Insulation R-Values:
Fact or Fiction?

Insulation. It seems simple. There is an R-value listed on the bag. It says the higher the R-value, the better the insulating properties. While this is true, it is also misleading. Heat loss or heat gain occurs through several processes, and the method used for testing R-values only addresses one of the processes. The test used to measure R-values is done under strict laboratory controls and has little meaning in the real world. Additionally, different insulation products use different testing methods to determine the R values and each type of insulation can be tested using several test methods. There are no real "apples to apples" comparisons between laboratory tests, or the real world effectiveness of insulation.

INSULATION COMPARISONS

FIBERGLASS

The advantages to fiberglass are its low cost, speed of installation, and simplicity of application. Fiberglass is the most common and widespread insulation product. The R-value test was developed with the aid of the fiberglass industry; the R-value test is considered by most to highly favor fiberglass products. The Oak Ridge National Laboratory research shows that "perfectly" installed fiberglass batts lose 11% of the labeled R-value, and that "commonly" installed batts lose 28% of the labeled R-value. Test results from The Department of Energy show that a building insulated with fiberglass, which has an interior temperature of 70ºF and an outside temperature of -18º degrees, the R-value of the fiberglass is decreased to less than 50% of the labeled R-value. Fiberglass is subjected to convection, air intrusion, air infiltration and radiation which affect its performance. If moisture is present in the fiberglass, the performance will also decrease. Its conduction rating is based on the R-value test developed by the fiberglass industry.

PLANT MATERIALS

The most common plant product is cellulose insulation made from shredded newspaper. Recycled "Blue Jeans" (cotton) insulation and straw bale walls are also used. Cellulose has better initial insulating properties than fiberglass, however, cellulose is heavy, making it prone to settling. As a paper product, it is highly subject to absorbing moisture, which will greatly reduce its R-value (a piece of wet newspaper has little insulative value). While not related to R-values, moisture can leech the fire retardant and fungicide out of the cellulose, creating a food source for mold. According to the California Bureau of Home Furnishing, the fire retardant (which is also the fungicide) in cellulose can disappear as much as 28% in the first 2 years.

FOAM INSULATIONS

The disadvantage of foam insulations is their cost; per R-value, the cost is much higher than for other insulations. Foam insulations, for the most part, are unaffected by convection, air intrusion, air infiltration and moisture. Foams provide a monolithic barrier which is hard to achieve with other insulation products. Foams are rated as air impermeable and FEMA has listed most foams as the only approved insulation where water or moisture is an issue. The real world conduction or R-value is greatly increased due to the lack of external forces which effect other insulations. Foams are not rated as a radiant barrier. However, their emissivity is better than fibrous type insulations. Most foam insulations have a thermal drift. This is where the aged R-value is lower than from when the product is initially manufactured. The testing for this, as with all insulation testing, is varied. The products can be tested with different temperature parameters, different ages, with or without skins, etc. Regardless of the final determined laboratory R-value, foam insulations perform the best in the real world.

REFLECTIVE BARRIERS

These are used successfully in hot climates to reflect heat out of an attic. Reflective barriers work by reflecting infrared heat, which is primarily heat from the sun. Reflective insulations often list an R-value. Reflective barriers have little R-value by themselves and any comparison of reflective insulation to R-values

is difficult and inappropriate. Radiant barriers are cost effective at reflecting infrared heat in hot climates. Their use in cold climates has not been shown to be cost effective. Most reflective insulations, when subjected to the same R-value test as all other products, have an R-value of about 2. Reflective barriers are rated by emissivity, which is simply a way to gauge how shiny the barrier is.

