buyer's guide

HELPING READERS MAKE CHOICES

# Insulation

## Your choice of insulation goes far beyond what's on the shelf of the local home-improvement store. Here's what to consider.

BY MARTIN HOLLADAY

Most homes have several different types of insulation. For example, attic floors are often insulated with fiberglass batts or cellulose, while many basement walls are insulated with rigid-foam panels. For a variety of reasons, you probably don't want to insulate your basement walls with cellulose or your attic floor with rigid-foam panels.

If you're selecting insulation, you need to make sure that your chosen material is appropriate for its intended location, that it will perform well, that it won't be prohibitively difficult to install, and that it won't blow your budget.

The higher a material's R-value, the better it is at resisting heat flow. In most cases, insulation with a high R-value per inch is preferable to insulation with a low R-value per inch, and insulation that resists airflow is preferable to air-permeable insulation. To save money, however, many builders choose air-permeable products with a low R-value. As long as air leakage is addressed by installing a tight air barrier and as long as an adequate thickness of insulation is installed, even inexpensive insulation products can perform well.

Martin Holladay is a senior editor.






Photos: this page, from left, Charles Bickford, Charles Bickford, Brian Pontolilo; facing page, courtesy of BASF.

Spray foam

# BATTS

These narrow, fluffy blankets of insulation are installed between studs, joists, or rafters. While most batts are made of fiberglass, batts also can be made of cotton, mineral wool, and even hemp.

## Fiberglass batts

**R-VALUE: R-3.2 to R-3.8 per in.**

**COST: Between 49¢ to $1 per sq. ft. (installed), depending on thickness**

**APPLICATION: Above-grade walls, ceilings, and vented roof assemblies**

Because fiberglass batts are inexpensive and can be installed without special equipment, they are by far the most common type of residential insulation. Most fiberglass batts are made from spun glass fibers held together by a phenol-formaldehyde glue; however, at least two manufacturers—Johns Manville and Knauf—sell formaldehyde-free batts.

Fiberglass batts are available unfaced (photo above) or faced with a variety of materials, including kraft paper, foil-faced paper, MemBrain (a "smart" vapor retarder with variable vapor permeance), and vinyl (either perforated or unperforated). These days, most building scientists discourage the use of interior vapor barriers—that is, materials with a very low permeance—except in very cold climates. A vapor retarder is safer than a vapor barrier; kraft facing (with a permeance of 0.3 perm) is usually safer than interior polyethylene (with a permeance of 0.06 perm). The kraft facing on fiberglass batts satisfies the code requirement for an interior vapor retarder in cold climates.

Fiberglass batts have R-values ranging from R-3.2 to R-3.8 per in. Denser batts have higher R-values; the only virtue of the low-density batts is their comparatively low cost. The installed cost of R-13 to R-15 fiberglass batts for a 2x4 wall is about 49¢ to 80¢ per sq. ft., R-19 to R-21 batts for a 2x6 wall cost about 55¢ to 90¢ per sq. ft., and R-38 batts for an attic cost 71¢ to $1 per sq. ft.

Fiberglass batts do little to slow air leakage, so they must be installed in conjunction with a well-detailed air barrier to perform their best. Unaddressed air leaks through fiberglass-insulated walls can easily lead to condensation and moisture problems.

Installing batts well is difficult, in part because each batt must be carefully cut (and sometimes split) to conform to the idiosyncrasies of each framing bay. Small installation mistakes will lead to large performance penalties.

## Cotton batts

**R-VALUE: R-3.5 to R-3.7 per in.**

**COST: About $1.27 to $1.40 per sq. ft. (installed), depending on thickness**

**APPLICATION: Above-grade walls, ceilings, and vented roof assemblies**

Cotton insulation is sold in the form of unfaced batts, the best-known brand being UltraTouch from Bonded Logic. About 75% of the material used to make cotton insulation comes from fabric scraps left over from the manufacture of blue jeans, with some synthetic fibers added to maintain loft. Nontoxic flame retardants similar to those used in clothing are also added.

Although less likely to irritate skin than fiberglass batts, cotton batts have some drawbacks. Like fiberglass batts, cotton batts are air permeable and difficult to install well. Cotton batts are also manufactured in a larger width (16¼ in. instead of 15½ in.), a drawback that is complicated further by the fact that they are difficult to cut. Some installers complain that cotton batts compressed for shipping do not spring back to the thickness listed on the label. Finally, cotton batts are more expensive than their fiberglass counterparts. For example, the installed cost of R-19 to R-21 cotton batts in 2x6 walls is about $1.37 per sq. ft.

