

Insulation & Air Sealing

Introduction

Insulation and a tight exterior seal are two of the most important components of a home's protection against outside conditions, often called its "thermal envelope." This envelope consists of all six sides of the home—the four walls, roof, and foundation. All envelope components interact as a system to affect the flow of heat, air, moisture, and sound into or out of a home. The better the thermal envelope performs, the better the health and comfort of occupants and the lower their utility and maintenance bills.

Discussion

Insulation and R-value

Insulation is any material that *resists* the transfer of heat. Such resistance is measured by a numerical R-value--the higher the number, the higher the resistance and the better the insulation. A material's R-value is laboratory tested under ideal and controlled conditions, but actual or effective R-value is dependent on the quality of installation, the assembly within which the insulation is constructed, and the weather. Building codes require a minimum R-value for homes, with levels varying depending on installation location (i.e., roof or walls) and climate.

Priorities

The roof or attic is the most important part of the home to insulate in all climates. In hot weather, the sun beats directly on the roof, accumulating heat in the attic which then radiates into the living space and requires cooling. Radiated heat moves in all directions (from hot to cold), but heated *air* rises through a natural process called convection. In cold weather the loss of rising hot air from the conditioned space through the ceiling and roof is a particular problem. Because they are prone to be weak points in the

envelope, attic hatches must be well insulated and weather-stripped (sealed).

Wall insulation is far more important in a cold climate than a hot one. In a hot climate, wall insulation serves primarily to keep indoor temperatures even--it will have much less effect on energy bills in a warm climate than in a cold one. Envelope walls that separate the attic space from the living space (knee walls) must be carefully insulated in all climates because, as mentioned, attics typically get much hotter than the outdoor temperature.

Floor insulation is very important in areas where the ground freezes. Where it does not freeze, insulation is not needed under slab foundations but is required under pier-and-beam systems. Insulation is also needed under living area floors located over an unconditioned space such as a garage or carport. In addition to the walls, keep in mind that windows and their installation are also vital important components of the thermal envelope--select and install them appropriately for the given climate and orientation (see the Windows fact sheet).

Installation

Correct installation is a critical but frequently overlooked means of ensuring that insulation performs near its stated R-value. The insulation system's integrity must not be compromised by gaps or voids (such as at the top or bottom of walls or around pipe penetrations), should be encased on all six sides, and must touch the surface it is intended to insulate. Insulation should not be compressed but must be dense enough to prevent air currents from passing through it (a problem with fiberglass batts in very cold climates).

To adequately control the transfer of heat, air, moisture, and sound, the thermal envelope must be *continuous and unbroken*—an issue often more critical than rated R-value. Care must be taken to insulate at the tops of walls next to roof rafters where space is usually inadequate (*energy-heel trusses*, an advanced framing technique, can alleviate this problem). Pay close attention to adequately insulating hard-to-reach places such as at band joists and behind



tubs and showers on exterior walls. A better insulation job can be accommodated by a framing method known as Optimum Value Engineering (OVE). OVE requires less lumber while enabling wider member spacing and improving accessibility (see the Wall Insulation technical bulletin on the Southface Energy Institute's web site listed at the end of this fact sheet). If metal framing is used, it is critical to reduce "thermal bridging," a process in which the high conductivity framing members significantly compromise wall R-value via their rapid heat transfer effectively bypassing the installed insulation. One way to lessen such an undesirable effect is to install foam board on the building exterior.

Any cracks or holes that cannot be filled with insulation must be sealed with caulk or foam to stop airflow. Note that air is not only a "conduit" for heat, but also for moisture in the form of water vapor, which can cause discomfort, rot, and mold problems. Careful sealing also minimizes pest and dust entry and even fire passage.

Air Tightness

Cracks and holes should be sealed and not relied on as a means of bringing fresh air into the home. The envelope should be as tight as possible and fresh-air ventilation provided under occupant control. Ventilation options include whole house fans, operable windows and skylights, and mechanical fresh air intakes. Mechanical options, such as heat/energy recovery ventilators (HRVs/ERVs), can stand-alone or be incorporated into the heating or cooling systems.

Complexity

Be aware that determining the ideal level of insulation is actually more complicated than just considering climate, even though current codes address mainly this factor. Proper levels also depend on house design, construction type and materials, ventilation, occupant-generated moisture inside the home, the inside to outside temperature difference, and more.

Types and Forms

Insulation comes in many materials and forms. Suitability for a given application varies, as does cost, availability, and tradition in a given area. Some insulation products are now available without harmful chemicals such as formaldehyde and HCFC or CFCs, or with a high recycled material content. Approximate R-values per inch (of thickness) are given in parentheses. "Total-fill" type insulations will provide a higher effective R-value than batts, which fit in-between framing members.

Cellulose insulation (3.0-3.7 + total fill) is made of ground-up, recycled newsprint treated with borate as a fire and pest retardant. Cellulose can be damp- or dry-blown into walls and dry-blown into attics.

