Window Technology

Technical Brief TB0302

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Background

Windows have a lot to do with the success of a house, from the appeal of that house to a potential buyer to the buyer's satisfaction. It wasn't too long ago that windows, though beautiful and great sources of light, fresh air, and views, were inefficient and led to drafts, discomfort, condensation, fading of furnishings, and high utility bills. According to a Honeywell survey of homeowners' ten pet peeves, number three was high utility bills and number five was window condensation. Now, with new window technologies, most of these problems can be avoided. By choosing windows wisely, builders can gain a marketing advantage over their competition while also reducing complaints and call-backs after the sale.

This builder brief describes the currently available window technologies and provides some guidance on selecting windows. A follow-up document will look at issues such as window orientation, overhangs, ventilation, and HVAC sizing.

Advances in Technology

Over the last 10 to 15 years, several new technologies have been applied to residential windows.

Low-emissivity (low-e) coatings can greatly reduce heat loss in winter and heat gain in summer. These coatings are actually very thin layers of metal or metal oxides applied to the glass surface, usually on the inside of the outer pane. Low-e coatings reflect the room heat back into the room. This not only reduces heat loss, but results in warmer windows and greater comfort for occupants. Adding a low-e coating to ordinary double-pane glass will reduce the heat loss of a wood or vinyl framed window by 16 - 22%. All low-e coatings are not the same, so you must look at the performance ratings (discussed later) along with cost to select the best window for your situation.

Another recent advance in low-e coatings is the development of "selective coatings" that distinguish between visible light and the infrared energy in sunlight. Windows with this coating allow good light transmission but have low solar heat gain and thermal transmission.

Triple and quadruple glazing can also greatly reduce heat loss. Because glass is so heavy, triple and quad-glazings are often built using plastic film for the inner layers of glazing. Special edge fastening systems are used to keep the film taut. These films usually also have a low-e coating. Triple glazed low-e windows reduce the heat loss versus double-pane low-e by about 25% for wood framed windows, and by about 38% if combined with insulated frames.

Inert gases between glass layers, such as argon or krypton, reduce heat loss in the window because they do not conduct heat as well as air. Using a low-e double-pane window with argon fill will reduce the heat loss by another 8-11%.

Improved glass spacers reduce the heat loss that can occur near the edge of the glass by conduction through the spacer. We know the edges of a window are cooler because that is where condensation occurs. Glass spacers used to be made of aluminum, which resulted in high heat loss. Now a wide range of insulating spacers is used in order to cut down on the heat loss in this area. A major benefit of improved spacers combined with low-e glass is greatly reduced condensation on the windows in the winter.

Window frame choice is affected by many factors including cost, strength, durability, consumer appeal, and thermal transmission. After achieving a reduction in heat transfer through the glass part of a window, the industry focused its attention to window frames. Frame options today include aluminum, aluminum with thermal break, wood, vinyl, vinyl-clad wood, fiberglas, hybrid, and composite.

Hybrid frames combine two or more types of materials such as vinyl-clad wood framing. Some vinyl frames are now available with wood veneers on the inside surfaces for consumer appeal. The newest type of frame material is a composite; a wood/polymer compound made from recycled wood and polymer is often used. These composites are very stable, and have the same or better structural and thermal properties as conventional wood, with better moisture resistance and more decay resistance.

Understanding Window Performance

All of these advances in technology have resulted in modern windows that can be both beautiful and efficient. But choosing the best window has become more challenging because there are more choices and the choices are more complicated. Another issue that builders face is choosing windows to meet the energy code requirements in Pennsylvania. By understanding the window rating values, builders can make informed selections of possible windows for a project.

U-factor is a measure of the rate of heat transmission through the window due to temperature difference. The U-factor is the inverse of the R-value (a U-factor of 0.5 is an R-value of 2). The *lower the U-factor*, the greater a window's resistance to heat flow and the *better its insulating value*. Increasing the number of window panes, using low-emissivity (low-e) coatings, filling the window gap with argon, or using better insulated window frames are ways to reduce thermal transmission and the U-factor. U-Factor ratings generally fall between 0.20 (triple-glazed, low-e, improved spacers, and insulated frames) and 1.20 (single pane, aluminum frame).

