WINDOW FILM PERFORMANCE DATA | Architectural: North America

LLumar®

Solar Control Window Film

Solar Control Window Film	% Total Solar Transmittance	% Total Solar Reflectance	% Total Solar Absorptance	% Visible Light Transmittance	% Visible Reflectance (exterior)	% Visible Reflectance (interior)	Winter U-value	Shading Coefficient	% Ultraviolet Ray Protection (wavelengths 300-380nm)	Emissivity	Solar Heat Gain Coefficient	% Total Solar Energy Rejected	Light-to-Solar Heat Gain Ratio (LSG)***	% Summer Solar Heat Gain Reduction***	% Winter Heat Loss Reduction***	% Glare Reduction***
Clear Glass	83	8	9	90	8	8	1.04	0.99	29	0.84	0.86	14	1.05	0	0	0
Reflective Series	Reflective films feature reflectance on both interiors and exteriors for excellent reduction in summer cooling costs and heat retention in winter. Providing a high level of glare and heat control, they are scratch-resistant, shield 99% of ultraviolet rays, and provide excellent heat rejection.															
RN07G SR CDF (One-Way Mirror)	7	57	36	6	61	14	0.88	0.19	99	0.54	0.16	84	0.38	81	15	93
R15B SR CDF (Bronze)	8	39	53	8	20	62	0.89	0.25	99	0.62	0.22	78	0.36	74	14	91
R15BL SR PS (Blue)	9	42	49	9	27	62	0.93	0.25	>99	0.63	0.22	78	0.41	74	11	90
R15G SR CDF (Gray)	7	36	57	6	13	62	0.92	0.26	99	0.62	0.23	77	0.26	73	12	93
R15GO SR PS (Gold)	10	53	37	13	52	63	0.92	0.23	>99	0.62	0.20	80	0.65	77	12	86
R20 SR CDF (Silver)	11	57	32	15	62	63	0.90	0.22	>99	0.58	0.20	80	0.75	77	13	83
R35 SR CDF (Silver)	21	45	34	28	47	46	0.91	0.35	>99	0.61	0.30	70	0.93	65	13	69
R50 SR CDF (Silver)	39	27	34	49	26	25	0.95	0.55	99	0.67	0.47	53	1.04	45	9	46
Dual-Reflective Series	Dual-Reflective films are highly reflective on the exterior; lower on the interior, which helps provide clear day and night views. Traditionally specified on commercial buildings, Dual-Reflective films are also popular for sunbelt residential applications. They are scratch-resistant, shield 99% of ultraviolet rays, and provide excellent heat rejection.															
DR05 SR CDF (Warm Gray)*	7	58	35	6	61	16	0.89	0.18	>99	0.56	0.16	84	0.38	81	14	93
DR15 SR CDF (Warm Gray)	18	38	44	17	37	13	0.92	0.34	99	0.62	0.30	70	0.57	65	12	81
DRN25 SR CDF (Warm Gray)	23	31	46	22	30	12	0.92	0.39	99	0.62	0.35	65	0.63	59	12	76
DRN35 SR CDF (Warm Gray)	33	22	45	35	21	13	0.95	0.52	99	0.67	0.46	54	0.76	47	9	61
Deluxe Series	Deluxe films are specified for commercial buildings where high levels of heat rejection and glare reduction are needed. Deluxe films are ideal for privacy applications and exterior aesthetics. They are scratch-resistant, reduce 99% of ultraviolet rays, and come in gray and bronze.															
DL05G SR CDF (Gray)	14	26	60	7	11	11	0.95	0.35	>99	0.68	0.31	69	0.23	64	9	92
DL15B SR CDF (Bronze)	27	14	59	14	8	8	0.94	0.51	99	0.72	0.44	56	0.32	49	10	84
DL15G SR CDF (Gray)	27	14	59	16	9	8	0.93	0.51	99	0.71	0.44	56	0.36	49	11	82
DL30GN SR PS (Green)	32	18	50	33	14	14	0.99	0.53	>99	0.75	0.48	52	0.69	44	5	63
Neutral Series	Neutral films reduce glare, provide moderate heat rejection, and are specified where a soft, neutral appearance is desired. These films are made with sputtered technology, creating a film that allows for very uniform visible light transmission. Neutral films are scratch-resistant and shield 99% of ultraviolet rays.															
N1020 SR CDF (Neutral)	21	27	52	23	30	27	1.03	0.42	>99	0.82	0.37	63	0.62	57	1	74
N1040 SR CDF (Neutral)	34	17	49	37	19	16	1.05	0.56	99	0.85	0.49	51	0.76	43	-1	59
N1050 SR CDF (Neutral)	46	12	42	50	14	11	1.07	0.68	99	0.89	0.59	41	0.85	31	-3	44
N1065 SR CDF (Neutral)	64	9	27	69	10	8	1.07	0.83	99	0.90	0.72	28	0.96	16	-3	23
N1020B SR CDF (Bronze)	13	49	38	21	37	35	0.90	0.27	>99	0.59	0.23	77	0.91	73	13	77
N1035B SR CDF (Bronze)	26	37	37	37	26	23	0.92	0.41	99	0.61	0.36	64	1.03	58	12	59
Exterior Series	Exterior films are applied to the exterior face of the glazing and provide excellent heat rejection performance.															
NHE20 ER HPR (Neutral)	21	29	50	23	30	26	1.04	0.42	>99	0.86	0.36	64	0.64	58	0	74
NHE35 ER HPR (Neutral)	34	18	48	38	19	16	1.04	0.56	>99	0.86	0.49	51	0.78	43	0	58
RHE20 ER HPR (Silver)	12	63	25	16	62	59	1.04	0.22	>99	0.71	0.20	80	0.80	77	0	82
RHE35 ER HPR (Silver)	21	50	29	29	48	45	1.04	0.35	>99	0.72	0.30	70	0.97	65	0	68
RHE50 ER HPR (Silver)	38	30	32	49	26	24	1.04	0.55	>99	0.79	0.48	52	1.02	44	0	46
THE 80 BL ER (Clear)	41	6	53	78	9	9	1.04	0.66	>99	0.89	0.57	43	1.37	34	0	13
SHE CL ER PS4 (Clear)	82	8	10	89	9	9	1.02	0.97	>99	0.90	0.85	15	1.05	1	2	1
SHE CL ER PS7 (Clear)	81	8	11	89	9	9	1.04	0.97	>99	0.84	0.84	16	1.06	2	0	1
Specialty Series	AU-85UV SR HPR is an ideal solution to help protect interior furnishings from sun damage. It provides a high level of protection against harmful UV rays without altering glass aesthetics. AIR-80BL SR HPR is used where a combination of extremely low visible reflectance, high light transmission, and substantial reduction in solar infrared transmission is needed.															
AIR80 BL SR HPR (Clear)	43	7	50	79	9	9	1.07	0.67	>99	0.89	0.58	42	1.36	33	-3	12
AIR90 CL SR HPR (Clear)	63	7	30	85	9	9	1.07	0.83	>99	0.89	0.72	28	1.18	16	-3	6
AU85 UV SR HPR (UVCL-Clear)	82	9	9	89	10	10	1.07	0.97	>99	0.90	0.84	16	1.06	2	-3	1

