Reference Note 42

Vapor Barriers

What is a Vapor Barrier?

A vapor barrier is an impermeable membrane that blocks the flow of air through the building envelope. A vapor barrier is an essential part of the building envelope. Because the purpose of a vapor barrier is not obvious, this important component is often omitted or installed incorrectly.

The main purpose of a vapor barrier is preventing the passage of the water vapor that is contained in air. Vapor barriers and the insulation affect each other. They must both be installed so that they interact beneficially rather than harmfully.

Purposes of Vapor Barriers

The specific functions of vapor barriers are:

- ***protecting the envelope structure and insulation from condensation damage.*** Many wall materials are permeable to the flow of water vapor from inside to outside, or vice versa. As water vapor from the inside of the building moves outward through a wall on a cold day, it encounters progressively lower temperatures. At the point in the wall where the temperature of the air equals the dew point, the vapor starts to condense, and it keeps condensing from that point outward. Figure 1 illustrates this.

  Condensation damages all types of envelope structures. It rots wood structures, it rusts steel structural members and steel masonry reinforcements, and it causes freeze cracking of masonry. Installing a vapor barrier on the warm side of the envelope prevents water vapor from traveling through the wall, and thereby prevents condensation.

  The protective function of vapor barriers is not inherently related to insulation. Condensation can occur inside the envelope structure whether it is insulated or not. If water vapor condenses inside insulation, the dampness reduces thermal resistance, and may damage the insulation.

- ***preventing air leakage through the envelope.*** A well-installed vapor barrier prevents or greatly reduces air leakage through the envelope surfaces, although it does not reduce air currents inside the envelope structure itself. At the same time, the vapor barrier reduces air flow through the insulation, preserving the R-value. For more about this function, see Reference Note 40, Building Air Leakage. (As a matter of perspective, vapor barriers do nothing to reduce air leakage through the major envelope penetrations, such as doors, windows, roof hatches, and fan openings. These penetrations

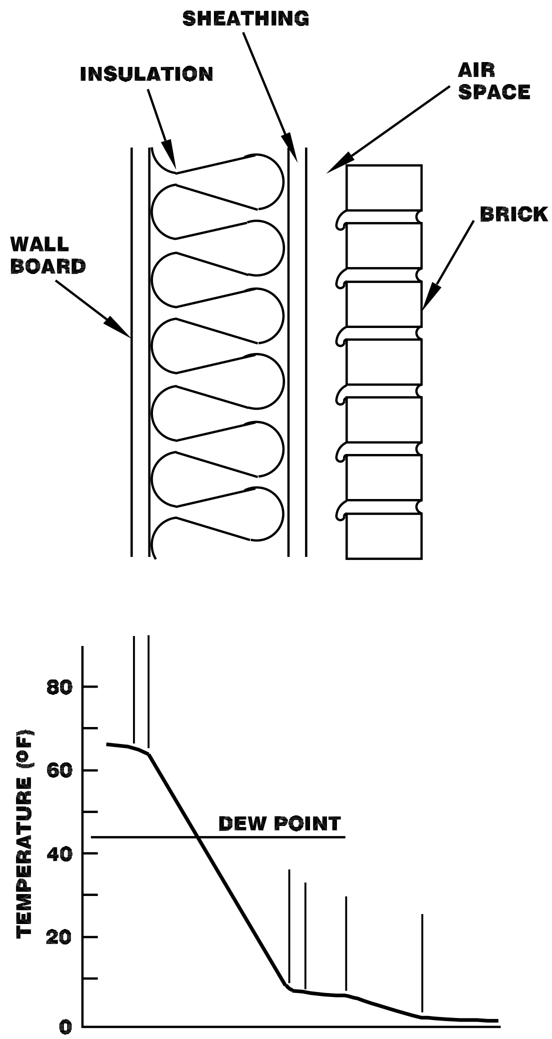

Fig. 1 Why building structures need vapor barriers This is a cross section of an insulated stud wall with an outer brick veneer. Below it is a graph of the temperature inside the wall. It is cold outside and warm inside. It is also humid inside. If water vapor can flow through the wall, it will reach a point at which it condenses. From that point outward, the wall is damp. A vapor barrier on the inner surface keeps the water vapor from flowing through the wall.

account for a majority of air leakage in most buildings.)

- ***maintaining interior humidification.*** If humidification is used, a vapor barrier reduces the amount of energy and water required to maintain the desired level of humidity.

Where Should the Vapor Barrier be Installed?

Vapor barriers must be installed on the warm side of the insulation. This is because condensation occurs as water vapor moves from the warm side of the wall to the cold side. If a vapor barrier is installed on the cold side, it traps moisture inside the envelope, making moisture problems worse.

This poses a dilemma in climates where the weather can be hot and humid in summer, but cold in winter. The deciding factor is how cold it gets. Where the winters are seriously cold, as in Minnesota, the best compromise is to install the vapor barrier on the inside. In humid climates where winter temperatures are mild, as in Houston, the best compromise probably is not to use a vapor barrier. If this decision is made, the envelope should be made of materials, such as masonry, glass, and aluminum, that withstand periodic dampening.

It might be tempting to solve this problem by installing a vapor barrier on both sides of the envelope. However, this is the worst approach. Vapor barriers on both sides of the envelope would almost certainly trap harmful amounts of moisture.

