INSULATION MATERIALS

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Cellulose, a fiber insulation material with a high recycled content, is blown into a home attic. | Photo courtesy of Cellulose Insulation Manufacturers Association.

Insulation materials run the gamut from bulky fiber materials such as fiberglass, rock and slag wool, cellulose, and natural fibers to rigid foam boards to sleek foils. Bulky materials resist conductive and -- to a lesser degree -- convective heat flow in a building cavity. Rigid foam boards trap air or another gas to resist conductive heat flow. Highly reflective foils in radiant barriers and reflective insulation systems reflect radiant heat away from living spaces, making them particularly useful in cooling climates. Other less common materials such as cementitious and phenolic foams and vermiculite and perlite are also available.

FIBERGLASS

Fiberglass (or fiber glass) -- which consists of extremely fine glass fibers -- is one of the most ubiquitous insulation materials. It's commonly used in two different **types of insulation**: blanket (batts and rolls) and loose-fill and is also available as rigid boards and duct insulation.

Manufacturers now produce medium- and high-density fiberglass batt insulation products that have slightly higher **R-values** than the standard batts. The denser products are intended for insulating areas with limited cavity space, such as cathedral ceilings.

High-density fiberglass batts for a 2 by 4 inch (51 by 102 millimeter [mm]) stud-framed wall has an R-15 value, compared to R-11 for "low density" types. A medium-density batt offers R-13 for the same space. High-density batts for a 2 by 6 inch (51 by 152 mm) frame wall offer R-21, and high-density batts for an 8.5-inch (216-mm) spaces yield about an R-30 value. R-38 batts for 12-inch (304-mm) spaces are also available.

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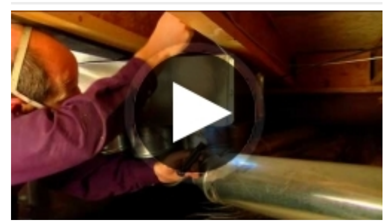
ENERGY 101



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One unconventional fibrous insulation product combines two types of glass, which are fused together.

As the two materials cool during manufacturing, they form random curls of material. This material may be less irritating and possibly safer to work with. It also requires no chemical binder to hold the batts together, and even comes in a perforated plastic sleeve to assist in handling.

Fiberglass loose-fill insulation is made from molten glass that is spun or blown into fibers. Most manufacturers use 20% to 30% recycled glass content. Loose-fill insulation must be applied using an insulation-blowing machine in either open-blow applications (such as attic spaces) or closed-cavity applications (such as those found inside walls or covered attic floors). Learn more about **where to insulate**.

One variation of fiberglass loose-fill insulation is the Blow-In-Blanket System® (BIBS). BIBS is blown in dry, and tests have shown that walls insulated with a BIBS system are significantly better filled than those insulated using other forms of fiberglass insulation such as batts.

The newer BIBS HP is an economical hybrid system that combines BIBS with spray polyurethane foam.

MINERAL WOOL INSULATION MATERIALS

The term "mineral wool" typically refers to two types of insulation material:

- Rock wool, a man-made material consisting of natural minerals like basalt or diabase.
- Slag wool, a man-made material from blast furnace slag (the scum that forms on the surface of molten metal).

Mineral wool contains an average of 75% post-industrial recycled content. It doesn't require additional chemicals to make it fire resistant, and it is commonly available as **blanket (batts and rolls) and loose-fill insulation**.

CELLULOSE INSULATION MATERIAL

Cellulose insulation is made from recycled paper products, primarily newsprint, and has a very high recycled material content, generally 82% to 85%. The paper is first reduced to small pieces and then fiberized, creating a product that packs tightly into building cavities, inhibits airflow, and provides an R-value of 3.6 to 3.8 per inch.

Manufacturers add the mineral borate, sometimes blended with the less costly ammonium sulfate, to ensure fire and insect resistance. Cellulose insulation typically requires no moisture barrier and, when installed at proper densities, cannot settle in a building cavity.

Cellulose insulation is used in both new and existing homes, as loose-fill in open attic installations and dense packed in building cavities such as walls and cathedral ceilings. In existing structures, installers remove a strip of exterior siding, usually about waist high; drill a row of three inch holes, one into each stud bay, through the wall sheathing; insert a special filler tube to the top of the wall cavity; and blow the insulation into the building cavity, typically to a density of 3.5 lb per cubic foot. When installation is complete, the holes are sealed with a plug and the siding is replaced and touched up if necessary to match the wall.

