Chapter

4

Vapor and Air Retarders

Vapor Retarders

Vapor retarders are materials that restrict or reduce the rate and volume of water vapor diffusion through a building's ceilings, walls, and floors. Available in a variety of materials, they are commonly made of polyethylene sheets, treated papers, and metallic foils. Historically, they have been called *vapor barriers* but are now called *vapor diffusion retarders* or simply *vapor retarders*. Although the familiar term *vapor barrier* implies that the material halts all moisture transfer, this is incorrect. Vapor retarders actually only reduce the rate of moisture transfer, they do not stop moisture flow completely. As you will discover in this chapter, the main reason to retard the transmission of gaseous water vapor through building envelopes is to prevent it from condensing to liquid water within the structure or insulation.

Thermal insulation has only been prevalent in residential construction during the last 50 years. As originally designed, older structures did not need to restrict the flow of airborne moisture because there was little within the affected cavities to hold it. Older homes tend to have less insulation and more air gaps in their thermal envelope. The wall cavities, if wetted, dried quickly because of the leaky construction methods employed. Windows and doors were not sealed tightly, and most construction materials were not vapor-tight. Simply stated, water vapor was able to pass through the building envelope unobstructed, thereby not becoming trapped within the structural assembly. As residential design became more energy conscious during the second half of the twentieth century, the homes became more airtight.

Storm windows, caulking, weatherstripping, and thermal insulation interfered with the movement of water vapor. It soon became evident that moisture movement was of prime concern if insulation was to remain effective and structures were to remain sound.

Water vapor/moisture migration

Water exists in the atmosphere in three forms: as an invisible, gaseous vapor, as liquid droplets, and as solid ice crystals. One important and relatively unique characteristic of water is its almost universal existence in air in the form of vapor, its gaseous form. Vapor is not to be confused with steam. Steam is water that has been elevated in temperature above its boiling point (212°F or 100°C), whereas water vapor, also in a gaseous state, is below the boiling point.

Water is present as vapor in indoor and outdoor air and as absorbed moisture in many building materials. Water moisture is continuously being generated by the activities and bodies of a home's occupants. A family of three generates 16 lb per day. Additional activities such as cleaning, cooking, and showering, and even the presence of plants, produce 1 lb of moisture per day.[1] The amount of moisture in a home is also especially high immediately after construction is completed. For example, significant amounts of water are used in the mixing of concrete, mortar, and even plaster when applicable. A new house of medium size may require 300 gal of water to be mixed in the concrete alone.[2]

Moisture-related problems may arise from changes in moisture content, from the presence of excessive moisture, or from the effects of changes of state, such as freezing, within walls or deterioration of materials due to rotting or corrosion.

Moisture moves in four ways: bulk moisture, capillary action, air leakage, and vapor diffusion. The primary source of bulk moisture is rainwater. Improper flashing and caulking permit bulk moisture to enter a building envelope. Capillary action occurs when moisture moves through porous materials such as concrete or through cracks in materials. Proper detailing and waterproofing help prevent capillary action. Both air leakage and vapor diffusion transport vapor in its gaseous state. This is more difficult to eliminate because the average person respires up to 1 gal of water vapor per day.

Relative humidity

The term *relative humidity* is a measure of the amount of water vapor held in a given volume of air compared with the maximum amount of moisture the air could hold at the same temperature. The ratio is usually expressed as percent relative humidity. Thus, 50 percent relative humidity means that the air contains half the water vapor it is capable of holding at that temperature. At 100 percent relative humidity, air contains the maximum amount of vapor it can hold, and such air is said to be *saturated*. The temperature at which saturation occurs is called the *dew-point temperature*.

Since psychrometry is the branch of physics relating to the measurement or determination of atmospheric conditions, particularly regarding the moisture mixed with the air, humidity is measured using an instrument called a *psychrometer*. It involves measurements of dry-bulb temperature and wet-bulb temperature.

