Save Energy With Rigid-Foam Insulation

Get the details right, and a small increase in wall thickness can make a big difference in energy performance

BY RICK ARNOLD

Like most builders in the Northeast, I've been using rigid-foam insulation for a long time. I've used it to insulate foundation walls and basement slabs, and to meet code-required R-values in cathedral ceilings. Until about five years ago, however, I never used it as part of a wall assembly. Then I worked on a house that required a high R-value in walls built with 2x4 studs on 12-in. centers. The best solution was to add a layer of rigid insulation over the exterior sheathing.

Unlike most products, which insulate only between studs, rigid foam provides a continuous insulating blanket across the entire wall surface. This results in a greater overall R-value, which can have a significant impact in either a heating or cooling climate. After installing rigid-foam insulation on the exterior of that house and doing some research, I learned that the benefits outweigh the investment in material and labor.

An additional layer affects wall performance

Rigid-foam insulation is a generic term that is used to describe a few different materials (sidebar facing page). The most common are expanded polystyrene, extruded polystyrene, and polyisocyanurate, which I used in the photos shown here. The R-value of rigid-foam insulation ranges from R-3 to R-6.5 per inch, but when used over sheathing, it greatly increases the overall R-value of conventionally framed walls.

In a typical wood-frame house, about 25% of the wall area is composed of uninsulated wooden structural elements. Relatively speaking, wood is not a good insulator, and the thermal bridge it provides conducts heat from one side of the wall to the other.

Unlike insulation that fills wall cavities between the studs, rigid foam applied over the entire wall provides a continuous thermal barrier. This layer isolates the framing assembly, including the mudsills and the band joists, significantly increasing the wall's effective R-value.

According to the Building Science Corporation's *Guide to Insulating Sheathing* (available at www.buildingscience.com), "Adding one inch of insulating sheathing (R-5 for this example) will increase a 2x6 stud wall from an effective R-14.4 to an effective R-19.4. This represents an increase of 35% effective thermal resistance with only 15% increase in the overall wall thickness."

Rigid-foam insulation also can serve as an air barrier. Properly sealed, it restricts air movement into a wall cavity, helping insulations like fiberglass and cellulose to perform to their full potential. As an air barrier, rigid foam also helps to prevent infiltration of moisture-laden air, which can cause a number of different problems in wall cavities, and it keeps conditioned air from escaping.

An effective building envelope depends on a number of different elements. I've settled on a few designs that work well in the coastal climate of New England and for the types of

Prepare windows and doors before insulating. *Use furring strips ripped to the thickness of the rigid-foam insulation to create a solid nailing surface around window and door openings. Install 2½-in.-wide furring strips around all sides of the openings. Thinner strips may split when windows and doors are installed.*

THERE'S MORE TO CHOOSING A PRODUCT THAN R-VALUE

Rigid-foam insulation packs a lot of R-value into a thin package, but not all rigid foam performs the same. Choose insulation wisely, and consider the effect its characteristics will have on the performance of the walls.

Expanded polystyrene (EPS)

EPS is the insulation used most widely in insulated concrete forms and structural insulated panels. EPS has the lowest average R-value of the three types of rigid-foam insulation, around R-4 per inch. At about 19¢ per sq. ft. for a 1-in.-thick 4x8 sheet, it also costs the least. Although EPS is acceptable for ground contact and can be treated to resist insects, it does absorb water. When applied as sheathing, EPS should be used over housewrap. Most EPS is unfaced, which means it is fragile to work with and is considered semipermeable, so it does not create a vapor barrier.

Extruded polystyrene (XPS)

Easily recognized by its blue, green, or pink color, XPS falls in the middle of the three types of rigid-foam insulation in both cost and R-value. At about R-5 per inch, XPS costs around 42¢ per sq. ft. for a 1-in.-thick 4x8 panel. XPS comes unfaced or with a number of different plastic facings. Unfaced 1-in.-thick XPS has a perm rating around 1, making it semipermeable. Thicker and faced XPS is stronger and can have a lower perm rating, but either way, it is considered a vapor retarder, not a vapor barrier.

