

The Last Word (We Hope) on Vapor Barriers

JLC Staff Report

Answers to the most common questions about moisture migration through walls and ceilings



We receive more questions each year about vapor barriers and their close cousins, air barriers, than any other single topic. In an effort to clear up any lingering confusion about these pesky membranes, we've assembled this list of the most common queries along with the clearest answers we could provide.

Q. What is the difference between a vapor barrier and an air barrier? Between a "barrier" and a "retarder"?

A. A vapor barrier is a material or coating that significantly reduces the passage of water vapor by diffusion through wall, ceiling, and floor materials. In general, its purpose is to keep moisture from getting into exterior wall and ceiling cavities, where it can condense on framing members and sheathing.

Diffusion is the transfer of moisture through tiny pores in building materials. The amount of diffusion through a material depends on the material's permeability (perm rating) and the vapor pressure that pushes the moisture through. It's a scientific fact that moisture will always move from areas of higher temperature and relative humidity (higher vapor pressure, to be precise) to areas of lower temperature and humidity. The greater the pressure difference, the greater the push.

In cold climates, the vapor pressure is always higher indoors during the winter, so the moisture wants to move towards the outside. In hot, humid climates, the reverse is true — the moisture usually wants to move indoors if the building is air-conditioned.

In climates with both heating and cooling, the vapor flow changes with the seasons and weather, but it's usually the strongest during colder weather when it's heading from the inside to the outside.

An air barrier, on the other hand, blocks the passage of air through leaks in the walls, ceiling, or other building components. Because air often carries a lot of moisture, air barriers and vapor barriers work together to keep moisture out of building cavities. In fact, a single material such as polyethylene often performs both tasks, and hence is often called an air/vapor barrier.

Currently, most codes do not recognize the distinction between an air barrier and a vapor barrier. Most codes require a vapor barrier of one perm or less. Researchers, however, have found that air leakage generally moves a lot more moisture than diffusion. Therefore the air barrier actually is more important than the vapor barrier. So if you're concerned about really keeping moisture out of your wall and ceiling cavities, you ought to be paying close attention to the air barrier. That means using either (1) a continuous, airtight membrane, such as poly, or (2) a lot of caulk, foam sealant, and gaskets to block up any significant leaks (see "Air Sealing Details," page 19).

As to the difference between a "barrier" and a "retarder," there is no difference. It's just that some people like to be super-precise so they call it a retarder, since no barrier is perfect. At best a material will only slow down the passage of moisture or air, but will never stop it completely.

The bottom line: You need both an air barrier and a vapor barrier,

and the colder the climate, the more you need them.

Q. Does a vapor barrier need to be installed perfectly to be effective?

A. No. At a given vapor pressure, the amount of diffusion you'll get is directly proportional to the surface area that is exposed to the moisture. So if you have only 90% of your walls covered with poly, your vapor barrier will still be 90% effective.

This is not true of an air barrier, however, since air seeks the path of least resistance. Under pressure (air pressure, that is, not vapor pressure) a great amount of air can leak through even a small crack in a building — just as a lot of air can rush out of a small hole in a balloon.

How fanatical you need to be about vapor barrier installation and air sealing depends on (1) how moist the interior of the building will be, and (2) how cold the climate is.

An office building that is unoccupied at night and where no cooking or bathing takes place generally has pretty low indoor humidity levels, whereas a small house where three teenage children take two showers a day will likely have quite high levels.

As for climate, a house in northern Minnesota is much more prone to moisture problems than one in southern California. So you'll need to pay attention to local codes and practices, or talk to an experienced

local energy consultant.

The bottom line: Don't knock yourself out with the vapor barrier, but do a thorough job with the air barrier — particularly in cold climates.

Q. Should the vapor barrier go on the inside or the outside of a building?

A. In most of the continental United States, code requires you to put a vapor barrier on the inside. That's because the strongest vapor flows are during cold weather from indoors out.

