Retrofitting Exterior Insulation

Adding rigid foam to the outside of the shell dramatically increases R-value while reducing thermal conduction

by David Joyce

In late 2008 my company contracted to do an energy retrofit on an 80-year-old home in the Boston suburb of Arlington. Energy efficiency is one of our specialties, so this wasn't our first energy retrofit, but it was one of the most comprehensive.

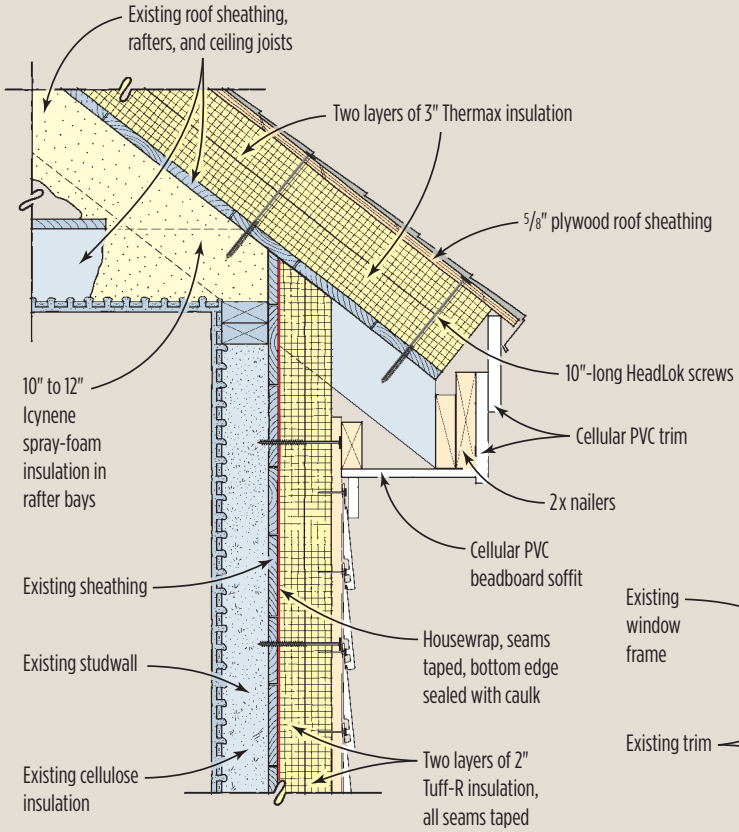
Because the owner wanted to replace the roofing, siding, and windows anyway, we had an opportunity to increase the R-value of the shell and eliminate thermal bridging by wrapping the entire exterior with rigid foam insulation.

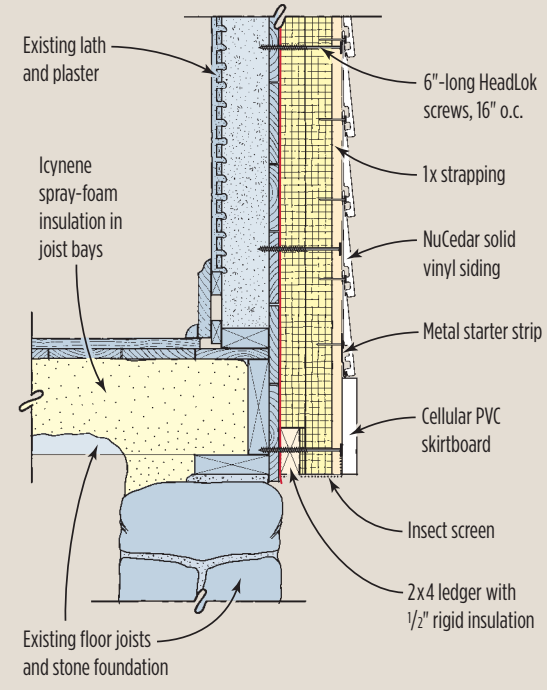
The key to getting this type of installation right is deciding what role each layer of the installation will play. The house needs a drainage plane to make it watertight and an air barrier to keep it draft-free. The plans called for a layer of Tyvek housewrap over the existing board sheathing, followed by two layers of foam, a layer of vertical strapping, and cellular PVC clapboards nailed to the strapping, creating a rain-screen wall (**see illustration, page 2**). The outermost layer of foam would be the primary drainage plane, while the underlying foam and the Tyvek housewrap would serve as backups. The housewrap would also serve as the home's air barrier.

