

Insulation and vapor barriers

By Martin Harris

Houses in this part of the country (Vermont) date from the early 1800's, and most of them are insulated. Not with Fiberglas, but brick. My point is that insulating buildings against outside temperature extremes is nothing new. Today the materials are new and some of the problems are new, but the principles are unchanged from what they were when ancient Babylonians made their mud-brick houses thick enough to store daytime solar heat gain against the cold desert nights.

It's not my intent here to extol brick as an insulating material: it would take about nine feet of thickness in a brick wall to equal the insulating value of modern wood frame construction with Fiberglas insulation between the studs. It is my intent to take a close look at what's been happening in recent years as Americans, responding to energy costs, have raised building insulation to a high science and have created buildings so well insulated that a range of new problems has surfaced.

Today, of course, the insulation of choice is Fiberglas, not the brick or sawdust or newspapers or hay used by our New England forebears. It works by creating untold millions of tiny trapped-air spaces, thus resisting the

transmission of heat that would occur if the surface of the warm area (usually inside, at least around here in the North Country) were separated by only a single thickness of some dense construction material from the outside ambient (usually lower) temperature.

Its effectiveness at resisting heat transfer is measured in terms of R values. Fiberglas doesn't have the highest R-value around—at a rating of 3.12 per inch of thickness (a 3 and ½ inch-thick batt has an R-value of 10.92) it's less than half as effective as isocyanurate foam with an R-value of 7.2 per inch of thickness. But Fiberglas is relatively inexpensive, fireproof, easy to handle, manufactured to fit conventional wood frame construction, even available as a blow-in material; no on-site chemical mixing and spraying, no worries about toxic fumes or bio-degrading over time.

Isocyanurate is a lot more expensive and difficult to handle—indeed it's prohibited for residential construction in some states because of health-hazard fears—but it's ideal for applications like refrigerators and high-tech construction where space is at a premium.

Most of the non-high tech insulation materials—Fiberglas, cellulose, beadboard, and so on—are in the 3 to 4 range for R value. There's a slightly

less effective product called vermiculite—a kind of shredded mineral—which rates at 2 to 3. Vermiculite and Fiberglas are fire-proof, the others not so unless specially treated. Fiberglas and beadboard are structural, in the sense that they can be placed in upright openings and not collapse to the bottom; the others are pourable or blowable, and therefore will flow or settle to some extent. All can be used, some more easily than others, to insulate housing to modern standards: R-19 in the walls, R-38 in the cap or attic.

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These high R-value numbers are part of the reason why we now have new problems associated with insulation that we didn't have years ago when R-values rarely got into double digits. The other part comes from new construction material practices, all of which combine to insure that housing is more air-tight (less drafty, if you like) than it used to be.

Buildings used to be sheathed in 6-inch boards under the finish siding; now it's 4x8 sheets of plywood or waferboard. Finish roofing used to go on over 1x3 nailing strips 4 inches apart; now a solid deck is the norm. Windows and doors were installed with an air-space between the finish millwork and the rough-stud opening; now that opening is carefully filled with insulating caulk.

All this technology change means one thing: there's a lot less outside air circulating through the structure today than there used to be. And this drop in natural ventilation means that a formerly insignificant problem—condensation moisture—is now a major concern. That's because now, once once such moisture gets into the walls or roof structure, it can't get out.

Condensation moisture—dew—happens when air temperature drops. Warm air can hold more moisture, in invisible vapor form, than cold air; but



most building materials are now air-tight. As you sit in your heated kitchen, the warm air in the room is migrating outward through the walls toward the cold outdoors. The temperature within the wall varies: equal to the kitchen air temperature on the inside, equal to the ambient air temperature on the outside. At some point on its travel through the wall, the escaping inside air will chill enough to drop some of its moisture.

In the old days, that didn't matter: there was so much uncontrolled outside air blowing through the thickness of the structure that any dew thus deposited would be quickly evaporated and removed. Today that's not true any more, and condensation, once deposited, stays and accumulates, with destructive results. The solution is obvious enough, in theory: make the warm inside surface of the wall air-tight.

In practice, that's not easy to do: popular building materials like sheet rock are nowhere near air-tight. So the industry has gone for the next-best thing: we put a thin plastic vapor on the backside of the sheet rock, so that moisture-laden air can't penetrate deep into the wall, into the insulation layer, and there lose its moisture because of cooling. Usually we specify a 6-mil plastic vapor barrier to be secured on the warm side of the wall studding or the ceiling joists before the sheet rock is installed.

The insulation industry also recognizes the problem; manufacturers offer batt insulation, to be stapled between studs or joists, with a built-in vapor barrier for the warm side. They also offer beadboard with a vapor barrier on one side.