*Developmental data, based on data obtained during product development and is subject to change. Data was captured using the National Fenestration Rating Council's (NFRC) standard guidelines for window film solar performance measurement as measured on single pane, 1/8 inch (3mm), clear glass. Reported values are taken from representative product samples and are subject to normal manufacturing variances. Actual performance will vary based on a number of factors, including glass type and properties. ***These are calculated numbers which may differ between similar products due to averaging and rounding. (03/21) L2278

Definitions of Key Terms

% Solar Transmittance (T-sol): The ratio of the amount of total solar energy in the full solar wavelength range (300-2,500 nanometers) that is allowed to pass directly through a glazing system (e.g., a film/glass combination) to the amount of total solar energy falling on that glazing system. Value is usually expressed as a percent.

Relevance to the consumer or specifier: The smaller this number, the cooler objects will be when directly exposed to sunlight passing through the window, since they will be exposed to less incident solar energy.

% Solar Reflectance (R-sol): The ratio of total solar energy which is reflected outwardly by the glazing system to the amount of total solar energy falling on the glazing system. Value is usually expressed as a percent.

Relevance to the consumer or specifier: This number together with the T-sol determines the solar absorption value of the film. This latter value is most critical in determining what film is suitable for a given glass type & situation. Generally, the higher this number, the better.

