INSULATING GLAZING IN A WARM CLIMATE -EVEN MORE IMPORTANT THAN A COLD CLIMATE

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There were 280 million square metres of insulating glass units produced globally in 2000. Approximately 80% of these were used in North America and Europe, predominantly in areas with cold climates. The use of insulating glass units in the warmer climates of Asia, South America and Africa is small by comparison. Even though the use of insulating glass units is increasing in Asia, the areas of highest use are the colder climate countries including Japan, Korea and northern China. There is a mentality of providing insulation against cold, but in tropical locations, the common solution is to turn up the thermostat on the air conditioning.

The purpose of insulating glass units, just as any form of insulation, is to reduce the effect of the external climate inside the building; in cold climates the aim is reduce infiltration of the cold, and hence maintain internal heated temperature and reduce the cost of heating; in hot climates the aim is to reduce heat coming in and hence reduce the cost of air conditioning. The interesting fact to note is that heating is far more efficient than air conditioning, hence the cost of heating is less that the cost air conditioning. Therefore, from a financial point of view, it is more important to use insulating glass units in a hot climate than in a cold climate.

The aim of this presentation is to discuss how the use of different glass and sealant types in insulating glazing can reduce heat transfer, while maximising light transmission, hence reducing energy consumption in hot climates.

Key Words
- Insulating glazing
- Energy reduction
- Light transmission
- Hot climates
- Silicone sealants

Why IG in Warm Climates?
The purpose of insulating glass units, just as any form of insulation, is to reduce the effect of the external climate inside the building. In cold climates the aim is reduce infiltration of the cold, and hence maintain internal heated temperature and reduce the cost of heating.

In a hot climate there are 2 main reasons for using insulating glass units:
1. Reduction of heat coming in, without too much loss of light. This allows savings on the cost of the air-conditioning, because a smaller unit is needed, and on the running cost of the air conditioning.
2. Increased comfort behind the insulating glass unit due to less radiation from the glass.
Comfort behind the glazing is important because the temperature of the glass can reach 70C to 80 C. The radiated heat from the glass is such that it is impossible to stay close to the window for long. Thus space of at least one meter from the glass is lost.

As the glass heats up by 10 C per 200 watts of absorption in the glass, the temperature in the glass can reach easily 70 to 80 degrees after some hours of exposure in the sun. For example 8mm grey glass has absorption of 55% of the energy of the sun. With sun radiation at 1000W/m2, it means absorption of 550 Watt. Thus temperature rise is: 10Cx 550/200=27.5C. With external temperature already at 45C, temperature in the glass reaches: 45C+27.5=72.5C. The heat is also transferred by conduction and convection into the room and this puts an extra load on the air conditioning system.

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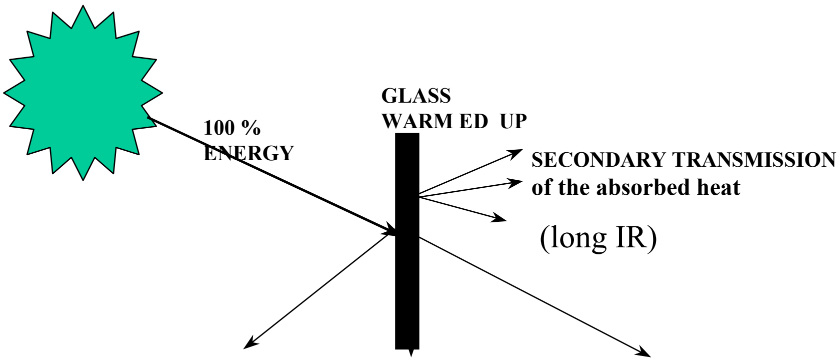
Split of Energy Falling on Glazing

Lets first consider what happens when radiation from the sun hits the glass. As you can see from the diagram below, the energy is reflected, absorbed or transmitted. The internal air is also warmed by convection and secondary radiation from the warmed glass. In a warm climate, by reducing direct energy crossing the glass, secondary radiation, conduction and convection, savings in air conditioning costs can be made.



