Energy–Efficient
Window Technologies

Important Elements in Your House

The windows in your house provide you with light, view, and natural ventilation. They can make you feel better about your house and can even increase your feelings of personal safety, because they let you observe what happens outside. However, they also make it more expensive to heat and cool your house.

Although they may increase household energy use, windows are desirable. People want them because of their positive qualities. Fortunately, you can control the amount of heat allowed to pass through your windows. When you cover the glass at night during cold weather and shade it during hot weather, you keep in furnace heat or keep out unwanted heat from the sun. Today, preventing heat gain and heat loss remains a prime goal in window technology research.

Windows and Heat Transfer Basics

A review of the basics of window heat transfer will help you understand how heat gains and losses affect your home, your comfort, and your utility costs. When you understand how heat moves, you can determine how to control or direct it. **Figure 1** shows four methods of heat transfer near a window: radiation, conduction, convection, and infiltration.

Radiation may be the most obvious. When the sun shines in the window on you or on furniture, floors, or walls, you see the light and feel the heat. Solar transmission or radiated heat is the heat you feel.

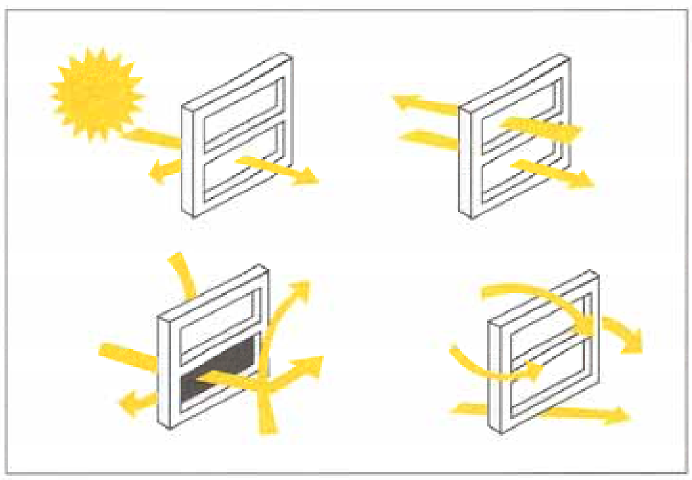

Figure 1. Methods of Window Heat Transfer

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Conduction involves window glass absorbing the heat from either the sun or from a heated room. That absorbed heat moves through the glass toward the cooler side. Therefore, during winter, the room loses heat through the glass to the outside. During summer, heat transfers or conducts into the room. This process of conduction is called *heat loss* in winter and *heat gain* in summer.

Presently, R-values tell you how much a specific material resists the flow of heat. You may be familiar with R-values, because this term is used for home insulation. Window manufacturers may refer to the energy efficiency of windows in terms of U-values (or U-factor). An R-value is a measure of resistance to heat flow; a U-value is a measure of the rate of heat flow through a material. The R-value is the inverse of the U-value. Look for the R-value or U-value of the entire window unit. This unit includes all glass panes, reflective films, inert gases, suspended elements, frames, and fasteners. Rating the whole unit allows you to compare competing products. Knowing the rating of your window unit also lets you to compare wall and window ratings.

Typically, a single pane of glass has an R-value of less than 1, which does not compare well to the recommended R-19 for the walls of a house. One square foot of glass can lose as much heat as 10 square feet of wall. Adding storm windows or insulating glass provides an air space between two layers of glass. This combination increases the R-value. Additional layers increasethe R-value and continue to raise the temperature of the inside surface of the glass.

When making comparisons among windows, look to see that the R-values or U-values listed are:

* *Based on current standards set by the ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers;*

* *Calculated for the entire window unit (frames included and not only for the center of the glass; and Representative of the same size and style of window.*

Convection heat transfer depends on air to move heat. The movement of air currents through an open window is a good example. Another example of convection is the air movement on either the inside or the outside of a closed window surface. Air flowing past a closed window moves warm air toward a cold surface or removes heat from a warm surface.