% Solar Absorptance (A-sol): The ratio of the amount of total solar energy absorbed by a glazing system to the amount of total solar energy falling on the glazing system. Solar absorption is that portion of total solar energy neither transmitted nor reflected. Since solar transmittance and solar reflectance are measured directly, the following equation should be used in calculating solar absorption. Solar absorption =1.00 - (solar transmittance) - (solar reflectance).

Relevance to the consumer or specifier: Generally, the lower this number, the better. This number is a critical determinant in the potential for thermal stress (how hot the glass gets). Too much solar absorption can excessively warm the glass cause window failure, either though glass breakage or seal failure. Always use the **Film-to-Glass Recommendation Chart** (a web app is available for specifiers) to avoid wrongly specifying a film for a given glazing system.

% Visible Light Transmittance (VLT): The ratio of the amount of total visible solar energy (380-780 nanometers) that is allowed to pass through a glazing system to the amount of total visible solar energy falling on the glazing system. Value is usually expressed as a percent. Glare is influenced by visible light transmittance through a glazing system. Visible light accounts for about 44% of the sun's energy reaching Earth's surface. The VLT value is often weighted or measured in the area of the spectrum most easily sensed by the human eye, around 550nm.

Relevance to the consumer or specifier: The smaller this number, the greater the glare reduction. Of concern to many clients because while they want glare reduction, they often do not want a room "too dark."

% Visible Reflectance-exterior and interior (VLR-ext and VLR-int): The percent of total visible light falling on a glazing system that is reflected by that system. Generally, VLR values are for exterior surfaces, those exposed to sunlight, unless otherwise specified. For dualreflectance films, values are often given for each surface, the exterior (usually listed first in specification charts) and the interior (listed second).

Relevance to the consumer or specifier: A guide to how "shiny" a film looks from the exterior of a building relative to other films. Clear glass has a VLR of about 8%. And the lower the ***interior*** reflectance value, the less shiny the window will appear at night from the interior when it is very dark outside but brightly lit inside.

% UV Transmission: The ratio of the amount of total UV solar energy (from 300-380 nanometers) that is allowed to pass through a glazing system to the amount of total UV solar energy falling on the glazing system (little if any UV light from 100-300 penetrates glass). Ultraviolet is one portion of the total solar energy spectrum which greatly contributes to fading and deterioration of fabrics and furnishings. Sometimes UV performance numbers are given in term of how much is "**rejected**," that is, what percentage of incident UV is **prevented** from passing through the glazing system. UV is generally subdivided into 3 smaller bands, progressively smaller in wavelength (therefore higher in frequency): UVA (380-320nm); UVB (320-280); UVC (280-100). Clear glass blocks very little UVA but most UVB. High quality window films can block well over 99% of both UVA and UVB.

Relevance to the consumer or specifier: This parameter is a very important factor in the purchase of window films. Excessive UV is the most dangerous part of the solar spectrum for human health (it's implicated in cataracts and skin cancer, and adversely affects people with Lupus, Xeroderma Pigmentosum, Porphyria, and other such diseases. UV is generally the biggest factor in damage to drapes, carpets, furniture, though shorter wavelengths of visible light (extending into the violet and blue bands) may play an important role as well. UV blocking is also important for the longevity of the window film itself.

U-value: The U-value (sometimes called the "U-Factor") should be understood as the overall heat transfer coefficient of the glazing system. The U-value is a measure of the heat transfer that occurs through the glazing system between its outer and inner surfaces. This value is a function of temperature, and is expressed in BTUs per square foot per hour per degree Fahrenheit (BTU/ ft2/hr/°F or w/m2). The lower the U-value, the better the insulation qualities of the glazing system. Alternative definition: The "coefficient of heat transfer;" a measure of the ability of a material to resist heat transfer. The number is actually the number of BTUs per square foot per hour per °F of temperature difference (or w/m2 per °C) across a barrier. The lower the U-value, the slower heat moves by conduction through the material.

Others in the insulation and construction industry use the measure of "R-Value," which denotes a material's ability to act as an insulator. The higher the R-Value, the slower the heat transfer rate; it is the reciprocal of the U-Value, expressed as R = 1/U. A window with a U-value of 0.25 has an R-value of 4.0 (1 divided by 0.25).