100 % = REFLECTION + ABSORPTION + TRANSMISSION

50 % LIGHT = REFLECTION OF LIGHT + ABSORPTION OF LIGHT + TRANSMISSION OF LIGHT

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50 % IR = REFLECTION OF IR + ABSORPTION OF IR + TRANSMISSION OF IR IR(DIRECT/SECONDARY)

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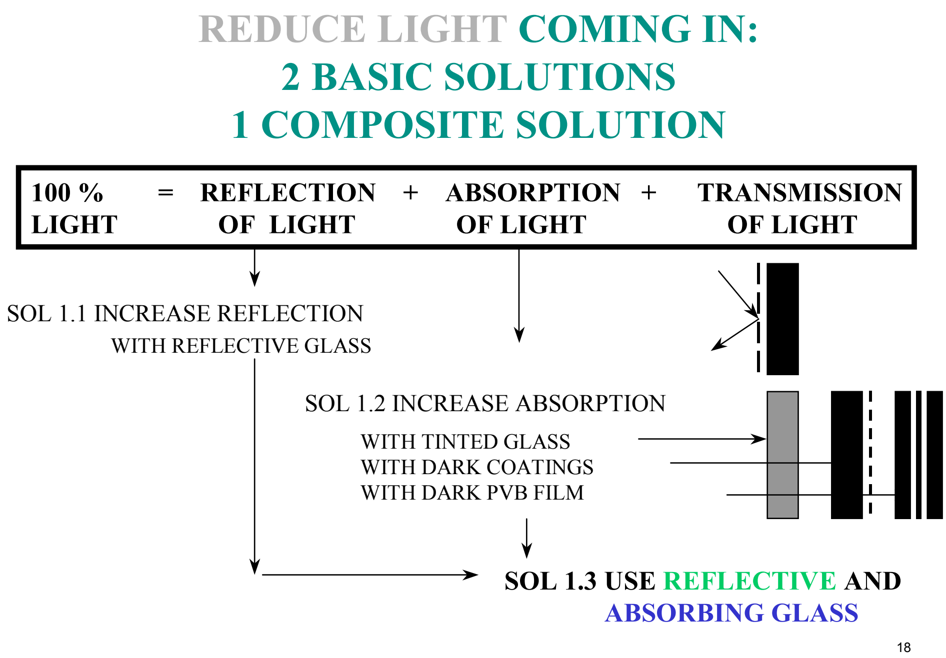
Energy from the sun is about 50% in the visible range and 50% in the IR range. Hence incoming energy can be reduced by reducing light, IR or a combination of both. The proposed solutions focus on ways to reduce reflection, absorption and transmission for visible light and IR radiation. It is important to note that reflection, absorption and transmission are linked. If reflection or absorption increases, transmission would decrease. Thus one cannot have at the same time, high reflection, high absorption and high transmission. A trade off would have to be made.

Reduction in Light Energy
If we first consider light energy; it can be reduced in 3 ways, as summarised in the diagram below:

1. Increase light reflection with reflective glass, either with a pyrolitic coating that can be placed outside or soft coating that is usually glazed to the inside. This can result in medium to high light reflection but IR transmission is still high. Also highly reflective glasses can have negative aesthetics on the surrounding environment.
2. Increase absorption with tinted glass, dark coatings or dark PVB. The downside is secondary radiation of the absorbed energy, and reduced transmission of light, which means higher requirement for internal lighting, with associated cost.
3. A combination of reflective and absorbing glass and the resulting combined properties, both positive and negative, as noted above.



To improve internal comfort levels and decrease air conditioning costs it is important to reduce the IR energy entering. This can be done in 3 basic plus 2 composite ways:

1. Increase reflection of IR with IR reflective coating on the inside of an IG, while still maintaining reasonable light transmission.
2. Increase IR absorption with tinted glass, dark coatings or dark PVB. Tinted glass absorbs visible and IR radiation equally. Associated downside is secondary radiation of absorbed energy and reduced light transmission.
3. Decrease indirect IR transmission from heated glass with insulating glazing and different coatings.
4. Increase both IR reflection and absorption with IR reflective and absorbing glass.
5. Increase both IR reflection and absorption and decrease indirect transmission with IR reflective and absorbing glass, and insulating glazing.