Vapor flows from the outside in are significant only in very hot and humid climates, such as southern Florida and along the Gulf Coast. In those areas, there is a great deal of controversy over whether to install the vapor barrier on the outside or leave it out altogether. Leaving it out is probably the most prudent course, provided you do a good job sealing the building against air leaks.

The bottom line: Put the vapor barrier on the inside except in very hot, humid climates.

Q. Is paint a vapor barrier? How about black paper, Tyvek, and plywood?

A. A material's perm rating indicates the ability of moisture to diffuse through the material. The lower the perm rating, the better a material's resistance to moisture diffusion.

Vapor Resistance of Common Building Materials

Material	Perms	Reps
3/4" plaster on wood lath	15	0.067
1/2" drywall	37.5	0.027
1/2" 5-ply plywood	0.36	2.8
1" extruded polystyrene	1.2	0.83
1" expanded polystyrene (beadboard)	2.0 to 5.8	0.5 to .17
Aluminum foil	0.0	—
6-mil polyethylene	0.06	17
15-lb. asphalt felt	5.6	0.18
Kraft paper laminated with asphalt (used on insulation batts)	0.3	1.8
1 coat latex primer (vinyl-acrylic)	8.6	0.12
1 coat latex semi-gloss enamel (vinyl-acrylic)	6.6	0.15
1 coat latex vapor retarder paint	0.45	2.22
2 coats of oil enamel on smooth plaster	0.5 to 1.5	2 to 0.66

Note: A perm is a measure of a material's permeability — the capacity to diffuse moisture. A rep is the reciprocal of a perm, and measures a material's resistance to water vapor. Most codes define an interior "vapor barrier" as any material with a perm of one or less. However, because some exterior sheathing materials are not very permeable, there is a risk of trapping moisture in the wall cavity. To avoid problems, keep the outside of the wall five times as permeable as the inside.

In general, codes call a material a vapor retarder if it has a perm rating of one or less.

From the table above you can see that a couple of coats of oil-based paint can act as a pretty effective vapor barrier. However, 15-pound asphalt-impregnated felt is not a vapor barrier. Plywood is technically a vapor barrier, but usually has enough cracks between sheets to allow moisture to escape from the wall.

A useful rule of thumb is to keep the outside of the wall five times more permeable than the inside. To calculate the added value of two or more layered materials, you need to add the inverse of their perm ratings. This inverse figure is called a rep, and is a measure of a material's resistance to vapor transmission.

The bottom line: Keep the outside of the building significantly more permeable to moisture than the inside and you'll avoid trouble.

Q. If the house is covered with a housewrap such as Tyvek on the outside, do I still need a tight air/vapor barrier on the inside?

A. Yes. Housewrap on the outside will not keep air from leaking into the walls and ceiling. Housewrap functions primarily as a wind barrier, preventing air from blowing through the gaps in the sheathing and around the band joist. It also acts as a secondary rain barrier during construction, and later protects against any water that might leak behind siding and trim. But because housewrap is typically installed only over the wall sheathing, it does not form a continuous envelope around the house. You still need to seal the most prominent air

leaks in a house — around doors and windows, along the mudsill, behind tubs and cabinet soffits, and through the ceiling.

The bottom line: Install a continuous air/vapor barrier on the inside even if you use housewrap on the exterior.

Q. Where should the vapor barrier go in a finished basement?

A. Moisture control in finished basements is tricky, since the vapor drive between the soil and the basement is small and could go either way depending on conditions. The most common practice is to place the vapor barrier below the wall finish as you would with an above-grade wall. This is a safe bet because it keeps heated basement air from contacting the cool basement walls where it might condense.

Dampproofing or waterproofing the basement wall on the exterior is also helpful for keeping soil-borne moisture from migrating into the building.

The bottom line: Treat below-grade walls the same as above-grade walls.