You'd think that any of these solutions would be enough, but, increasingly, we're learning that they're not. First of all, we've learned that vapor barriers aren't really barriers: under pressure from the legal industry, manufacturers now call their products vapor retarders, admitting that some moisture will get through even if installation is perfectly by-the-book. Second, we're having to admit that in the real world of construction, vapor barriers—oops, retarders—are sometimes installed with gaps, sometimes pierced during construction, some-

times develop leaks after construction. Third, we're learning that making construction air-tight on the outside with new materials—plywood sheathing, metal roofing, vinyl siding, silicone caulking, acrylic paints—calls for new concerns about vapor and moisture build-up on the inside.

So, we in the design end of the construction business are facing reality: we're now designing into buildings the structural ventilation that used to occur automatically. No, we're not going back to board sheathing and we're not giving up on space-age caulks. We are making sure that there's an air space behind (on the cold side, that is) every thickness of insulation, and that these air spaces are connected to the outside world so that outside air will circulate through them either naturally or mechanically assisted. The intent is to restore the natural ventilation that used to occur, so that moisture won't accumulate.

In most design situations, this has been pretty easy. The construction industry now has inexpensive metal vents for use on soffits (the underside of roof cornices), for roof ridges, for gable ends. They come in a wide variety of shapes and sizes, and are easy to install. More traditional wood vents are also available. The rule of thumb for ventilation is that the clear vent opening (not counting cross-slats) for, say, an attic, should be usually 1.5% of the area of the attic floor. A 1,200 square foot house, for example, would most likely have a 1,200 SF attic, and should have a total of 18 SF of ventilation arranged so as to encourage outside air to flow through from one side to the other. Some building codes allow that amount of ventilation to be cut in half if soffit and ridge vents are used, under the theory that soffit and ridge vents supposedly work better than gable-end vents.

The industry has lightened its ventilation load in another way; by declaring that walls aren't a problem. Standard wood frame construction doesn't call for vents on the back side (the cold side) of each stud space, even though the cold air in that wall is really trapped there and moisture can't readily escape. I suppose that we in the industry get away with this

because it usually works; if it doesn't in your situation, I'd suggest that you install small button vents at the top and bottom of the outside wall covering each stud space in the problem area, and see if that doesn't help.

Sometimes the industry doesn't get away with it. For a long time we believed that cathedral ceilings required no ventilation on the cold side of the insulation, because there was virtually no free space up there above the insulation and below the roof deck. Now we've learned that doesn't always work, and so now we're careful to design cathedral ceilings with an air space above the insulation and provision for an unobstructed flow of outside ventilation air through each rafter space.

Sometimes we as individual designers learn things before the industry recognized them as true. I've learned, for example, that batt insulation designed to be stapled between the studs and rafters comes with a built-in vapor retarder that doesn't always work. Maybe that's because there's a break at each framing member; I don't know. I do know, that for large cathedral-ceiling buildings like churches and community halls I won't depend on the insulation vapor retarder and will specify unbroken sheet plastic instead.

Sometimes it works the other way: the industry tells us individual designers what in-the-field problems they've seen. That was the case with attic insulation being installed so that it blocked the flow of ventilating air from the soffit vent, up into the attic, then out through the ridge vent. Some builders, it seems, thought it good to stuff each rafter space with insulation at the cornice level, thereby making the soffit vents worthless. Now we call for the use of light-weight snap-in-place sheet Fiberglas "insulation dams" in each rafter space to make sure an airway is kept open. I've never known a builder to make that installation error, but it must be happening out there somewhere.

I shouldn't end this discussion without some comments on air-conditioning. If it's needed, it means that the whole design process designed above is reversed: now the warm, moisture-

laden air is on the outside and the cold side is the inside.

Under these conditions, putting the vapor retarding membrane in the "normal" place isn't going to help much: warm air will infiltrate through the outside walls and condense somewhere in the thickness of the insulation.

The infiltration will be worse if the air conditioning is fan-driven and is creating a slight negative pressure inside the occupied rooms, thus drawing more outside air through the walls. Under these conditions, logic suggests that there should be a vapor retarder on both sides of the insulation, on the outside for air-conditioning and on the inside for normal heating. To follow that logic would create an insulation layer that is completely unventilated (and quite difficult and expensive to ventilate), so the industry follows its own logic and pretty much ignores the problem.

How much of a problem is air-conditioning? Statistically, not significant, explaining why there are no widely accepted design standards for moisture control in air-conditioning situations. (Maybe it helps that almost all the U.S., areas which use air-conditioning heavily don't experience really high humidities.) But even here in Vermont we see, particularly on unusually warm days in early spring, situations where moisture-laden outside air gets into a cold masonry structure and the condensation comes down like rain. Theoretically, it's possible to design for both air-conditioning and heating—the double-vapor-retarder situation—but I wouldn't do it unless other air-conditioned structures in your own neighborhood are pretty clearly having problems.

One final thought: how can one possibly go back into an old structure, say one with blow-in insulation and no vapor control, and solve the problem? Surprisingly easy: just apply an interior paint with the highest-possible perm rating (vapor retardance) to all interior surfaces. It may not be perfect but it will be close enough.

(Martin Harris is a Vermont architect, cofounder of *The New England Builder*, and author of numerous home building articles.) Δ

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