BY STEVE EASLEY

Continuous Insulation: Problems and Solutions

If you've watched the evolution of energy codes over the past couple of decades, you've probably noticed an increasing emphasis on exterior insulation for walls. As early as 2006, the International Energy Conservation Code (IECC) specifically allowed exterior insulation as an option in its insulation tables. By 2012, the prescriptive insulation requirements had mandated only continuous insulation options for climate zones 6, 7, and 8. The upcoming 2021 IECC, which recently passed, will allow a "fat" (R-30) cavity insulation option for zones 6, 7, and 8, but it has stepped up requirements in climate zones 4 and 5, where all insulation options require some continuous insulation.

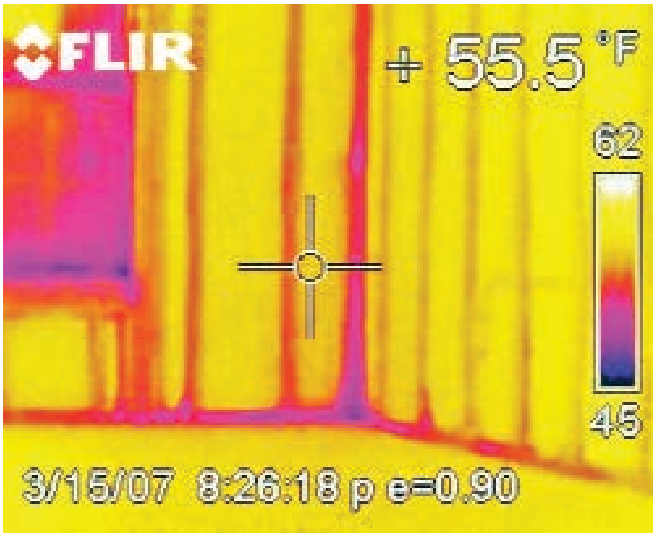
Continuous exterior insulation has advantages. First of all, it substantially increases the true R-value of walls at a fairly low cost. For example, adding one inch of R-5 exterior insulation raises the real R-value of a 2x4 wall with R-12 cavity insulation from just R-10.7 to R-16. Secondly, most homes have framing factors of 25% (meaning that the true R-value of 25% of the windowless walls is the R-value of the wood, or R-3.5). Exterior insulation reduces thermal bridging across the wall through framing members, and it keeps the sheathing warmer (which reduces the risk of condensation and mold growth on the sheathing).

But the practice of applying foam insulation to wall exteriors can be complicated, and it comes with some drawbacks. In particular, plastic foam is vapor impermeable, which means walls can't dry to the outside if they do get wet. To avoid callbacks, you have to address water and moisture management with greater diligence when you make the move to exterior foam insulation. And you may have to rethink the way you attach and flash your windows and do diligent inspections.

THE ADVANCING CODE

In the prescriptive tables of the upcoming 2021 IECC, a combination of cavity insulation with exterior insulation is strongly favored. In climate zones 6, 7, and 8, you can have either R-30 in the wall cavity, or a combination of R-20 cavity insulation with R-5 exterior insulation (R-20+5), or a combination of R-13 cavity insulation and R-10 exterior insulation (R-13+10). In climate zones 4 and 5, continuous exterior insulation will be the only options: R-20+5 or R-13+10. In climate zone 3, you can choose among R-20 in the cavity, R-13+5, or R-0+15. And in climate zones 1 and 2, you can choose between R-13 in the cavity or R-0+10.

Extruded polystyrene foam is rated at R-5 per inch and polyiso at R-6.5 per inch. So depending on the options they choose, builders may need to apply an inch, 2 inches, or sometimes even



Photos by Steve Easley

An over-framed wall like this (above left) is a good candidate for exterior foam insulation. The infrared image (above right) shows the cold studs in a heated house on a winter day. Exterior foam insulation could prevent this source of heat loss.

Studs conducting heat (above left) stand out on a frosty morning. Exterior insulation would eliminate this heat loss. Air-sealing is critical when walls are vapor-closed to the outside. Here, a builder has correctly air-sealed a bottom wall plate (above right).

3 inches of foam. The energy benefit aside, there are practical problems to applying that much foam to a building exterior.

MOISTURE RISKS

In the 1980s, we built a demonstration home at Purdue University that had heating and cooling costs of less than $200 a year. Part of how we accomplished that was by sheathing the exterior of the building with polystyrene. At that time, structural codes allowed us to install wood structural panel sheathing only at the building corners. But modern wall bracing codes in most regions require more extensive use of structural panels, and using continuous structural wood panel sheathing is the best way to get a stiff, rugged building. Although installing exterior insulation is still a way to get a high-performing building, there's an increased level of risk when you cover a hygroscopic material like OSB sheathing with an impermeable material like rigid polystyrene foam. To forestall this risk, follow good moisture management principles and inspect everything before cladding is installed.

