"R" Fairy Tale
The Myth of Insulation Values

by David B. South

One of the fairy tales of our time is the "R-value." The "R-value" is touted to the American consumer to the point where it has taken a "chiseled in stone" status. The saddest part of the fairy tale is the R-value by itself is almost a worthless number.

It is impossible to define insulation with a single number. It is imperative we know more than a single "R" number. So why do we allow the R-value fairy tale to be perpetuated? I don't know. I don't know if anybody knows. It obviously favors fiber insulation. Consider the R-value of insulation after it has been submersed in water or with a 20 mile per hour wind blowing through it. Obviously the R-value of fiber insulations would go to zero. Under the same conditions, the solid insulations would be largely unaffected. Again R-value numbers are "funny" numbers. They are meaningless unless we know other characteristics.

None of us would ever buy a piece of property if we knew only one dimension. Suppose someone offered a property for $10,000 and told you it was a seven. You would instantly wonder if that meant seven acres, seven square feet, seven miles square, or what. You would want to know where it was -- in a swamp, on a mountain, in downtown Dallas. In other words, one number cannot accurately describe anything. The use of an R-value alone is absolutely ridiculous. Yet we have Code bodies mandating R-values of 20's or 30's or 40's. A fiber insulation having an R-value of 25 placed in a house not properly sealed will allow the wind to blow through it as if there were no insulation. Maybe the R-value is accurate in the tested material in the lab, but it is not even remotely part of the real world. We must start asking for some additional dimensions to our insulation. We need to know its resistance to air penetration, to free water, and to vapor drive. What is the R-value after it is subjected to real world conditions?

The R-value is a fictitious number supposed to indicate a material's ability to resist heat loss. It is derived by taking the "k" value of a product and dividing it into the number one. The "k" value is the actual measurement of heat transferred through a specific material.

Test to Determine the R-Value

The test used to produce the "k" value is an ASTM test. This ASTM test was designed by a committee to give us measurement values that hopefully would be meaningful. A major part of the problem lies in the design of the test. The test favors the fiber insulations -- fiberglass, rock wool, and cellulose fiber. Very little input went into the test for the solid insulations, such as foam glass, cork, expanded polystyrene or urethane foam.

The test does not account for air movement (wind) or any amount of moisture (water vapor). In other words, the test used to create the R-value is a test in non-real-world conditions. For instance, fiberglass is generally assigned an R-value of approximately 3.5. It will only achieve that R-value if tested in an absolute zero wind and zero moisture environments. **Zero wind and zero moisture are not real-world.** Our houses leak air, all our 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 vapors from inside a house will very quickly semi-saturate the insulation above the ceiling. Even small amounts of moisture will cause a dramatic drop in fiber insulation's R-value -- as much as 50 percent or more.

Vapor Barriers

We are told, with very good reason, that insulation should have a vapor barrier on the warm side. Which is the warm side of the wall of a house? Obviously, it changes from summer to winter -- even from day to night. If it is 20 F below zero outside, the inside of an occupied house is certainly the warm side. During the summer months, when the sun is shining, very obviously the warm side is the outside. Sometimes the novice will try to put vapor barriers on both sides of the insulation. Vapor barriers on both sides of fiber insulation generally prove to be disastrous. It seems the vapor barriers will stop most of the moisture but not all. Small amounts of moisture will move into the fiber insulation between the two vapor barriers and be trapped. It will accumulate as the temperature swings back and forth. This accumulation can become a huge problem. We have re-insulated a number of potato storages which originally were insulated with fiberglass having a vapor barrier on both sides. Within a year or two the insulation would completely fail to insulate. The moisture would get trapped between the vapor barriers and saturate the fiberglass insulation to the point of holding buckets of water. Fiber insulation needs ventilation on one side; therefore, the vapor barrier should go on the side where it will do the most good.

We understand air penetration through the wall of the house. In some homes when the wind blows, we often can feel it. But what most people, including many engineers, do not realize is that there are very serious convection currents that occur within the fiber insulations. These convection currents rotate vast amounts of air. The air currents are not fast enough to feel or even measure with any but the most sensitive instruments. Nevertheless, the air is constantly carrying heat from the underside of the pile of fibers to the top side, letting it escape. If we seal off the air movement, we generally seal in water vapor. The additional water often will condense (this now becomes a source of water for rotting of the structure). The water, as a vapor or condensation, will seriously decrease the insulation value -- the R-value. The only way to deal with fiber insulation is to ventilate. But to ventilate means moving air which also decreases the R-value.

Air Penetration

The filter medium for most furnace filters is fiberglass -- the same spun fiberglass used as insulation. Fiberglass is used for an air filter because it has less impedance to the air flow, and it is cheap. In other words, the air flows through it very readily. It is ironic how we wrap our house in a furnace filter that will strain the bugs out of the wind as it blows through the house. There are tremendous air currents that blow through the walls of a typical home. As a demonstration, hold a lit candle near an electrical outlet on an outside wall when the wind is blowing. The average home with all its doors and windows closed has a combination of air leaks equal to the size of an open door. Even if we do a perfect job of installing the fiber insulation in our house and bring the air infiltration very close to zero from one side of the wall to the other, we still do not stop the air from moving through the insulation itself vertically both in the ceiling and the walls.

R-value tables are truly part of the "Fairy Tale." They show the solid and the fiber insulations side by side, implying they can be compared. The fact is, without taking installation conditions into account, comparisons are meaningless. Spray-in-place urethane foam provides its own vapor barrier, water barrier, and wind barrier. None of the other insulations are as effective without special care taken at installation. The fiber insulations must be protected from wind, water and water vapor. Again the tables need a second table to state installation conditions.

My experience is that R-value tables can be used as indicators. They need modifications to make them equal to real world conditions. There needs to be allowances made. They must show equivalents. These equivalents will be more like one inch of spray-in-place urethane equal to four inches of fiberglass in a normal installation. Footnotes to the table will need to define degradation of insulations in real world conditions. Only then will the "R-value" Fairy Tale become a real world success story.