Cold Climate Housing Research Center
CCHRC

Using Vapor-Open Exterior Insulations in Wall Retrofits

Many homeowners in Interior Alaska look for ways to lower energy costs through making their homes more energy efficient. A common retrofit technique is to add rigid foam board insulation on exterior walls of the house, typically performed as part of a siding replacement project (See Figure 1). However, this is a tricky job that can cause more harm than good if not done correctly. While adding exterior insulation does reduce heat loss, it can also change the flow of moisture through the walls. For example, most standard 2x6 frame walls have a leaky plastic vapor retarder directly behind the drywall that allows moisture to permeate into the framing elements. When you add a vapor-impermeable material like plastic foam insulation to the exterior of this wall, it can no longer dry to the outside as it did before. This retrofit has resulted in compromised indoor air quality and damage to the structure caused by moisture accumulation, mold, and rot.

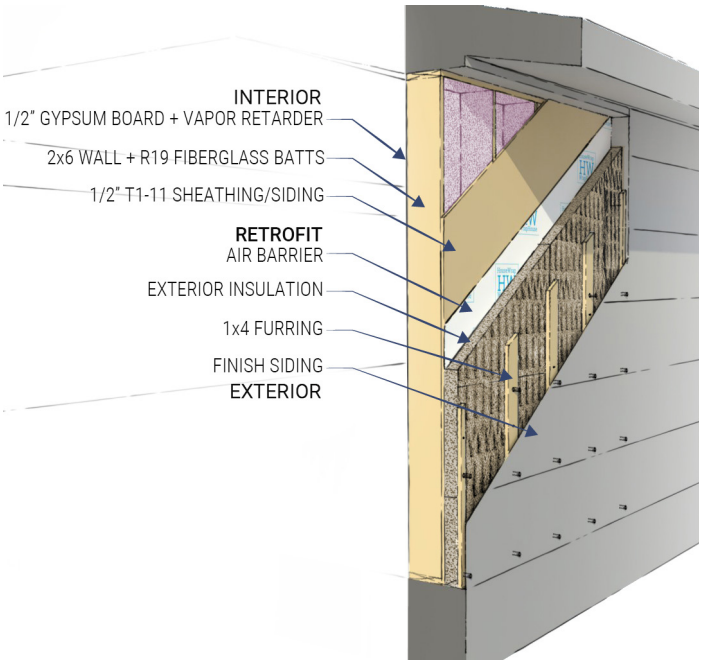

Figure 1. A typical wall retrofit in Fairbanks, Alaska consists of a 2x6 frame wall with a layer of exerior insulation under the siding. The 1x4 furring creates a drainage/ventilation area for any liquid water or water vapor that might get behind the siding, also called a rain screen.

This study looked at alternative options to see if vapor-permeable (or vapor-open) insulations are safer than impermeable insulation like EPS foam. Using both physical testing and modeling, researchers looked at seven different retrofit walls to evaluate their moisture performance. Each consisted of a 2x6 frame wall insulated with R-19 fiberglass, and featured varying types of exterior insulation listed in Table 1.

Table 1. The moisture performace of the nine test walls. Shaded rows indicate walls that developed visible mold in some form.
* Low-density EPS foam was used in this study because it has a higher permeance

Wall	Additional Exterior Insulation	Vapor Permeance (perm)	% Exterior R-value	Days in Danger Zone (Year 1)	Days in Danger Zone (Year 2)	Consecutive Days in Danger Zone
Wall 1	1.5 in. stone wool board	78	21%	64	65	36 (spots of mold)
Wall 2	2 in. unfaced EPS board*	2.5	30%	153	135	122 (visible mold)
Wall 4	3 in. stone wool board	39	34%	50	0	33
Wall 5	None - control wall	None		25	8	5
Wall 6	3.5 in. blown-in cellulose	20	39%	75	3	34
Wall 7	3.5 in. blown-in fiberglass	28	39%	42	0	17
Wall 8	4 in. unfaced EPS board*	1.25	46%	84	0	67

Results

Moisture performance was measured by how long the temperature and relative humidity (RH) at the plywood sheathing were conducive to mold growth, which requires RH above 80% and temperatures above freezing. We refer to this as the "danger zone." If those conditions persist for 4-8 weeks, the wall has a strong likelihood of developing mold. Table 1 depicts how long each wall was in the danger zone. The longer a wall is in the danger zone, the greater the likelihood of growing mold, as seen in Figure 2.