Looking beyond rated R-values, the overall performance, long term durability, home comfort, energy savings and payback of different insulation products need to be taken into consideration. Some insulation products settle or are affected by dirt and mold, some insulations are extremely durable while others are not. Products that provide a monolithic insulation create better home comfort and energy savings. In a building, heat loss or gain occurs by conduction, convection, air intrusion, air infiltration and radiation. All of these sources of heat loss work in unison. The better method to determine insulation qualities is by using a Whole-Wall R-value. This is where the wall assembly is measured for R-value rather than just the insulation. This helps reflect more real world construction. For a sample, with a 2X6 wood stud wall insulated with R19 batts, the wall assembly has a Whole-Wall R-Value of 12. A metal framed 6" wall with R19 batts has an R-value of about 6. These measurements do not even take into account air infiltration, air intrusion or other sources of heat loss. While labeling any insulation product with an R value is required for consumer information, the R-value has little meaning other than just for a general comparison. While gaps, voids, compression, long term durability and settling of insulation greatly affect the performance of any insulation, heat loss is generally measured by the following :

Conduction

This is the most commonly used standard for measuring insulation values, and is what R-values are based on. Conduction is the direct transfer of heat through a material. Think of conduction as touching your hand to a hot skillet, the heat travels through the metal. R-values are a measure of conductibility. R-value testing is done by placing a sample of insulation between two metal plates. Heat is applied to one plate and the amount of heat transferred to the other plate is measured, providing a number from which R-values are derived. While in a laboratory this measurement is accurate, it quickly looses it meaning in the field. Take a piece of fiberglass for example; a R-19 batt may test to be a R-19 in the R-value test, yet get it wet and hold it out in a cold wind, and it has almost no insulation value.

Convection

Convection is the transfer of heat caused by the movement of air. As cold air meets a heated surface, it rises, creating air movement. This is often why a solid picture window feels drafty. It is the air current created by the cold air next to the window being heated and rising up. Inside a wall cavity insulated with a loose or fibrous material, this same phenomena happens, creating what is called convection looping. As the outside air is warmed up, it rises on the exterior side of the insulation and cold air travels down on the interior side of the insulation. This air movement reduces the effectiveness of the insulation, reducing its R value and causing more heat loss. Just as a convection oven cooks faster from the use of moving air, moving air can cool an assembly down faster.

Air Intrusion

This is also referred to as wind wash. As air is forced into the insulation, the air pockets which create the insulative value in insulation are compromised, reducing its effectiveness. Air intrusion is comparable to having a cold wind blow through your shirt. Many furnace filters are made with fiberglass, and the air blowing through the filter is a prime example of air intrusion.

Air Infiltration

While air infiltration is not a direct measurement of an insulation's effectiveness, it is a major cause of heat loss. Different types of insulations seal better than others. Those which provide a more effective seal greatly reduce air infiltration. Air infiltration, on the average, accounts for 40% of the heat loss in most buildings. Air infiltration is like driving your car with the window rolled down. Air infiltration results in uncontrolled air infiltrating the house, generally in unwanted locations.

Radiation

Radiation is generally heat gain caused by radiant or infrared heat. It is the movement of energy caused by electro-magnetic waves. When you look into the sun and the sunlight makes your face warm, this is radiant

energy. Radiant heat control is most often used to keep heat out of a building rather than keep heat in it as sunlight contains many times more infrared energy than what is radiated out from the interior of a building. There are other factors which affect the R-value of materials. The main and most common culprit for the reduction of R-values is moisture. In a perfect world, all insulation would be dry. However, moisture from the house or outside will find its way into some insulation products. This moisture will greatly decrease the R-value of the insulation. Settling of insulations, while not directly effecting R-values, will reduce the overall R-value rating of a wall or ceiling system. Dust or dirt accumulations on or within insulations or the leeching out of fire retardants can also affect the thermal performance of insulation products.

The overall performance of the entire insulation system is affected by the choice of products used in different climates. The R-value of the product does not always reflect the building's performance. One of the causes of inefficient building performance is from the "Chimney" effect. This is where the building sucks air in from the walls and lets it out the ceilings. This event happens because of air leakage and is caused by gaps, settled insulation and air permeable insulation, which allow air to pass through. Drafts coming in mean that air needs to get out.

The most common insulation materials are Mineral Wools (Fiberglass and Rock Wool), Foam Insulations (Polystyrene, Rigid Polyisocyanurate Boards and Spray Urethane Foam), Plant Materials (Cellulose, Straw, Cotton, Cork) and Minerals (Vermiculite and Perlite), and Radiant Barriers (Foil Facing). The choice of the type of insulation used is most often based on the prevailing climate.