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The R-Factor

Take advantage of new insulation products to meet the high-performance challenges of today's building science details.

By: Mark LaLiberte

Nowhere is an understanding of building science more important than in designing the building enclosure. To optimize its performance, we must attend to the whole system as well as to the details. Each component plays an important role on its own and in relationship to the others.

It would be hard to find a more critical decision than your choice of insulation. In addition to R-value, you also need to look at these materials' relationship with the rest of the building envelope. Though the fundamentals of building science are unchanging, new products and evolving best practices allow insulation to play an increasingly important role in whole-house system design.

A comprehensive insulation strategy takes into consideration the products' efficiency, cost, application techniques, and environmental impact. But we also need to factor in the cost of potential warranty claims, comfort complaints, and durability challenges. Let's take a closer look at some of the products and practices being used to insulate today's high-performance homes.

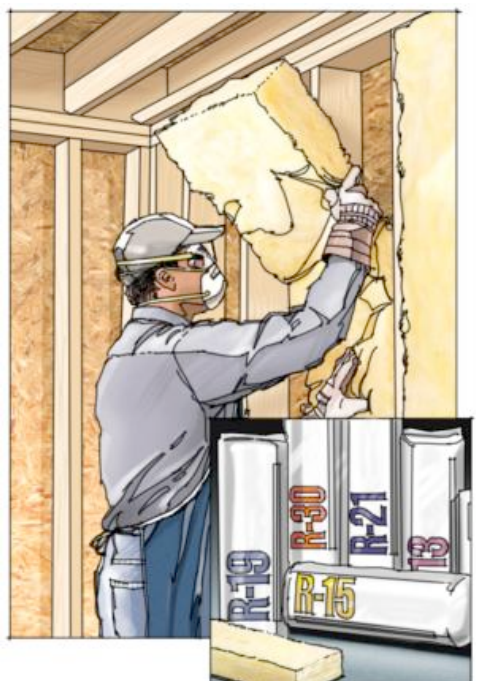
Thermal Resistance Defined

Thermal energy travels from hot to cold, so we lose heat from inside to outside in cold months and lose our cool in the summer as heat tries to move indoors.

Insulation's job is to slow down that transfer of heat. R-value is a measurement of a material's ability to resist the transfer of energy; as we all know, the higher the R-value, the more effective the insulation. By doubling the thickness of an insulating material, we can double its R-value, cutting energy transfer in half; however, the law of diminishing returns means that the same resources applied over again yield half the net change. Looking at a complete wall assembly design and its energy analysis is the only way to find the right balance between construction cost, long-term energy savings, and overall environmental impact.

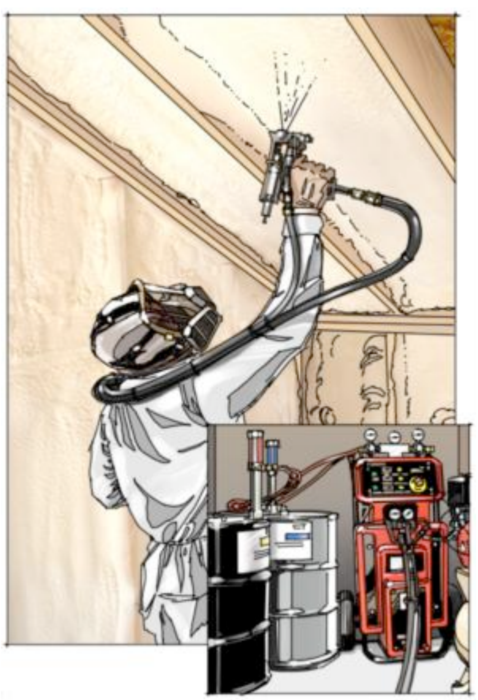
Product Selection

Below is a brief review of the major types of insulation, from simplest to more complex and from least cost to most. Remember: As we improve our thermal enclosure, we also can reduce the complexity and size of our heating and cooling systems. This reduces first cost and saves on long-term operating cost. In a Life Cycle Assessment of this approach, higher-performing insulation will result in the best choice.