The *dry-bulb temperature* is simply the air temperature and is sometimes called *ambient* or *sensible temperature,* commonly measured using a thermometer. The *wet-bulb temperature* is the temperature indicated by a wet-bulb transducer (thermometer), at which liquid or solid water, by evaporating into air, can bring the air to saturation at the same temperature. The results are plotted on a *psychrometric chart,* a graph drawn to represent the thermodynamic properties of moist air. A psychometric chart provides data to analyze the interaction between dry-bulb temperature and relative humidity. This allows experts to predict whether moisture condensation may occur on a particular surface, given the air temperature (dry bulb), the relative humidity, and the temperature of the particular surface. Knowing the air temperature and relative humidity, "they" also can predict the condensation temperature necessary to convert water vapor into liquid water.[3]

There are two simple facts to keep in mind:

1. As air warms, its ability to hold a greater quantity of water vapor increases.
2. As air cools, its capacity to retain moisture decreases.

For example, air at 68°F (20°C) with 0.216 oz of water (H_2O) per pound of air (14.8 g H_2O/kg air) has a 100 percent relative humidity. The same air at 59°F (15°C) reaches 100 percent relative humidity with only 0.156 oz of water per pound of air (10.7 g H_2O/kg air). The colder air loses the capacity to hold about 28 percent of the previous temperature's airborne moisture. This moisture will condense on the first cold surface it encounters. If this surface is within an exterior wall cavity, for instance, wet insulation and framing may be an early result.[3]

When the relative humidity of air approaches about 92 to 98 percent, a drop in temperature of as little as one degree, or the addition of a small amount of water vapor, will cause the vapor to condense and precipitate from the air. In nature, this is known as rain, sleet, or snow.

When it occurs in our dwellings, we refer to it as *steaming* or *sweating* on windows and other surfaces. Sweating can be found easily as a dew formation on a surface such as a cold glass of iced liquid or on the inner surfaces of window panes. Sweating or condensation also can occur in walls, roofs, ceilings, and floors of buildings. When it does, it can make insulation inefficient; cause rot, decay, or mildew on wood framing; and even result in deterioration of masonry materials. To make matters worse, this type of damage occurs inside the wall cavity, where it is hidden from sight and can go unnoticed for long periods of time.

Dew point

The temperature at which water vapor will condense from the air at any specific relative humidity is called its *dew point*. As mentioned earlier, water vapor within dwellings normally is present only in its invisible gaseous state. However, when vapor-laden air comes into contact with a cold surface, at or below its dew point, such as a window pane in winter or an article removed from the refrigerator, it promptly condenses into water droplets (dew). If the surface it contacts is below 32°F (0°C), the vapor becomes ice crystals. Air with a high relative humidity always has a higher dew point than does drier air. A given temperature and relative humidity determine the dew point.

Temperature differences between indoor and outdoor environments create conditions that promote condensation. The difference between outdoor temperatures and indoor thermostat set points is typically greater in the winter than in the summer. This leads to a greater likelihood of condensation occurring in the winter season.

In the design and construction of the thermal envelope of buildings (the enclosure of desired temperatures and humidities), the behavior of moisture must be considered, particularly the change of state from vapor to liquid (condensation). Problems arise when moisture comes into contact with a relatively cold surface (temperature below the dew point), such as a window or within outdoor walls or under-roof ceilings. Excessive condensation within indoor walls that enclose cold spaces must also be considered.

Moisture problems

Moisture problems in residences generally occur in seasons when the outdoor temperature and vapor pressure are low and there are many indoor vapor sources. As mentioned earlier, these may include cooking, laundering, bathing, breathing, and perspiration for the occupants, as well as automatic washers and dryers, dishwashers, and humidifiers. All these sources combine to cause vapor pressure indoors to be much higher than outdoors so that the vapor tends to migrate outward through the building envelope.

