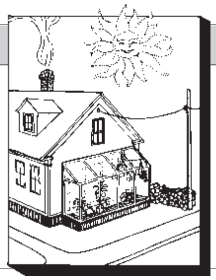

What to Look for in Energy-Efficient Windows

by Alex Wilson

Windows account for a huge percentage of heat loss in the typical New England home. Even though most houses now incorporate insulated (two-layer) glass, this still provides an R-value of only about 2 for window areas—hardly a match for the R-20 to R-26 going into walls.

Further, the R-value tells only part of the story: the amount of heat lost by conduction. Windows also are major sources of infiltration (convective) heat loss.

Most estimates suggest that windows account for 20 to 25 percent of the heat lost from the average American home. Considered another way, that's 5 percent of the nation's total energy use! Clearly there is room for savings.

Two key issues relating to window energy efficiency are the number of glazing layers and the effect of so-called "high performance" glazings.

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How Many Layers?

Single glazing is being used less and less in the Northeast. With an R-value of only about 1, it just doesn't make sense in most situations. Not only does the extremely low R-value translate into a substantial waste of energy, but it also means very low glass-surface temperatures in the winter and substantial discomfort and moisture problems (see Table 1).

If the indoor relative humidity is 50 percent, condensation on the glass will occur when the outside temperature drops below about 40 F. If the outside temperature is below about 20 F, Jack Frost will pay a visit.

Used with exterior storm windows and/or interior moveable insulation, however, single glazing can be satisfactory when other considerations rule out insulated glass.

Historic-restoration projects, for example, may call for traditional 12-over-12 windows. Using applied grills over insulated glass is unacceptible to most restoration aficionados, but the alternative—individual, insulated sealed-glass units—may be hard to find and prohibitively expensive. In these situations, consider exterior storm windows and insulating curtains or blinds on the interior.

Double-Paned Windows

Insulating double-glass units have been the standard in New England since the mid-70s. The trapped air between the two layers of glass results in an R-value of approximately 2, more than double the R-value of single glazing.

The effectiveness of insulated-glass units depends quite a bit on the thickness of the air space between the layers of glass. If the air space is too thin, convective heat loss will be significant, and the full benefit of the air space will not be realized.

With a 3/16-inch air space, the R-value is about 1.6. At ¼ inch, the R-value is about 1.7 , and at ½ inch, the R-value is about 2. For the best performance, then, avoid windows with an air space of less than ½ inch between the layers of glass.

Even with double glazing, however, the interior glass temperature can be quite low on cold winter days (see Table 1). If the outside temperature is 10 F, for example, the glass surface temperature will be 50 F—cold enough to result in condensation on the glass if the indoor relative humidity is a typical 50 percent.

Triple-Paned Windows

Triple-glazed windows hit the market several years ago and were made by a number of manufacturers. Most manufacturers no longer offer them, however, concentrating instead on so-called "high performance" windows.

Three layers of glass result in very thick, bulky and heavy windows. Not only have these posed installation difficulties (they require nonstandard casings, for example), but their cost is quite high. They also require two seals instead of one, which results in more frequent fogging problems.

If you do consider triple-glazed windows, examine the overall glass thickness. Just as with double-glazed windows, narrow air spaces mean lower R-values. If the total glass thickness is only ¾ inch and 1/8-inch glass is used, for example, that means you have an air space of only 3/16 of an inch. Getting the optimal half inch of air space in triple-glazed windows requires an overall glass thickness of 1-3/8 inches—with comparably thick sash and casings!

Plastic-Film Glazing

One alternative to three layers of glass that some manufacturers have pursued is suspending a very thin plastic film between the two layers of glass. Weather Shield offers both tri- and quad-pane windows using one or two layers of 3M "Sungain" film.

Using the suspended plastic film rather than glass for the additional glazing layers eliminates the problem of added weight and reduces the thickness somewhat. But tri- and quad-pane windows still are thicker than conventional two-layer insulated windows, so this can pose installation problems in some cases.