BATTS: If you are considering using batt insulation, select high-density batts with a higher insulating value. Remember that careful installation is vital; too often, poor installation techniques, design complexities, framing challenges, and other factors can cause gaps and voids between and around batts, seriously deteriorating their performance over time.

LOOSE-FILL SPRAY: Fibrous spray insulations are an innovative use of some traditional blown insulation products or recycled materials all using low-toxicity binders. These loose-fill solutions can be sprayed when mixed with moisture or binding agents. Some are intended for filling cavities while others are designed to adhere to exposed surfaces such as joists and floor pans. Correct installation requires careful management of moisture content and carefully watching the installed density. Cellulose-based solutions such as Green Fiber's Cocoon System are made from recycled newspaper and incorporate EPA-registered fungicide. Some companies are fine-tuning their blends to emphasize fireproofing and acoustical attenuation along with energy-saving insulation.



SPRAY FOAM: Foam-in-place technology is playing an increasingly important role in establishing a tight building envelope. Historically, most of these products utilized high-density, closed-cell polyurethanes, which involved exposure to potentially hazardous chemicals during application. Today they usually flash their VOCs quickly and become fairly innocuous after a short time. Closed-cell foams are very effective at managing air leakage and can have high R-values of up to 7 per inch. Unfortunately, most still use HCFCs as blowing agents (with some notable exceptions such as SuperGreen).

But there are now a number of non-ozone-depleting, open-cell products available. These open-cell foams have lower R-values, but manufacturing them requires fewer hydrocarbon resources. Some are managing to replace petrochemicals with bio-based raw materials. The Icynene insulation system has a very long track record and is the most widely installed open-cell foam used today. BioBased 501 is a polyurethane foam with a soybean-oil base that uses carbon dioxide as a blowing agent. These products seem to be gaining rapid acceptance as builders look for alternatives to traditional insulation.

SIPS: An alternative to installing traditional insulation, Structural Insulated Panels (SIPs) are typically constructed of OSB sandwiching a foam core. Pros appreciate the ease of assembly and the improved performance SIPs can provide. Typical wall system R-values are from 22 to 30; these walls actually perform remarkably well as they have less framing materials thus reducing thermal bridging. This would eliminate the conventional framing approach and provide a faster and very tight enclosure. Still, these are not perfect either and require some training to install them correctly.

Framing Details

Regardless of the system you choose, remember that structural framing has a significant impact on insulation performance. The space between the studs may be R-22, but the studs, trimmers, headers, and rim joists themselves are only R-7 or R-8. Also remember that complex framing designs increase the building envelope’s surface area, and more surface area means more energy loss. Design the building shell with less surface area, and you’ll be miles ahead before you even start thinking about insulation.

Most wall insulation is traditionally installed in wood stud cavities, but adding insulation on the outside of the frame can significantly improve building performance if traditional framing is used. Besides adding additional insulation value, insulating the exterior of the enclosure also reduces dew-point potentials in cold climates and condensation potentials in high latent-load cooling climates. Exterior insulation also reduces the thermal bridging effect that studs have in a wall.

Because steel-stud exterior walls lose much more heat than wood-framed walls, they have the additional need to be sheathed in extruded or expanded polystyrene. The Department of Energy specifies the application of a minimum 1- to 2-inch layer over steel framing members to prevent thermal transfers that bypass the insulated cavities. In most climates, I would recommend installing at least 2 to 3 inches of foam if steel studs are being used. Enclosing the box with rigid insulation also can tighten up the envelope and will keep framing materials warmer and drier. Remember, in all but the most extreme climates a house enclosed in foam sheathing should not have an interior polyethylene vapor barrier. (More on this topic in the next issue.)

Put It All Together

With all of these approaches, real success comes from paying attention to the details. When wall and roof assemblies effectively connect with improved insulation products, we achieve synergistic gains. As our industry increases understanding of and respect for the fundamentals of building science, it is leading to many significant product innovations. Keep your eyes and knowledge tuned to improving our buildings' performance.

President of LaLiberteOnline and a principal of Building Knowledge Inc., Mark LaLiberte is a highly regarded green building consultant who helps builders nationwide understand and apply proper building science construction principles to improve their homes. www.buildingknowledge.com; www.laliberteonline.com.

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