In new construction, cellulose can be either damp-sprayed or installed dry behind netting. When damp sprayed, a small amount of moisture is added at the spray nozzle tip, activating natural starches in the product and causing it to adhere inside the cavity. Damp-sprayed cellulose is typically ready for wall covering within 24 hours of installation. Cellulose can also be blown dry into netting stapled over building cavities.

PLASTIC FIBER INSULATION MATERIAL

Plastic fiber insulation material is primarily made from recycled plastic milk bottles (polyethylene terephthalate or PET). The fibers are formed into **batt insulation** similar to high-density fiberglass.

The insulation is treated with a fire retardant so it doesn't burn readily, but it does melt when exposed to flame.

The R-values of plastic fiber insulation vary with the batt's density, ranging from R-3.8 per inch at 1.0 lb/ft^3 density to R-4.3 per inch at 3.0 lb/ft^3 density. Plastic fiber insulation is relatively non-irritating to work with, but the batts reportedly can be difficult to handle and cut with standard tools. In many areas of the United States, plastic fiber insulation might not be readily available.

NATURAL FIBER INSULATION MATERIALS

Some natural fibers -- including cotton, sheep's wool, straw, and hemp -- are used as insulation materials.

COTTON

Cotton insulation consists of 85% recycled cotton and 15% plastic fibers that have been treated with borate -- the same flame retardant and insect/rodent repellent used in cellulose insulation. One product uses recycled blue jean manufacturing trim waste. As a result of its recycled content, this product uses minimal energy to manufacture. Cotton insulation is available in batts with an R-value of R-3.4 per inch. Cotton insulation is also nontoxic, and you can install it without using respiratory or skin exposure protection. However, cotton insulation costs about 15% to 20% more than fiberglass batt insulation.

SHEEP'S WOOL

For use as insulation, sheep's wool is also treated with borate to resist pests, fire, and mold. It can hold large quantities of water, which is an advantage for use in some walls, but repeated wetting and drying can leach out the borate. The thermal resistance or R-value of sheep's wool batts is about R-3.5 per inch, similar to other fibrous insulation types.

STRAW

Straw bale construction, popular 150 years ago on the Great Plains of the United States, has received renewed interest. Straw bales tested by Oak Ridge National Laboratory yielded R-values of R-2.4 to R-3.0 per inch. But at least one straw bale expert claims R-2.4 per inch is more representative of typical straw bale construction due to the many gaps between the stacked bales.

The process of fusing straw into boards without adhesives was developed in the 1930s. Panels are usually 2 to 4 inches (5 to 102 mm) thick and faced with heavyweight kraft paper on each side. Although manufacturers claims vary, R-values realistically range from about R-1.4 to R-2 per inch. The boards also make effective sound-absorbing panels for interior partitions. Some manufacturers have developed **structural insulated panels** from multiple-layered, compressed-straw panels.

HEMP

Hemp insulation is relatively unknown and not commonly used in the United States. Its R-value (about R-3.5 per inch of thickness) is similar to other fibrous insulation types.

POLYSTYRENE INSULATION MATERIALS

Polystyrene -- a colorless, transparent thermoplastic -- is commonly used to make foam board or beadboard insulation, concrete block insulation, and a type of loose-fill insulation consisting of small beads of polystyrene.

Molded expanded polystyrene (MEPS), commonly used for foam board insulation, is also available as small foam beads. These beads can be used as a pouring insulation for concrete blocks or other hollow wall cavities, but they are extremely lightweight, take a static electric charge very easily, and are notoriously difficult to control.

Other polystyrene insulation materials similar to MEPS are expanded polystyrene (EPS) and extruded polystyrene (XPS). EPS and XPS are both made from polystyrene, but EPS is composed of small plastic beads that are fused together and XPS begins as a molten material that is pressed out of a form into sheets. XPS is most commonly used as foam board insulation. EPS is commonly produced in blocks. Both MEPS and XPS are often used as the insulation for structural insulating panels (SIPs) and insulating concrete forms (ICFs).

The thermal resistance or R-value of polystyrene foam board depends on its density, and ranges from R-3.8 to R-5.0 per inch. Polystyrene loose-fill or bead insulation typically has a lower R-value (around R-2.3 per inch) compared to the foam board.