U-Value and R-Value measurements are similar—but reciprocal—in nature. They quantify the rate at which heat is transferred through a material due to temperature differences between its opposing surfaces. The window films industry uses two standards of measurement to determine U-values for glazing systems:

Winter U-value: With (a) the outside temperature set at -0.4°F (-18°C), (b) the inside temperature set at 69.8°F (21°C), (c) no sunlight illuminating the glass, and (d) the outside wind speed set at 12.3 mph (5.5 m/s). The "Winter U-value" can be measured in terms of the number of BTU's per square foot per hour (w/m2) lost through the glass.

Summer U-value: With (a) the outside temperature set at 89.6°F (32°C), (b) the inside temperature set at 75.2°F (24°C), (c) sunlight illuminating the exterior of the glass at the intensity of 248.2 BTUs per square foot per hour (783 w/m2), and (d) the outside wind speed set at 6.2 mph (2.8 m/s), the "Summer U-value" can be measured in terms of the number of BTUs per square foot per hour (w/m2) gained through the glass by conduction and re-radiation.

Relevance to the consumer or specifier: U-values of glass are not much affected by most films, although newer classes of low-e films offer significant heat loss reduction in winter, and improved heat rejection in summer by reflecting re-radiated far-infrared energy.

Shading Coefficient (SC): The ratio of the solar heat gain through a given glazing system to the solar heat gain under the same conditions for clear, unshaded double strength window glass (DSA). Shading coefficient defines the sun control capability or efficiency of the glazing system relative to a standard window.

Relevance to customer or specifier: The smaller the number, the greater the solar heat reduction. This term is a standard measure in the glass industry; used to rate the relative effectiveness of a glazing system compared to a "standard window." However, the glazing industry is moving away from use of the term since a "standard window" is no longer a single pane clear window with double strength glass. SHGC is a better term for quantifying glazing performance because it allows for easy comparison of the solar performance of a given window to any other.

% Total Solar Energy Rejected (TSER): The percent of incident solar energy rejected by a glazing system. This value equals solar reflectance plus the part of solar absorption that is both re-radiated and conducted/convected outwardly.

Relevance to the consumer or specifier: The higher this number, the better. Like "shading coefficient" in the glass industry, this term historically has been a standard one in the film industry. The number is a good way to compare relative performance of various film products. (Remember that this number is measured for a film on clear, 3mm glass, unless otherwise stated.)

Solar Heat Gain Coefficient (SHGC): Also known as the g-value, the SHGC is the fraction of incident solar radiation that actually passes through that window, including solar energy that is both directly transmitted and that which is absorbed and subsequently released inwardly by re-radiation and conduction. SHGC is expressed as a number between 0 and 1. The lower a window's solar heat gain coefficient, the less solar heat enters a room space. This number is the mathematical complement of the TSER value. In other words, the sum of the TSER (Total Solar Energy Rejection, in decimal form) of a glazing system and its SHGC value is 1; therefore,

1 - TSER = SHGC
Thus, if the TSER of a specified film/glass combination is 58%, then 1 - .58 = .42, which is the SHGC of the window.

Note: This term is being increasingly used in the window film industry because it is a central term in the window glazing industry which does not use the term “TSER.”

Relevance to the consumer or specifier: This is the industry's standard number for comparing the solar performance of a window. The lower this number, the better.

Emissivity: *Short definition:* the measure of a surface's ability of reflect or emit heat in the form of *radiation* (wavelengths from 2500-60,000 nm).

Long definition/discussion: Emissivity is a measure of a surface's ability to *emit* radiation. When heated, a low-E surface will radiate less electromagnetic energy than a high-E surface at the same temperature. The "E" (Emissivity) value is actually the ratio of the amount of radiation emitted from a given surface to the amount of radiation emitted by an ideal "black body" at the same temperature. Thus, emissivity values must be between 0 and 1. (Emissivity simply answers the question: How good does this object radiate heat as compared to a black body?) In the process of emission (re-radiation), the surface is shedding radiant energy to the environment, thus cooling itself. A low-E surface cools itself more slowly than a highly emissive surface. Therefore, installers and sales reps should be aware that sun-exposed Low-E glass with film, all other factors being equal, will tend to remain at a higher temperature than a regular filmed glass. This fact is taken into consideration in the film-to-glass recommendations calculations.