Roof Down

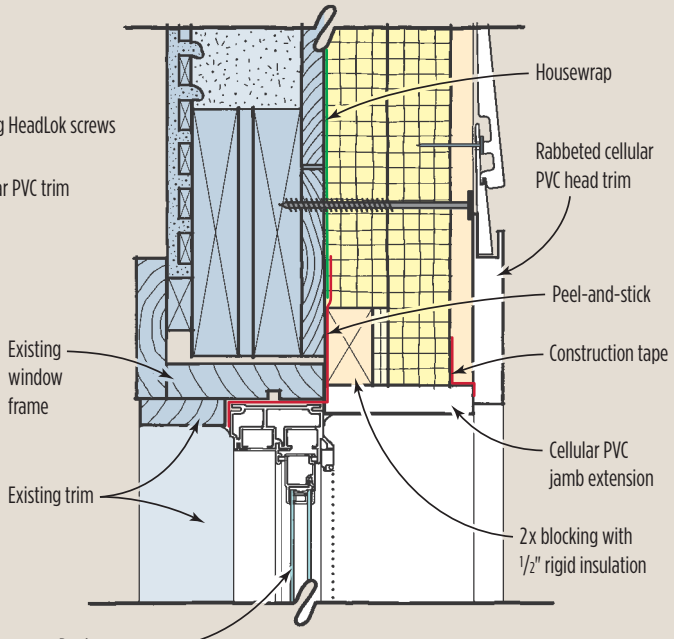
We started with the roof, stripping it down to the sheathing, then installing two layers of 3-inch Dow Thermax foil-faced polyisocyanurate insulation, per the recommendation of Betsy Petit and Kohta Ueno of Building Science Corp. in Somerville, Mass. We staggered the

Exterior Insulation Details





Head Detail



Sill Detail

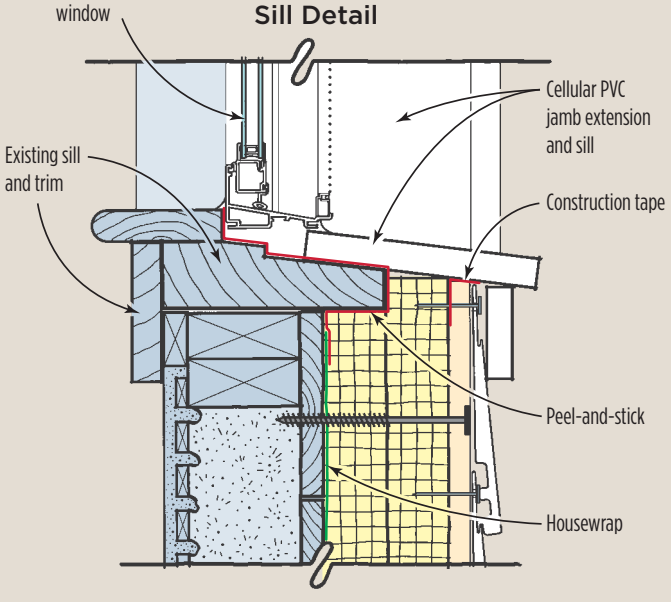


Figure 1. After stripping the existing roofing (above left), the crew installed two staggered layers of 3-inch-thick rigid foam, secured with 10-inch HeadLok screws (inset) driven through the sheathing into the rafters (above).

joints in both directions and taped the seams to prevent air movement through the edge gaps, then laid 5/8-inch plywood sheathing on top and attached it to the rafters with 10-inch FastenMaster HeadLok screws (**see Figure 1**). We then installed the roofing right on top.

Next we stripped the old shingle siding and installed the Tyvek. Because the housewrap was serving as both a drainage layer and an air barrier, we secured the bottom edge to the sheathing by embedding it in silicone caulking and taped all the seams with Dow Weathermate construction tape. We like this particular tape because it can be installed regardless of the weather. It sticks to wet surfaces and holds well even if it's left exposed for a long time.

Installation of the replacement windows followed, with the double-glazed Pella Impervia double-hung replacement units sized so that we could keep the original interior trim intact (**Figure 2**). We flashed the rough openings with Grace Ice & Water Shield, then taped the housewrap to the peel-and-stick. As the windows were installed, we also attached 2-by blocking around the perimeters to provide backing for the deep exterior jamb extensions that we would be adding.

Figure 2. The replacement windows were sized to fit the original double-hung window jambs, which were retained and flashed with a peel-and-stick membrane (left). The interior sills and casing were also preserved (below).

