Window Technology Update

by Alex Wilson

Marvin Windows

Today's window market offers everything from old-fashioned double-hungs to insulated curved units, such as this corner unit made by Marvin.

A wide range of options exist, but your best value remains a quality double-glazed, low-e unit

As window technologies have developed in recent years, so has the complexity of window shopping. Selection now requires decisions about glazing type, frame and sash construction, edge seals, air tightness, special convenience features, and an assortment of different finishes. To help you sort through the many options, this article looks at what's available in window components.

Glazings

Glazing is the most obvious part of a window — and the one that has gone through the greatest changes in recent years. The biggest development was the introduction of low-emissivity (low-e) coatings about ten years ago. A low-e coating can reduce the heat loss through a double layer of insulated glass by 50 percent (from a U-value of .49 to .25 — see chart, page 00).

There are three types of low-e coatings: soft-coat, hard-coat, and Heat Mirror suspended film. While all low-e glazings accomplish the same basic thing — reflecting heat radiation back into the building while allowing the vast majority of visible light to penetrate — the three types are quite different.

Soft-coat low-e glazings have a thin layer of silver applied to the surface of the glass after the glass has been manufactured. This coating is fairly delicate (thus the "soft"), so it must be sealed inside an insulated glass unit. Even so, it is more likely to degrade than other treatments.

A hard-coat low-e coating, also known as a pyrolytic coating, is a thin layer of tin oxide added to the surface of the glass during manufacturing. Since the coating is incorporated into the molten glass, it is very durable. As a result, it does not need to be protected within an insulated glass unit (IGU) and can be used on storm windows. Hard coatings don't insulate as well as soft coatings do, however.

Soft coating advances. The past two years has seen significant advances with both soft-coat and hard-coat products. Perhaps the biggest advance is Heat Mirror, a suspended low-e film produced by Southwall Technologies and used in Hurd Windows, in Visionwall's system, and by several other smaller manufacturers. Heat Mirror is a soft-coat low-e film deposited onto a thin layer of transparent polyester film, which is sandwiched between the two panes of a sealed, double-glazed unit. A window with Heat Mirror outperforms standard soft-coat low-e units, mainly because the plastic inner layer provides an extra dead air space, creating a triple-glazed window.

Another soft-coat innovation, this one by Cardinal Glass, is a product called Low-E2. This has even lower emissivity than standard soft-coat low-e coatings, and therefore better energy performance. This coating is currently available on some Weather Shield windows. It may soon be adopted as the standard for the entire Andersen line, according to an Andersen spokesperson.

Hard coatings not so blue. With pyrolytic (hard-coat) coatings, the big news recently has been LOF's introduction of its "Energy Advantage" glass. This glass almost matches standard soft-coat low-e glass in energy performance, yet offers the more durable hard coat. In addition, it transmits more solar energy, making it better for buildings with passive solar heating. Perhaps more important for most consumers, this product doesn't have the bluish tint common with standard hard-coat low-e glazings. Energy Advantage glass is used by Pella and Marvin in some of their windows, and also by over 80 smaller, regional window manufacturers, such as Trimline and Weather-Tite.

How much light do you want? Depending on the installation and location, a window's light transmittance properties can be important. Here you must consider three kinds of light:

- *visible light*, of which most people want as much as possible;
- *total solar transmittance*, which is desirable in passive solar designs but a liability in hotter climates; and
- *ultraviolet*, or UV, radiation, which fades fabrics and is undesirable.

Different window types allow different levels of each kind of light. Which one you want will depend on the location and design of the house. In general, low-e coatings allow good levels of visible light and moderate solar gain while cutting UV transmittance 60% or more. A few windows, including those with Heat Mirror, cut UV transmittance to almost nothing. Special formulations of Heat Mirror are designed to reject a large portion of solar gain. The insulation and light transmission qualities of various glazings are shown in Table 1 next page.

Shopping around. Some manufacturers, such as Pella and Weather Shield, offer various glazing options for their windows (for example, soft-coat vs. hard-coat). In other cases, if you want a particular type of glazing you may have to shop around among manufacturers. Now that LOF has eliminated the bluish tint in hard-coat low-e glass, you can afford to be choosy about the low-e windows you buy.

Low-Conductivity Gas Fill

After low-e coatings, gasfills (which fill the space between glass layers) have had the greatest impact on reducing heat flow through windows. By replacing the air in sealed IGUs with a gas such as argon, which has a much lower conductivity, manufacturers can cut heat loss through the window another 15% to 20%.

