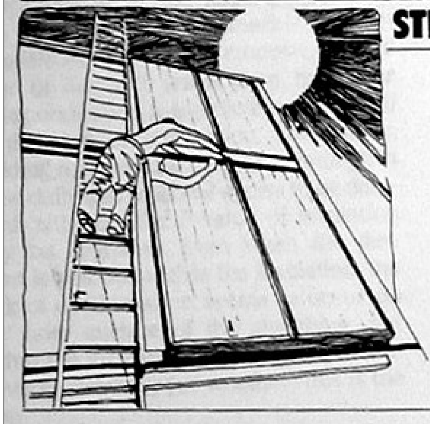

Moisture Problems:
Causes and Cures

Understanding moisture problems can steer you free of trouble.

Is it possible to get a simple answer to our questions about vapor barriers, infiltration barriers, and condensation within building components? Well, yes and no. While the physics of vapor transmission, airflow, and dew points is well known, if complicated, what happens inside walls and roofs is not so easy to say short of careful monitoring or ripping into the walls and ceilings for inspection.

On moisture problems in well-insulated homes, the jury is still out. While stories abound of rotted framing and sheathing, and cellulose fiber turned to papier-mâche, the damage in these cases can usually be blamed on external water leaks or extraordinarily high-moisture conditions, often combined with cold spots due to gaps in the insulation. Controlled experiments and field investigations of condensation in building cavities have turned up fewer problems than anticipated. Condensation on windows, frost on attic ceilings, and, in some cases, peeling of exterior paint may be the more likely risks.

Dry rot—a misnomer for a wood-eating fungus—will, in fact, attack a home where there's no light, saturated wood, and temperatures over 50°F. In a typical uninsulated wall, these conditions rarely occur together, which is why so many older wood-frame homes are still going strong. With the warmer walls and higher moisture levels of today's tighter homes, care should be taken to avoid this type of decay. As for the effect of moisture on the thermal efficiency of fiberglass insulation, reports I've heard vary widely. Sorry!

The National Bureau of Standards says that a family of four typically produces from two to three gallons of water vapor a day. Additional moisture migrates up from basements and crawl spaces. Once in the house, water vapor gets into walls and cavities by two primary means—diffusion and convection. *Diffusion* refers to the migration of water vapor, independent of the air, from areas of greater to lesser vapor pressure—roughly from warmer, moister areas to cooler, dryer areas. The rate at which vapor passes through building materials varies according to vapor pressure differentials and the permeability of the materials. *Convection* is the movement of air across air-pressure differentials—up into ceilings and attics via the "stack effect" or out through windswept walls.

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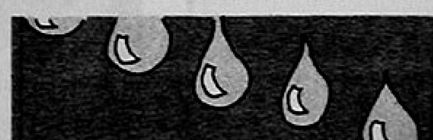
Many experts now consider convection, not diffusion, to be the major vehicle of moisture transport out of homes. Computer simulations of a typical small home with an average vapor barrier and one air change per hour predict that diffusion will account for less than two percent of the total moisture expelled.

Little evidence exists that moisture condensation poses much of a problem in conventional homes.



While this is interesting, it doesn't tell us how much of this moisture passes through or is trapped in wall cavities and how much passes directly out of doors. One study at the National Bureau of Standards found 28 percent of the air in a pressurized room leaked right through the walls (through hairline cracks) in typical drywall construction. Combined with leaks at floor and ceiling joints and around door and window frames, this adds up to a tidy sum of air and moisture flowing into wall cavities.

Moisture only becomes a problem if it condenses in sufficient quantities and remains in liquid form long enough to saturate building and insulation materials. Condensation occurs when moisture-laden air is cooled to its dew point. At the dew point the surplus water vapor condenses and wets the nearest surface. If more water vapor is supplied or temperatures drop, more water condenses. Fortunately, wood sheathing and framing can store and later release large quantities of this moisture before reaching fiber-saturation levels. As wall temperatures rise again or humidity levels drop, the water reevaporates and is expelled from the wall by diffusion or convection. Fortunately, building materials rarely get wet enough in these daily and seasonal cycles to be damaged, although the R-value of insulation may be degraded. Even when the dew point is reached within the insulation, the bulk of condensation seems to occur on the inner surface of the sheathing, not within the insulation. There remains controversy over why (or whether) this is the case.

What to do

An insulated home, then, should have two barriers—an air barrier and a vapor barrier—which may or may not be the same thing. Air barriers control heat loss through infiltration and exfiltration, which together account for up to 50 percent of the annual heat loss in a well-insulated home. An air barrier must be carefully planned and well-executed to be effective. This means lapping joints over solid backing, caulking seams with flexible sealants, and tightly sealing around electrical and plumbing penetrations, doors, and windows. The material should run continuously between floors and over plates. If the air barrier is installed on the exterior, for example on a heavily windswept wall, then it should consist of material that allows water vapor to diffuse out, such as Tyvek®. If a separate vapor barrier is installed in conjunction with a proper air barrier, then it probably needn't be so meticulously sealed. Care should be taken, however, to seal interior spaces from wall and ceiling cavities.

Generally, the most economical (and therefore the most common) solution in new construction is to combine both air and vapor control in one barrier—usually comprised of 4- to 6-mil polyethylene or thin foils. The material is carefully installed toward the warm side of the insulation. Harold Orr at the Building Research Division of the National Research Council of Canada, has developed a rule of thumb that places the air-vapor barrier within the inner one third of insulation value. In thick, superinsulated walls, this protects the barrier from plumbing and electrical penetrations and interior finish work. With 70°F indoor temperatures, outdoor temperatures would have to drop to −20°F to reduce the temperature at the one-third point to 40°F, the temperature at which condensation in walls is likely to occur. Condensation on double-insulated glass is Harold Orr's indicator that inside relative humidity is too high for outdoor temperatures and that ventilation is necessary. Water is no friend of interior window millwork either.

Condensation in walls may not pose the problems some suspect in conventional homes. However, in smaller, tighter homes—some with the added moisture of a greenhouse or earth coupling—caution should be exercised. In all but extreme situations these guidelines should steer us free of trouble:

- Keep the building's outside skin five to ten times as permeable as the inside skin so moisture is not trapped in the wall, but keep it tight to water and wind.
- Make the air barrier, wherever it is, as airtight as possible. We prefer it on the winter-warm side of the wall.
- Seal well all cracks and joints connecting wall cavities to inside and outside air.
- The vapor barrier, if separate from the air barrier, may be of conventional type, except in high-moisture areas.
- Provide at least twice as much insulation outside the vapor barrier as in. In high-moisture areas, keep the vapor barrier on the warm side of the insulation.
- If air exchange rates are kept to 0.3 air changes per hour or less, or if window condensation becomes a problem, then ventilate with air-to-air heat exchangers or use bath and kitchen vents with good backdraft dampers.
- Avoid thermal short-circuits and gaps in the insulation, which will cause cold spots and condensation.
- Provide adequate airflow through attic and cathedral ceiling spaces with venting from eaves to ridge.