Get the Right RIGID FOAM

BY MICHAEL MAINES

POLYISO

POLYISOCYANURATE

$0.42 to $0.96 per bd. ft.

Polyisocyanurate, a urethane-based product closely related to spray polyurethane foam, is available in a couple of varieties. Polyiso is always formed between facings of some sort, usually aluminum foil, fiberglass, or fiberboard. It has an R-value of 5.6 per in. at 75° and a compressive strength of 25 psi. The primary blowing agent for all polyisocyanurate foam, pentane—with a global warming potential (GWP) of 5—is benign compared to the hydrofluorocarbons (HFCs) used in the manufacturing of XPS. Unfortunately, the foam will absorb moisture if unprotected and its R-value drops by about half a point per inch in temperatures below 25°.

EPS

EXPANDED POLYSTYRENE

$0.44 to $0.79 per bd. ft.

Tiny beads of polystyrene are heated, expanded with a blowing agent, and then molded with steam to form blocks. EPS is most often white in color, and you can see the expanded beads packed together in the finished product. It is produced in a range of types, with R-values from R-3.1 to R-5.0. Lightweight type I EPS (10 psi), which is fine for roofs and foundation walls, is what you're most likely to find at the home center, but type II (15 psi), and type IX (25 psi) are available for residential slabs and foundation footings. In fact, EPS rated up to 60 psi is available for high-load applications.

XPS

EXTRUDED POLYSTYRENE

$0.43 to $0.83 per bd. ft.

Formed by injecting a blowing agent as the melted polystyrene beads are extruded through a die, XPS can be virtually any color, but green, blue, and pink are the readily available versions. XPS is generally rated at R-5 per in. and is available in densities from 15 psi to 100 psi, but type X (15 psi) and type IV (25 psi) are the most common. At the same density, XPS is stronger than EPS, but its manufacturing process is the most damaging to the environment. The most common blowing agent, HFC-134a, has a GWP 1000 to 1500 times more damaging than CO_2. The switch over to less damaging blowing agents with a GWP of 7, called hydrofluoroolefins (HFOs), has been slow in the U.S.

Photos: this page and facing page bottom, Patrick McCombe; facing page top, Brian McAward; middle, Andy Engel

Foam-board insulation can boost R-value, slow thermal bridging, and control condensation—but you better choose the right type

Suitable for insulating foundations, walls, and roofs of all types, rigid foam is one of the most versatile types of insulation. It has a high R-value. It blocks airflow and is good at controlling moisture movement. Unfortunately, it's often flammable and releases toxic fumes when it burns. The sheets can be clunky and fragile, and most foam has a much greater environmental impact than fluffy types of insulation. And even though rigid foam can be used in nearly any part of your home's thermal boundary, not all types are suitable for all applications. If you choose to use rigid foam, there is a lot to know. Here are the basics to help you make the right choice. □

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FOUNDATIONS AND SLABS

Because EPS and XPS are available with good compressive strength and won't degrade in water, they are the two preferred foams for insulating the exterior of foundation walls and under concrete slabs. But when EPS or XPS are used on the inside of foundation walls, they must be covered with a thermal barrier (generally drywall) to protect them in the event of a fire. Because it can absorb water, polyiso is not suitable for contact with soil, but it can be appropriate for the inside of crawlspaces and foundation walls, and many code officials will allow some types of foil-faced polyiso in non-living spaces without requiring a thermal barrier as described in section R316.5.4 of the IRC.

WALLS

Recent versions of the IRC encourage the use of rigid-foam insulation on the exterior to minimize thermal bridging through the framing and to reduce the chances of condensation within wall cavities. Builders in colder climate zones who take this approach can use rigid foam over 2x4 studs and R-13 cavity insulation instead of 2x6 studs and R-20 cavity insulation. A layer of foam on walls in warmer climates can reduce cooling loads. In all climates, a conscientiously installed layer of taped exterior foam can also significantly reduce air leakage.

ROOFS

Rigid foam in roof assemblies allows you to get a lot of R-value in a relatively thin layer, usually only a few inches thick—a problem-solver for remodelers looking to meet current energy codes in existing buildings. Builders and designers sometimes call for a rigid-insulation layer on top of the roof sheathing, which minimizes thermal bridging and, in the proper thickness, reduces the potential for condensation on the underside of the roof sheathing. This type of assembly also brings any attic ductwork into the building envelope, improving heating and cooling efficiency.

