BY CLAYTON DEKORNE

Lessons in Building Science

Not long ago I was sitting in an educational session for builders in upstate New York. The speaker was a retired code official turned building inspector, addressing the audience on recent changes to the energy code, also known as Chapter 11 of the Residential Code of New York State. Recent in this case meant the 2010 edition, because the state hasn't yet settled on adoption of the 2012 IECC. (Rumor has it that the new air-sealing standard that lowers the tested air-leakage rate from 7 ACH50 to 3 ACH50 is one of the primary sticking points.)

The speaker had a PowerPoint slide showing an exterior wall section that looked like an illustration out of an old *Audel's Carpenters and Builders Guide*, and he had just finished explaining the "new" insulation requirements for climate zones 5 and 6, and the differences between cavity insulation and continuous insulation. He then pointed to the interior face of the wall and said, "In climate zones 5 and 6, a vapor barrier is required on the inside face of the wall. Code allows either poly or Kraft-faced batts, nothing else. And you have to seal this vapor barrier tightly around penetrations, like the electrical outlets, otherwise hot, humid air will come whistling through there and condense on the back side of the cold sheathing in winter."

I started to cringe because not only are there other vapor-retarder materials allowed, but the speaker was beginning to confuse diffusion with pressurized air leakage. It got worse: "See, moisture moves from wet to dry," the inspector continued. "If the air is humid from occupants breathing and cooking and taking showers, this air is going to rush out all those holes around the outlets and the base of the wall to the drier outdoor air, unless you have a good vapor barrier." Ugh. I raised my hand and asked if we shouldn't be slowing things down to explain the difference between a vapor barrier and an air barrier.

In most homes, air leakage is the biggest driver of moist air into wall cavities. But in the case of a thin wall without a vapor retarder in a cold climate, high indoor humidity can diffuse through the interior finish and condense on the cold surface of the exterior sheathing.

Photos: Steve Easley

UNPACKING DIFFUSION

Back in August 1993, *JLC* published what we then titled "The Last Word (We Hope) on Vapor Barriers." It was hardly the last word, but we (mostly) got it right. I was working on the article under the sage guidance of Steve Bliss, and for me it was the first time I was clear on the difference between an air barrier and a vapor barrier. Since then I feel like I've had to relearn it at least a half a dozen times. So I was sympathetic to the blank stares from the attendees sitting in the room, and decided then to write about it here. Of course, I imagine at least half of you reading this now will think this too pedestrian, and the other half won't be interested. Either way, I hope you'll freely comment online, and push the discussion forward. The half or so that understand the difference between diffusion and pressurized air leakage are probably building high-performance homes or fixing failed ones, and the other half are running the risk of creating building failures.

Diffusion is moisture-vapor movement through building materials. The driver of diffusion is vapor pressure, which can be understood loosely as the weight of the moisture in air. Humid air has a high vapor pressure and wants to move from the humid side of a material to the drier side. Like any pressure, vapor pressure wants to equalize; the drier air in the wall cavity is pulling the more humid air to it. (Or is it the wetter air is pushing out?) I think of the air in a room in winter laden with water. Forgetting about air movement in the room for a moment, think about the moisture as uniformly distributed through the air in the room and "soaking," so to speak, into the drywall. As if pulled by the drier air, it moves through the microscopic interstices of the wall materials into the wall cavity, floats through all the air pockets in the cavity insulation and, if the back side of the exterior sheathing is below the dew point, will condense on that surface. This can lead to the mold seen in the photo on page 65. Of course, you need to have really high humidity in the room and dry, cold air outside for this to be a significant problem.

Diffusion is not a big deal unless you have humid conditions and a big difference in temperature. We've all seen these conditions: tiny houses with three teenagers taking two showers a day. Hundreds of house plants. Cords of firewood drying in the basement. Indoor pools. Nate Adams' "Petri Dish House" (Dec/14) is a great example of conditions that are ripe for significant diffusion problems. But in truth, most of the time diffusion is not a big a deal, except when you use super-low-perm materials like poly and foil.

THE VAPOR DRIVE CHANGE-UP

The problem with vapor pressure is that the vapor drive can change direction with climate conditions. While hot humid indoor air is likely to move outward in winter, it can change-up on you. Even in climate zones 5 and 6, you can have wet, warm conditions outside when the outdoor humidity is high and the vapor pressure wants to equalize to the inside. What happens when this humidity hits the back side of that poly you have on the interior walls? It condenses. Better hope that it doesn't last long and the inside of the wall dries out, or you will get black slime on all the poly.

Instead of using poly, which can trap moisture in a wall, use paper-face batts. Kraft paper is considered a "smart vapor retarder," so-called because the permeability increases as the relative humidity increases. Or, you can use those other, more-forgiving vapor retarders allowed under the energy code that the good inspector did not mention; latex paint is enough to slow the diffusion of moisture vapor and is allowed under the 2010 IECC, as well as the 2012 and 2015 versions (even the current NYS energy code) when used in a wall with vented siding or continuous exterior insulation.

Kraft paper is the better choice, by far, for a vapor retarder in a cold climate, because no cold climate is always cold. The permeabilty of the paper facing increases as the indoor relativity increases, so when the vapor drive reverses, the wall will dry out, rather than trapping moisture from outdoors in the wall cavity.

Of course in a hot, humid climate, moisture vapor migrating from outside is a really big deal. It will hit the back side of the interior drywall, which is cool from indoor air conditioning, and the moisture will condense on this surface, turning the back side of the drywall black. These days, vapor barriers are not typically used at all in southern climates (that's part of what we didn't get quite right in the "Last Word" article). Sometimes they are mistakenly used, though. Vinyl wallpaper is a classic problem wall finish in hot, humid climates. Everyone knows that, right?

IT'S ALL ABOUT AIR LEAKAGE

While I've talked a lot about diffusion, I hope the lesson is clear that vapor diffusion plays second fiddle to pressurized air leakage. Any air-pressure difference—indoor mechanicals, stack effect, and wind are the big ones—will push or pull large volumes of air through the tiniest of holes.

Diffusion is slow and plodding. It is a function of area, so even a ripped-up, poorly installed vapor barrier that covers only 80% of a wall will still be 80% effective. Air pressure, on the other hand, is fast and dangerous. If the air-pressure difference is great enough, a tiny hole can allow an enormous amount of air to escape or enter a building. All this moving air can carry moisture and the same thing can happen: It can condense on any surface below the dew point.

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