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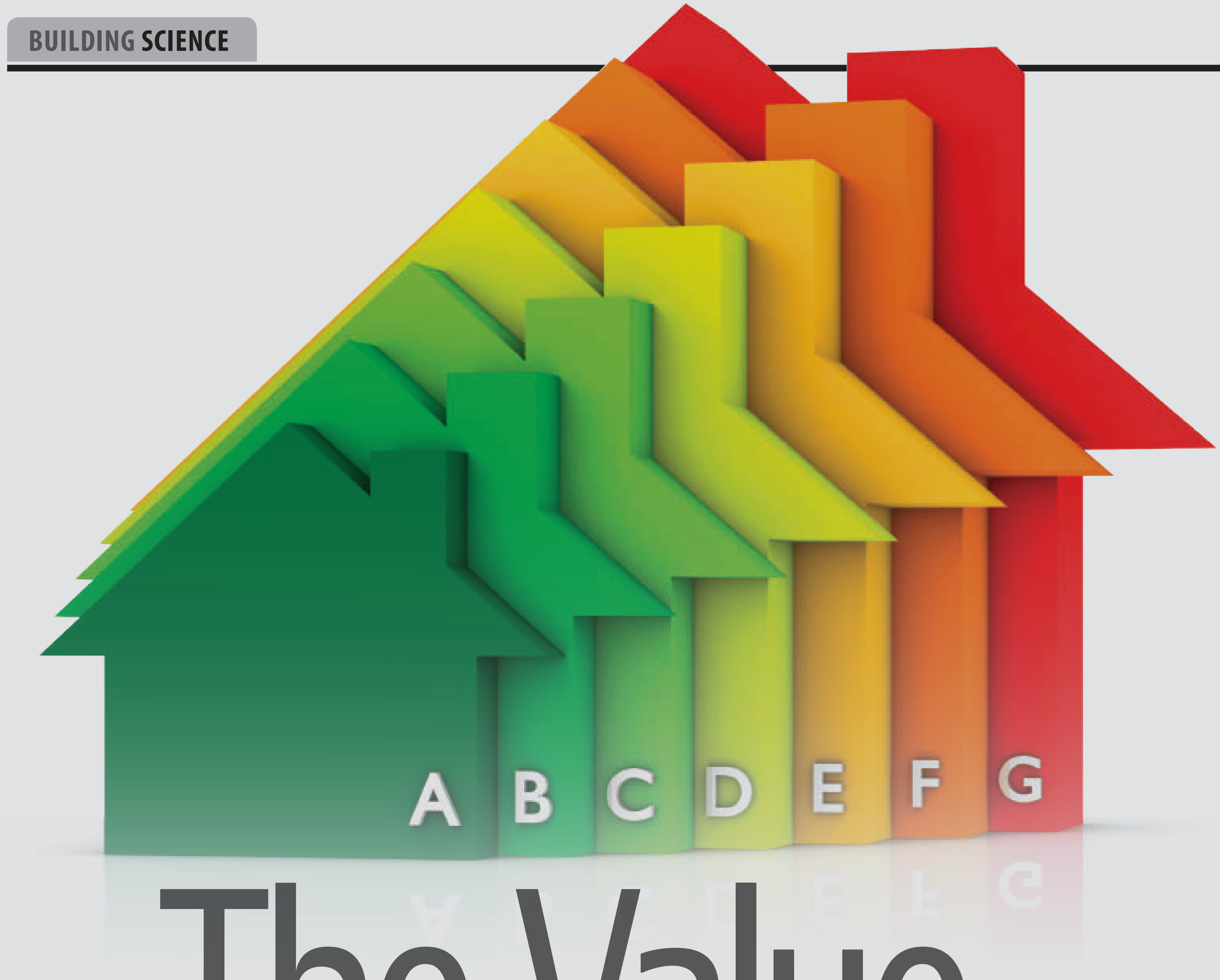


The Value of R-Value

Discussing the limitations of the well-known insulation metric

By Ken Wells

U.S. ENERGY USAGE STATS

Source: U.S. DOE

BUILDINGS

40%
U.S. Energy Demand

40%
U.S. CO^2 Emissions

ENERGY BILLS

44%
Heating & Cooling

$1300
Annual Energy Bill Per Family

ENERGY-EFFICIENT DESIGN/MATERIALS

10% - 50%
Reduction in Energy Bills

Most know R-value as a simple rating system for building insulation products, but what exactly is an R-Value? (see sidebar) This is a great question, and one that is not asked often enough in today's environmentally conscious society. However, an even better question is whether R-value is still a valid unit of measurement for the performance of insulation products. If not, then why is it still being utilized as the predominate gauge to compare these products? To answer these questions it is important to discuss how R-value came to be and how it is used today.