In an ideal world, construction water should be evaporated before the building is occupied. Concrete, plaster, even water-based paints all evaporate water and could contribute to potential condensation problems. Construction water is usually removed within a year, but other sources still exist. Moisture is constantly being generated within a home by the users after occupancy as well. For example, in the winter months, $^1/_2$ lb of moisture is generated with each shower, whereas 0.12 lb is generated per bath. Appliances generate 5.66 lb per day, including dishwashing, and a person generates 11 lb in a 24-hour period.[4] Venting of moisture-laden air from bathrooms, laundry rooms, and kitchens will reduce indoor vapor pressure, as will the introduction of outdoor air with low moisture content. Finally, undrained and unvented crawl spaces, as well as wet basements or bare-earth floors, will continue to be a problem unless corrective measures are performed.[4]

Moisture in building materials usually increases their thermal conductance significantly and unpredictably. Porous materials that become saturated with moisture lose most of their insulating capability and may not regain it when they dry out. Dust, which usually settles in airspaces, may become permanently affixed to originally reflective surfaces. Moisture migration by evaporation, vapor flow, and condensation can transport significant quantities of latent heat, particularly through fibrous insulating materials.

More than 90 percent of the moisture entering a perimeter structural cavity is from air leakage. The other 10 percent or less occurs as vapor diffusion. This happens because air, by nature, moves toward low pressure through any possible pathway. It acts as a fluid, draining through any imperfection. Moisture diffusion directly through a material is usually a much slower process. Most materials of any density retard this flow somewhat. Standard gypsum wallboard or plaster assemblies, once painted, seriously impede moisture diffusion.[3]

There are several ways to prevent condensation inside and outside a home:

1. Moisture should be removed by drainage, venting, or isolating moisture-generating sources.
2. Moist air should be kept away from cold surfaces within walls, floors, or roof by means of a vapor barrier.
3. Sufficient insulation should be used on the cold side of assemblies to keep critical surfaces warmer than the dew point temperature.

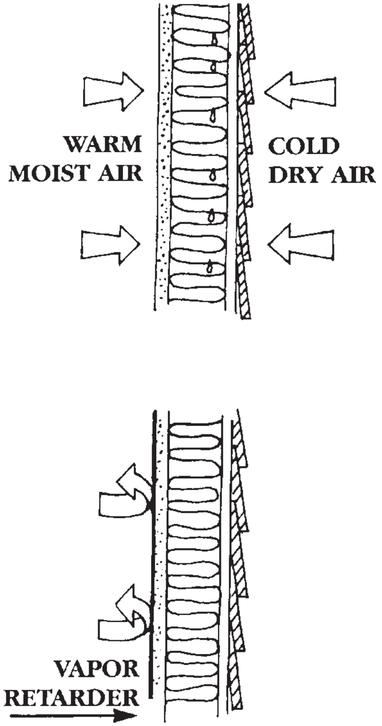


Figure 4.1 Moisture migration. (*Better Homes and Gardens*)

4. Water vapor within the construction assembly should be allowed to escape by using vapor-porous materials.
5. Vapor traps (i.e., double vapor barriers) formed between two vapor-resistant components must be avoided[4] (Fig. 4.1).

History of Vapor Retarders

Historically, vapor accumulation has been remedied by a number of strategies. Prior to the construction of energy-efficient homes, less vapor-resistant materials were used in outer walls. Lowering the indoor relative humidity can be accomplished either by lowering the rate at which water vapor is added to the indoor air or by increasing the ventilation of the house indoor air to the exterior. With today's lifestyle and indoor activities such as clothes washing and drying, showers, baths, hot tubs and spas, dishwashers, and humidifiers that tend to raise the indoor relative humidity, it has become necessary to increase the vapor resistance on the warm side of the insulation. These behaviors and design preferences have led to the scientific study of the proper placement of a vapor retarder.

Historically, the implementation of an insulating material with an asphalt/kraft paper or aluminum foil backing resulted in one of the first simple means of achieving a relatively effective "barrier" to the transmission of water vapor through exterior walls. The attachment flanges were configured to require the material to be installed with the backing material on the warm interior side of the walls in an effort to make the installation foolproof. The method was not entirely perfect, however, because water vapor could pass readily through the studs themselves and through the significant crack length where the insulation was attached to the studs.

The relative success of this first step led to further consideration of the problem. Before long, the application of 6-mil-thick sheets of polyethylene film on the interior sides of exterior walls, under the dry wall, or other finish, lapping and taping all joints, became standard practice. It is one of the most effective available means of inhibiting the transmission of water vapor through exterior walls that is currently employed.[5] Even this concept is now being scrutinized by many experts.