Argon is the most common gasfill used, but some window manufacturers are experimenting with krypton, which is even better, and other gases or combinations of gases. For instance, Yankee Windows, a small custom window manufacturer in

Table 1. Glazing Properties

Glazing Type	Thermal Performance				Light Transmittance		
	Center of Glass		*Unit Value*				
	R-Value	U-value	R-value	U-value	Visible Light	Total Solar	U.V.
Single glass							
Standard clear 1/8" gl;ass	0.9	1.1	1.1	0.90	90%	84%	80%
Insulated glass (2 layers)							
Standard 1/8" glass (1/4" air space)	1.8	.57	1.9	.54	81%	70%	52%
Standard 1/8" glass (1/2" air space)	2.0	.49	2.0	.49	81%	70%	52%
Hard-coat low-E standard glass (E=.40)							
1/2" space with air	2.5	.40	2.5	.40	76%	64%	36%
1/2" space with argon	2.9	.35	2.7	.37	76%	64%	36%
Hard-coat low-E w/ Energy Advantage (E=.20)							
1/2" space with air	2.9	.35	2.8	.36	76%	64%	36%
1/2" space with argon	3.3	.30	2.9	.34	76%	64%	36%
Soft-coat low-E (E=.15)							
1/2" space with air	3.2	.31	2.6	.39	77%	52%	27%
1/2" with argon	4.0	.25	2.8	.36	77%	52%	27%
Soft-coat low-E^2 (Cardinal glass)							
1/2" space with air	3.5	.29	2.9	.35	69%	35%	13%
1/2" space with argon	4.4	.23	3.3	.30	69%	35%	13%
Insulated glass with suspended film							
Hurd with Heat Mirror 88	4.1	.25	2.9	.34	71%	48%	<0.5%
Hurd InSol-8 (2 low-e suspended films)	8.1	.12	4.6	.22	62%	34%	<0.5%
Visionwall	8.0	.13	6.2	.25	Not avail.	Not avail.	Not avail.

Cornish, N.H., has just introduced a window with carbon dioxide between the sealed panes of glass. The company claims CO^2 outperforms argon and is far easier to obtain in high purity.

You can usually tell if a window is gas-filled by looking for a small aluminum rivet in the aluminum spacer between the panes of glass near one of the corners. Some manufacturers may soon begin using a different gas filling procedure, which will not require a filling tube and rivet to stop up the hole.

Edge Seals in IGUs

The edge seal in an IGU is what keeps the air or gas in and water vapor out. If that seal breaks, the window will fog up, and any low-conductivity gas will leak out and lower the R-value.

Double-seal systems. The conventional system used by most quality window manufacturers today relies on a double seal, which has a primary (inner) seal and a secondary (outer) seal at the unit's edge. The primary seal forms a small thermal break between the panes of glass and the aluminum spacer. The secondary seal provides a continuous seal from glass to glass on the outside of the aluminum spacer.

Thermally, the weak link in this system is the hollow aluminum spacer. Though hollow, the spacer generally conducts more heat than does any other part of the window.

The primary seal should have excellent resistance to moisture permeability, while the secondary seal should have high strength. Durability is a major concern, lest the seal break and the window fog. Top-quality windows often use polyisobutylene as a primary seal, with silicone, butyl, or polysulfide hot-melt as the secondary seal.

As you examine different makes of window, study the literature or ask the sales rep whether double seals are used and, more importantly, what kind of warranty the windows have relative to the glazing seal. The best seal warranties last as long as 20 years, while some products have warranties as short as one to five years. The length of the warranty is a good indicator of the edge seal's quality.

Two new challengers. While aluminum spacers and double seals have been the industry standard for decades, two new competitors to aluminum spacers are gaining widespread attention. "Swigglestrip," manufactured by Tremco, and "Edge-Tech" spacers, manufactured by Loren Manufacturing, serve as both glazing spacer and seal (see Figure 1).

Swigglestrip is a squarish strip of butyl rubber surrounding a thin corrugated aluminum strip, which provides rigidity. The product is now used by several hundred window manufacturers (out of some 2,500 manufacturers in the U.S.), including Peachtree, Alcoa, and Better-Built.

The Edge-Tech system is silicone foam rubber backed with a mylar layer to block moisture diffusion. Edge-Tech is used in the Pella Architect Series windows.