Vapor Barrier Materials

In principle, a vapor barrier can be any unbroken surface that is impermeable to water vapor. For example, a common vapor barrier material is polyethylene plastic film, typically installed in thicknesses from .002" to .008" (0.05 mm to 0.2 mm). This material is inexpensive, transparent, easy to handle, and is available in wide widths. It can be attached by stapling, mastic, and other means. Figure 2 shows a properly installed vapor barrier using this material.

Vapor barriers can be attached to permeable insulation, such as glass fiber batts or blankets. The vapor barrier is commonly in the form of impregnated kraft paper, sometimes with a thin foil layer. This type of vapor barrier is unreliable because there is no effective way to close the gap between adjacent lengths of insulation. Fold-over strips intended for overlapping the vapor barrier of adjacent batts are generally ignored by installers.

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Fig. 2 Perfectly installed insulation and vapor barrier This large room has wood stud walls and a wood rafter cathedral ceiling. Glass fiber batt insulation has been inserted snugly into the stud and rafter spaces, leaving no gaps. The tabs on the paper backing of the insulation are overlapped and closely stapled to the edges of the studs and rafters. A vapor barrier of 0.008” thick polyethylene sheet is stapled over the insulation. The vapor barrier is overlapped several feet at all joints. Plenty of excess plastic material is left in all corners. This slack keeps the plastic from being torn when the wallboard is installed. The vapor barrier is stapled to the window frames, preventing air leakage around the windows.

If the insulation material itself is very impermeable, such as extruded foam board insulation, it may act as its own vapor barrier. This characteristic is useful only if adjacent sheets of insulation are joined to create an unbroken surface. This requires special installation techniques that are difficult to enforce on the job.

Some envelope construction materials, such as asphalt roofing and sheetmetal walls, are impermeable. Therefore, they act as a vapor barrier, whether this is desirable or not. The critical question is whether these impermeable materials are located on the warm side of the insulation. If they are, they can serve as the vapor barrier. If not, they create a moisture venting problem that must be handled properly to prevent damage.

How to Vent the Water Vapor

When installing insulation, create a path for venting water vapor from the insulated cavity. A vapor barrier on the warm side of the envelope must be combined with a venting path on the cold side of the insulation. This is because no vapor barrier is perfect, and because water may get into the structure, typically from rain. In general, the better the vapor barrier and the drier the conditions, the less venting is required.

Effective venting is a challenge with roofs, because they are susceptible to leaks and have an impermeable outer surface. In buildings with attics, a common solution is to vent the attic to the outside. In cathedral ceilings, leave an air space above the insulation to allow water vapor to travel out to the vents, which should be installed along the full lengths of the ridges and eaves.

Venting walls and soffits is just as important, and the same principles apply. If there is an impermeable surface on the cold side of the insulation, such as a sheetmetal outer wall, leave a gap between the cold side of the insulation and this surface. The gap acts as a path for water vapor. In turn, vent this gap to the outside of the cold surface. Walls that can be wetted by precipitation require thorough venting.

At the other extreme, some wall materials are so porous that moisture may vent directly through the wall. Such material is especially vulnerable to rain soaking. Keep insulation away from direct contact with the wall. Generous roof overhangs are an excellent means of keeping walls dry, if the walls are not too tall.

Portions of the building that are located over soil have the problem of moisture migration into the building, rather than outward. The usual solution is to vent the crawl spaces to the outside, as with attics.

All insulated cavities where water may accumulate should have drains, as discussed in Reference Note 44, Insulation Integrity.

House Wraps are Not Vapor Barriers

"House wraps" are an item that goes through episodes of popularity. House wraps tend to be confused with vapor barriers, although their function is entirely

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Fig. 3 This is not a vapor barrier This is a house wrap. It must be made of appropriate permeable material. Using vapor barrier material as a house wrap would cause moisture damage in the walls. The outer sheathing of this house is plywood. If the plywood is well installed, the house wrap is superfluous.

different. Using vapor barrier material as a house wrap can cause serious moisture damage to the structure. Conversely, house wrap material will not work as a vapor barrier.

The purpose of a house wrap is to prevent air infiltration through the building structure. It is always installed on the outer surface of the building. It plays the same role as a wind breaker in human clothing. As we said previously, one of the benefits of a vapor barrier is preventing air leakage. However, in most climates, vapor barriers are installed on the inner surface of the structure. Therefore, they do not protect the structure, or the insulation inside the structure, from heat loss that is induced by wind.

House wrap material must be permeable. Otherwise, it will act as a vapor barrier that is installed on the wrong side of the surface, and cause moisture damage. A common material used for house wrap is a fiber-reinforced paper. The material is stapled to the outer surface of the structure before installing the outer weather surface (siding, brick, etc.). Figure 3 shows a typical house wrap installation.

The fact that the material is permeable does not significantly interfere with its wind protection. It is like human clothing that protects from wind while allowing moisture to vent from the body.

We should ask whether house wraps are really needed. If a building is constructed properly, house wrap is superfluous. If the exterior sheathing is installed with sufficient care, it will shield the wall structure from wind. Furthermore, a building should not depend on a structural component that has a reliable life that is less than the life of the building. House wraps are fragile, compared to other structural materials. It is unlikely that they will survive for the life of the building, especially if the exterior surface that protects the house wrap will be replaced during the life of the building.

House wraps are not snake oil, but they have a limited range of useful application. They are most valuable when renewing the exterior of a house with leaky walls.