Perm ratings

Perm ratings are assigned to many of the materials intended for use as vapor retarders. Materials intended for use as vapor retarders are constantly being improved and tested to establish their effectiveness. The perm ratings assigned to such materials are usually established by a reputable testing laboratory. Such ratings may be considered reliable when the data are published, or certified, by the testing laboratory.

Water vapor transmission is the rate of water vapor flow expressed in grains per hour per square foot. A pound contains 7000 gr, and a gram contains 15.43 gr. *Permeance* is the water vapor transmission of a material under unit vapor pressure difference between two specific surfaces. The concentration of water vapor also may be stated by giving its pressure, commonly expressed in inches of mercury (inHg). The unit of permeance is the *perm,* which is equal to grains per hour per square foot per inch of mercury. The ability of a material to retard the diffusion of water vapor is measured in units known as *perms,* short for *permeance.* A perm measures, at 73.4°F (23°C), the number of grains of water vapor that pass through a square foot of material per hour at a differential vapor pressure equal to one inch of mercury. Technically, a vapor diffusion retarder is a material with a perm value of 1.0 or less. A material with a perm value greater than 1.0 is not a vapor diffusion retarder because it allows too much water vapor to pass through it. Knowledgeable professionals typically use vapor diffusion retarders with ratings of 0.1 or less to guard against possible future changes in building science. One square foot of a material with a rating of 0.1 perm will transmit approximately 2 fluid ounces of water in 1 year. Polyethylene films, which have perm ratings in the 0.02 to 0.08 range, are the most popular. Several new products that are more resistant to tearing than polyethylene are also available.

There is a common rule of thumb, as reported by the Department of Energy and the Southface Energy Institute, to prevent trapping any moisture that may enter a perimeter structural assembly. The structure's cold-side material permeance should be at least 5 times greater than the perm value of the warm-side vapor retarder.

Product types

Vapor retarders typically are available as membranes or coatings. Membranes generally are thin, flexible materials but also include thicker sheet material sometimes termed *structural* vapor diffusion retarders. Thin membrane vapor diffusion retarders come in rolls or as integral parts of building materials. One such integrated product is the single-side aluminum-faced or specially treated kraft paper–faced batt insulation. Foil-backed wallboard is another popular material incorporating a vapor diffusion retarder. Polyethylene, a plastic sheet material, is perhaps the most commonly used vapor diffusion retarder. It is available in various roll configurations. Thus 4-mil or 6-mil polyethylene sheeting, available in rolls, is rolled out horizontally and stapled to the face of the framing after installation of unfaced insulation. Materials such as rigid insulation, reinforced plastics, aluminum, and stainless steel are also relatively resistant to water vapor diffusion. These types of vapor diffusion retarders usually are fastened mechanically. When sealed at joints, they seriously restrict air leakage. [A vapor diffusion retarder is only effective when it is continuous, fully covering the exterior envelope (walls, floors, and ceilings). By contrast, a sheet of drywall only retards vapor diffusion over the area it covers, not the edge joints, holes for electrical outlets, or window openings.[3]]

Paints and other coatings, when applied to a finished wall or ceiling, also may retard vapor diffusion. These coatings are asphaltic, resinous, or polymeric. They are applied by brush, trowel, roller, spraying, or dipping, depending on the surface. "Vapor barrier" paints are an effective option, but always verify that the paint formula is low in pigment. The paint label usually indicates the percentage of pigment.

It is best to use paint labeled as a vapor retarder. Most paint experts agree that, for this purpose, glossy paints work better than flat paints, acrylic paints are generally better than latex paints, and the more coats applied, the better.

Placement within the wall, floor, or ceiling assembly

The need for vapor retarders and their proper location within a wall assembly is influenced by the interior and exterior environmental conditions as well as the wall's thermal and vapor flow characteristics. It is important to note that each building is fairly unique in terms of wall construction, interior use, and environmental conditions, and should be evaluated individually by the building designer.