## Mineral-wool batts

**R-VALUE: R-3.8 to R-4.3 per in.**

**COST: About $1.08 per sq. ft. for R-23 batts for a 2x6 wall**

**APPLICATION: Above-grade walls, ceilings, and vented roof assemblies**

Most mineral-wool batts sold in North America are slag wool, an insulation made from steel-mill slag. The two main manufacturers of mineral-wool insulation are Roxul and Thermafiber.

Mineral-wool batts have R-values ranging from R-3.8 to R-4.3 per in. The insulation is available in densities from 4 to 8 lb. per cu. ft. Because mineral-wool insulation is resistant to high temperatures, it's the best insulation to use near a chimney or metal flue. The installed cost of R-23 batts from Roxul, meant for a 2x6 wall, is about $1.08 per sq. ft.



Photos this page, from top: Charles Bickford, courtesy of Bonded Logic, Rodney Diaz.
Photos facing page: left, courtesy of National Fiber; right, Charles Bickford.

# BLOWN IN

Loose-fill and blown-in insulation materials include fiberglass, cellulose, and (less commonly) mineral wool. Because blown-in products fill all the nooks and crannies of the framing bays where they are installed, performance is typically much better than with batt insulation.

When blown-in insulation is installed on an attic floor, it is referred to as a loose-fill application. When blown-in insulation is installed in a closed framing cavity, it's possible to achieve higher insulation densities than can be achieved on an attic floor.

Dense-packed cellulose or fiberglass allows less air movement and has a higher R-value per inch than insulation installed at a lower density.

Because installing blown-in insulation requires special equipment, most builders subcontract the work to an insulation contractor. Although insulation blowers can be rented, the machines are usually underpowered models that are unable to achieve the high densities required for insulating closed cavities. However, such rental machines are usually adequate for loose-fill installations, such as on an attic floor.

## Blown-in fiberglass

**R-VALUE:** R-2 to R-4.2 per in.

**COST:** About 60¢ to $1.20 per sq. ft., depending on installation and density

**APPLICATION:** Above-grade walls, ceilings, and vented roof assemblies

Blown-in fiberglass (photo above) consists of chopped glass fibers (and in some cases, an adhesive). The R-value of blown fiberglass increases with density and ranges from R-2.2 to R-4.2 per in. High densities also help to lower air-infiltration rates.

Like cellulose, fiberglass can be blown into a closed cavity through drilled holes, installed behind air-permeable netting stapled to studs, or blown into open framing cavities, if the product includes adhesive.

Among brands of blown-in fiberglass that include an adhesive, perhaps the best known is Johns Manville's Spider. Spider fibers are fine and short, and special spray equipment adds a polyester-based liquid adhesive during installation. Dry Spider fibers (without adhesive) also can be installed behind netting or dense-packed into wall cavities.

Typically installed on an attic floor, loose-fill fiberglass has a lower R-value per inch (R-2.2 to R-2.7) than any other common insulation product, so it's best applied in attics that have enough room at the eaves to accommodate a very deep layer—as much as 16 in. to 26 in. The cost to install R-19 to R-21 blown-in fiberglass in a 2x6 wall is around 90¢ per sq. ft. To reach R-38 in an attic, you'll pay around 60¢ to $1.20 per sq. ft.

## Blown-in cellulose

**R-VALUE:** R-3.2 to R-3.8 per in.

**COST:** About 40¢ to $1.80 per sq. ft., depending on installation and density

**APPLICATION:** Above-grade walls, ceilings, and vented roof assemblies

Between 75% and 80% of the weight of cellulose insulation consists of ground-up newspapers. The shredded paper is mixed with one of several fire retarders, most commonly borate.

The insulating value of cellulose is comparable to that of fiberglass batts; however, because cellulose is more resistant to airflow than fiberglass, it performs better. In a closed cavity, cellulose should be installed by the dense-pack method—that is, to a density of at least 3½ lb. per cu. ft.

When cellulose is installed in an existing building with empty stud cavities, it is usually blown through holes drilled in the exterior sheathing. This work typically requires the temporary removal of some of the building's siding.