Fiberglass insulation (2.2-4.0) has been the industry standard, is made from spun glass fibers, and is available in faced or unfaced batts or loose-fill. Precautions should be taken during installation to avoid contact with skin or inhalation of airborne glass fibers. Traditionally, formaldehyde has been used to bind these glass fibers. Formaldehyde is a volatile organic compound (VOC) that can offgas potentially irritating or harmful chemicals into a home. Recycled-content and "no added formaldehyde" products are readily available at comparable costs.

Cotton insulation (3.0-3.7) is available in faced or unfaced batts. It is manufactured from post-industrial recycled content fibers of the textile industry (primarily blue jean factories), with some polyester fiber for strength and "loft." Unlike fiberglass and mineral wool, cotton insulation is not irritating or potentially dangerous to handle. It should be torn, not cut, to fit. **Cork** and **wool** insulation are options made from rapidly renewable, natural sources and now available.

Foam board typically has a higher R-value per inch than batt and loose-fill products (e.g., expanded polystyrene, 3.8; extruded polystyrene, 5.0; polyisocyanurate, 5.8-7.0). Well-installed foam board (taped at the seams) creates an improved air barrier. Look for products that use water or pentane as the



blowing or foaming agent instead of HCFC, which contributes to ozone layer destruction.

Spray-in place foams (3.9-4.3 + total fill) have excellent air-sealing properties, high R-values, and most of them can easily be installed anywhere, including overhead. They are a particularly effective choice for “cathedralized” attics (insulation is installed at the rafters, so the attic is within the thermal envelope--a good approach if ductwork is placed in the attic). Most of these foams are low-density, open-cell polyurethane or polyisocyanurate. HCFC-free foam is available, as is soy-based foam. Spray foams are newer in the market, so installers may be hard to find and costs may be high.

Mineral wool (2.8-3.7) is produced as batts or loose-fill made from rock wool (from natural rock) or slag wool (an iron ore blast furnace waste product).

Structural insulated panels (SIPs) (4.0 + total fill) consist of rigid expanded polystyrene foam sandwiched between panels of oriented strand board (OSB). SIPs are fabricated off-site, come in thicknesses from 4 to 12 inches, and are fairly interchangeable with wood frame construction if incorporated early in a project’s design phase. SIPs advantages include a very high *effective* R-value, excellent soundproofing performance, and rapid on-site installation. Note that mechanical ventilation is typically required when using SIPs due to the resulting airtight nature of such construction. As with foam board and spray foams, look for products fabricated with and from more environmentally friendly foam materials.

Green Building Benefits

Energy Savings and Cleaner Air

Insulation and air sealing lowers monthly utility bills by reducing electric and gas use at the point of consumption. Due to the inefficiency of energy production and transmission, the small amount of electricity that is saved at the home reduces a larger amount of produced power demand at the power plant, thus reducing the demand for electrical power plants. Fewer required power plants means less air and water

pollution as well as a reduction in the environmental impacts of resource extraction.

Recycled Content

Some insulation materials also include recycled content, which offers the environmental benefits of resource conservation and reduced waste. The typical recycled content of various insulations is as follows:

Fiberglass: 0-30%, mostly post-industrial, some post-consumer

Cellulose: 75-95%, mostly newspapers

Mineral wool: 0-90%, rock wool – 0%, slag – 90%

Cotton: 75-95%, post-industrial fabric trimmings

Foam board: 0-50%, post-industrial foam

Spray foam: 0-15%, post-industrial chemicals

Durability

All insulation products are very durable and do not degrade under normal conditions. Some loose fill insulations may settle somewhat over many years, especially in attics, so it may become necessary to “top off” some 10-20 years down the line. If insulation becomes wet it will lose much of its R-value and it may permanently degrade. Keeping all building materials dry should always be a concern and top priority in all areas of the home and its construction.

California Suppliers

There is a vast array of insulation suppliers. Traditionally, fiberglass is the default insulation as it is the cheapest, but there is growing supply and market recognition of frequently better choices such as cellulose, cotton, rigid foam board, spray foam, and SIPs. Research the various options, installers, costs, and benefits available for each product. Remember that your insulation investment is a one-time decision that will have performance repercussions for the lifetime of your home.

- Search Build It Green’s **AccessGreen Directory** to find local suppliers and services: www.builditgreen.org



For More Information

- **Southface Energy Institute** has a number of fact sheets, technical bulletins, and other information on insulation, air sealing and testing, as well as green homes, workplaces, and communities:
www.southface.org
- **Building Green's** website provides detailed material and environmental comparison information concerning different types of insulation products:
www.buildinggreen.com/features/ins/insulation.cfm
- **Consumer Guide to Home Energy Savings** (in online and print form) from the American Council for an Energy-Efficient Economy (ACEEE) outlines energy-efficient practices and lists the most efficient products:
www.aceee.org/consumerguide/index.htm

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