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Solar, Safety and Security Window Films: **White Paper**

IR Rejection

Claims about "infrared rejection" or other infrared controlling characteristics imparted to glass by solar control window film are abundant in current marketing literature, but the claims that are being made do not reflect the true performance of the product in rejecting heat. There is no formally recognized measurement of infrared rejection by the fenestration industry, and as a result, a few manufacturers have decided to publish "IR Rejection" values at specific wavelengths or over a narrow range. This methodology results in an incomplete assessment of the solar infrared energy, since the energy across the infrared portion of the solar spectrum varies widely. Measuring IR at a single point or in a small range does not encompass the total amount of heat gain caused by the infrared component of the spectrum, only a small part of it. Bekaert Specialty Films, the manufacturer of Solar Gard window film, believes it is critically important to become informed about the entire solar energy spectrum, not just one factor in the range, as well as the additional effects of absorption on heat gain.

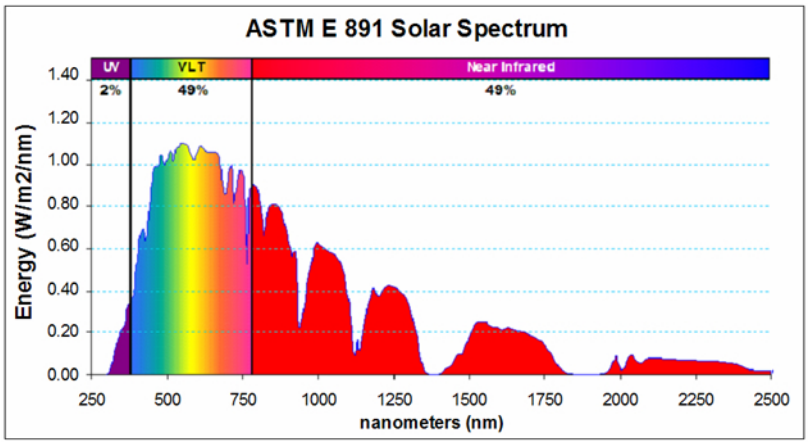
Solar Energy

An understanding of solar energy is required to fully understand infrared rejection claims. The Solar Spectrum is made up of visible light (49%), Ultraviolet Light (2%) and Infrared or NIR (49%). The visible light reaching the surface of the earth that can be seen by humans is located between the wavelengths of 400 and 780 nanometers (nm) in the spectrum. UV falls between 100 nm to 380 nm and is not visible to the human eye. This energy is highly energetic and destructive, but the amount of energy it carries is small compared to the amount of energy contained by visible and infrared light. Lastly, the remaining energy is infrared radiation. The near infrared portion of the solar spectrum runs from approximately 780 nm to 2,500 nm and carries about 49% of the solar energy - just under half of the total solar energy. Technically, radiation beyond 2,500 nm is also infrared, but this "long wave" radiation is a very small portion of the total solar energy, and is mostly associated with radiation from room temperature and warm objects. It is widely accepted that the NIR radiation is 780 nm to 2500 nm, meaning the entire NIR "band" is 1,720 nm wide.

Industry Recognized Performance

The Solar Heat Gain Coefficient (SHGC) is the industry recognized performance characteristic describing the heat transmitted by glazing. The methods for developing the procedure to test SHGC were developed by the National Fenestration Rating Council (NFRC), which is comprised of window manufacturers, vendors, and government agencies. The SHGC is recognized by the U.S. government, federal energy laboratories, Energy Star, the window and glazing trade associations, the American Society of Heating, Refrigeration, and Air Conditioning Engineers, the International Window Film Association (IWFA), Association of Industrial Metallizers, Coaters and Laminators (AIMCAL), the Air Conditioning Contractors Association, consumer groups, and many more organizations. The SHGC (or its counterpart, the Total Solar Energy Rejected, TSER) reflects the true performance of solar heat gain or rejection through a window into a building, and its calculation includes IR rejection. Separating the IR rejection for purposes of reporting heat gain is misleading.

