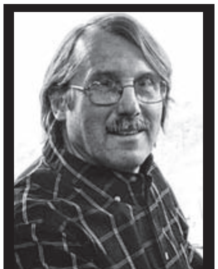
BY MARTIN HOLLADAY

When sunshine drives moisture into walls



"Musings of an Energy Nerd" showcases the best of Martin Holladay's weekly blog at GreenBuildingAdvisor.com, where he provides commonsense advice about energy issues to residential designers and builders. His conclusions usually fall between minimum code compliance and the Passive House standard, which often makes them controversial to both building-science geeks and everyday builders.

Green Building Advisor

Green Building Advisor is for designers, engineers, builders, and homeowners who craft energy-efficient and environmentally responsible homes.

Builders first started worrying about vapor diffusion in 1938, when Tyler Stewart Rogers published an influential article on condensation in the *Architectural Record*. The article, "Preventing Condensation in Insulated Structures," states, "A vapor barrier undoubtedly should be employed on the warm side of any insulation as the first step in minimizing condensation." Rogers assumed that the main source of condensation on sheathing was the result of the diffusion of water vapor through the wall and ceiling plaster in wintertime.

Rogers' recommendation to use interior vapor barriers, which was eventually incorporated into most model building codes, became established dogma for over 40 years. But eventually, building scientists discovered that interior vapor barriers were causing more problems than they were solving. Interior vapor barriers are rarely necessary, since wintertime vapor diffusion doesn't typically lead to problems in walls or ceilings. What Rogers didn't know back in 1938 is that the main way that sheathing gets damp in the winter is actually via air leakage, not vapor diffusion. But a different phenomenon—summertime vapor diffusion—has become the far more serious matter.

Nothing going on here. *From the outside, this house looks perfectly normal. But inside, water vapor driven through the brick veneer has spiked the reading on a moisture meter and supercharged mold growth.*

Zaring Homes goes bankrupt

During the 1990s, summertime vapor diffusion began to wreak havoc on hundreds of North American homes. This epidemic of rotting walls was brought on by a combination of two factors that Rogers did not predict: The widespread adoption of air conditioning, and the use of interior polyethylene vapor barriers.

Rogers had conceived of interior vapor barriers as a defense against the diffusion of water vapor from the interior of a home into cold wall cavities. But he couldn't foresee that these vapor barriers would eventually be cooled by air conditioning, thereby turning them into condensing surfaces that would drip water into walls during the summer.

Interior vapor barriers—such as polyethylene under the drywall or vinyl wallpaper over it—are unforgiving. They not only prevent outward diffusion during the winter; but also inward drying during the summer. These days, building scientists instead recommend the use of vapor retarders like MemBrain, kraft paper, or vapor-retarder paint.

It took a series of disasters to fully illuminate the phenomenon of summertime vapor diffusion. One early victim was Cincinnati builder