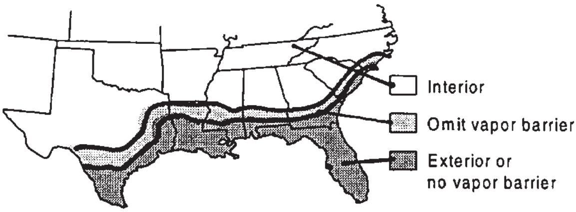
When a vapor-pressure differential exists, water vapor will move toward the lower pressure independently of air. For instance, with a winter condition of 0°F and 75 percent relative humidity, an outside vapor pressure of 0.027 inHg would exist. Inside a building heated to 70°F and with 35 percent relative humidity, vapor pressure would equal 0.259 inHg. The vapor pressure inside would be nearly 10 times as high as outside. Like other gases, water vapor moves from an area of high pressure to an area of low pressure until equilibrium is established. During cold weather, the difference in pressure between inside and outside causes vapor to move out through every available crack and directly through many materials that are permeable to water vapor. When vapor passes through pores of homogeneous walls, which are warm on one side and cold on the other, it may reach its dew point and condense into water within the wall.[6]

Vapor retarders are applied to the warm side of an exterior structural assembly. In cold climates this occurs toward the interior of the building, whereas in hot climates this occurs toward the exterior of the building. Generally speaking, the dividing line can be drawn between the southern tip of Texas and the Florida-Georgia border on the Atlantic Ocean. (Always verify with local building officials as to the proper placement.) Two vapor retarders on opposite sides of a single wall can trap water vapor between them and create moisture-related problems in core materials (Fig. 4.2).

A cold climate is an area that has more than 2200 heating degree-days. (A *degree-day* is a unit that measures the extent to which the outdoor mean daily dry-bulb temperature falls below or rises above an assumed base, normally 65°F (18°C), for heating and for cooling. Although specific exceptions may apply to a particular area, it is best to verify with local practice.[3] Unless relative humidity is extremely high, moisture will not condense on a warm surface. This is usually accomplished by using vapor retarder-faced insulation or unfaced insulation plus a separate polyethylene vapor retarder.[7]

This practice prevents wintertime condensation, but summertime conditions on buildings that are cooled instead of heated also must be examined. Even though an interior side vapor retarder is on the "cold"

Vapor barrier placement by geographical location



Perm Ratings of Different Materials

(Rating of 1 or less qualifies as a vapor barrier)

Asphalt-coated paper backing on insulation	0.40
Polyethylene plastic (6 mil)	0.06
Plywood with exterior glue	0.70
Plastic-coated insulated foam sheathing	0.4 to 1.2
Aluminum foil (.35 mil)	0.05
Vapor barrier paint or primer	0.45
Drywall (unpainted)	50
Drywall (painted - latex paint)	2-3

Figure 4.2 Vapor retarder placement. (*Southface Energy Institute*)

side in summer, the dew-point temperature of hot, humid summer air is nearly always lower than the temperature to which we cool buildings. That means that an interior-side vapor retarder will nearly always be warmer than the dew-point temperature, and therefore, condensation will occur only very rarely and will be of very short duration, causing no problems.[3]

In warm, humid climates, the flow of water vapor will be reversed, and vapor will flow from the outside to the inside.[6] These areas are defined as cooling-dominated climates below the 2200 heating degree-day [base 65°F (18°C)] mark set by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).[6] In some areas of the South, it may be difficult to determine where the vapor retarder should be placed. Where there is uncertainty, it is best to follow local practice and local codes. In southern coastal areas with a long cooling season and high exterior humidity, air conditioning causes continuous moisture flow from the exterior toward the interior cooled area. If a vapor retarder is used, it should be on the exterior of the wall.