The SHGC value includes two elements of heat gain through a window. The first is the amount of radiation directly transmitted thru the glass and entering the home (or building or auto). The second element is the amount of radiation that is absorbed by the window, and subsequently re-radiated into a home. Some window films and coatings operate by absorption, which blocks radiation and converts it to heat energy in the window pane. The higher the absorption of a window or window film, the more blocked heat it re-radiates into the home as the window heats up. The SHGC is determined by NFRC standards, and includes both energy transmitted directly through a window into a home, as well as energy that is absorbed by the window and re-radiated into a home. Radiation through window film is measured with a spectrophotometer according to the method ASTM E903, and absorptive effects are calculated with formal NFRC standard thermophysical conditions. A critical component of these methods is that they take the weighted solar spectrum into account, meaning that rather than treating each wavelength the same, they are weighted according to the amount of energy they carry.



Performance Claims
Some window film manufacturers report performance for "IR Rejected" in a variety of ways because there is not one, uniformly accepted test method for measuring IR. SHGC, the accurate and recognized performance value of the heat rejecting ability of a window film, varies widely between window film products with similarly claimed "IR Rejection" values. This is due to the fact that each manufacturer measures "IR Rejection" differently, generally at a single point or narrow range at which the film may perform great and thus, best marketed in that range. This is a misleading calculation as it does not reflect the total IR measurement. The window industry prefers SHGC because it accounts for infrared heat as well as heat from visible light, which is greater than infrared light, and because absorption effects are a significant contributor to heat gain through windows.

The testing standard ASTM E903 is the method used to take transmission and reflection data along the entire spectrum, including the infrared. The data collected for a product with this method is used along with standard simulation conditions in the calculation of the SHGC. Companies reporting "IR Rejected" use E903 to collect data, but report only specific wavelengths.

Some specific examples of these claims include:

Product A: A product manufacturer reports the "IR Rejected" at only one wavelength, 1000 nm, where the energy from the sun has already significantly tapered off.

Product B: A manufacturer of a product chose to report the "IR Rejected" at 1025 nm, which carries about 10% less solar energy than reporting it at 1000 nm.

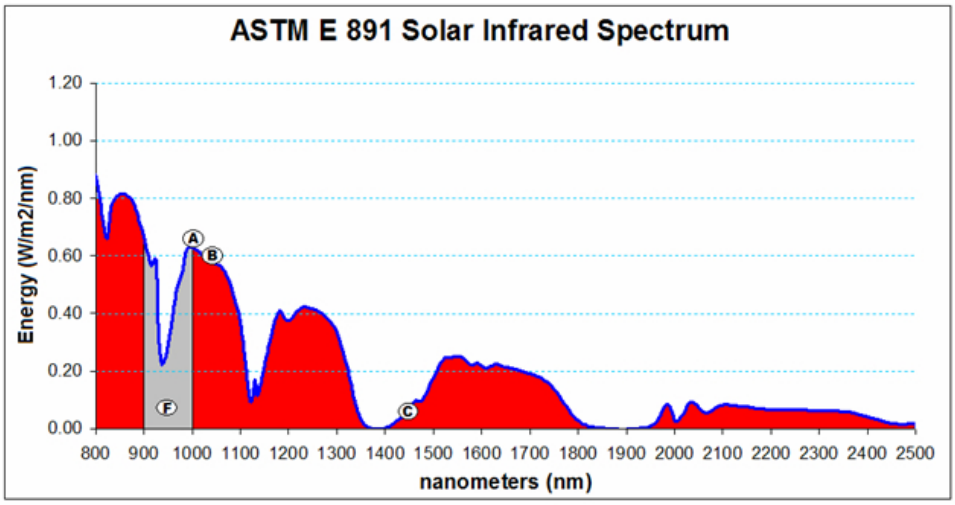
Product C: The manufacturer chose a point to the far right of the spectrum, out in the near infrared at approximately 1450 nm, where there is almost no solar energy left.