Yet another alternative — fusing the edges of the glass — was attempted for a while some years ago by several manufacturers, including Andersen and Pella. But the system proved problematic when used with large air spaces — the fused glass would crack if it got too thick. Just recently, however, Yankee Windows introduced a new welded-glass window with a 1/2-inch space filled with carbon dioxide. The trick, according to Yankee, is distributing the stress by rounding the edge properly. Yankee Window glazing comes with a 20-year warranty.

Thermal breaks. When more than two layers of glazing are used, as with Heat Mirror glazings, a complete thermal break can be incorporated into the edge system so that only low-conductivity materials touch both layers of glass. This substantially raises the unit's overall insulative value. Hurd has done this with its InSol-8 windows, which have the best energy performance of any windows commonly available in the United States.

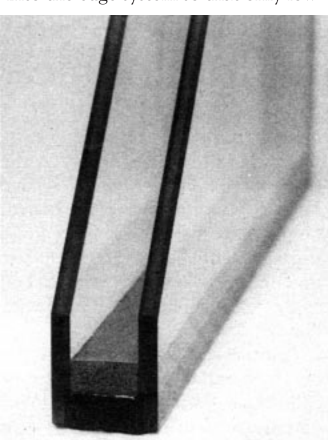


Figure 1. *New energy-efficient edge seals are replacing the standard aluminum spacers in double-glazing. The Edgetech spacer, shown above, is made of silicon foam backed with a mylar moisture barrier.*

The Visionwall system, currently being introduced into the U.S., takes this approach a step further by expanding the air spaces. The Visionwall system (shown in Figure 2 next page), like the InSol-8, has outer and inner layers of glass and two suspended Heat Mirror films. But in the Visionwall system, the spaces between different layers are much larger (the overall thickness of the glazing is over three inches!), and air rather than a low-conductivity gas mixture is used between the glazings. A unique aspect of this new window (really a clear wall system) is that the air space is not sealed in the conventional sense. A thin tube connects the sealed air space with the inside building air via a special dessicant chamber. This is a patented design, which the manufacturers are staying tight-lipped about; it's a mystery how they actually keep moisture from entering the air space. But Visionwall says the system has been used in Europe by its parent company for 10 years without a problem, and the company provides a reassuring 20-year warranty on residential applications.

Frame Considerations

Before the advent of high-performance glazings, window frame

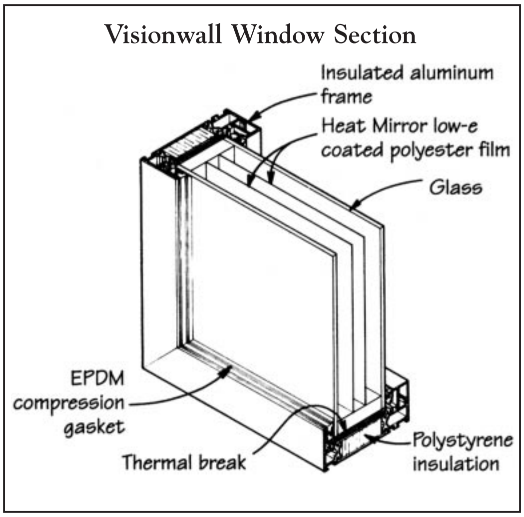


Figure 2. *The "Visionwall" is just that — a wall you can see through. With two layers of low-e film sandwiched between two glass layers, it is almost 3 inches thick and has an R-value of 6.3.*

construction was not a big issue, because the glazing usually had a much lower R-value than the frame components (at least with wood and vinyl windows). But with high-performance glazings, the frame has become a weak thermal link. To account for this, the energy rating method for windows is currently being revised (see "Window Ratings Take a U-Turn," below).

Wood is still the primary sash and frame material in new residential windows, often with aluminum or vinyl cladding to reduce maintenance. Unclad wood windows are also increasingly available with factory-applied finishes that hold up better than field-applied paints.

Extruded vinyl sash and frames are becoming increasingly common with replacement windows. Vinyl channel is generally less expensive than the straight-grained, old-growth pine used in most wood windows, and the energy performance is about the same. If the hollow vinyl channel is insulated with isocyanurate foam, as is done by a number of manufacturers, including Quaker Windows and Enco Industries, the energy performance will be much better than wood.

Metal frames — both aluminum and steel — have generally lost popularity in the northern parts of the U.S., though they are still widely used in the South, where energy and condensation concerns are not as great. With no thermal breaks, metal frames lose a lot of heat.

