NSG GROUP

Technical Bulletin

ATS-116
04/2025

GLASS AND ENERGY

Summary

Windows play a very important role in the design of a building. The psychological and physiological implications of windows and their role in increasing occupant well-being and worker productivity have been well documented. Windows also play an important role in the energy usage of a building. With a wide array of coatings, tints, and gas filled insulating unit configurations; the choice of glazing materials and options is very large.

In general, the thermal performance characteristics of any glazing material can be best described by two attributes, which are not obvious to the naked eye: Solar Heat Gain Coefficient (SHGC) and U-Factor.

Desired SHGC and U-Factor performance is typically dependent on project climate, orientation, and adopted energy code requirements.

SOLAR HEAT GAIN COEFFICIENT

The SHGC is the ratio of the solar heat gain through the glass relative to the incident solar radiation on the glazing. SHGC includes both the solar energy directly transmitted through the glazing plus the solar energy absorbed by the glazing and subsequently thermally radiated inward. In Europe this quantity is sometimes called "g value", "solar factor" or "TET" (Total Energy Transmittance).

The Shading Coefficient (SC) is the dimensionless ratio of the solar heat gain of a particular glazing relative to that through clear 1/8" (3 mm) thick glass. As such, the shading coefficient

Pilkington North America, Inc.

811 Madison Avenue, Toledo, Ohio 43604-5684

Telephone 800 221 0444 Fax 419 247 451

of 1/8" (3mm) clear, glass is 1.0, and glazing's which block greater levels of solar energy than 1/8" clear will have lower shading coefficient values. The SC is an obsolete measure of performance, partly because it was never fully defined what 1/8" (3 mm) glass composition, or what exact thickness, should be used. Another reason for not using SC is its name: normally, coefficients have a greater numerical value as their named characteristic increases, but for SC you get less solar 'shading' as the SC value increases. SHGC is correctly named: The larger the SHGC value, the greater the 'solar gain'.

Desired SHGC may be dependent on climate. Buildings in southern climates whose energy use is driven by summer air conditioning will have lower SHGC specifications. Buildings in northern climates whose energy use is driven by winter heating can benefit from passive solar heat and have a higher specified SHGC.

Methods to reduce the solar heat gain into a building interior include the use of tinted glass substrates, the use of solar reflective coatings, and/or a combination of the two.

Heat Absorbing Glass

The primary method to limit solar gain is by using tinted glass substrates. Tinted glass is produced by the addition of small amounts of metal oxides to typical float glass batch material. These small amounts do not change the basic mechanical properties of the glass but do impact the color and in turn transmission and reflection characteristics. The use of darker tints has a visible impact on light transmittance but is also more absorbing outside of the visible light spectrum and allows less heat to be transmitted into the building. High-performance tinted substrates like Pilkington **EverGreen™** and Pilkington **Arctic Blue™** allow for lower SHGC values while allowing for higher VLT.

A comparison of ¼" (6mm) tinted glass substrate performance shows the impact tints may have on visible light transmittance (VLT) and SHGC.

¼" (6mm) Glass Type	VLT (%)	SHGC
Pilkington **Optifloat™** Clear	88	0.82
Pilkington **Optifloat™** Green	76	0.61
Pilkington **Optifloat™** Blue-Green	75	0.62
Pilkington **Optifloat™** Bronze	51	0.62
Pilkington **Optifloat™** Grey	44	0.58
Pilkington **EverGreen™**	66	0.53
Pilkington **Arctic Blue™**	53	0.52
Pilkington **SuperGrey™**	9	0.36

SGHC also has an inverse linear relationship with glass thickness. For most substrates, SHGC decreases as you increase the glass thickness. Magnitude of impact is dependent on substrate type.

Low-e Coatings

There are two basic methods of producing low-e coatings.

Vacuum sputtered or "soft coat" low-e, which must be incorporated into a sealed insulating unit because the film will degrade if left exposed to air. They also need to have the coating deleted or ground off the glass edge to ensure adequate long-term sealant adhesion.

Pyrolytic or "hard coat" low-e coatings are very durable and may be used monolithically as a storm panel to improve performance of existing glazing or in an IG unit.

Solar Low-E Coated Glass

LOF introduced vacuum coated, off-line filmed glass products in the 1960's. These films consisted of mirror-like metallic layers on a glass substrate which were designed to reflect the solar energy away from the glazing, rather than absorbing it as tinted glass did. Today, Pilkington North America produces solar control and thermally insulating films using a pyrolytic, on-line operation giving durable, temperable, and cost-effective glass products. Solar control low-e films such as Pilkington **Eclipse Advantage™** and Pilkington **Solar-E™** can be applied to clear and tinted substrates.

Low-e coated glass coatings have thin, metallic oxide layers designed to reflect long wavelength (IR) heat energy, but not significantly impact the visible energy wavelengths. That is why they are nearly invisible. Low-e coated glass reflects or redirects radiant heat generated from a warm object back towards the source of warmth four to thirty times better than uncoated glass.

When solar energy is incident on a glazing, the sun's heat is flowing into the building interior. All low-e coatings reduce the heat flow through a glazing by some amount, and therefore using a low-e coated glass instead of ordinary glass will always show a reduction in the glazing's SHGC value. Pilkington **Eclipse Advantage™** reduces SHGC by increasing solar reflectance, while Pilkington **Solar-E™** combines a solar absorption layer with a low-e layer further reducing SHGC.