Low-E surfaces also tend to reflect longer wave far-infrared radiation, the kind of radiation emitted by objects at room temperature, indeed by all objects cooler than about 1300°F (705°C). Many low-E coatings on window glass may be *excellent* reflectors of far-infrared (thus reducing winter heat loss through a home's windows) but very *poor* reflectors/absorbers of UV, visible, and near infrared wavelengths found in *solar* radiation, and thus may not be sufficient for solar control purposes without additional coatings (such as high-performance window films). There is some advantage in low-e coatings in summer since such glazing can reduce the transmission of far-infrared energy emitted by objects warmed by the sun outside a home (sidewalks, rocks, pavement, outside adjacent walls, etc.).

Relevance to the consumer or specifier: The lower the emissivity value, the lower the heat gain in summer and the lower the heat loss in winter, including those times when the sun is not shining on the window.

Emissivity is a measure of how much heat is emitted from an object by radiation. Heat is transferred to and from objects through three processes: conduction, convection, and radiation. For instance, on a hot night, heat will be conducted through a window from the outside, causing the inside pane to become warm. Convection, or natural circulation, of the air in the room past the window will transfer some of that heat into the room. But the window will also radiate heat as infrared waves, which will warm objects throughout the room. This radiative heating is why you can feel the heat of a red-hot piece of metal (for instance, a heating element on an electric stove) from several feet away.

Low-emissivity, or low-e, coatings are put on window panes to reduce the amount of heat they give off through radiation. In hot climates, where the outside of the window will typically be hotter than the inside, low-e coatings work best on the interior of the outside window pane. In cold climates, where the inside of the window is typically hotter than the outside, the low-e coatings work best on the inside window pane, on the side that faces toward the outside. To learn more about window coatings, see "Advances in Glazing Materials for Windows," prepared by the U.S. Department of Energy's Energy Efficiency and Renewable Energy Clearinghouse." Quoted from the following Department of Energy web site: http://www.eren.doe.gov/consumerinfo/energy_savers/glossary.html)

Light to Solar Heat Gain Ratio (LSG): the ratio of the amount of visible light to the amount of solar heat that is allowed to pass through a glazing system. If this ratio is greater than 1.00, it means that the glazing system (a window system with film installed on it, for example) blocks more heat than light, which requires the selective blocking of more infrared radiation than visible light. This term is replacing "LE" (luminous efficacy) because of the gradual extinction of the term "shading coefficient." The higher the LSG ratio, the better the glazing is at reducing unwanted solar heat gain and maximizing desirable natural light transmittance. This term is replacing "luminous efficacy" in the industry. VLT / SHGC = LSG.

Relevance to the consumer or specifier: The higher this number, the more efficient the film product is at reducing solar heat gain rather than visible light.

% Summer Solar Heat Gain Reduction (Summer SHGR): The percent by which incoming solar heat energy is reduced by the addition of a filtering material. For example, if a clear glass pane has solar heat gain of 86% (a solar heat gain coefficient of .86), and the addition of a window film yields a new solar heat gain of only 40%, then the HEAT GAIN REDUCTION is from .86 to .40. We compare the difference in heat gain to the original heat gain to get the percentage of heat gain reduction. The calculation runs as follows: (.86 - .40)/.86 = 0.535, or 53.5%.

Relevance to the consumer or specifier: The higher this number, the greater heat gain is reduced. This is an accurate way to directly compare the difference in heat gain before and after a film installation.

% Winter Heat Loss Reduction: The percentage by which heat energy loss (via conduction, convection, and radiation) through a given glazing system is reduced by the addition of an insulating material. For example, if a clear glass pane has heat loss value of .9 BTUs per square foot per hour per degree F, and the addition of an insulating window film reduces the heat loss to .5 BTUs per square foot per hour per degree F, then the HEAT LOSS REDUCTION is from .9 to .5. We compare the difference in heat loss to the original heat loss to get the percentage of heat loss reduction. The calculation runs as follows: (.9 - .5) / .9 = 0.44, or 44%.

Relevance to the consumer or specifier: The greater this number, the better. This value is a way to compare the (non-solar) insulation of a film, irrespective of its solar performance.

% Glare Reduction: The percent by which visible light transmission is reduced by the addition of a filtering material. For example, if a clear glass pane has a VLT of 90%, and the addition of a window film yields a new VLT of 50%, then the GLARE REDUCTION is from 90 to 50. We compare the difference in light transmission to the original transmission to get the percentage of glare reduction. The calculation runs as follows: (.90 - .50)/.90 = 44.4%

Relevance to the consumer or specifier: The greater this number, the better (in terms of reducing harsh or excessive light).