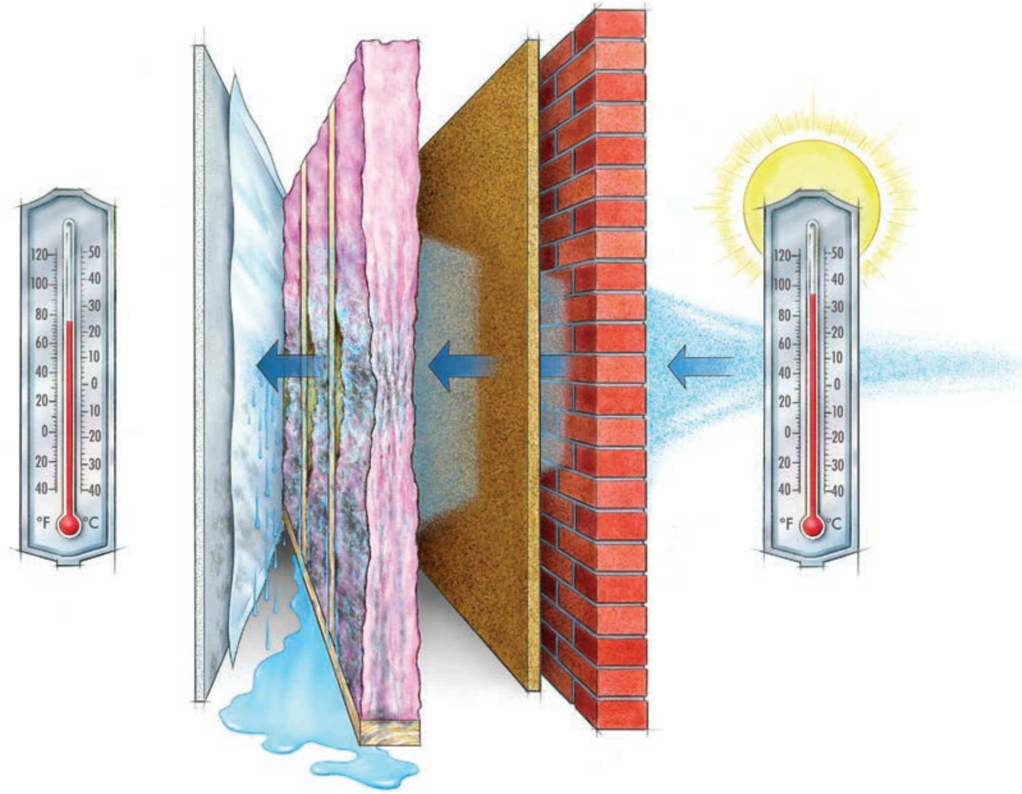
Photos: left, courtesy of Karyn Patno; right, Mark Parlee

Zaring Homes. In the mid-1990s, Zaring Homes was a thriving midsize builder that completed over 1,500 new homes a year. But the company's expansion plans came to a screeching halt when dozens of its new homes developed mold and extensive rot.

The first signs of a problem surfaced in July 1999, when homeowners at Zaring's Parkside development in Mason, Ohio, began complaining of wet carpets only 10 weeks after the first residents moved into the new neighborhood. When inspection holes were cut into the drywall, workers discovered ¼ in. of standing water in the bottom of the stud cavities. "We were able to wring water out of the fiberglass insulation," said Stephen Vamosi, a consulting architect at Intertech Design in Cincinnati.

Consultants concluded that water vapor was being driven inward from the damp brick veneer through permeable Celotex fiberboard wall sheathing. During the summer months, when the homes at Parkside were all air conditioned, moisture was condensing on the back of the polyethylene sheeting installed behind the drywall.

"Zaring Homes went out of business because they had a $20 million to $50 million liability," said building scientist Joseph Lstiburek. "Hundreds of homes were potentially involved. To fix the problems would probably cost $60,000 to $70,000 per home. It was a spectacular failure."



VAPOR DRIVE WORKS BOTH WAYS

Historically, vapor drive was thought to be a winter problem, when warmth from inside a house drives moisture outward to condense on the back of the sheathing. This assumption led to code-required vapor barriers behind the interior wall coverings. But the advent of residential air conditioning introduced a new worry; inward moisture drive in the summer. Once sun hits the exterior, moisture is driven through vapor-permeable sheathing into the wall, where it condenses on plastic vapor barriers or behind vinyl wallpaper.

How inward solar vapor drive happens

The phenomenon that destroyed Zaring Homes' walls came to be known as inward solar vapor drive. It requires four elements: a reservoir cladding (siding that can hold significant amounts of water), permeable wall sheathing, a polyethylene vapor barrier on the interior of the wall, and an air-conditioned interior.

Reservoir claddings include brick veneer, stucco, manufactured stone, fiber-cement siding, and, to a lesser extent, wood siding. Though the failures are less spectacular, inward solar vapor drive can also cause problems in walls sheathed with less permeable types of sheathing, especially OSB.