Many professionals believe that in such situations a continuous air/vapor retarder such as polyethylene should not be used. The reason is that there may be times when the weather becomes cool and vapor movement reverses and moves from the interior toward the exterior (winter condition). When this happens, it is best to have a discontinuous retarder such as that provided by faced fiberglass insulation, to retard the passage of vapor but permit some vapor to pass. This approach is reinforced by a number of sources that state that in humid climates where very little heating is required, vapor retarders can be placed on the exterior side of insulation without causing problems in winter.[7] Under such circumstances, it is necessary to avoid use of interior wall coverings, i.e., vinyl wallpaper, that have low permeance to water vapor.[6] Avoid using low-perm products on the outer skin of a wall in areas with high indoor humidity. This includes vinyl or metal siding without vents, metal siding used on uninsulated homes in cold climates, insulated sheathings with foil coverings, and low-perm plastics that are substituted for breathable building papers.[8]

Some professionals dispute the need for a continuous, sealed, vapor diffusion retarder in warmer climates. ASHRAE, on the other hand, makes no recommendation on where or whether to install a vapor diffusion retarder in the fringe zone. In the remaining zone, one generally hotter and more humid, ASHRAE recommends omitting a vapor diffusion retarder.[3] In a fringe zone nearest where interior vapor diffusion retarders are recommended, the placement gets a little trickier. According to North American Insulation Manufacturers Association (NAIMA), the highest dew-point temperatures in the United States occur in places like Biloxi, Mississippi, and Galveston, Texas, where dew-point temperatures sometimes reach 78°F. Fortunately, this happens rarely; dew-point temperatures are nearly always 75°F or lower. And because winter temperatures in Biloxi and Galveston drop below freezing temperatures on occasion, there is some justification for interior-side vapor retarders there.[7]

NAIMA recommends another option of using either an interior- or exterior-side vapor retarder with moderate permeance. Inset stapled (or unstapled) kraft facing, with a permeance of about 1 perm, meets this requirement. Foil and polyethylene do not; their permeance ratings are much lower. (Omitting the vapor retarder entirely would work but would not allow energy-efficient cooling. However, if the building structure itself is a vapor retarder, unfaced insulation would be suitable.)[7] Where winter heating loads and summer cooling loads are equal, the vapor diffusion retarder will be on the wrong side for half the year. An air retarder, described later in this book, may be a better choice.

Cellulose Insulation Manufacturers Association (CIMA), along with the year 2000 editions of the *International Building Code* (IBC), the

International Residential Code (IRC), and the *International Energy Conservation Code* (IECC), has provided several exceptions to the prescriptive vapor retarder requirement. These include moisture-resistant materials, certain geographic areas, and "where other approved means to avoid condensation in unventilated frame wall, floor, roof, and ceiling cavities are provided." A growing number of experts are of the opinion that the matter of moisture control is too complex to be addressed by an absolute universal prescriptive requirement for a 1-perm vapor retarder. As studies continue, more will be learned about the complicated task of limiting moisture-related damage inside walls. Breathable walls, moderate climate zones, and the actual water vapor transportation aspects of air movement, as opposed to vapor diffusion, are of interest. As stated earlier, if unsure as to the vapor retarder placement within a wall, floor, or ceiling assembly, it is best to follow local practice and local codes.

Vapor retarder locations in the home

As mentioned earlier, water vapor that is trapped in a wall, ceiling, or floor assembly can lead to a number of problems. There are some locations in the home, under certain conditions, where a vapor retarder is not required. Attic vapor retarders are commonly omitted when blown-in insulations are used. If sufficient attic ventilation exists, condensation problems do not occur in most U.S. climates. CIMA does provide general guidelines for attic ventilation. In vented attics without vapor retarders, standard practice is to provide 1 ft^2 (0.093 m^2) of net vent area for each 150 ft^2 (13.94 m^2) of ceiling area. In vented attics with vapor retarders, standard practice is to provide 1 ft^2 (.0903 m^2) of net vent area for each 300 ft^2 (27.87 m^2) of attic floor area. When using a combination of roof and eave vents and no ceiling vapor barrier, there should be 1 ft^2 (0.093 m^2) of net vent area for each 300 ft^2 (27.87 m^2) of ceiling area. Vents should be installed with 50 percent of the total area in the eaves and 50 percent of the total area in the roof near the peak. The design professional or builder should verify these required minimums with local building codes.