POLYISOCYANURATE INSULATION MATERIALS

Polyisocyanurate or polyiso is a thermosetting type of plastic, closed-cell foam that contains a low-conductivity, hydrochlorofluorocarbon-free gas in its cells. The high thermal resistance of the gas gives polyisocyanurate insulation materials an R-value ranging from R-5.6 to R-8 per inch.

Polyisocyanurate insulation is available as a liquid, sprayed foam, and rigid foam board. It can also be made into laminated insulation panels with a variety of facings. Foamed-in-place applications of polyisocyanurate insulation are usually cheaper than installing foam boards, and perform better because the liquid foam molds itself to all of the surfaces.

Over time, the R-value of polyisocyanurate insulation can drop as some of the low-conductivity gas escapes and air replaces it -- a phenomenon is known as thermal drift. Experimental data indicates that most thermal drift occurs within the first two years after the insulation material is manufactured. For example, if the insulation has an initial R-value of R-9 per inch, it will likely drop to R-7 per inch, then remain unchanged unless the foam is damaged.

Foil and plastic facings on rigid polyisocyanurate foam panels can help stabilize the R-value. Testing suggests that the stabilized R-value of rigid foam with metal foil facings remains unchanged after 10 years. Reflective foil, if installed correctly and facing an open air space, can also act as a **radiant barrier**. Depending upon the size and orientation of the air space, this can add another R-2 to the overall thermal resistance. Panels with foil facings have stabilized R-values of R-7.1 to R-8.7 per inch.

Some manufacturers use polyisocyanurate as the insulating material in structural insulated panels (SIPs). Foam board or liquid foam can be used to manufacture a SIP. Liquid foam can be injected between two wood skins under considerable pressure, and, when hardened, the foam produces a strong bond between the foam and the skins. Wall panels made of polyisocyanurate are typically 3.5 (89 mm) thick. Ceiling panels are up to 7.5 inches (190 mm) thick. These panels, although more expensive, are more fire and water vapor-diffusion resistant than EPS. They also insulate 30% to 40% better per given thickness.

POLYURETHANE INSULATION MATERIALS

Polyurethane is a foam insulation material that contains a low-conductivity gas in its cells. The high thermal resistance of the gas gives polyurethane insulation materials an R-value ranging from R-5.5 to R-6.5 per inch.

Polyurethane foam insulation is available in closed-cell and open-cell formulas. With closed-cell foam, the high-density cells are closed and filled with a gas that helps the foam expand to fill the spaces around it. Open-cell foam cells are not as dense and are filled with air, which gives the insulation a spongy texture and a lower R-value.

Like polyiso foam, the R-value of closed-cell polyurethane insulation can drop over time as some of the low-conductivity gas escapes and air replaces it in a phenomenon known as thermal drift. Most thermal drift occurs within the first two years after the insulation material is manufactured, after which the R-value remains unchanged unless the foam is damaged.

Foil and plastic facings on rigid polyurethane foam panels can help stabilize the R-value, slowing down thermal drift. Reflective foil, if installed correctly and facing an open air space, can also act as a **radiant barrier**. Depending upon the size and orientation of the air space, this can add another R-2 to the overall thermal resistance. Panels with foil facings have stabilized R-values of about R-6.5 per inch.

Polyurethane insulation is available as a liquid sprayed foam and rigid foam board. It can also be made into laminated insulation panels with a variety of facings.

Sprayed or foamed-in-place applications of polyurethane insulation are usually cheaper than installing foam boards, and these applications usually perform better because the liquid foam molds itself to all of the surfaces. All closed-cell polyurethane foam insulation made today is produced with a non-HCFC (hydrochlorofluorocarbon) gas as the foaming agent.

Low-density, open-cell polyurethane foams use air as the blowing agent and about an R-3.6 per inch which doesn't change over time. These foams are similar to conventional polyurethane foams, but are more flexible. Some low-density varieties use carbon dioxide (CO_2) as the foaming agent.

Low-density foams are sprayed into open wall cavities and rapidly expand to seal and fill the cavity. Slow expanding foam is also available, which is intended for cavities in existing homes. The liquid foam expands very slowly, reducing the chance of damaging the wall from overexpansion. The foam is water vapor permeable, remains flexible, and is resistant to wicking of moisture. It provides good air sealing and yields about R-3.6 per inch of thickness. It is also fire resistant and won't sustain a flame.