In the past, when energy was cheap, little thought went into energy efficient building design, and there were even fewer associated products; people did the best they could with what was available. Then, as energy prices rose, heating and cooling costs became an issue. (see sidebar) The Federal Trade Commission recognized the importance of energy expenditures on housing to homeowners and other consumers, and in 1979, it promulgated the R-value Rule, 16 CFR Part 460. The R-value Rule requires that, "thermal insulation manufacturers, among others, disclose the thermal performance of their products, based on uniform testing procedures adopted by the thermal insulation industry."

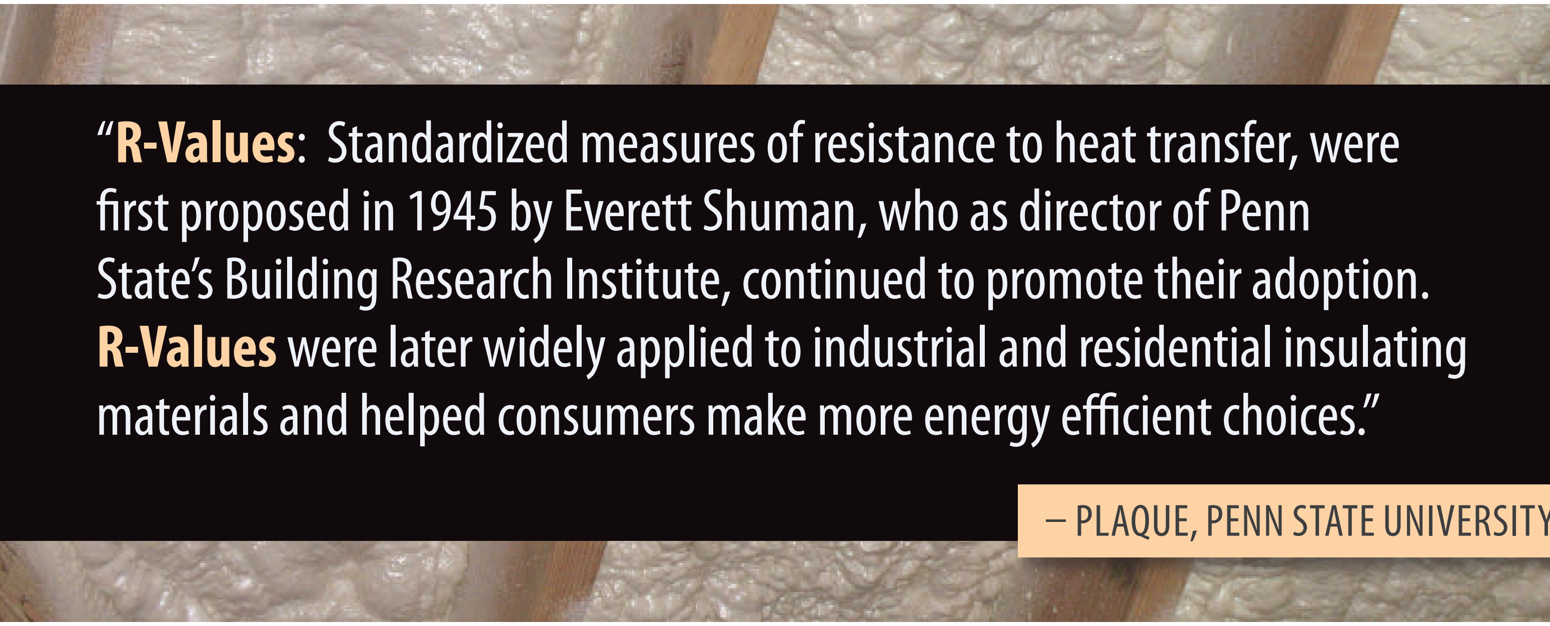
Specifically, per the FTC, an R-value "is the recognized numerical measure of the ability of an insulation product to restrict the flow of heat and, therefore, to reduce energy costs. R-values may be expressed per unit of thickness (e.g., one inch) or for the total thickness of a particular insulation product or installation. The higher the R-value, the better the product's insulating ability." Regardless of how an R-value is