In homes with cathedral ceilings, a continuous vapor diffusion retarder with sound, reliable airsealing is very important. Moisture vapor can move through many materials, including fibrous insulation, by diffusion. Therefore, moisture vapor that gets around or through a vapor retarder must be allowed to exit a cathedral ceiling rafter bay through a vent opening even when an airspace does not exist. Moving air can carry lots of moisture, but air movement is not necessary for moisture to escape from buildings. For example, since commonly used asphalt roof shingles have very low vapor permeance, cathedral ceilings can be likened to walls with very-low-permeance exterior skins.

Continuous vapor retarders can prevent condensation problems, but if the vapor retarder is penetrated by recessed lights that are not air/vapor-tight, some means must be provided to allow moisture to escape. (When ventilated airspaces are provided in milder climate areas, kraft vapor retarders may be adequate.) This can be accomplished with eave, ridge, or other vents. Note that airspaces alone, without both eave and ridge vents, will not add protection against moisture condensation in sloped ceilings. Air will not move through a space unless it has a place to exit as well as a place to enter. When both eave and ridge vents are provided, a $^1/_2$" or thicker airspace between the top of the insulation and the roof sheathing is desirable. As stated before, the design professional or builder should verify these required minimums with local building codes. Not only does this arrangement remove any unwanted moisture vapor, an airspace also helps remove heat in hot weather, and many professionals believe that it extends the life of roofing shingles as well.

Even when not required to prevent condensation problems, attic vapor retarders may be worthwhile; their presence may help maintain more comfortable humidity levels. When a vapor retarder is desired and blown-in ceiling insulation is used, a combination of faced batts and blown-in insulation, followed by a vapor retarder ceiling paint, can be used. Homes with irregular ventilation or high moisture levels should have a continuous vapor retarder. Vapor retarders are not necessary or recommended on interior walls where unfaced sound batts are installed.

As with wall assemblies, vapor retarders in floor assemblies should be installed on the warm side of the structure. In a heating climate, install it either in the space between the subfloor and finish floor or between the floor joists and the subfloor. An exception to placing the vapor diffusion retarder on the warm side of the floor is in houses constructed over a concrete slab. To protect the slab from soil moisture, place the vapor diffusion retarder above the gravel subbase.

In any climate, a crawl space vapor retarder may be necessary to reduce condensation resulting from ground moisture. In most traditionally constructed homes, the ground is a significant source of moisture. Moisture condenses on the colder sections of the foundation and framing, including nail penetrations. Placing 6-mil polyethylene sheeting directly over the ground cover reduces this likelihood. Local building codes require vapor retarders unless minimum crawl space vent requirements are adhered to. Additional strategies to help eliminate unwanted crawl-space moisture should include making sure the minimal constructed clearance meets all regulatory requirements, installing small, area, or through-the-wall drains, sloping the grade toward the drain intakes, verifying that all polyethylene seams are overlapped at least 6 in (seal to drain), and extending it up the foundation wall on the interior (avoid covering vents). Regardless of the number of foundation vents or climate, it is always good practice to install a vapor retarder over the soil.

For extensive renovations where wall cavities are opened and filled with blanket or rigid board insulation, it is simple to add a vapor retarder before the wall is refinished. Walls that have been retrofitted with blown-in or loose-fill insulation typically do not have vapor retarders. In cases where indoor moisture levels are not extreme, researchers have found that moisture that enters the wall eventually will evaporate and not damage the building materials. Many design professionals guard against this strategy because a homeowner's activities and lifestyles vary with time and technology, leading to unpredictable and possibly undesirable consequences.

Vapor retarder installation guidelines

Polyethylene sheeting (usually 4 or 6 mil) is used when an improved continuous, airtight vapor retarder is desired because of added moisture. The polyethylene sheeting, available in rolls, is rolled out horizontally and stapled to the face of the framing. It is recommended that the polyethylene be stapled at the sides and the excess material folded back into the room. If more than one sheet of polyethylene is required, a double fold should be made at the meeting of the two pieces and stapled, or the sheets may be overlapped and taped. The pieces, if stapled, should meet only at a stud or a joist. Foil-backed gypsum wallboard is also an effective vapor retarder. It is important to cover the polyethylene with gypsum wallboard or other approved interior material, as required by local codes, as soon as the insulation and polyethylene have been installed properly.

