Installing PVC-Type Sidings in Cold Climates

Beware of impermeable sidings without vented rainscreens

BY GEORGE TSONGAS

Photos by George Tsongas

In a recent advertorial that appeared on *JLC*'s website, the author exclaims the virtues of solid PVC siding and trim, including "not having to add a rainscreen." Yet the lack of a rainscreen (or enough continuous exterior insulation) with any polymer-base siding (including vinyl, "solid" PVC, and similar materials that are not vapor permeable) in residences can potentially cause serious and widespread moisture damage to wall sheathing and framing.

It has long been known that water vapor produced indoors can migrate by air leakage or vapor diffusion into walls and condense on the wood sheathing or the exterior portions of framing in cold climates. That commonly and naturally happens during wintry weather. During winter, the moisture content in sheathing rises and peaks, and eventually falls again with warmer spring and summer weather. The key is that wood or similar siding or fiber-cement siding is vapor permeable (what some call "breathable") and allows moisture in the sheathing to slowly but surely dry to the outside air. If it dries enough, the sheathing moisture content drops below the fiber saturation level of about 26% to 30%. Below this level, decay cannot occur during warm spring and summer weather.

It is important to note that decay occurs only when wood is both wet and warm for extended periods of time. The optimal temperature range for the growth of decay fungi is about 65°F to 95°F (18°C to 35°C). There is little or no growth below 50°F (10°C).

The effects of trapped water vapor. These walls **(1, 2)** on single-family homes in northern Wisconsin had been covered with a weather-resistive barrier (WRB) that acted as a vapor barrier. Moisture-laden indoor air migrated toward the outdoors by air leakage and vapor drive and condensed on the back of the sheathing, leading to extensive rot.

It also has been known since the 1950s or so that in cold climates, the vapor permeability of exterior cladding must be much greater than the permeability of the interior surfaces of the wall to allow indoor water vapor that enters a wall cavity to dry to the outdoors. That means that the outside cladding system must be vapor permeable. However, siding materials like cellular PVC, poly-ash, metal (steel or aluminum), and vinyl are not vapor permeable. They may act like vapor barriers on the wrong side of the wall. In such cases, the water vapor that enters the wall cavity from indoors and condenses in the sheathing and framing leads to much higher sheathing moisture contents (higher, that is, than in walls with vapor-permeable siding materials) and cannot dry out as easily during warm weather when decay can occur. Thus, it is possible that the sheathing moisture content will remain above the fiber saturation level well into warm weather and lead to decay of sheathing and framing. Mold growth inside the wall cavity is also possible, along with deterioration of WRBs.

Whether or not the sheathing and framing get wet enough to cause moisture damage depends on several factors. Interior vapor barriers can reduce the amount of water vapor entering wall cavities, but in practice, it is hard to keep all interior moisture from entering walls given the myriad ways air and water vapor can enter them.

One key is to keep the relative humidity of the interior air low. This will minimize the moisture load that is driven into walls. Most damage in walls has been found to be in walls adjacent to bedrooms where relative humidities are typically higher than in other indoor locations. Oftentimes, indoor ventilation, especially in bedrooms, does not keep indoor relative humidities low enough to prevent damage in walls.

MULTIFAMILY VS. SINGLE-FAMILY HOMES

A critical distinction should be made between multifamily and single-family walls. Single-family homes lose moisture that is generated indoors through four (or more) walls. A unit in multifamily housing, however, loses indoor moisture through many fewer walls—often just one or two. So the moisture load in multifamily walls is much greater than in single-family walls. Wall-cavity moisture problems, especially vapor-drive problems, are more likely to occur in multifamily housing walls. That said, there is a real potential for similar problems in single-family housing in cold climates, especially in very cold climates, as well as in homes that are very airtight and underventilated and thus have elevated indoor relative humidities and higher dew point temperatures. As all housing gets tighter via new codes, the problems may only grow worse. That is not to say we need to stop tightening houses. Rather, we need to alleviate the resulting moisture loads with effective ventilation and condensation control in walls.

I saw an example of what can happen when single-family walls are installed with a vapor barrier on the outside of the wall cavity

Increased moisture loads. Inspections of multifamily housing in Oregon revealed water staining on gypsum sheathing beneath contact-applied vinyl siding **(3)**, and serious decay and mold damage on the OSB sheathing beneath the gypsum **(4)**. With fewer walls facing the exterior in multifamily units, moisture loads driven by air leakage through those walls tend to be higher than in single-family homes, where an equivalent moisture load may be driven through walls on all sides.

when I had the opportunity to remove all the hardboard siding from 15 single-family homes in Wisconsin (climate zones 6 and 7) that mistakenly had a low-permeability (0.6 perms measured) exterior water-resistive barrier (WRB) installed. This WRB had trapped moisture coming from indoors in the plywood sheathing. Inspections prior to mine had found widespread sheathing damage in hundreds of these homes. Fourteen of the 15 homes I inspected had plywood decay, with 12 severe enough that the plywood could easily be torn apart by hand. We determined that the extensive and widespread damage (see examples in photos 1 and 2, facing page) was caused by vapor diffusion and air leakage from indoors rather than from rain leakage from the outside of the wall cavities. None of the outside surfaces of the siding exhibited any signs of water damage.

While this example involved an impermeable WRB, it demonstrates the condensation potential from trapped moisture in single-family homes in very cold climates. As we shall see, it's plausible that similar damage can be expected with impermeable siding materials, even vinyl siding (contrary to widely held beliefs), in cold winter climates.