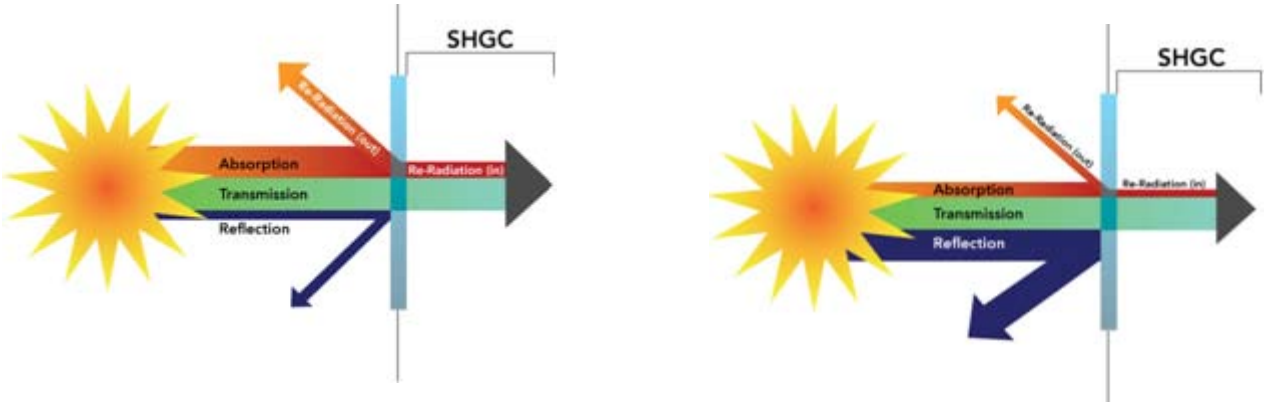
Product D & E: Manufacturers not reporting a specific wavelength or range of wavelengths over which they make their "IR rejected" claims.

Product F: The manufacturer of this product only reports their "IR Rejected" number between 900 nm and 1,000 nm, for a total bandwidth of 100 nm. Noting that the entire NIR band is 1,720 nm wide, this figure represents about 6% of the entire width of the NIR. Therefore, the "IR Rejected" reported by this company ignores 94% of the infrared wavelengths.

Below is an energy graph of the infrared portion of the solar spectrum. It shows the solar spectral irradiance (the energy of the sun at sea level) of the near infrared (NIR) between 780 and 2500 nm. This graph demonstrates two things; first, the pink segment represents the portion over which "Product F" has reported its "IR Rejected" value. Please notice the amount of IR that is not accounted for. Additionally, the respective single wavelengths at which products A, B, and C have reported their "IR Rejected" can be noted on this graph. Notice that none of these wavelengths is indicative of the entire spectrum.

Transmission, Reflection, and Absorption in Solar Performance
It is important to understand transmission, reflection, and absorption when discussing the behavior of films in the infrared portion of the solar spectrum. Reflected energy never enters a building through a window, nor does it enter the glass. It is ejected away from the building without affecting the temperature of either the glass or the interior. 100% of transmitted energy passes through a window and becomes heat gain inside of a home. Absorbed energy takes a more complicated path in the window system. Absorbed energy is taken into the pane of the glass, heating up the window and its frame. Some of this absorbed energy that is stored in the window is radiated back outdoors, while some of it enters the home anyway. This is important because the Solar Heat Gain Coefficient (SHGC) takes into account the effects of all three phenomena. Infrared numbers currently reported in the industry refer only to energy that is not transmitted, and ignore the heating effect of absorbed radiation. This is another reason the SHGC is the superior and industry recognized performance of a window, since not only does it take into account the full solar energy spectrum, but it also accounts for the harmful effects of absorption on home interior temperatures.





The window on the left is more absorbing than the window on the right. The heat gain into the home from the left window (A) is greater than the right (B), because the left window has higher absorption. "IR Rejected" claims do not address this phenomenon.

If you go to any home improvement store and look at the windows, you will find an NFRC label reporting SHGC. Building codes, energy simulations and Energy Star ratings all use SHGC as a means of measuring total solar heat gain. Additionally, numerous municipalities, energy companies, and organizations are offering rebates for solar control films that have a low SC and/or SHGC.

Some window film manufacturers chose to publish IR figures which could mislead the consumer. As we look to publish IR performance, we find it important to weight it against the energy striking the glass, thus we will be providing a **weighted average** for IR Rejection accounting for the entire IR region, 780 to 2500 nanometers. Reporting IR values by any other means negates the fact that energy at shorter wavelengths is exponentially more powerful than energy at longer wavelengths. At 780 nm there is much more energy than at 2000 nm. An unweighted average would not account for this difference in energy over the entire range.

"IR Rejected"

The purpose of this paper is to inform the general public on the subject of infrared energy. The infrared portion of solar energy is only one part of the total energy transmitted to earth within the solar spectrum, and it does not take into account the significant effects of absorption. Furthermore, there is no standard method to report these values, and most window film product manufacturers report "IR Rejection" for their products at a single wavelength or narrow band. The industry accepted and most accurate performance values used to report heat gain or rejection due to the application of window film are Solar Heat Gain Coefficient (SHGC) and its counterpart Total Solar Energy Rejected (TSER).

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