If quality thermal breaks are incorporated into the frames, however, energy performance with metal windows can be acceptable. In fact,

Window Ratings Take a U-Turn

What with gas fills, invisible films, and high-tech edge seals, shopping for windows is confusing enough. Over the next year, unfortunately, it may become more confusing still, as more manufacturers abandon the old center-of-glass R-value method of rating energy efficiency in favor of a new standard using "unit U-values."

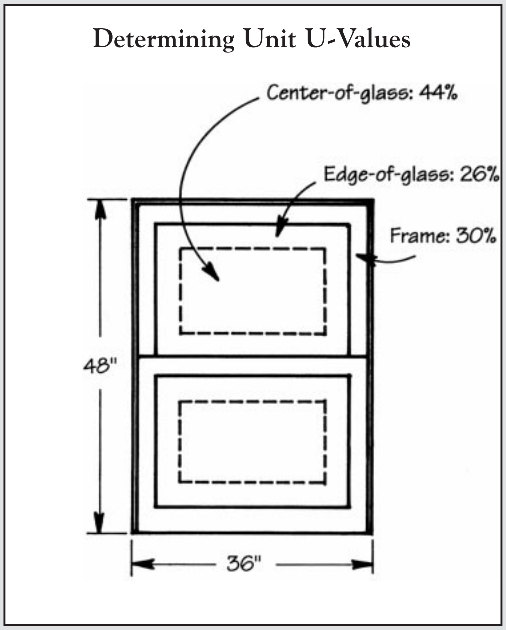
This new standard, revised by ASHRAE, and now being adopted by the National Fenestration Ratings Council (NFRC), will take into account heat loss through all parts of the window proportionately — not only the center-of-glass, but framing material and edge seals as well. (A future version of the standard will also account for air leakage and solar gain.) The resulting "unit values" of the NFRC rating will reflect more accurately the overall window's heat loss. The standard numbers will be for a 3x4-foot residential window (see illustration). Some manufacturers have already been using the new unit values for a year or two, although in some cases only in the fine print at the bottom of ads that emphasize higher center-of-glass R-values.

Lower, more realistic values. The new standard was developed because the old standard was giving inaccurate R-values for today's windows. The old industry standard, based on an ASHRAE standard, measured the center-of-glass R-value and made a simple adjustment depending on the frame material. It didn't account for variation in edge seal quality or for the expanding variety of frame designs. As a result, it gave R-values that were artificially high in some cases, or too low in others.

The new rating procedure, however, which was developed by ASHRAE and the NFRC in conjunction with the Lawrence Berkeley Laboratory, takes edge seals and frame construction fully into account. Called "NFRC 100-91: Procedure for Determining Fenestration Product Thermal Properties" — or the NFRC U-Value Procedure, for short — the method is based on a computer program called Windows 3.1. The procedure also includes actual tests of windows to verify the computer model findings.

Why U-values? The NFRC decided on U-values rather than the more familiar R-values "because it is technically more correct," says Jim Benney of the National Wood Window and Door Association (NWWDA). "A U-value is an air-to-air measurement. An R-value measures the conductivity of a homogeneous product, and windows aren't homogeneous."

Mike Kroenig, manager of advanced research at Andersen Windows and chair of the NFRC technical committee, feels that contractors and the public will soon become comfortable with U-values. "It's been my experience that with a little education, people understand U-values intuitively — the smaller the number, the less heat transferred. It's also more accurate, because you don't get the huge differences in number you do with R-values."



The new "unit U-value" window ratings are based on three main areas: the window's frame construction and materials; the edge-of-glass area, which includes the spacers used between sealed double panes; and the remainder of the glazing area, called the center-of-glass. For residential windows, the standard rating is for 3x4-foot double-hung unit; the standard for commercial windows is a 4x6-foot fixed unit.

U-values are the inverse of R-values — that is, you can convert either rating to the other by dividing it into 1. A U-value of .25, for instance, corresponds to an R-value of 1÷.25, or 4, and vice-versa.

With U-values, the lower the number, the better the insulating qualities of the window. Shopping for windows, you'll see unit values ranging from around .15 for the most insulative R-6.3 units, to around .35 to .40 for more typical double-glazed, low-e units. For comparison, an R-25 wall has a U-value of .04.

