**U-Factors - Analyze**

A principal energy concern about windows is their ability to control heat loss. Heat flows from warmer to cooler bodies, thus from the inside face of a window to the outside in winter, reversing direction in summer (see Figure 3). Overall heat flow from the warmer to the cooler side of a window unit is a complex interaction of all three basic heat transfer mechanisms—conduction, convection, and longwave radiation. A window assembly’s capacity to resist this heat transfer is referred to as its U-factor (U-value). It is expressed in units of Btu/h∙ft2 ∙°F (U.S.) or W/m 2 ∙°K (European metric). Essentially, the lower the window’s U-factor, the greater its resistance to heat flow and the better its insulating properties.

National Fenestration Rating Council’s (NFRC) U-factor rating method is for the whole window, including glazing, frame, and spacers. Center-of-glass U-factor is also sometimes referenced, and describes the performance of the glazing alone without the effects of the frame. For most energy-efficient windows, the whole window U-factor is higher (worse in performance) than the center-of-glass U-factor.

The U-factor is used to express the insulation value of windows; R-value is used for insulation in most other parts of the building envelope (walls, floors, roofs). To compare R-value and U-factor, divide 1 by the U-factor number; e.g., a 0.25 U-factor equals a 1/0.25 = 4 R-value.

Low U-factors are most important in heating-dominated climates, although they are also beneficial in cooling-dominated climates. ENERGY STAR provides recommended U-factors for all U.S. climates (<https://www.energystar.gov/products/building_products/residential_windows_doors_and_skylights/key_product_criteria>).

**The Effect of Multiple Layers on U-Factors**

Multiple layers of glass or plastic films improve thermal resistance and reduce the heat loss attributed to convection between layers. Double glazing reduces heat loss (as reflected by the U-factor) by more than 50% compared to single glazing. Although U-factor is reduced significantly, the VT and SHGC for a double-glazed unit with clear glass remain relatively high. Adding a third layer of glass reduces the VT and SHGC.

**The Effect of a Warm Edge Spacer on U-Factors**

Warm edge spacers have become increasingly important as manufacturers switch from conventional double glazing to high performance glazing. To determine the overall window U-factor, the edge spacer has an effect that extends beyond its physical size to a band about 2½ in. wide. The contribution of this 2½-in.-wide “glass edge” to the total window U-factor depends on the size of the window. For a typical residential-size window (3 ft × 4 ft), changing from a standard aluminum edge spacer to a good-quality warm edge.