Cavities in a new home can be insulated using one of four methods:

1. Damp-spray cellulose—a mixture of cellulose insulation and water—can be sprayed into the open wall cavities before drywall is installed.
2. Dry cellulose can be installed through holes in air-permeable netting that has been stapled and sometimes glued over the interior face of the studs (photo left).
3. Dry cellulose can be installed through gaps in the interior drywall.
4. Dry cellulose can be installed through holes in rigid-foam insulation that has been installed on the interior side of studs or rafters.

Cellulose insulation is inexpensive. The cost to install R-19 or R-21 of dense-packed cellulose in a 2x6 wall is 81¢ to $1.80 per sq. ft., and loose-fill installed to R-38 is between 42¢ and 99¢ per sq. ft. Proponents of green building appreciate its high recycled content and low embodied energy. One disadvantage of cellulose is that it doesn't respond well to moisture. Because cellulose is able to absorb and hold a lot of water, roof or plumbing leaks may go unnoticed longer than with other insulation materials.


# RIGID FOAM

This insulation can be used on walls, roofs, and foundations, and it is suitable for retrofits and new construction. All foam-insulation products are petroleum-derived, and most have a higher R-value per inch than fiberglass, cotton, or cellulose.

Rigid-foam sheets are sold in several thicknesses; most lumberyards carry sheets ranging from ½ in. to 2 in. thick. Thicker sheets (up to 6 in. thick) are usually available by special order. The installed cost of rigid insulation varies widely, depending on the project and location.

Rigid-foam insulation is a more effective air barrier than batts or blown-in insulation, especially if the seams between sheets are carefully sealed with caulk, canned spray foam, or tape.

Rigid foam is routinely used to insulate the interior or exterior of foundation walls. On above-grade walls, exterior foam improves the performance of a wall or insulated roof by reducing thermal bridging, improving airtightness, and raising the R-value of the entire assembly. Be sure to install foam sheathing that is thick enough to keep the wall above the dew point.

## Expanded polystyrene (EPS)

**R-VALUE:** R-3.6 to R-4.2 per in.

**COST:** 31¢ per sq. ft. at 1-in. thickness (material only)

**APPLICATION:** Under slabs; below-grade walls; above-grade walls; ceilings; and roofs

The highest R-values for EPS are found in high-density foams. EPS is the least expensive and most vapor permeable of the three types of rigid foam. One inch of EPS has a permeance of 2.0 to 5.8 perms.

EPS has long been made with non-ozone-depleting pentane blowing agents rather than HCFCs or HFCs. However, many brands of EPS contain the flame retardant HBCD, a persistent, bioaccumulative toxin.

If the correct density is chosen for the application, EPS is not affected by moisture. While EPS with a density of 1 lb. per cu. ft. is adequate for use in structural-insulated panels (SIPs) and insulating concrete forms (ICFs), only the higher-density (generally type IX EPS with a density of 2 lb. per cu. ft.) foam should be specified for below-grade applications.

## Extruded polystyrene (XPS)

**R-VALUE:** R-5 per in.

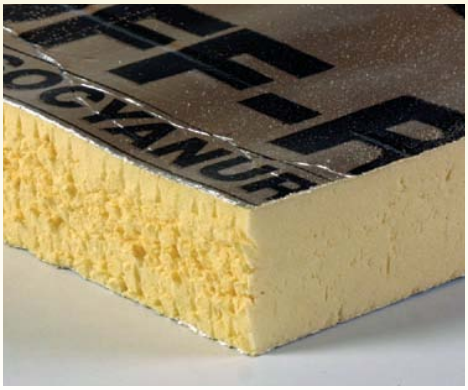
**COST:** 47¢ per sq. ft. at 1-in. thickness (material only)

**APPLICATION:** Under slabs; below-grade walls; above-grade walls; ceilings; and roofs

XPS shares many of the strengths of EPS but is stronger, denser, smoother, and more water resistant; moreover, it has a higher R-value per inch. One inch of XPS has a permeance of 1.1, while 2 in. have a permeance of 0.55, classifying the material as semi-impermeable.

Because of its high compressive strength and water resistance, XPS is often used below grade to insulate slabs and foundation walls. The two most common brands of XPS are Dow Styrofoam, which is blue, and Owens Corning Foamular, which is pink.

For green builders, XPS has two major strikes against it: It contains the flame retardant HBCD, and its blowing agents have a very high global-warming potential. For these two reasons, most green builders try to avoid the use of XPS.