These solutions are summarised below.

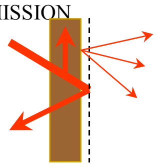
TO REDUCE IR COMING IN:
3 BASIC SOLUTIONS
2 COMPOSITE SOLUTIONS

100 % IR	=	**REFLECTION OF IR**	+	**ABSORPTION OF IR**	+	**TRANSMISSION OF IR DIRECT/INDIRECT**

SOL 2.1 INCREASE IR REFLECTION

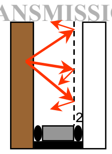
SOL 2.2 INCREASE IR ABSORPTION

SOL 2.3 REDUCE INDIRECT TRANSMISSION



SOL 2.4 INCREASE BOTH IR REFLECTION AND ABSORPTION
WITH IR REFLECTIVE AND ABSORBING GLASS

SOL 2.5 INCREASE REFLECTION+ABSORPTON+REDUCE INDIRECT TRANSMISSION
WITH IR REFLECTIVE AND ABSORBING GLASS
AND INSULATING GLAZING



How is incoming Heat measured?
In order to simplify the process there is a standardised approach for measuring the incoming heat, making it easy to compare different glazing options.

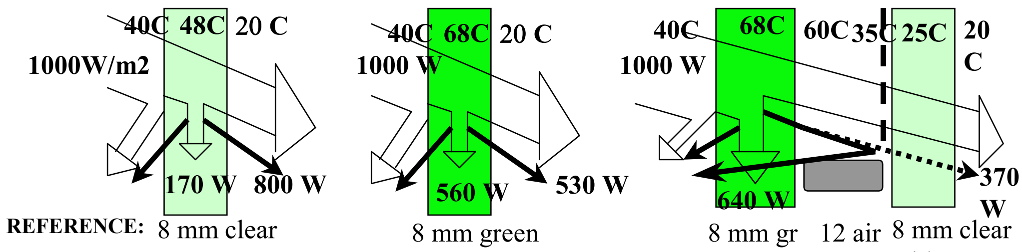
1. SOLAR FACTOR (SF) = total energy transmission (direct and indirect)
Unit is % of energy of the sun falling on the glazing
Objective it to keep SF as low as possible

2. U VALUE is a measure of the rate of heat gain or loss through glazing due to environmental differences
Unit is watt per m2 per degree C
Objective in warm climate is to keep U Value as low as possible
Keep heat outside, A/C cold inside

From these values it is very easy to compare the performance of various single and insulating glass combinations. This information is readily available from manufacturer's glass catalogues, and it becomes immediately obvious, that the best way to decrease the U value significantly is with insulating glazing. An example is shown below. This particular example uses 8mm green glass plus 8mm clear with a low E coating in an insulating glass unit. It has a low reflection (only 9%) and a high light transmission, plus a low heat transmission (reflected by the low E). These properties are a must for an airport control tower, for instance! Check when you travel in any airport around the world.
Green glass is much clearer than other tinted glass because with its iron oxide content that gives it its green colour. It has a high peak of absorption of the short Infra Reds. (This is why

it is used also in cars: high visibility, low glare (reflection) and good sun protection.). Compare the figures for bronze glass quoted below.