During the winter, cold outside air cools the surface of windows. When warm air from the top of a room circulates behind draperies or curtains, it passes the cold surface of the glass and releases its heat to the glass. This is heat transfer by convection.

During the summer, outside warm air heats the surface of the windows by convection. When air-conditioned air passes the window, heat from the window releases to the cool air. This is also heat transfer by convection.

Air infiltration or leakage is the air that filters through cracks around the openings. A 1/16-inch crack around a 3-foot by 5-foot window is equal to a 4-inch diameter hole in your wall.

The following affect the R-Value of a window:

- *The type of glazing material.*
- *The number of layers of glass.*
- *The size of the air space between layers of glass.*
- *The thermal resistance of conductance of the frame and spacer materials.*
- *The tightness of the window installation.*

Figure 2.

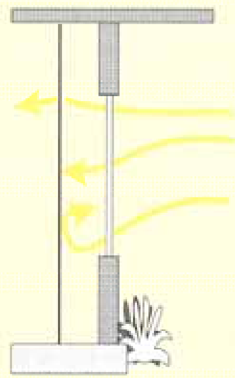


Figure 3.

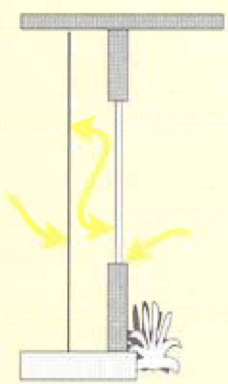
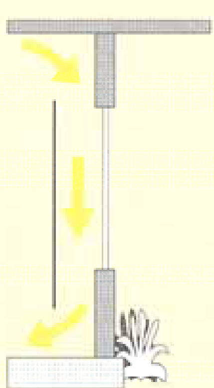


Figure 4.



Window Treatments That Reduce Heat Flow

A window system consists of the frame, glass, thermal breaks, and interior and exterior window treatments. The most cost-effective window system considers money saved and the total system cost. Several types of window treatments control heat transfer. Coverings inside or outside the window can reduce radiation by reflecting or absorbing heat. **Figure 2** shows how radiation or solar heat transmits through or absorbs into a drapery. In summer, opaque or silver roller shades reduce heat gain by reflecting it back through the glass. The design and type of material used control both light and heat gain.

Exterior shading, like awnings, is the more effective, because it controls excessive summer radiation before it reaches the glass pane. This also prevents some conductive and convective heat gain.

Window treatments must trap air to control heat transfer, as in **Figure 3.** Air pockets between layers are important insulation factors. Layers of shutters, blinds, shades, curtains, and draperies provide additional air spaces. Caulking and weatherstripping around doors and windows reduce the heat loss and gain caused by infiltration.

In winter, cascading air movement, as shown in **Figure 4,** creates cold air currents as it moves to the floor causing drafts. Cooled air requires re-heating, which means you are paying to re-heat the air you have already heated. Several methods to prevent this problem are cornice boards, sealed draperies, lambrequins, and window inserts, such as roller shades of insulated panels.

Cornice boards are not just decorative window treatments; they offer practical winter insulation when they prevent warm air from reaching the cold window. Draperies sealed on the sides and extending from floor to ceiling also help contain warm room air. Products like pressure tape with one side sewn on the drapery and the other side fastened to the wall will seal the edges. A lambrequin is a structure that frames an opening and is decoratively covered, trimmed,painted, or stained. Use this to cap and seal sliding glass doors, window groupings, or single windows. Tight fitting shades or insulated panels prevent circulating air from reaching the cold glass surface.

No window treatment will prevent air leakage through cracks around windows and doors. Careful installation, good caulking, and weatherstripping are needed to prevent high rates of air infiltration. Check caulking twice a year for consistent seals.

Windows Have Changed

Today, glazing materials, gas fills, number of layers of glass, window frames, and spacer materials and window frames offer other options for energy conservation. For years practical window applications have required many of the above window treatments to strike a balance between a high R-value and good transmittance of light. This is no longer the case; today's window systems can be made to be extremely efficient.