How do you prevent this in your wall retrofit?

If you decide to use foam, follow the rules:

Sticking to the 1/3 to 2/3 insulation ratio rule for Interior Alaska is a fail-safe way to prevent moisture problems in your wall when adding impermeable insulation to the outside. The rule holds that placing 2/3 of the total wall R-value outside the sheathing keeps the wood framing above the dew point, preventing condensation from forming. For example, when retrofitting a 2x6 wall, 8-10 inches of exterior foam insulation would be necessary in Fairbanks. (In Anchorage, 60% of the R-value should be exterior of the sheathing and in Juneau, 43%.) Refer to the online calculator for more information: dewpointcalc.cchrc.org.

Or, try a different material

If you don't want to be locked into the 1/3 to 2/3 rule, there are other types of insulation you could use in your wall retrofit that are more forgiving. For example, vapor-open exterior insulation can work if the existing building envelope has **ALL** of the following:

- A well-sealed interior 6-mil polyethylene vapor retarder (this is hard to determine without hiring an inspector)
- The house is fairly tight, with an air leakage rate less than 5 Air Changes per Hour 50 (measured post-retrofit)
- The retrofit includes an exterior vented rain screen that is at least ½-inch wide

Controlling air leakage is critical in wall retrofits, as leaks through the building envelope can account for 18% of the home's total space heating loss. Air leakage is also the major source of moisture getting into the walls. This means that in any home retrofit, special detail must be paid to the air barrier.

Figure 2. Unsurprisingly, the wall with 2 inches of exterior EPS grew mold after 2 years. This is a common retrofit technique in Fairbanks and occured in more than 60% of wall retrofits between 1996-2015.

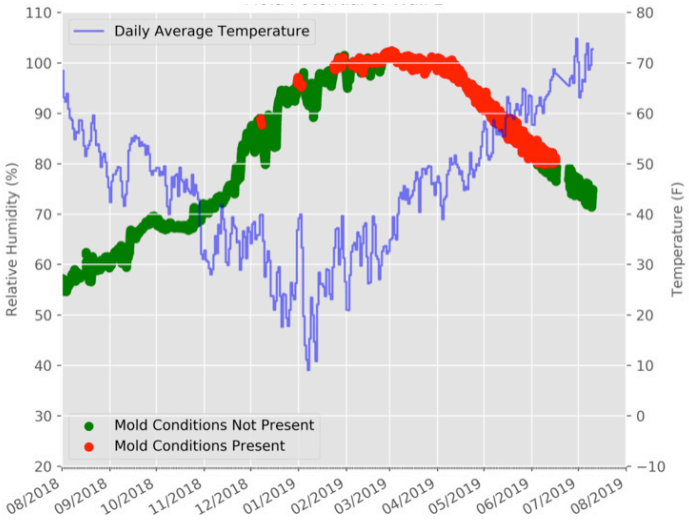

Figure 3. Data from the wall pictured above. With conditions of 80% RH and temperature above freezing, the wall was the danger zone for 17 consecutive weeks.

While using vapor-open insulation on an exterior retrofit relaxes the rules a bit, it doesn't mean you're free to use any amount you want. There is still a minimum insulation thickness based on the material, the energy savings target, and the house location. If you're planning to do an exterior retrofit, be sure to do plenty of research and err on the side of caution.

LEARN MORE

See the full report at cchrc.org/library:

Safe, Effective, and Affordable Retrofits for Cold Climates