Polyisocyanurate (ISO)

ISO panels are expensive, costing as much as 70¢ per sq. ft. for a 1-in.-thick panel, and they pay off with (aged) R-values as high as R-6.5 per inch. (R-values start around R-8 and degrade slightly over time.) Because ISO starts as liquid foam and has to be sprayed against a substrate to form a rigid panel, all ISO panels are faced. A few different facings used on ISO affect the performance of the panel in both durability and perm rating. Foil-faced ISO panels are considered impermeable. Because applying these products as sheathing creates an exterior vapor barrier, they never should be used with an interior vapor barrier. More permeable ISO panels are faced with fiberglass and can be used without creating a vapor barrier.

START SQUARE FOR PERFECT COVERAGE

Start at a corner and just above the siding. *The bottom of the insulation should be at least ¾ in. higher than the bottom of the siding or trim. Snap a line to mark the appropriate height for the bottom of the first-course panels, and use a straight board to align the first panel with the corner. Fasten each panel with 1¾-in. or longer* ***aluminum roofing nails*** *every 12 in. on center around the edges and every 16 in. on center in the field.*

Marking the panels in place is easier than measuring. *Around rough openings, it's just as quick and more accurate to lift the panels into place to mark them rather than take measurements. Mark the panel for the horizontal cuts, and measure the distance from the furring strip to the closest panel for the vertical cut. Use a T-square to draw cutlines, and cut through the panel in one pass with a* ***heavy-duty snap-blade knife*** *(www.tajimatool.com).*

Insulate between the rafters, but leave an air gap at the roof. *Cut small pieces of insulation to fit between the trusses (or rafters), making sure they stop at least 1½ in. shy of the underside of the roof sheathing. This gap keeps air flowing into the attic.*

materials I typically use. When I decided to include rigid-foam insulation in wall assemblies, I had to consider how it would affect the entire wall system. For instance, the foil-faced polyisocyanurate used here is a vapor barrier, so I eliminated the interior vapor barrier of the original design.

On the project shown here, the rigid-foam insulation acts as both the air barrier and the secondary drainage plane, which eliminates the need for housewrap. However, I don't always eliminate housewrap from the assembly; it depends on the type of rigid-foam insulation, the siding, and the water-management strategy I choose.

Two people can insulate a house in a day

With the right engineering and bracing, and with code approval, rigid-foam insulation can be used in place of structural sheathing. Because I build in high-wind areas, I rely on the shear strength that plywood or oriented-strand-board (OSB) sheathing panels provide, so I use rigid-foam insulation on top of ½-in. structural sheathing.

Although I generally apply structural sheathing to walls as they are built lying down, I prefer to install rigid-foam insulation after the walls have been raised. Because some of the structural sheathing is installed or nailed only after the walls are standing, I would be able to apply insulation only in certain areas beforehand. Fitting in the remaining pieces later would not be efficient.

I work from both staging and ladders to install rigid-foam insulation. I install the first course of panels oriented vertically and continue working this way with tongue-and-groove and shiplapped panels (sidebar facing page). If I am working on staging, I install square-edged panels horizontally after the first course. If I'm working off ladders, I continue installing them vertically. This is a matter of convenience. At the manufacturer's urging, I offset the panel seams with the sheathing seams.

Before I begin, I check the walls' interior for sheathing nails that missed the studs. I pound them out from the inside, then go back outside to pull them and locate them properly. Because I'm used to having a solid nailing surface behind window and door flanges, I prefer to build out around windows and doors using wood furring strips ripped to the thickness of the rigid-foam insulation.

To start the layout of rigid-foam insulation, I determine the elevation of the bottom of the siding and mark the foundation ¾ in. up from that location to indicate the bottom edge of the rigid foam. Allowing the siding or trim to overhang the rigid foam helps to prevent water from wicking up behind the siding by capillary action.

As long as the building is plumb, I can start the layout at a corner, and the bottom edges of all the first-course panels will stay level. If the building is not plumb, which happens occasionally when I'm re-siding an old building, I line up the bottom edges even with the line and trim the panels to follow the out-of-plumb corners of the house.