## Polyisocyanurate (polyiso)

**R-VALUE:** R-6.5 per in.

**COST:** About 60¢ per sq. ft. at 1-in. thickness (material only)

**APPLICATION:** Below-grade walls (interior side only); above-grade walls; ceilings; and roofs

Polyiso has the highest R-value per inch of any rigid insulation. Its blowing agent (water) is environmentally benign, and it is free of the brominated flame-retardant chemicals that taint EPS and XPS. However, polyiso absorbs water easily, so it can't be used below grade.

Polyiso always has a facing on both sides, most often foil. One inch of foil-faced polyiso has a very low permeance of 0.03 perm. When used as exterior sheathing, it creates an exterior vapor barrier; that means that an interior plastic vapor barrier should never be used on a polyiso-sheathed wall.

Foil-faced polyiso is more resistant to fire than unprotected XPS or EPS, so some building inspectors allow it to be left exposed on crawlspace walls or in attics without requiring a layer of drywall.



Photos this page: top, Brian Pontolilo; bottom, Daniel Morrison. Photos facing page: top, courtesy of CertainTeed; bottom, Rodney Diaz.

## SPRAY FOAM

Made from polyurethane, this product reduces air leakage better than any other type of insulation. It fills the nooks and crannies of unusually shaped building cavities easily.

There are two main types of spray foam: open-cell spray foam, which has a density of about ½ lb. per cu. ft.; and closed-cell spray foam, which has a density of about 2 lb. per cu. ft. The higher the density of the foam, the greater the R-value per inch.

The two ingredients used to make spray foam—conventionally called the "A" and "B" components—are mixed on site using special equipment mounted in a trailer or truck. Heated hoses convey the chemicals to a mixing gun that sprays the chemicals on the surfaces to be insulated. An exothermic chemical reaction begins as soon as the chemicals are mixed; the liquid mixture foams, expands, and eventually hardens.

For small jobs, builders can purchase disposable tanks of two-component closed-cell polyurethane foam. Sold in various sizes, these tanks cost from about $250 to $600. For very small jobs, small aerosol cans of one-component (moisture-cured) polyurethane foam can be purchased at most building-supply stores for about $5 a can.

### Open-cell spray foam

**R-VALUE:** R-3.5 to R-3.6 per in.

**COST:** Varies widely, but filling a 2x4 cavity to R-13 with open-cell spray foam costs about $1 to $1.20 per sq. ft.

**APPLICATION:** Walls, ceilings, and roofs

The low density of open-cell foam makes it relatively vapor permeable (a 3-in.-thick layer of open-cell foam has a permeance of 16), so when it's used to create an unvented conditioned attic in a cold climate, the interior face of the foam should be covered with a vapor retarder. This can be accomplished by spraying the cured foam with vapor-retarding paint.

Open-cell foams use water or carbon dioxide as the blowing agent. Some open-cell foams are made in part from bio-based raw materials—for example, soybean oils—in place of a portion of the petrochemicals.

Like closed-cell foam, open-cell foam creates an effective air barrier. Unlike closed-cell foam, however, open-cell foam absorbs and holds water, has a lower R-value per inch, and is vapor permeable. The permeable nature of open-cell foam can be a virtue or a drawback, depending on the application.

### Closed-cell spray foam

**R-VALUE:** R-6.5 per in.

**COST:** Varies widely, but filling a 2x4 cavity to R-13 with closed-cell spray foam costs about $1.75 to $3 per sq. ft.

**APPLICATION:** Under slabs; walls (below grade and above grade); ceilings; and roofs

Closed-cell spray foams provide a higher R-value per inch than less expensive insulation types like fiberglass, cellulose, or open-cell foam, all of which have R-values of R-3.2 to R-3.8 per in.

Closed-cell spray foam is the most expensive residential insulation. When installed well, however, it performs better than any other insulation. It is an excellent air barrier, is impervious to moisture, and is an effective vapor retarder. Because of its density and gluelike tenacity, it also adds structural strength to a wall, ceiling, or roof assembly. To seal air leaks in retrofit applications as well as new construction—for example, at rim joists or the attic side of partition top plates—closed-cell spray foam is an extremely useful material.

Many green builders avoid the use of closed-cell spray foam because the blowing agents in most types of closed-cell spray polyurethane foam are hydrofluorocarbons (HFCs) with a high global-warming potential.