Smaller makers may lag. So when will windows start coming with these new values on the labels? Jim Benney says that most of the leading window makers, including Marvin, Andersen, and Hurd, are already using them in the technical literature. The move to the new values will get extra impetus in 1992, as California, Oregon, Washington, and Idaho begin requiring that all new windows sold in those states carry a label stating the NFRC unit U-value. Benney says that by the middle of 1992, all of the members of the NWWDA, which together account for 80% of the U.S. residential window market, will be using them.

Willie duPont, NFRC technical director, feels that within a few years, smaller window makers will use the rating as well, making it much easier to compare windows.

"There's a strong force driving this, which is the state and local legislatures and code agencies that will increasingly specify the NFRC standard. And some makers will want to use the NFRC stamp as a marketing tool. Those that don't will eventually suffer the problems associated with having an unusual labeling system. As time goes on and the label gets used more broadly, the NFRC stamp itself will be a selling point."

Until the standard really takes hold, you can expect to see both R-value and U-value numbers, sometimes based on the new rating, sometimes based on the old. In either case, your best bet is to verify whether it is a unit value derived by the NFRC unit U-value procedure or a simpler, but misleading, center-of-glass number.

— David Dobbs

Visionwall casement windows, which have the highest unit R-values of any residential window available (R-6.3, as compared to R-4.6 for Hurd), have aluminum sash and frames.

Weatherstripping

Different window styles offer tremendous differences in energy performance, primarily because of the different weatherstripping and seal qualities.

As a general rule, casement, awning, and tilt-turn windows are tighter (and therefore more energy efficient) than sliders and double-hung windows. This is because the former group can use compression gaskets as weatherstripping. EPDM gaskets are generally considered the best compression seals for these windows, though a combination of V-strip vinyl and nylon-wrapped compressible foam beading is also very effective. The better casement and awning windows have double or even triple weatherstripping to block wind at key points.

Inward-opening tilt-turn windows, relatively uncommon in this country, tend to be the tightest type of window, because of the six cam-action locking pins, which pull the operable sash in snugly all the way around.

Windows with a sliding sash (double-hung, single-hung, and sliders) generally cannot use compression gaskets, and so must rely on other types of weatherstripping that are not as effective. Among these windows, however, you'll find substantial differences in tightness from one manufacturer to another. In fact, one company's double-hung window might actually be tighter than another's casement window.

Yankee Windows solves the air tightness problem on its single-hung windows by putting the operable sash on a separate track with cams, so that the sash shifts 1/4 inch inward, away from the frame, as you slide it up, and is pulled tight to the frame as you close it. This allows the use of compression gaskets for a tight seal. Other manufacturers use double or triple channels in the track to make the air leakage route more circuitous and the windows, therefore, more airtight.

Shopping around. It is difficult to assess window tightness by just looking at the weatherstripping. You will generally do better by studying the manufacturer's literature — especially with the large national window manufacturers. Air tightness is generally listed on the technical specifications page of the manufacturer's catalog. It is most commonly listed as cubic feet of air flow per lineal foot of crack (cfm/ft) at a pressure difference across the window corresponding to a 25-mile-per-hour wind. Because this testing is based on nationally adopted standards and because most manufacturers (at least the large companies) use the procedure, it provides a good means of comparison.

How tight is tight? Look for air tightness ratings of .1 cfm/ft or lower with casement and awning windows, and .2 or lower for double-hung and sliding windows. The tightest windows on the market have ratings as low as .01 cfm/ft, and there are many casement and awning windows available with ratings in the .02 to .03 range. The Yankee single-hung window described earlier has a remarkable air tightness of .02 cfm/ft.

Special Features

With so many choices, it's easy to get confused. However, the best bet for most residential projects will continue to be what it has been for the last few years: a double-glazed, low-e, argon-gas-filled window made by a reputable manufacturer and carrying a good guarantee.

For the client who is willing to spend, of course, there are a slew of bells and whistles, some of which are mere icing, some of which are useful in particular climates or situations. Pella offers mini-blinds between unsealed panes of glass. Several companies are starting to use Weather Shield glass with a special Kleen-Shield coating on the glass to reduce dust and dirt accumulation. Most major manufacturers offer a tilt-in feature on double-hung windows for easy cleaning from the inside.

Special glazings that resist breakage (tempered and laminated glass), cut fabric-fading UV light penetration, minimize heat gain, or more effectively block sound transmission are also available in custom windows from a few of the larger manufacturers.

Finally, a number of high-end custom window manufacturers offer such design-oriented amenities as curved insulated glass (Pella and Marvin), insulated glass corner windows with a 90-degree bend (Marvin), and various custom hardwoods for the frames. ■

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