Whenever a wall separates environments with different temperatures and moisture conditions, moisture vapor will be driven across the wall from the hot, moist side toward the cool, dry side. In the case of solar vapor drive, after a soaking rainstorm, the sun eventually comes out to bake the damp siding, driving moisture inward. Problems with inward solar vapor drive show up first on elevations that get the most sun exposure, so north walls are usually immune.

The heat of the sun easily drives the moisture in damp siding through housewrap and permeable wall sheathing. The fact that housewrap is vapor-permeable allows damp sheathing to dry outward, which is good, but housewrap does little to prevent inward solar vapor drive. The first cold surface that sun-driven vapor encounters is usually the polyethylene behind the drywall. That's where the moisture condenses, then it runs down the poly to pool at the bottom of the wall cavity. It doesn't take long before mold begins to grow and the walls begin to rot.

Data from a 2003 to 2004 study by building scientists John Straube, Eric Burnett, and Randy Van Straaten confirmed the phenomenon of inward solar vapor drive. "Inward vapor drive redistributes moisture quite dramatically," said Straube. "Solar-driven vapor is much more important" than winter diffusion.

Once inward solar vapor drive was well understood, it was identified as one of the main causes of a cluster of wall rot in EIFS-clad homes in North Carolina. Inward solar vapor drive through a variety of stucco types is also blamed for many of the "leaky condo" problems in stucco-clad multifamily buildings in Vancouver, British Columbia.

Avoiding problems from solar vapor drive

If the components of a wall assembly are poorly chosen, as they clearly were at the Parkside development built by Zaring Homes, there may be no faster mechanism for destroying a house than inward solar vapor drive. After only 10 weeks of occupancy, some of the Zaring homes were so wet that most of the brick veneer,

Drawing: Don Mannes

sheathing, insulation, and drywall had to be removed.

But once you understand inward solar vapor drive, it's relatively easy to choose building details to avoid moisture problems. You'll probably only need to adopt one or two of them at most.

- Never include interior polyethylene or vinyl wallpaper in an air-conditioned home. If your building inspector insists on an interior vapor retarder that comes in a roll, choose a smart retarder like MemBrain that allows drying to the interior.
- Avoid high-permeance sheathings like fiberboard behind reservoir claddings. Instead, specify a less permeable sheathing (OSB, CDX, or foam), especially behind brick veneer, stucco, or manufactured stone.
- Use an asphalt-felt water-resistive barrier (WRB). Homes built with this type of WRB experience fewer problems with inward solar vapor drive than homes with plastic housewrap.
- Consider using a vapor-impermeable WRB. The best-known example is Delta-Dry, a stiff, high-density polyethylene formed into a 5/16-in.-thick egg-carton configuration. This three-dimensional WRB creates two air spaces—one between the siding and the WRB and the other between the WRB and the sheathing. Unlike typical housewraps, Delta-Dry depends on air movement to keep the sheathing dry.
- Build rain-screen walls. Walls with a rainscreen gap between the siding and the sheathing experience much less inward moisture transfer than walls without a gap. Ventilated rainscreen gaps are more effective at limiting inward moisture transfer than unventilated rainscreen gaps.
- Use light colors. Because darker colors absorb heat more efficiently, more vapor drive problems occur in homes with dark-colored siding than light-colored siding.
- Choose a traditional stucco formulation without modern polymeric admixtures, since stuccos with these admixtures dry much more slowly than traditional stucco.
- Choose a siding such as vinyl that is not a moisture reservoir.

Special thanks to architect Steve Bostwick, one of the consultants who investigated the Zaring Homes disaster, and to William Rose, whose research highlighted Tyler Stewart Rogers' role in establishing the idea that the warm-in-winter side of wall insulation should be protected by a vapor barrier. Rose is a building researcher at the University of Illinois in Urbana-Champaign.