Figure 3. One-by-three strapping screwed to the framing on 16-inch centers holds the double foam layer securely in place (above) and provides a drying and drainage channel behind the siding. Seams on both layers were taped to block air movement. Metal screen (seen hanging, right) keeps insects out of the drainage space.

Wrapping the Walls

Over the housewrap we placed two layers of 2-inch Dow Tuff-R foil-faced polyiso. We started by fastening a 2x4 ledger across the bottom of the wall to provide support for the first layer of foam as well as nailing for the skirtboard. As we were installing the 2x4, we stapled insect screening to the wall; this would later be folded up and fastened to the strapping to keep bugs out of the air space (**Figure 3**).

We laid out the foam board with drainage in mind, making sure to stagger the field joints and weaving the edges on outside wall corners. That way, any water that gets past the first layer will hit solid foam rather than another seam. We also taped the seams on both layers.

Wall strapping. We held the foam board in place temporarily with long screws, then followed with 1x3 vertical strapping screwed to the studs. To prevent notice-

Figure 4. Porch floor joists had to be cut off to allow the insulation board to pass behind (above and top right). The new ledger was attached through the foam into solid framing with structurally rated screws (right).

able waves and bumps in the clapboards, we took pains installing the strapping, making sure the surface of each piece was in the same plane as the pieces on either side. This is a good idea for any type of siding, but it was critical in this case because the PVC clapboards the owner had chosen — called NuCedar — have an interlocking edge that would make any irregularities in one course show up in the next course. The nailing surface needs to be almost perfectly flat — there's little tolerance for error.

We fastened the strapping to the underlying wall framing with 6-inch HeadLok screws, then pulled string or laid a straightedge over the faces. By tightening or loosening the screws, we could adjust the depth by 1/8 to 1/4 inch to create a flat wall. Because it was an old house, we needed every bit of that adjustment in some areas.

Siding support. We've been asked several times whether, with 4 inches of foam between the strapping and the sheathing, we worry that the weight of the plastic siding will bend the screws and cause the courses to sag. Although the job isn't that old, we're confident that we won't have such problems. Another job we did had an identical rain-screen detail over 4 inches of foam — but in that case we installed fiber-cement siding, which is heavier than cellular PVC. Revisiting that job after four years, we saw no evidence of sagging.

Figure 5. In order to secure the deep exterior jambs needed to cover the double layer of foam, carpenters fastened 2-by blocking around the windows directly against the housewrap (top left). The blocks were covered with 1/2-inch-thick foam, then buried beneath the second layer of 2-inch foam, effectively preventing thermal conduction (top right). Stainless fasteners secure the PVC extensions, which were also taped to the foil-faced foam (above photos).

Porch Ledger Over Foam

Installing the porch ledger was tricky, because we had to maintain the strength of the connection as well as the thermal break provided by the foam (**Figure 4, page 4**). We did this by cutting back the porch joists and removing the original ledger. We securely fastened a new 2-by ledger over the Tyvek into the framing, then covered it with 1/2-inch rigid foam. This created a total thickness of 2 inches, matching the first foam layer. We then installed the second layer of 2-inch foam, placed a second ledger on top of that, and again fastened through to solid framing. We flashed the ledger with Ice & Water Shield and aluminum.

Window Jambs

Anytime you add rigid foam to the outside of the shell, you end up having deep jamb extensions either inside or outside, depending on whether the windows are installed on the face of the sheathing or the face of the foam. We've done it both ways. On this job the windows were "innies," meaning we had to add exterior jamb extensions to cover 4 inches of exposed foam plus the 3/4-inch strapping (**Figure 5**).

This is without a doubt the most vulnerable part of the installation; if there's

ever a problem, it will be because of a leak around the windows. For that reason, I usually build and install the extension boxes myself, taking care to tape and seal every possible leakage point.

On this house I used cellular PVC boards supplied with the siding package, screwing the pieces together with stainless steel trim screws and applying silicone caulk in every joint. The sill has a 10-degree slope. I bedded the backs of the extension boxes in a generous bead of silicone on the window frame, then screwed them into the wood blocking around the perimeter. On the outside, I taped the sides of the extensions to the foil surface of the insulation board.

PVC Siding

The owner chose NuCedar siding to reduce maintenance costs; according to the manufacturer, it never needs to be painted. We found that it was scratch-resistant and easy to handle. Not only is it lighter than fiber cement, but it doesn't give off any nasty dust when it's cut.

