	2400 x 5000

The above information relates only to manufacturing limitations. The actual "Safe Glazing Size" will depend on design wind-load, dead-load, slope of glazing, whether single or double glazed etc. For confirmation of "Safe Glazing Size" and Center-Of-Glass-Deflection (COGD) please contact SAG Technical Department.

EDGE DELETION

K-Lite KE742/3 and K-LITE Optima coatings require edge-deletion to provide an un-coated glass surface where primary and secondary IGU sealants are in contact with the glass. As result, in all structural silicone, or butt-joined, applications, the IGU sealants will be visible from the exterior. K-LITE HP coatings do not require edge-deletion.

EDGE-WORKS

In order to avoid external edge reflection in structural silicone curtainwall applications, SAG recommends flat ground (FG) edges for all heat-treated-K-LITE HP high performance glass. This must be specified on the order, drawings and cutting lists. In the absence of this information, all heat treated glass will be documented and processed with standard arrissed edges.

الشركة السعودية الأمريكية للزجاج
SAUDI AMERICAN GLASS

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