AAMA ANALYSIS

Why R is Not Simply the Inverse of U

BY KEN BRENDEN

Quick question: which is better—something rated 0.2 or 5?

When the Department of Energy introduced its "R-5" window program, some folks in the window industry might have done a double-take. After all, window thermal performance rating systems have always used the term "U-value" or "U-factor" to define window thermal performance. The latter, in fact, is clearly emblazoned on the National Fenestration Rating Council (NFRC) thermal performance label. So, why the sudden reference to "R-value?"

Many consumers have heard of R-values—a measure of a product's resistance to heat flow—and easily grasp that materials with higher R-values, such as R-19 vs. R-11 wall insulation, are more energy-efficient. That is, the better the product is at stopping the flow of heat to the outside during winter or to the inside during summer, the easier (and cheaper) it is for HVAC systems to maintain the desired indoor temperature for a longer time.

Usually, an R-value is given for a certain thickness of a specific homogenous material such as fiberglass insulation. The R-value of a structure that is made of layers of different materials (exterior sheathing, insulation, interior dry wall, etc.) can be estimated simply by adding the R-values of the individual layers.

While R-value measures resistance to heat transfer, U-value measures the rate of heat transfer. The lower its U-value, the better the product's ability to resist heat conduction.

In simple terms, U-value is the mathematical reciprocal of R-value; that is, U = 1/R and R = 1/U. For instance, a material with an R-Value of 5 has a U-value of 0.2 (1 divided by 5). As the R-value goes up, the U-value goes down, and vice-versa. However, it actually is more complicated than that.

> "As the R-value goes up, the U-value goes down, and vice-versa. However, it actually is more complicated than that."

Known officially as thermal transmittance, U-value is more of an engineering term used to designate the thermal performance of a system as opposed to that of a homogeneous material. U-value thus has been used traditionally to express the thermal efficiency of windows, which, unlike wall insulation, are complex assemblies of components with a variety of sometimes conflicting missions.

Wall insulation is singularly intended to limit heat transfer, making it fairly straightforward to assess insulation strictly on its ability to achieve that objective. However, windows may need to permit ventilation while limiting unwanted air infiltration and admit daylight while optimizing the effects of solar heat gain. Since R-value currently is applied to homogenous materials with a singular purpose and is understood in the marketplace based on such products, it may not be equitably applicable to multi-purpose products with varying construction, such as windows.

U-value accounts for how energy enters and leaves the material; it considers both conduction and radiation. R-value accounts only for the resistance to heat flow by conduction.

Per NFRC 100-2010, *Procedures for Determining Fenestration Product U-Factors*, the overall U-value of a window product is a prorated summation of U-values of the center of glass, edge of glass and frame areas. This takes into account such details as insulating glass edge spacers, certain hardware and frame cross-section.

Commercially, R-value is used to define the energy efficiency of many building materials because it is intuitively easier for consumers to understand that R-19 insulation is better than R-11, rather than trying to explain how U=0.05 insulation is better than U=0.09. However, in the case of windows, using U-values avoids comparing a window's multi-faceted overall performance to the purely insulating value of a wall.

So, while it is unusual to see window energy efficiency expressed in terms of R-value, it does relate well to the average consumer's understanding of insulating capability. However, it also could lead to confusion since R-value doesn't take into account all of the facets of a fenestration product the way U-value does. (*For more on U- versus R-values, see July-August* ***DWM****, page 21.*)

Ken Brenden serves as technical standards manager for the American Architectural Manufacturers Association in Schaumburg, Ill. He may be reached at kbrenden@aamanet.org. His opinions are solely his own and do not necessarily reflect those of this magazine.