High-Performance Windows

High-performance, or low-emissivity (low-E), windows are the current state of the art in energy-efficient window technology. The idea was developed by researchers at the Massachusetts Institute of Technology during the late '60s and early '70s and finally has made its way into the mainstream of the window industry.

To understand how high-performance windows work, you need to know something about sunlight and heat radiation. Sunlight coming through a window is in the short-wavelength part of the spectrum. When that sunlight enters a house, it is absorbed by the walls, floors, ceilings and furnishings (with darker surfaces absorbing more). In turn, these heated surfaces release energy in the form of heat radiation, which has a longer wavelength.

Low-emissivity glazings work by transmitting short-wavelength light and reflecting long-wavelength light. The first such product developed was named "Heat Mirror," which aptly describes the principle involved. (Emissivity is defined as the relative ability of a surface to radiate energy as compared with that of a black surface under the same conditions.)

Manufacturers follow two main approaches in producing low-emissivity glazings. Heat Mirror, manufactured by the Southwall Corp. (a company founded by the MIT researchers who pioneered the technology), uses a reflective coating deposited onto a thin plastic film. This film is sold to window manufacturers (Hurd is the only major wood-window manufacturer currently using Heat Mirror) who suspend it between two glass layers in much the same manner as Weather Shield suspends the 3M film in its tri- and quad-pane windows.

One alternative to three layers of glass is a very thin plastic film between two layers of glass. This eliminates the problem of added weight and reduces the thickness somewhat.

The other approach involves depositing a transparent, reflective coating directly onto the glass. With direct depositing, either a "hard" or a "soft" coat can be obtained.

The hard coat is more durable than the soft coat and therefore can be used on single glazings that are exposed to air; the

Table 1:
Inside Glass Surface Temperatures for Various Glazings (°F)

Outside Temp (°F)	*Single Glazing*	*Double Glazing*	*Low-E (Hard)*	*Low-E (Soft)*	*Heat Mirror™*
40	47	60	62	64	65
30	39	57	60	61	64
20	32	53	57	59	62
10	24	50	55	57	61
0	17	47	52	55	59
—10	9	43	49	53	58

Source: Energy Design Collaborative, Scarsdale, N.Y.

Table 2:
Properties of Common Window Glazings

Glazing Type	*U-Value*[1]	*Emissivity (%)*	*Shading Coefficient*[2]
Conventional Glass (Single)	1.16	88	1.0
Insulated Glass (Double)	.55	88	.88
Solar, Low-Iron Glass (Double)	.55	88	1.0
Low-E Hard-Coat Glass (Double)	.40	40	.79
Low-E Soft-Coat Glass (Double)	.32	10	.74
Low-E "Heat Mirror" (Triple)	.26	5	.65

Source: Timothy Johnson, MIT

[1]Calculate the R-value by dividing 1 by the U-value (R = 1/U).

[2]The shading coefficient is a measure of how much sunlight passes through the glazing relative to a single layer of standard glass. The total solar transmission can be calculated by multiplying the shading coefficient by .86 (the total solar transmission of a single layer of glass).

soft coat must be sealed in insulated-glass units. As shown in Table 2, soft-coat, low-E glazings have lower emissivity—and therefore higher R-values—than hard-coat glazings.

Choosing a Product

Of the three different types of low-E glazings, Heat Mirror has the best overall performance, with an R-value of about 4. Some people lean toward the direct-deposit approaches, however, because of concerns about the long-term durability of suspended plastic film. The jury is still out on the durability question, though all evidence seems to point toward a very long life.

As shown in Table 2, with all the low-E glazings, transmissivity (the amount of radiant energy a window transmits relative to the amount it absorbs) is quite low. For south-facing, passive-solar applications, some designers prefer conventional (two-layer) insulated-glass units or special high-transmission, low-iron insulated units to obtain greater solar gain.

Windows deserve a lot of our attention when it comes to building energy-efficient and comfortable houses. Future columns will address other aspects of energy-efficient windows, including tightness, sash material and thermal breaks, closure mechanisms, sun screens and insulated window coverings. ■

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