Here's an example of what can happen in multifamily housing with impermeable siding that acts as an exterior vapor barrier. I was present at site inspections in which we opened up walls at seven, mostly large multifamily housing complexes in Oregon and Washington. These housing complexes in a relatively mild marine climate zone each included numerous buildings, and dozens to hundreds of apartments, with vinyl siding. None of the exterior walls had a rainscreen or exterior insulation (a condition I call "contact-applied" siding).

On a multifamily housing complex in Washington state, removal of contact-applied vinyl siding, paper, and gypsum sheathing revealed moldy, decayed OSB **(5)**. The damage was worse on the inside face of the OSB. On a different housing complex in Oregon **(6)**, moisture driven from the interior caused sporadic deterioration of the WRB and decay of OSB sheathing.

Most people believe that walls clad with contact-applied vinyl siding work well because the siding is applied "loose" and reportedly "drains well." However, in every one of those seven cases, most of the buildings had some damage to wall components behind the vinyl siding, and there was no evidence of excessive rainwater intrusion or construction defects that would have led to rainwater intrusion. Rather, the damage, which included WRB deterioration, mold, and serious decay of the plywood and OSB sheathings and wall framing, was found to be directly related to water-vapor transport into the wall cavities from indoors. Oftentimes, the back face of the vinyl siding was dripping wet (see the photo on page 33).

Observations at the wall-opening inspections revealed that OSB decay was surprisingly widespread, but it occurred sporadically. Not all wall areas were affected. It occurred mostly on north-facing walls and seldom on warmer, south-facing walls; often at intersections of interior walls; and in some cases, between floors where air leakage typically was highest. The sheathing was routinely wettest on the inside faces, indicating moisture was coming from indoors. In addition, the sheathing and WRB damage (including decay, mold growth, and WRB deterioration) and elevated moisture contents, as well as elevated indoor air relative humidity and dew points, correlated in most cases to bedroom walls. Notably, there was very little indoor mold observed, although the wall damage did not appear to be related to lack of sufficient indoor ventilation. The photos above and on the facing page are typical of the sheathing decay and housewrap deterioration we found at the wall-opening inspections.

POTENTIAL FOR WIDESPREAD PROBLEMS

Mold and decay problems inside wall cavities with vinyl siding are not widely known, since not much vinyl siding gets removed and wall cavities behind it are seldom inspected. As a further verification of this problem, WUFI modeling (using software that evaluates vapor diffusion and moisture transport through building materials) in one case compared OSB sheathing moisture contents behind vapor-impermeable vinyl siding and vapor-permeable fiber-cement siding. OSB moisture contents with fiber-cement siding remained well below levels that allow decay, whereas the OSB with vinyl siding reached moisture contents well above levels that allow decay. Those modeling results would be the same for single-family walls, as well. It is important to note that, while not widely known, decay can produce significant strength loss even when it is barely visible. Substantial visible decay of plywood and OSB structural sheathing was often observed. So, while not studied, it appears possible that some walls with contact-applied vinyl siding or any other impermeable cladding could be at risk of structural failure, which is an obvious life-safety concern.

TWO WAYS TO AVOID PROBLEMS

To avoid these problems, contractors have two clear choices: Add continuous exterior insulation that warms the sheathing and considerably reduces condensation, or use a rainscreen with a WRB. Choosing exterior insulation reduces wall heat loss while avoiding wall damage, but at the greatest cost. You must use enough continuous insulation; too little continuous insulation over cavity-insulated walls is risky (see “Avoiding Wet Walls,” Apr/17). With the rainscreen choice, the key is not only preventing damage to sheathing and framing from condensation, but also allowing water that may leak to the back face of the siding to drain out of the wall and dry.

WRB effectiveness. A laboratory study I conducted for a major supplier of wall WRBs tested the relative performance of walls with a regular, flat WRB, a crinkled WRB, and a rainscreen (with an air gap and a flat WRB). We tested each under wall leakage conditions where water was leaked into the tops of the wall cavities between the back of fiber-cement siding and the outside of the WRBs for four months. At the end of the test, the sheathing was very wet, moldy, and decayed on the wall with the flat WRB; somewhat less wet and moldy with no decay with the crinkled WRB; and completely dry and without mold or decay on the wall with the rainscreen. Many contractors are now selecting crinkled or other “drainable” WRBs, but that is not sufficient to prevent damage in walls with impermeable siding. The only prudent choice is to employ a rainscreen design to prevent major damage to walls with impermeable siding.

BOTTOM LINE

The point of all this is that walls with impermeable siding—including conventional vinyl as well as solid, or “cellular,” PVC or polymer-based materials—definitely need to have a fully top- and bottom-vented rainscreen, or sufficiently thick continuous insulation, behind the siding. The fully vented rainscreen allows interior moisture to dry out, while exterior insulation warms the sheathing. In both cases, condensation-related elevated moisture contents are kept to a minimum. Choosing to “not add a rainscreen,” or not include continuous insulation, can potentially cause serious and widespread moisture damage to wall sheathing and framing. Is the cost savings worth the risk?

Details of many of the research findings and other pertinent information can be found in my article “Cautionary Case Studies: Damage in Multifamily Housing Walls with Vinyl Siding” (*ASHRAE Journal*, July 2017; ashrae.org).

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On the walls of the same Oregon housing complex shown on the facing page, deterioration of the OSB and WRB occurred sporadically, but the worst damage correlated with bedrooms with high indoor air dew-point temperatures. Note the green pen knife, which easily penetrated the OSB **(7)**. A similar condition was found in a wall beneath vertical board-and batten-style vinyl siding **(8)**.