Understanding Thermal Conductivity

ecomate® LBA Technology

Understanding how insulation works can be confusing. There are many different types of insulation products (cellulose, fiberglass, rock wool, expanded polystyrene/EPS board, extruded polystyrene/XPS board, polyurethanes, etc.) and several methods to measure a product's insulating power. Many of the testing methods lack objectivity, and too much of the information is misleading and biased. Although not well known, polyurethanes have proven to be the best insulating products.

One objective method for comparing insulation materials is to measure a material's thermal conductivity. Thermal conductivity (also known as lambda value) is the rate at which heat passes through a material. Thermal conductivity/lambda is measured in watts per square meter of surface area for a temperature gradient of one Kelvin per one meter of thickness; expressed as W/m-K.

Thermal conductivity is independent of product thickness. The lower the conductivity, the more thermally efficient a material is. For a comparison of some common insulating materials' thermal conductivity/lambda values, see Table 1.

The Lower the Lambda, the Higher the R-Value
The more commonly known insulation term, R-value, is obtained from the inverse of thermal conductivity (1/K or 1/λ) multiplied by the thickness of the material. The higher the R-value, the better its thermal resistance – and the better its insulating power. See Table 2 for the R-values of various insulating materials.

Although Polyurethanes Are the Best Insulators, Not All PU Foams Are Created Equal
In the case of polyurethane foams, some of their insulating power actually comes from the blowing/expansion agents used to manufacture the foams. The thermal conductivity of the blowing agent itself is what makes a significant difference. The lower the lambda value of the blowing agent, the better starting point for a foam's insulating performance. Table 3 shows the thermal conductivity of some commonly used polyurethane blowing agents.

NOTE: Thermal conductivity may also be expressed as K-factor when dealing in Imperial units, in which case it is measured in BTU-in/hr-ft^2-°F.

Insulation Power Comparison

Table 1

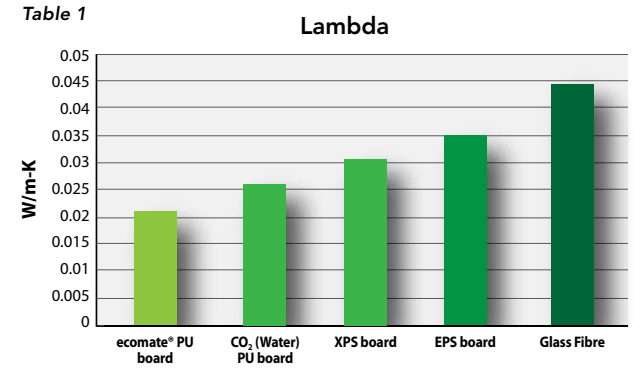
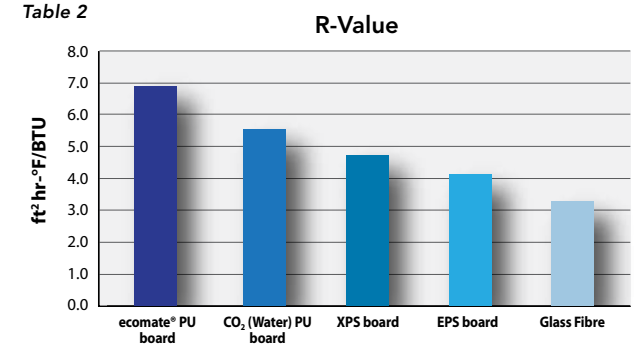


Table 2



Better Products.
Better for the Environment.

Historically, manufacturers of polyurethane insulated board, panels, and ccSPF have found that the best-performing blowing agent for thermal efficiency has been HCFC-141b, and the worst blowing agent has been CO_2 (water). Although HCFC-141b is a great insulator, it unfortunately also carries environmental "baggage." HCFC-141b contributes to global warming and ozone depletion. The US Environmental Protection Agency enacted a ban on its use in 2006, and phase out schedules for HCFCs have recently been sanctioned worldwide.

Table 3

Thermal Conductivity: Blowing Agents

Blowing Agent	Lambda (λ) at 25°C (W/m-K)	K-Factor at 77°F (BTU-in/hr-ft²-°F)
HCFC-141b	10.0	0.069
HFC-365 mfc	10.6	0.073
ecomate	10.7	0.074
HFC-245fa	12.0	0.083
HFC-134a	13.0	0.090
CO_2 (Water)	14.7	0.102

The EPA has also announced phase out schedules for many HFC blowing agents which contribute to global warming as well. Fortunately, as Table 3 shows, there is an excellent blowing agent option for polyurethane product manufacturing – ecomate® liquid blowing agent (LBA) technology from Foam Supplies, Inc. Ecomate® is both thermally efficient and environmentally friendly, with no ozone depletion or global warming potential.

Just as With Thermal Conductivity, PU Foams Vary in R-Value, Based on the Blowing Agents

Table 4 compares the R-values of two polyurethane foams (one made with ecomate® LBA and one made with water as the blowing agent) at two different thicknesses. The foam made with ecomate® has a greater insulating power or R-value than the foam made with CO_2 (water). In this example, the insulation board made with ecomate®-based polyurethane foam can be approximately 20% thinner than the board made with a water-based polyurethane foam, yet still provide the same insulating power.

Table 4

Insulating Power