KNOW YOUR FOAM

HEALTH CONCERNS

XPS and EPS foam both contain brominated flame retardants in order to meet code-mandated fire-resistance ratings. Brominated flame retardants are considered persistent, bioaccumulative, and toxic to both humans and the environment, and are present in XPS and EPS at 0.5% and 2% by weight, respectively. Polyiso is more fire retardant than EPS and XPS by nature, but still includes a flame retardant. The flame retardants in polyiso are also bioaccumulative, but their health effects are unknown. The blowing agents for all three types of foam are released as the materials age. How fast the gasses are released depends on the material, its facing, and the thickness of the foam. The health effects from exposure to the blowing agents from installed foam insulation is hard to predict and depends on the amount of foam, the type, and the applied facings. Workers cutting foam should have eye and respiratory protection and wear cut-resistant gloves when working with foil-faced foams.

FIRE RESISTANCE

Rigid-foam insulation is made from petroleum products that are flammable and the gasses released when it burns are toxic. So the IRC requires at least a 15-minute thermal barrier, typically ½-in. drywall, over foam insulation. In attics and crawlspaces that are accessed only for repairs or maintenance, foam can be covered with a different material, such as ¼-in. wood structural panels, ⅜-in. gypsum board, or a painted-on intumescent coating. One polyiso product, Dow Thermax, has a Class I fire rating, allowing it to be left exposed in crawlspaces that are only accessed for maintenance and repairs.

THERMAL PERFORMANCE

There are four things to consider:

1. All rigid foams grows and shrink with age and temperature changes—up to 2%—so instead of one thick layer, it's best to use multiple layers with vertical and horizontal seams offset and taped. This prevents air leakage when the foam shrinks.
2. While the R-value of EPS remains constant over time, the R-value of XPS drops to R-4.1 or R-4.2 per in. over time as the blowing agents are slowly released from the foam and replaced with air. Some researchers think this happens over 40 to 50 years. Others say it happens more quickly.
3. When the temperature drops outside, the effective R-value of insulation changes—with EPS and XPS it increases, but with polyiso it decreases. Polyiso manufacturers now account for this in a long-term thermal rating (LTTR), which is usually between R-5.6 to R-6.0 per in.
4. Foam insulation in roof and wall assemblies needs to be thick enough in proportion to the amount of cavity insulation to prevent moisture accumulation on the sheathing. The minimum thickness for roofs can be found in the 2012 and 2015 IRC, table 806.5. The minimum thickness for wall insulation can be found in table 702.7.7.1.

WATER ABSORPTION

High-density (type II) EPS readily absorbs up to 3% of its volume in liquid water. Low-density (type I) EPS will take on 4%. Even though the polystyrene beads are closed to water, there are small spaces around them where water can accumulate, reducing the R-value by 10% to 20% when the foam is saturated. Because of the hit in R-value, best practice is to keep EPS foam dry. XPS can be considered impervious to water, taking on no more than 0.3% by volume. Polyiso can absorb up to 1% of its volume. Most manufactures say to avoid using polyiso when it will be in contact with damp surfaces, but it is appropriate for foundation-wall interiors as long as it's kept at least 1 in. or 2 in. above the slab.

All three types of foam are available in a range of thicknesses, typically in 2-ft. by 8-ft. or 4-ft. by 8-ft. panels.

VAPOR PERMEABILITY

How much water vapor can pass through a rigid insulation is expressed as its "perm rating," and depends on the material, its thickness, and the facing (if any) used on its exterior. EPS at 1 in. starts at 5.0 perms, but the perm rating drops to 2.0 perms or less at higher densities or increased thicknesses. At common thicknesses, unfaced EPS is considered a semipermeable, Class II vapor retarder, but plastic or foil facings can reduce the vapor transmission of EPS considerably. XPS is also somewhat vapor-open (1.1 to 2.0 perms) in thicknesses less than 1 in., and increasingly vapor-closed at 1 in. or more. With its usual foil or fiberglass facings, polyiso is a Class I vapor retarder—it essentially blocks all water-vapor movement.

Perm ratings for a 1-in.-thick insulation layer

Insulation	Compressive Strength	Permeance
EPS	10 psi	5.0 perms
EPS	15 psi	3.5 perms
EPS	25 psi	2.0 perms
XPS	15 psi	1.1 perms
XPS	25 psi	1.1 perms
Polyiso (fiberglass)	25 psi	1.0 perms
Polyiso (foil faced)	25 psi	.03 perms

Class I vapor retarder
Vapor semi-impermeable (1.0 perms or less and greater than 0.1 perms)

Class II vapor retarder
Vapor semipermeable (10 perms or less and greater than 1.0 perms)