Glazing Materials

Glass is the primary glazing material used in homes, although plastics are available.The most significant development in window technology is the use of a low-emissivity (low-E) coating on glazing materials. Low-E consists of a thin metal or metallic oxide coating that reduces the transfer of radiant heat energy. Low-E glazings allow the full amount of light to pass through a window while reflecting 40 to 70 percent of the heat that is normally transmitted through clear glass. For cold climates, the low-E coating should be on the outer surface of the inner pane of a double-pane window. This prevents heat from radiating out of the home. For warm climates, the low-E coating should be on the inner surface of the outer pane. This will cause radiative heat to be reflected away from the house.

Plastic glazing materials, such as acrylic, polycarbonate polyester, polyvinyl fluoride, and polyethylene, are available. They are stronger, lighter, less expensive, easier to cut, and can have higher solar transmittance than glass glazing materials. The concern with plastic is its tendency to be less durable and more susceptible to the effects of weather than glass.

By increasing the number of glass panes in a window unit, the window's ability to resist heat flow increases.

Layers of Glass

A single pane window has very little insulating value (approximately, R-.91). By increasing the number of glass panes in a window unit, the window's ability to resist heat flow increases. Double pane windows are usually more efficient than single pane or storm windows and can increase R-values to approximately 2. Double or triple pane windows have insulating air- or gas-filled spaces between the panes. Each layer of glass and air space increases resistance to heat flow. Air space width is important, however, because if it is too wide (more than 5/8 inches or 1.6 centimeters) it will allow more heat transfer.

Gas Fills

Other efficiency options in windows include using gas instead of air between panes of glass. Using gases such as argon, Krypton, sulfur hexaflouride, and carbon dioxide help insulate windows and increase R-values because they transfer less heat than air.

Window Frames and Spacer Materials

As center-of-glass R-values increase, more consideration is given to edge losses that occur through the frame in which glazing is held and through the spacers that keep insulatedglass layers separated.

To reduce edge losses, manufacturers are improving window frames and spacers. Instead of traditional aluminum spacers, alternatives such as fiberglass, steel foam, wood, welded glass (no spacer), or combinations of these are available.

Frames can be made from a variety of materials including wood, vinyl, fiberglass, aluminum, or a combination of these materials. Each material its good and bad points. Typical aluminum frames have not been efficient choices for window frames. However, the thermal resistance of aluminum frames has been improved by the addition of thermal breaks placed between the inside and outside of the frame and sash.

Wooden frames have higher R-values than aluminum and have fewer problems with condensation and temperature extremes. They must be properly maintained and painted in order to keep them from cracking, warping, and sticking.

Vinyl frames have moderate to high R-values, require low maintenance and are easily customized. There are concerns, however, with their rigidity and strength, which may limit their weight capacity. Vinyl frames also can soften, warp, twist, and bow.

Fiberglass frames are relatively new. They have the highest R-values of all frames and will not shrink, warp, rot, or corrode. Some frames are hollow while others are insulated.

Window Films

There are many types of window films available today. Unlike Low-E treatments, these films give windows a shiny appearance. Films reduce sunlight transmittance *and* heat radiation through windows. This results in cooler homes in the summer and warmer homes in the winter. Some manufacturers do not recommend the use of window film on insulated glass. Before installing any film, check manufacturer recommendations.

Frames can be made from a variety of materials including wood, vinyl, fiberglass, aluminum, or a combination of these materials.

Summary

The variety of resistance factors offered by these products shows that technology continues to produce better insulated windows. Some day you may have insulated windows equal to your insulated walls. Though initial costs will seem high, increased demand for energy efficient housing will lower the costs of manufacturing new products. Remember the early years of energy conservation, when it was suggested that you reduce the number and size of windows in your house? If you compare that to today's potential for increased R-values, you see steady progress toward the day when you can locate energy efficient glass walls where you want them.

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