To help expedite the installation, I tack the panels in place with a few nails when installing each course. Later, I go

SEAL GAPS AND SEAMS TO KEEP OUT AIR AND WATER

Use tape and more foam. *Fill gaps larger than ¼ in. with* ***closed-cell expanding spray foam.*** *Tape all the seams between panels and at the openings and corners with* ***foil tape*** *on foil-faced insulation and contractor's tape (used to seal housewrap) on unfaced panels. On polyisocyanurate panels, also tape the bottom edges of the first course to prevent degradation.*

back and fasten the panels every 12 in. on center around the edges and 16 in. on center in the field. Manufacturers recommend fasteners with at least a ⅜-in. head, so I use aluminum roofing nails. Cap nailers also work well.

As I go, I tape the seams and corners of the rigid-foam-insulation panels. If I'm using polyisocyanurate, I also tape the edge at the bottom of each panel of the first course to prevent degradation that can lead to lost R-value. For the foil-faced insulation I'm installing here, I use a foil tape with an acrylic adhesive, which bonds extremely well to the panels. For expanded- or extruded-polystyrene panels, I use the same contractor's tape used to seal housewraps.

As I work toward the roof, I stop the rigid foam about 1½ in. from the underside of the roof sheathing so that I don't block attic airflow. On gable end walls with unconditioned attic space, I stop the insulation about 1 ft. above the ceiling line and cover the gable end with housewrap. I then use furring strips to create a flat plane for the siding.

The payoff is twofold

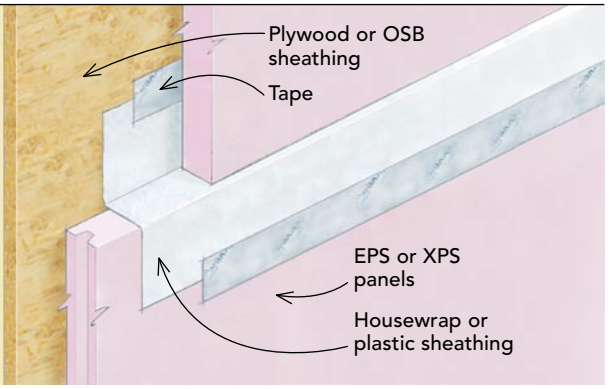
The investment in rigid-foam insulation pays off in a couple of ways. The first is strictly financial. Let's use the 2000-sq.-ft. house shown here as an example. Sixty-five sheets of insulation were required, which at the time cost about $900. The window and door furring cost about $100; labor was about $600. This total ($1600) was included in the mortgage at 6.5% over 30 years. That's about $7 a month. I have no way to measure energy savings accurately, but I'm sure it's more than $84 a year.

Rigid-foam insulation also pays off in comfort. A draft-free house with no cold corners or big temperature differences is an instant payback to some, including me. □

Contributing editor Rick Arnold lives and works in Wickford, R.I. Job-site photos by Brian Pontolilo; product photos by Krysta S. Doerfler.

Unfaced panels need flashing

The long edges of some expanded- and extruded-polystyrene panels have shiplapped or tongue-and-groove edges. Manufacturers recommend vertical panel installation, with seams sealed with tape. Because I don't trust the bond between the tape and the unfaced panels, I often add a piece of housewrap or plastic sheathing as flashing between the horizontal butt joints to prevent water intrusion.



A WORD ABOUT SIDING DETAILS

Adding a layer of rigid insulation can affect how siding is installed. For vinyl siding, you simply can use nails long enough to extend through the rigid-foam insulation and into a solid nailing surface. If you're installing wood siding directly on top of rigid-foam insulation, make sure the siding is back-primed with a good sealing primer, and again, use proper-length fasteners. The primer must be completely dry before you apply the siding over expanded or extruded polystyrene; certain finishes can eat through the foam. The best practice when installing wood siding is to install a drainage screen by applying furring strips over the rigid-foam insulation. The strips act as a nailing surface for the siding (see "Rain-Screen Walls: A Better Way to Install Siding," *FHB* #137).

Drawing: Dan Thornton