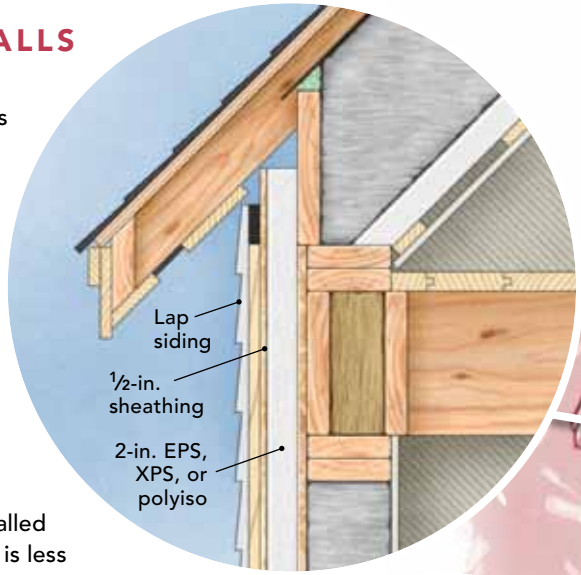
Class III vapor retarder
Vapor permeable (greater than 10 perms)

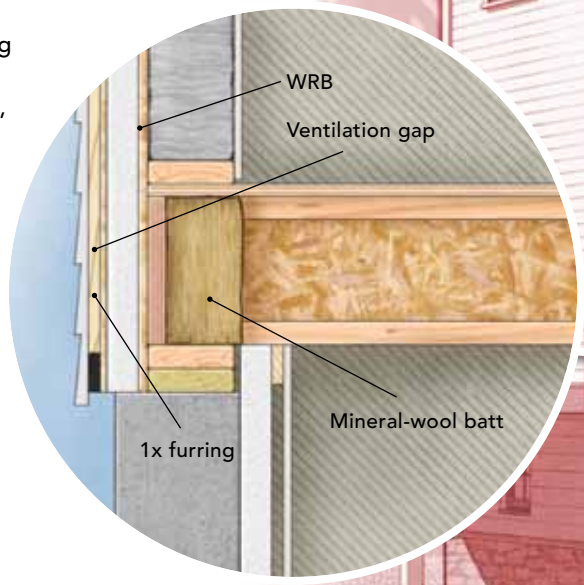
Photos: facing page, Brian McAward; this page, Rodney Diaz

PUT RIGID FOAM TO WORK

EXTERIOR WALLS

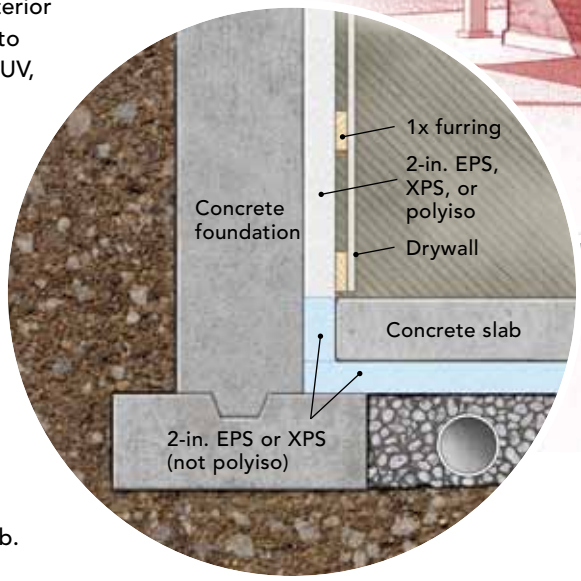
It's best to place the foam layer on the wall's exterior, which keeps framing lumber and sheathing warm and dry. Though some sidings like brick, synthetic stucco, and vinyl can be installed directly over exterior foam, lap sidings require vertical nailers at least ¾ in. thick for siding attachment. Foam installed on the interior of walls is less desirable because it keeps the framing and sheathing colder, making it harder for these materials to dry. Interior foam can complicate drywall, trim, and cabinet installation, because these items must be fastened through the foam layer and into the underlying framing.