National Fenestration Rating Council (NFRC)

NFRC performs tests and provides third-party ratings on window, door, and skylight products. This system allows a consistent basis for comparing product performance.

The NFRC label looks like this:

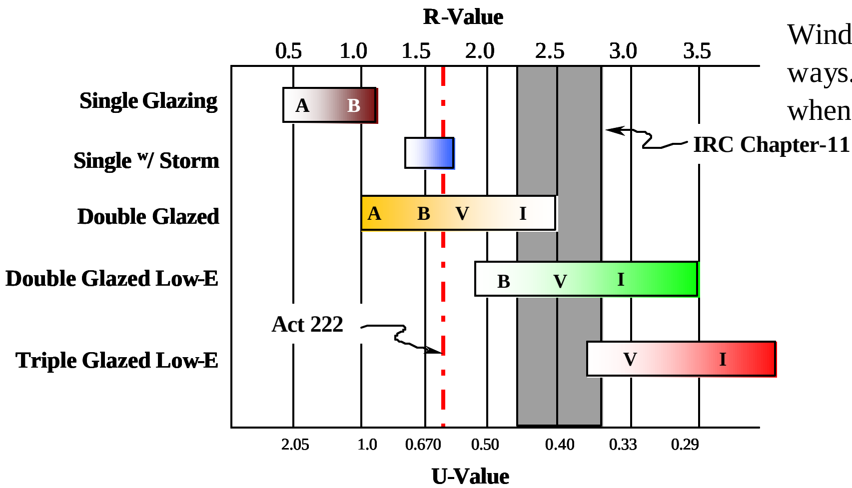
An important thing to note here is that the U-factor in the NFRC rating is for the window assembly and includes the window framing and mullions. Here's an example of showing how the window frame material affects the U–factor of a double-glazed, low-e window.

Frame Type	U-factor
Aluminum	0.61
Aluminum w/ break	0.49
Wood, clad wood, vinyl, composite	0.33
Insulated vinyl or fiberglas	0.27

These values are an average of similar products from several manufacturers. (Efficient Windows Collaborative)

Energy standards specify the maximum allowable U-factor (or minimum R-value). In Pennsylvania, the Act 222 Energy Standard required a window minimum R-value of 1.6, equivalent to a maximum

U-factor of 0.63. This level can easily be achieved with double-glazed windows. The figure below illustrates the range of U-factors and R-values achieved with different window designs.



A = Aluminum frame	B = Aluminum frame w/thermal break
V = Vinyl or wood frame	I = Insulated vinyl or fiberglas frame

The Uniform Building Code references the International Residential Code that requires U-factors for Pennsylvania ranging from 0.35 to 0.45, the shaded range in the figure. These levels are readily achieved with double-glazed, low-e windows with most types of framing.

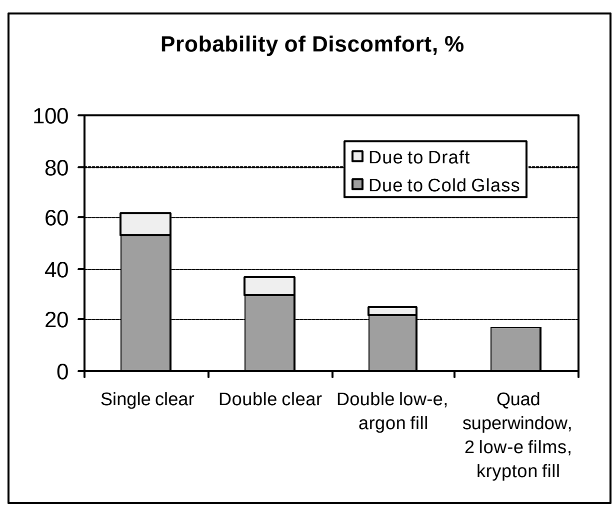
Solar Heat Gain Coefficient (SHGC) is the fraction of solar radiation admitted through a window or skylight, including what strikes the framing. It is expressed as a number between 0 and 1. The lower a window's SHGC, the less solar heat it transmits, and the greater its shading ability.