SOLUTION: PLAY ON IR BUT WITH HIGH LIGHT TRANSMISSION



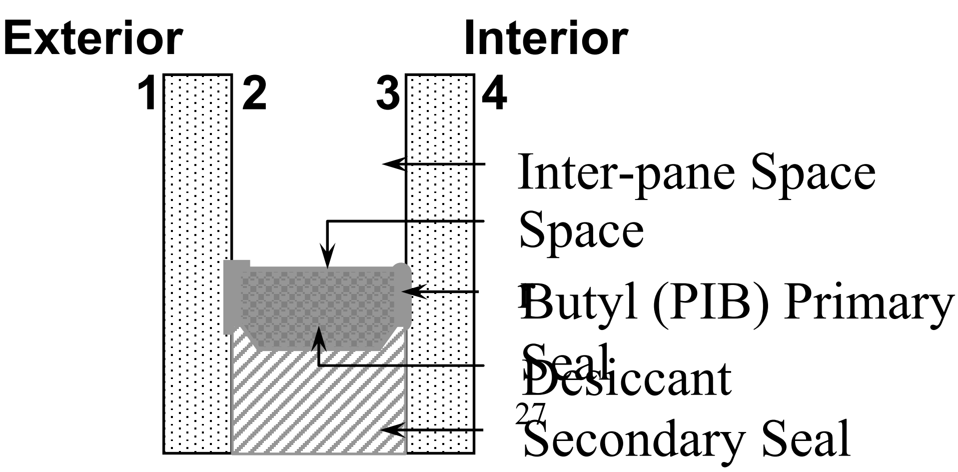
LR = light reflection	**8 %**	**5 %**	**9%**
LT = light transmission	**87 %**	**66 %** (Compare:	**57 %** bronze 34 %)
EA = energy absorption	**17 %**	**56 %**	**64 %** (bronze 65 %)
SF = solar factor	**80 %**	**53 %**	**37 %** (bronze 40 %)
U value =	**5.7 W/m2 x dT**	**5.7**	**1.5**
HG = heat gain	**943 Watt/m2**	**644 W/m2** (Compare:	**400 W/m2** bronze 456 W/m2)[36]

It is clear from this example that the IG unit offers far superior insulation to either single pane of glass. While the advantages of insulating glazing are well known it is important to consider what makes am IG unit perform well.

Insulating Glass Unit Performance and Service Life

A high temperature and humidity climate, typical of much of Asia, is the most severe environment for an insulating glass unit and it can reduce the service-life of an insulating glass unit. The service-life is defined as the period during which no moisture condensation occurs within the inter-pane space and it is controlled by the IG edge-seal.

The function of the edge seal is to provide a moisture- and gas-tight seal. The primary seal ensures gas- and moisture-tightness, while the secondary seal ensures structural integrity of IGU under all relevant loads (during manufacture, installation, and service).



The service life is affected by diffusion of moisture and gases through effective cross-section of primary seal. Premature failure is caused (in >95% of all cases) by loss of adhesion of secondary seal (IFT Study, 1986). Hence, in order to achieve optimum insulating glass unit service life the IG edge-seal must have excellent durability / resistance against environmental factors (physical properties and adhesion). It must also have high structural strength to constrain movement and to minimise changes in effective diffusion cross-section. It must also have low moisture- and gas-permeability under service conditions.

Water vapour and gas permeability of IG sealants is highly temperature dependent and is 6-8 times higher at 60°C than at 20°C. The permeability of the edge-seal is mainly influenced by the primary seal. WVP of silicones and polysulphides at elevated temperatures are comparable.

Elevated temperature accelerates most physical and chemical processes (e.g. ageing of sealant, moisture and gas diffusion, etc.). Temperature fluctuations induce mechanical stresses in the edge seal, including pressure fluctuations within inter-pane space (strongest load for small units) and differential movement between spacer and glass panes resulting in tensile-, shear- and peel-loads.

Under conditions of high temperature and humidity silicone sealants have long been proven to outperform other sealants, both in accelerated testing and in actual case histories.

Conclusion

In order to decrease heat with absorbing or reflective glass, the glass must be highly opaque, then the need of artificial light increases. With insulating glazing, heat can be reduced by up to 75 % compared with single panes, by use of effective soft coatings and by stopping the secondary radiation. This can result in substantial savings in air-conditioning purchase and running costs.

As well as providing thermal insulation, insulating glass units combine the advantages of the individual glass types into one unit. A common combination is an outer solar control glass and an inner low-emissivity glass, such as the example given with green glass and low E coated clear glass.

The advantages of insulating glass units are well known and documented, but in order for the insulating glass unit to offer a longterm cost benefit it must have a long service life. Since temperature, sunlight, and moisture have the strongest influence on service-life of IGUs, it is critical to use an edge seal, which will perform under these conditions. Only silicone sealants maintain their performance when subjected to high temperature, high humidity and UV.