Passive Low-e Coated Glass

Note low-e coatings simply block far infrared (IR) heat transmission. This means that low-e coatings may, or may not, have significant impact on SHGC. Some low-e's are considered passive low-e's and are intended to allow for passive solar heat gain. You need to examine the performance values to see if a low-e coating also has solar control properties.

Pilkington **Optiwhite™** low-iron glass has the highest solar transmission in the Pilkington glass range. When combined with Pilkington **Energy Advantage™** passive low-e coating, you get the highest possible free passive solar gains. In general terms it is probably beneficial to incorporate a higher SHGC glazing when the heating costs of a simple building exceed its cooling costs.

U-Factor

The second attribute relating to the energy characteristics of a glazing is the U-Factor. "U" describes thermal conductivity, that is, the heat flow through the glazing from the warm side to the cooler side. It is expressed in terms of BTUs per hour, per square foot, per degree Fahrenheit air temperature difference across the window. Most consumers are familiar with the term R-value, due to advertising by fiberglass insulation manufacturers. R-value is thermal resistance from surface to surface (not air to air), whereas U-Factor is thermal conductance. The two are related by: U = 1/R but watch for how the measurement has been made: air to air or surface to surface. For a given glazing, the lower the U-Factor (higher R-value), the better the insulation performance.

The first attempt to control thermal loss through glazing systems was to reduce air infiltration or leakage around the perimeter of the glass using tighter fitting, better sealed window units. Around 1940, LOF introduced **Thermopane™** insulating glass. By sealing dry air between two panes of glass, the thermal performance of a window was dramatically improved. Improvements to the original insulating glass unit consisted of wider air spaces, low-e coatings, multiple panes of glass with multiple air spaces, and lower conductive gas fills.

Low-e Coated Glass

Heat flows from warm objects to cold objects. The effect of low-e coatings is to significantly reduce the radiation heat transfer, and correspondingly improve (lower) the U-Factor of the glazing. The reason Low-E coatings are able to reduce radiation heat transfer is because they reflect long wavelength infrared (IR) heat. The lower the emittance of a glazing's surface, the higher the IR reflectance. While the emittance of glass is 0.84, the emittance of low-e coatings varies from approximately 0.21 to as low as 0.03. Use of low-e in an insulating unit instead of uncoated glass lowers the U-Factor by approximately 25% to 40%.

During the heating season, a low-e coating placed on either of the glass surfaces (#2 or #3) in the air space of an insulating glass unit will reduce the radiation flow from the warm, room side, glass to the cooler, outboard glass by an equal amount. Low-e coated glass in place of uncoated glass will reduce both the heating and the cooling costs associated with a glazing. The use of multiple low-e coatings in an IGU (surfaces #2 and #4) further reduces U-Factor and improves building insulation. For IGUs with multiple cavities, low-e coating placement is most impactful when limited to one coating per cavity (e.g. surface #2 and #4 or #2 and #5).

Gas Filled IG Units

Since part of the thermal heat transfer through the air space of an IG unit is accounted for by conduction and convection in the air space, another way to reduce the heat transfer (lower the U-Factor) is to substitute a gas other than dry air as the fill medium. By choosing a gas with a lower thermal conductivity than air, a reduction in the heat transfer will be realized. The most common gasses, other than air, are argon or krypton.

APPLICATIONS

Design professionals have a very wide array of products available today, making the choice of glazing systems more complex than ever. The design professional must first evaluate the environmental conditions at the proposed building site. Location, type, size, and orientation of the building, and specific conditions at the site will largely determine the performance requirements of the glazing.

All windows benefit from reduced U-Factor, in all seasons. If by chance the exterior air temperature is at a more desirable value than the building interior temperature then the energy-free way to change the latter is simply to open the window, or in a commercial building, put the HVAC on an 'economizer' setting to draw in outside air. But for most situations the air outside is either too hot or too cold and so a good U-Factor is required to prevent unwanted heat transfer.

For solar heat gain there is a more complex decision process: a building located in Phoenix or Houston is going to need a lower SHGC than a building located in Seattle. Conversely, a structure in Milwaukee has a greater need for lower U-Factor (IG and low-e) than a similar structure in a temperate climate such as Orlando. Generally with respect to site orientation, a project's north elevation could use clear insulating units incorporating low-e, while the other elevations may require reduced SHGC glazing and low-e. In some cases, local codes or other requirements may dictate a maximum SHGC and/or U-Factor.

Computer programs such as RESFEN and COMFEN are available free of charge from LBNL to simulate building energy usage, using daily heat load calculations throughout the year. Such analyses are particularly useful in helping select the right glazing as well as for enabling various glazing options to be evaluated in terms of their energy usage impact.

Pilkington North America, Inc.

811 Madison Avenue, Toledo, Ohio 43604-5684

Telephone 800 221 0444 Fax 419 247 4517

Change Summary	Date
Format Update; Restructure of contents	04/08/2025

Pilkington North America, Inc.

811 Madison Avenue, Toledo, Ohio 43604-5684

Telephone 800 221 0444 Fax 419 247 4517