For south-facing windows, a high SHGC is desirable to allow winter sun to help heat the house. In the summer, the sun is high overhead and south windows don't have a large solar load. In contrast, east and west windows receive a lot of direct sun in the summer and can contribute to higher cooling bills or discomfort. Windows facing these directions should have a lower SHGC. As a guideline for Pennsylvania, windows facing east (northeast through southeast) or west (northwest to southwest) should have a lower SHGC (less than 0.55) to reduce the impact on cooling loads or discomfort in the summertime.

Thermal Comfort

Windows affect the comfort of homeowners in two ways. The first is by thermal radiation that occurs whenever a surface is warmer or cooler than the person's skin. Even with a winter indoor air temperature of 72 °F, people will feel uncomfortable if they are close to a window with a high U-factor and low surface temperature. Using windows with low U-factors increases window surface temperature and reduces discomfort.

Second, windows affect occupant comfort by causing drafts. Assuming that windows with minimal air leakage are used, drafts are caused by cold air that falls off cold window surfaces in the winter. This is why heating units are located under windows – to counteract these drafts. Because the use of windows with lower U-factors reduces drafts, the builder has more freedom in locating registers and heating units and the occupants can lower their thermostat settings. NFRC is working on developing a rating factor for windows to correspond to comfort.



Source: Lawrence Berkeley National Laboratory (Lyons and Arasteh)

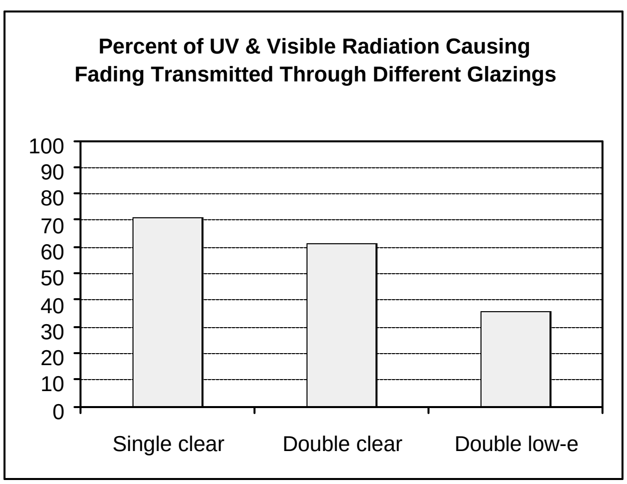
Condensation

Of all of the factors influenced by window design, the most noticeable to homeowners is condensation. (As noted earlier, condensation is number five on homeowners' lists of pet peeves.) In the winter, as explained in the previous section, window surfaces can be cold. With high U-factor glass and frames, these cold temperatures can cause condensation to form. Condensation can seriously damage window frame and wall surfaces and can lead to mildew and mold.

Recognizing the complexity and the importance of this issue, NFRC is developing a rating factor that indicates the likelihood of condensation and allows for a comparison of products. The new voluntary rating is called the Condensation Index, CI, and will begin to appear in 2003.

UV Fading

Some of the sun's energy is in the form of ultraviolet (UV) energy, which has a shorter wavelength than visible light. This UV energy, along with the visible light, causes fading of many types of materials in a house. As the chart below shows, fading can be reduced by using windows with more glazings or with low-e coatings. NFRC is also working on developing an ultraviolet rating for windows.



Source: Lawrence Berkeley National Laboratory

Competitive Benefits of Energy-Efficient Windows

In summary, energy-efficient windows offer homeowners: improved thermal comfort, reduced condensation, reduced UV fading, and lower energy bills. These qualities can be used in marketing to gain a competitive edge over other builders.

Watch for the next technical brief that will look at additional window design issues including window orientation, overhangs, ventilation, and HVAC sizing.

References and Resources

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www.efficientwindows.org

www.nfrc.org

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www.energystar.gov

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