Moisture problems come from two places—they come from inside the home, or from outside. Interior moisture is the trickiest. If there is a big moisture differential from inside to outside, and there is an impermeable material on the outside, that moisture is not going to dry to the outside so well. To avoid problems, pay attention to three things: First, don't install vinyl wallpaper or use oil-based paints on interior wall surfaces. Since the wall can't dry to the outside, you have to give the wall a chance to dry to the inside. Second, you need to pay close attention to air-sealing. Most of the moisture that enters the wall cavity from the interior is driven by air currents. Third, you need to reduce the indoor moisture load with ventilation. When moisture-laden air comes in contact with a cold surface, the moisture condenses out and dampens the surface. If the surface relative humidity moves up above the 70% range, then mold can start growing. Effective spot ventilation—good bathroom and kitchen exhaust fans—goes a long way towards reducing indoor moisture levels. Ideally, you should install technology that can automatically sense and control humidity.

The good news about exterior insulation is that because the insulation is outboard of the sheathing, that sheathing stays warmer. Warmer sheathing surface temperatures mean lower surface relative humidity. This means that the sheathing is less likely to dampen to the point that it reaches the threshold for mold growth. Even so, when you apply impermeable foam insulation to the outside of a building, you need to be fastidious about air-sealing the walls so that air currents across the wall are minimized.

One option is to install the foam board first, then sheathe over it. That lets the sheathing dry to the outside. But if you build in a location where higher levels of wall bracing or shear walls are required, you'll want to check with an engineer to make sure that the shear capacity of your sheathing is adequate. When sheathing is held away from the studs by insulation, its ability to resist racking forces is reduced.

THE WINDOW INSTALLATION PUZZLE

Controlling indoor humidity and building an airtight enclosure reduces the moisture risk from inside the home. That leaves the risk from outside the home—which is primarily found at penetrations like windows, doors, and roof-wall intersections. Most builders have plenty of experience at installing windows in a wood-frame wall without exterior insulation. But many builders

Sheathing can be applied outboard of the foam (above left). This lets the sheathing dry to the outside. ThermalBuck (above right), an insulated window mounting system, creates a positive attachment for the window while limiting thermal bridging.

may not have a usual method for installing windows when the wall has been packed out with an inch or two of extruded polystyrene.

And while the code may require exterior insulation, the code doesn't tell you how to fasten and flash the windows into a foam-insulated wall. However, there is a resource for this: a document called FMA/AAMA/WDMA 500-16, which goes by the title "Standard Practice for the Installation of Mounting Flange Windows into Walls Utilizing Foam Plastic Insulating Sheathing (FPIS) with a Separate Water-Resistive Barrier." In addition to following the guidance in this document, you should cross-check the window, housewrap, and flashing manufacturers' guidelines for their products. If there's a conflict, code will defer to the window manufacturer's instructions.

A lot of testing and thought went into the creation of FMA/AAMA/WDMA 500-16. Recognizing that the sequencing of the trades varies from builder to builder, the standard practice offers multiple alternatives for how to install the windows. In one method, housewrap is applied to the building before the window bucks and foam are attached; in another, the housewrap goes on after the bucks and the insulation. In a third method, the window is applied directly to the wall with no bucks. In every case, the flashing and housewrap are designed to direct water down and out of the wall assembly.

Method A. In one version of Method A from the standard practice, the foam is applied directly to the sheathing and the housewrap is applied over the foam. The window buck (termed a "Rough Opening Extension Support Element," or "ROESE," by the document) goes on the wall first. The full sequence is as follows: window buck; insulating foam; housewrap (WRB); sill flashing; window; jamb flashing; head flashing; head tape.

In another version of Method A, the housewrap is applied after the window is installed. In this version, the sequence is: window buck; insulating foam; skirt; sill flashing; window; jamb flashing; head flashing; housewrap (WRB); jamb tape; head tape.

If you are concerned about thermal bridging at the window buck, or ROESE, consider a rigid-foam prefabricated product that is designed to take the place of the wood buck. The product shown above is called ThermalBuck.

In Method B, the window is installed into the window buck over the housewrap, and the foam insulation is applied next. This method uses either fluid-applied or peel-and-stick flashing.

Method C takes a different approach, applying the housewrap and the window to the wall before the foam is applied. In this case, there's no window buck.

For added security, I recommend that builders consider a rainscreen wall assembly. With a rainscreen, water striking the cladding has to jump across a $1/4$- to $3/4$-inch gap to reach the weather barrier, and even if that happens, the water just hits the weather barrier and runs down. So rainscreens provide you with exponentially better protection against water getting behind the foam.

Steve Easley is principal of Steve Easley Associates, a company based in Scottsdale, Ariz., that provides building-science consulting, training, and quality assurance for builders nationwide.