The siding package we received included 1/2-inch clapboards, metal starter strips for the first course to lock into, flat plates for bonding adjoining clapboards, and premilled header, casing, and corner trim. In the fall of 2008 NuCedar cost about 10 percent less than red cedar and about three times more than fiber cement.

We completed the job over the winter, in temperatures that varied from mild to bitter cold. The siding was flexible when temperatures rose above 50°F but became brittle at colder temperatures, which

Figure 6. The cellular PVC siding had to be carefully hand-nailed through slots that allow for expansion (top right). Backing plates provide glued reinforcement at butt joints (above and right).

meant we had to handle the boards more carefully to keep them from cracking.

Accommodating Movement

Besides needing to keep the wall plane flat (the process I mentioned above), you also have to pay attention to movement, because any vinyl product expands and contracts a lot with changes in temperature. The siding we installed included a nailing flange at the top of each piece. It's fastened in place with roofing nails, but to allow for movement you have to leave a 1/16-inch gap between the nail head and the siding material (**Figure 6, page 6**). This meant nailing by hand, which probably added the most time to the job. (A few months after this job, NuCedar came out with a clip system that allows you to install the siding with a nail gun, but I haven't used it so can't comment on its effectiveness.)

Field seams are backed with a vinyl bonding plate that's glued to the back of the siding with PVC cement. The plate holds the siding in place but serves no waterproofing role. Because the plates are adhered with PVC glue, installing them in cold weather can be problematic; in fact, a few of the ones we installed on cold days later came loose.

Figure 7. Vertical trim pieces are rabbeted to allow the siding to move horizontally behind them (left). Sawtooth closure strips (below left) plug the gaps where the clapboards run behind the trim (below).

Trim and Flashing

The NuCedar trim goes on after the siding and has a rabbeted edge that overlaps the clapboards, giving them room to move (**Figure 7**). To allow for movement, the ends of the PVC clapboards have to land in the middle of the rabbet. The back of the trim boards have a mark showing where the clapboards should end, so we snapped vertical reference lines on the foam at this point. At outside corners we also used a block of trim to confirm our spacing as the siding went up.

The package comes with sawtooth-shaped inserts that close the gap between the trim and siding. This method no doubt works fine on the flat walls of a new home, but — as mentioned previously — with the rain screen over the old frame we had to constantly adjust the strapping depth to get the inserts to fit tightly. These details add a lot of time to the job; the siding took about a third longer to install than wood clapboards, though admittedly this was our first experience with the product.

The siding is also not as easy to replace as wood. You can't simply pull out a damaged piece and slip in a new one. Each course is locked into the one above and below it, so you need to remove the pieces above and below as well. NuCedar says that a skilled person can cut out the damaged area with a spiral saw and use a bonding plate to cement in a patch; it recommends Sherwin-Williams Duration or Super Paint for touch-up jobs. Both adhere well to the siding and come in matching colors.

My overall impression of this siding? It's not ideal from an installer's point of view, and my top choices are still fiber cement and wood, both of which install quickly and are easier to replace. But with maintenance-free exteriors in demand, we can expect to see more of this product and others like it.

There was one detail we found difficult to get used to: Instead of a cap flashing above doors and windows, the head

Figure 8. Open-cell spray foam in the attic (top photos) boosted roof R-value to around 60. The benefits of the added insulation were apparent as the job progressed: Ice dams that used to form were gone (left and below).

trim has a rabbeted groove on top that directs water to channels along the side of the window and out at the base. The rabbet also retains the bottom edge of the siding the same way the starter strip does at the base of the wall. We were not satisfied with this detail, so we decided to add head flashing to the windows that would be most exposed to wind-driven rain. The manufacturer says it's fine to add flashing as long as you nail a length of starter strip to the face of the flashing to retain the bottom edge of the clapboard above the window. Once the clapboard is installed, the nails are covered. We used the detail to add metal cap flashings to the most exposed windows.

No More Ice Dams

On the inside, the owner added 10 to 12 inches of Icynene to the unfinished attic, bringing the total roof R-value to 60 or more. Added to the blown-in cellulose already in the wall cavities, the additional 4 inches of foam on the outside brought the wall R-value to around 39.

The benefits of the insulation retrofit were obvious to us as the job proceeded: Ice dams that used to form on the roof after every snow — a sign of heat leaking through the top of the building shell — were gone (**Figure 8**). New Fantech HRVs on the inside ensure good air quality for the two units in the building, and the occupants describe the house as warm, draft-free, and quiet.

***David Joyce** is owner of Synergy Companies Construction LLC in Lancaster, Mass.*