BASEMENT WALLS

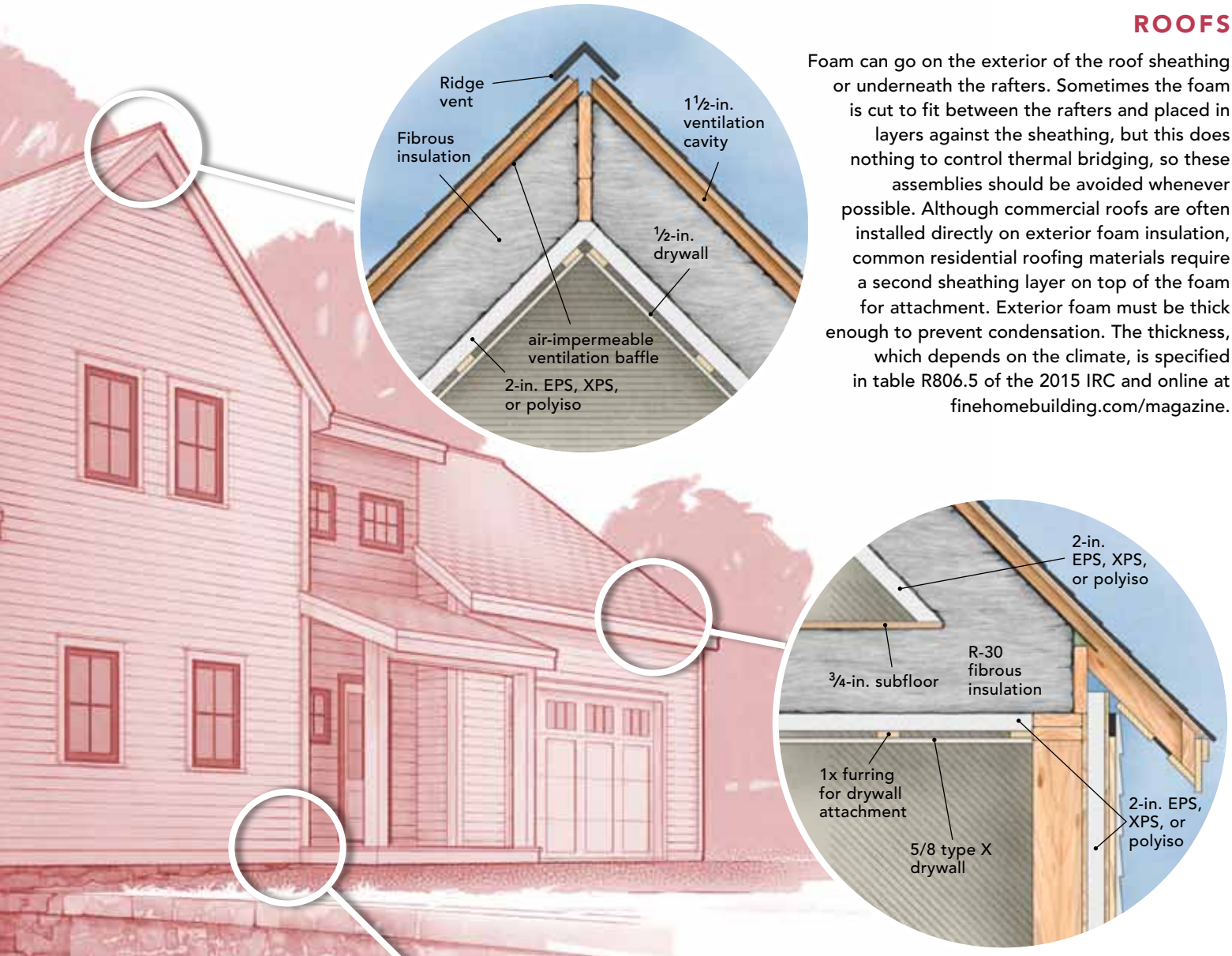
Foundations can be insulated from the exterior or the interior. Exterior foundation insulation is prone to damage from string trimmers, UV, and landscaping activities, so it should be protected with a waterproof material. Stucco, metal flashing, and cement board are common choices. Interior insulation needs a fire barrier, usually ½-in. drywall. Installing interior foundation foam before pouring the basement slab allows the wall insulation to come in contact with the subslab insulation, minimizing thermal bridging through the footings into the basement slab.



Drawings: John Hartman

ROOFS

Foam can go on the exterior of the roof sheathing or underneath the rafters. Sometimes the foam is cut to fit between the rafters and placed in layers against the sheathing, but this does nothing to control thermal bridging, so these assemblies should be avoided whenever possible. Although commercial roofs are often installed directly on exterior foam insulation, common residential roofing materials require a second sheathing layer on top of the foam for attachment. Exterior foam must be thick enough to prevent condensation. The thickness, which depends on the climate, is specified in table R806.5 of the 2015 IRC and online at finehomebuilding.com/magazine.



CRAWLSPACES

Conditioned crawlspaces often have a layer of foam on the interior of the foundation walls fastened with concrete screws or plastic cap fasteners (Hilti IDP or similar). EPS and XPS require an ignition barrier (drywall, for instance), but Dow Thermax foil-faced polyiso can often be left exposed in uninhabitable areas. In warmer climates, it's advisable to leave a 2-in.-wide uninsulated gap of exposed foundation at the top of the wall for termite inspections.

GARAGE CEILINGS

Unconditioned garages below living space can exact a significant energy penalty because of thermal bridging and air leaks between the garage and living space. This poor separation between conditioned and unconditioned spaces makes the living space above the garage uncomfortable in both heating and cooling seasons. A layer of taped foam can boost the R-value of the assembly, reduce thermal bridging, and control air leaks. The foam layer is attached to the bottom of the joists and then covered with a layer of ⅝-in. type X drywall for fire prevention.