Soy-based, polyurethane liquid spray-foam products are also available. The cured R-value is about R-3.5 per inch. These products can be applied with the same equipment used for petroleum-based polyurethane foam products.

Some manufacturers use polyurethane as the insulating material in structural insulated panels (SIPs). Foam board or liquid foam can be used to manufacture a SIP. Liquid foam can be injected between two wood skins under considerable pressure, and, when hardened, the foam produces a strong bond between the foam and the skins. Wall panels made of polyurethane are typically 3.5 (89 mm) thick. Ceiling panels are up to 7.5 inches (190 mm) thick. These panels, although more expensive, are more fire and water vapor-diffusion resistant than EPS. They also insulate 30% to 40% better per given thickness.

VERMICULITE AND PERLITE INSULATION MATERIALS

Vermiculite and perlite insulation materials are commonly found as attic insulation in homes built before 1950. Vermiculite insulation materials aren't widely used today because they sometimes contain asbestos. However, according to the U.S.

Environmental Protection Agency, asbestos is not intrinsic to vermiculite. Only a few sources of vermiculite have been found to contain more than tiny trace amounts. Still, if you have vermiculite insulation in your attic, do not disturb it. If you want to add insulation to your attic, use an insulation contractor who is trained and certified in handling asbestos.

Vermiculite and perlite consist of very small, lightweight pellets, which are made by heating rock pellets until they pop. This creates a type of loose-fill insulation with a thermal resistance of up to R-2.4 per inch. These pellets can be poured into place or mixed with cement to create a lightweight, less heat-conductive concrete.

UREA-FORMALDEHYDE FOAM INSULATION MATERIAL

Urea-formaldehyde (UF) foam was used in homes during the 1970s and early 1980s. However, after many health-related court cases due to improper installations, UF foam is no longer available for residential use and has been discredited for its formaldehyde emissions and shrinkage. It is now used primarily for masonry walls in commercial and industrial buildings.

UF foam insulation has an R-value of about 4.6 per inch, and uses compressed air as the foaming agent. Nitrogen-based UF foam may take several weeks to cure completely. Unlike polyurethane insulation, UF foam doesn't expand as it cures. Water vapor can easily pass through it, and it breaks down at prolonged temperatures above 190°F (88°C). UF foam contains no fire retardant.

CEMENTITIOUS FOAM INSULATION MATERIAL

Cementitious insulation material is a cement-based foam used as sprayed-foam or foamed-in-placed insulation. One type of cementitious spray foam insulation known as air krete® contains magnesium silicate and has an R-value of about 3.9 per inch. With an initial consistency similar to shaving cream, air krete® is pumped into closed cavities. Cementitious foam costs about as much as polyurethane foam, is nontoxic and nonflammable, and is made from minerals (like magnesium oxide) extracted from seawater.

PHENOLIC FOAM INSULATION MATERIAL

Phenolic (phenol-formaldehyde) foam was somewhat popular years ago as rigid foam board insulation. It is currently available only as a foamed-in-place insulation.

Phenolic foamed-in-place insulation has a R-4.8 value per inch of thickness and uses air as the foaming agent. One major disadvantage of phenolic foam is that it can shrink up to 2% after curing, which makes it less popular today.

INSULATION FACINGS

Facings are fastened to insulation materials during the manufacturing process. A facing protects the insulation's surface, holds the insulation together, and facilitates fastening to building components. Some types of facing can also act as an **air barrier**, **radiant barrier**, and/or **vapor barrier** and some even provide flame resistance.

Common facing materials include kraft paper, white vinyl sheeting, and aluminum foil. All of these materials act as an air barrier and vapor barrier. Aluminum foil can also act as a radiant barrier. Your climate and where and how you're installing the insulation in your home will determine what type of facing and/or barrier, if any, you'll need.

Some of the same materials used as insulation facings can be installed separately to provide an air barrier, vapor barrier, and/or radiant barrier.

Learn More

- Types of insulation
- Insulation
- Where to insulate in a home
- Insulation for new home construction
- Adding insulation to an existing home
- Types of insulation
- Moisture control
- Vapor barriers and vapor diffusion retarders
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