In general, the colder the climate, the tighter the vapor retarder should be. Also, the more vapor-tight the building's outer skin, the tighter the vapor retarder should be (relative to the 5 to 1 rule mentioned earlier). In milder climates of less than 4000 heating degree-days, inset stapled kraft facing is adequate for most installations. Inset stapled kraft paper–faced insulation is also adequate in cooler climates in buildings whose outer skins are vapor-permeable, as in those with wood fiber sheathing and loose-jointed vinyl or aluminum siding. In northern areas with 6000+ heating degree-days, face-stapled or separate polyethylene vapor retarders should be considered. Polyethylene or other tight, continuous vapor retarders should be installed in all but deep South/Gulf Coast areas when very-low-permeance exterior sheathing/siding combinations are used.[9]

Research indicates that vapor retarders may not be required for basements, but it is prudent to keep moisture vapor away from cold surfaces such as basement walls where they are above grade. Therefore, for watertight walls in cool climate areas, vapor retarders are recommended in basements. Unfortunately, not all basement walls are watertight. While poured concrete walls usually are both watertight and vapor-tight, block walls are often neither. For this reason, vapor retarders are not always recommended for below-grade block basement walls unless they have been waterproofed as opposed to the usual damp-proofed.[9]

Vapor retarders are not recommended for all insulation types. For example, most cellulose manufacturers recommend against the use of vapor retarders in walls insulated with spray-applied cellulose. Most cellulose producers regard vapor retarders as unnecessary with dense-pack cellulose under most conditions. If design temperatures are below −15°F (−26°C) the interior surfaces of exterior walls and ceilings, where the cold side cannot be ventilated, can be painted with a vapor barrier paint.

Some insulation facings are intended only for installation behind ceiling, wall, or flooring materials because they are flammable. (Always verify installation procedures with the manufacturer's instructions.) A great deal of air leakage can occur through penetrations in the exterior envelope of a building. Plumbing, ductwork, wiring, and electrical outlets are a few of the less obvious points where air can move through a building's thermal envelope. Strategies that include caulking, weatherstripping, and careful insulation installation should be implemented in these inconspicuous areas.

Air Barrier/Retarder

An *air barrier* or *air retarder* is any material on a building that prevents the movement of air from the interior to the exterior (infiltration) or from the exterior to the interior (exfiltration). Also called housewraps, these materials are barriers to air and liquid water but not to water vapor. Typical exterior housewraps are not vapor retarders and will allow water vapor to diffuse easily through them.

Infiltration can comprise almost 50 percent of all heat loss from a home during the winter months. The major sources of air infiltration are sill plates (25 percent), wall outlets (20 percent), and duct systems (14 percent), followed by windows (12 percent).[1] These sources can be reduced by the use of caulking, weatherstripping, and air infiltration barriers. It is important to note that homes need some fresh air to remove odors, chemicals from interior sources, and even exhaust gases. Tests have shown that a building with a poorly air-sealed exterior suffers accelerated heat loss or gain because of outside air infiltration into

Figure 4.3 Housewrap. (*Owens Corning*)

the wall cavity. Exterior air retarders protect the wall from the effects of weather and help eliminate air infiltration.

Product description

The most popular, flexible air retarders (also called *housewrap*) are composed of polyolefins, which include polyethylene and polypropylene. These air retarder materials typically are fiber-reinforced as spunbonded, woven, or laminated products. Standard gypsum panels, cement board, no. 15 felt, industry building wrap, and other common construction materials also can serve as air barriers if installed properly (but not as vapor retarders)[10] (Fig. 4.3).

Installation

All joints and seams must be sealed to create a truly continuous, effective air retarder. Installation errors not only increase energy use but also increase the risk of moisture damage to a house. An air retarder, therefore, should be inspected carefully after installation and before other work covers it. Small holes in an air retarder can be repaired with polyethylene or foil tape, whereas large holes can be repaired with a large patch of polyethylene. Patches always should be large enough to cover the damage and overlap any adjacent wood framing. Sealant should be used to thoroughly seal the joint.

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