R-VALUE

R-value is a material's resistance to heat flow, and can be defined by the following equation:

$$R = \frac{\text{Change in Temp.} \times \text{Area} \times \text{Time}}{\text{Heat Loss}}$$

Source: Sizes.com



> "**R-Values**: Standardized measures of resistance to heat transfer, were first proposed in 1945 by Everett Shuman, who as director of Penn State's Building Research Institute, continued to promote their adoption. **R-Values** were later widely applied to industrial and residential insulating materials and helped consumers make more energy efficient choices."
>
> – PLAQUE, PENN STATE UNIVERSITY

defined and calculated, it's relevance to this article and society in general is how it is used.

When it was created, the R-value was really the only useful tool in evaluating the effectiveness of the available building insulations, among other materials. After the R-value Rule was instituted, it improved the energy efficiency of buildings, contributed to the nation's energy conservation effort and improved the marketplace and technology for insulations.

The FTC defines the purpose of the R-value rule as, "a way for consumers to evaluate how well a particular insulation product is likely to perform, to determine whether the cost of the insulation is justified, and to make meaningful, cost-based purchasing decisions among competing products." The FTC is correct: there is a critical need for an accurate means to evaluate and compare the true performance of building insulations.

As consumers and contractors push to implement these modifications there has been a great demand for products and techniques aimed at trimming energy costs. Additionally, consumers have become more aware of the effects of their own energy consumption on the environment and the impacts of their carbon footprints. The building industry is now under an intense spotlight with regard to its considerable energy consumption and associated carbon emissions. Reducing a building's ecological impact through effective, high-performance insulation systems is becoming a priority. At the base of it all is a very controversial value, R-value. Does R-Value truly help consumers make more energy-efficient choices, or has today's building science and high-performance insulation systems outgrown R-Value as an accurate and reliable measurement of insulation's real-world performance? Is R-value simply a meaningless number on an insulation package that helps us to better organize our warehouses?

The R-Value can be an extremely misleading value to the average consumer, or even the seasoned building contractor, due to the laboratory test methods used in attaining these numbers. Zero-wind and zero-moisture test conditions are obviously not real-world conditions. Our homes and buildings leak air, and they often leak water. Water vapor from the atmosphere, showers, cooking, breathing, etc. constantly moves back and forth through the walls and ceilings. If an attic is not properly ventilated, the water vapor from inside a house, will very quickly condensate on the roof deck and drip into the insulation above the ceiling.

Because these R-value laboratory tests are conducted under ideal conditions, the real-world performance has absolutely no bearing on this test. As a result, the listed R-values can be higher than what actually is occurring in the real world, which favors fibrous insulations. Other insulations, like spray foam, drastically outperform fiberglass in real-world situations, but if it was up to simply the R-values derived from these tests, no one would ever know.

In fact, Oak Ridge National Laboratory states, "R-Values are a good starting point – but they are the results of small, meticulously prepared laboratory samples and do not necessarily reveal how an insulation system performs once installed in actual buildings. Different insulation systems with the same laboratory 'R-Value' can deliver much different levels of comfort and energy efficiency." (1) R-values are not indicative of a material's actual performance in a real-world performance, even with the best possible installation. Oak Ridge research shows that "perfectly installed" batts lose 11% of their labeled R-Value, and that "commonly installed" fiberglass batts lose 28% of their labeled R-Value. (2) This study confirms tests conducted 20 years ago by fiberglass manufacturers, and reveals the surprisingly large disparity between the labeled R-value and the installed R-value of fiberglass batts. (3)

Fiberglass, for instance, is generally assigned an R-value of approximately 3.5 per inch. It will only achieve that R-value if tested in a zero-wind, zero-moisture environment. Even small amounts of moisture will cause a dramatic drop in fiberglass insulation's R-value, as much as 50 percent or more, and it should be noted that fibrous insulation's performance will drastically drop with temperature fluctuations. (see sidebar) What further complicates this issue is that other insulations with proven higher performance per R-value, like spray foam, are held to this value and compared on a level playing field with fibrous insulations. For example, Code for Zone 4 stipulates an R-38 in a ceiling. Closed-cell spray foam's performance realistically tops out at around 4 inches, which is approximately R-25 to R-28, depending on brand. This R-25-28 has been shown to outperform an R-38 of conventional fibrous insulation. However, if someone wanted a closed-cell spray foam application in their attic, current code would require them to install an approximate six inches (R-38). This is a full one-third more material and labor that may unnecessarily prevent a great deal of people from using this product. Usually, when the code and the SPF situation is explained, along with the price tag, the customer will revert back to the much less effective, albeit code-approved, R-38 of fiberglass or cellulose. This comparison is happening every day and is and could be leading to misinformed decisions.

The use of R-Value alone is limiting, yet we have building codes that require these values. Passing building codes is like getting a D- on

FIBERGLASS & TEMPERATURE

"CIMA asserted that subsequent research by ORNL has shown a reduction of steady-state R-values caused by convective heat loss in very low density fiber insulation materials during very cold periods, when the temperature difference (delta T) between the heated area of a home and its cold attic becomes particularly great. CIMA stated that this phenomenon can reduce the steady-state R-value of affected products from 10% at a delta T of 50°F to 55°F (17°F to 25°F in the attic of a home heated to 72°F) to as much as 40% at a delta T of 90°F (-18°F in the attic of a home heated to 72°F), which can occur during the most severe winter conditions in some portions of the United States. CIMA recommended that the Commission require that insulation manufacturers provide winter design correction factors in coverage charts to compensate for R-value erosion due to convective heat loss, and require that, if insulation material is not subject to R-value loss under cold conditions, the manufacturer state on the package label that the insulation is not subject to convective heat loss at winter attic temperatures above -20°F."

a test–just barely passing. These codes were instituted mostly for safety and certainly not for building efficiency performance. There can be areas in a building, such as knee walls, or loose fill insulation in attic ceilings, where fibrous insulation is being installed with no air barrier on one side (the attic side). Some of these codes are slowly changing, but this extremely common practice even further reduces the actual installed R-Value from the package printed R-Value. Fibrous insulations absolutely depend on an air barrier, on both sides, to try and attain the performance their packaging states. Another complicating factor is that many other building-related calculations depend on an R-Value input. If R-Value is flawed from the beginning, what of the other calculations that require an R-Value input?

We've seen that insulation performance cannot be defined by any one number; multiple values are needed to describe its performance. Transfer this same logic to a real-world situation, such as buying a car. Suppose you are looking to buy a car and the salesperson tells you that he has the perfect car for you, and over the phone he tells you that this car is a 5. You would automatically wonder if it is a 2005, a 5-speed, a 5-liter, or a 5 on a scale of 1 to 10. It is likely you would want a bit more information that could give you better knowledge on how it will perform once you drive it off the lot, right? You might want to know how many miles to the gallon, and how many owners, among other things.

Although the thermal performance of any insulation product in actual use is a highly complex subject, with many parameters, in this day and age we can do better than R-value alone. It is critical that consumers, contractors, and specifiers alike have a useful, accurate tool for evaluating the true performance of the many types of building insulations. There is some very encouraging work being done by BuildingScience.com's Thermal Metric Project. A couple of sentences in the first paragraph really hit the nail on the head, "Ultimately, the project goal is to develop a metric that can capture the in-service thermal performance of whole assemblies. More accurate measurements will allow truly high-performance assemblies (of all types of construction and insulation materials) to be identified and promoted." When the testing criteria for a material's performance is flawed, antiquated, and not actually performance based, it is time to come up with new testing criteria and a new value truly based on performance, a P-Value.

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ABOUT KEN WELLS

Ken Wells has been part of the insulation industry for more than 17 years. In 2006, he started Elite Insulation & PolyPro LLC with his brother Chris, and father Bob; the company has been recognized with two National Industry Excellence Awards from the Spray Polyurethane Foam Alliance.