Q. How does foam insulation on framed walls affect moisture problems?

A. Foam on the interior of a wall is usually okay, since it serves as an interior vapor barrier, similar to poly. However, there is one important difference. Because of the high R-value of the foam, the wall cavity is now significantly colder, and moist air that does get past the foam is more likely to condense inside the wall. So it's important to

seal the foam well against air leaks with construction tape and foam sealant.

When foam is used on the exterior, it usually contradicts the old rule of thumb — to keep the outside of the wall five times as permeable as the inside. Yet it usually doesn't cause problems. Here's why: Although the foam will tend to trap moisture in the wall, it also warms the wall cavity, making it less prone to condensation. Moisture that stays in its vapor state and does not condense is harmless to the building. Therefore, it's best to use a relatively permeable foam such as beadboard or extruded polystyrene rather than the foil-faced products. Also, the colder the climate, the higher the R-value you'll want on the exterior foam to keep the wall cavity warm (see "Where Does the Dew Drop?," page 20).

The bottom line: If you put foam on the interior, seal it well. If you're going to put foam on the exterior, use an adequate thickness for the climate.

Q. Do you need to add a vapor barrier when you retrofit insulation into walls or ceilings?

A. An uninsulated leaky wall is generally not prone to moisture problems for two reasons: (1) the wall cavity is relatively warm from leaking household heat, and (2) the wind blows through and clears out any moisture that gets in. Once you insulate, however, the wall becomes colder at the outside sheathing and ventilation in the wall cavities is reduced. That means there may be more condensation on the sheathing, which can lead to possible exterior paint problems. There's a fair amount of anecdotal evidence linking retrofit insulation with peeling paint. Therefore, it's a good idea to add as good an air and vapor barrier as is practical.

If the wall is older, it probably has more than a couple of coats of oil-based paint on the plaster, so the vapor barrier is already there. As for the air barrier, caulk as many cracks as you can find at baseboards and other trim, and seal electrical outlets with foam and gaskets. When sealing an old house, it's worth working with someone with a blower door. By pressurizing the house with a blower door, you can pinpoint leaks that might be quite significant, but are not immediately obvious. Most public utilities can put you in touch with a blower door contractor.

The bottom line: You should try to seal the walls against moisture transport whenever you retrofit insulation. Pay particular attention to air sealing.

Q. Does it do any good to have a

Air Sealing Details

While much attention is given to vapor barriers, research suggests that air sealing is much more important.

Laps between pieces of a poly air/vapor barrier should be sealed with a tape made specifically for polyethylene sheeting, such as 3M Construction Tape. This is widely distributed with DuPont's Tyvek. Similar tapes are available from Stoco and Yunkers.

Window and door openings. Many builders still stuff the gap between the rough opening and a window or door with fiberglass insulation even though fiberglass will not stop air. Non-expanding foam sealant is a much better choice. (If you use expanding foam, use a light touch, or the foam can overexpand

and push the jambs outwards.)

Band joists. Sealing a second-story band joist is particularly hard — because unless you wrestle with the poly while you're framing, it's nearly impossible to get a continuous seal. The best solution we've seen is to inset the second-story band joist and run a strip of rigid insulation on the outside. This keeps the band joist area warm, so that it's not prone to condensation (see illustration below). For very cold or windy sites, you can improve upon this by adding a strip of housewrap around the band joist. Tyvek is available in 3-foot-wide rolls for this application. In colder climates, a tight band joist is critical for keeping blasts of cold air

out of the floor system.

Plumbing. Where pipes run into exterior walls, seal them to the air/vapor barrier with construction tape, or seal the opening around the drywall with spray foam. Plumbing stacks that run from a basement into an exterior wall are often ignored. Foam around the opening through the framing.

Electrical boxes. There are a number of products available for ensuring a tight seal around electrical outlet and switch boxes in exterior walls:

A Lessco Air-Vapor Barrier Box (Low Energy Systems Supply Co., 990 Mink Ln., Campbellsport, WI 53010; 414/533-8690) nails to the wall framing before an electrical box is installed. The box is sealed by caulking the small holes for incoming wires and taping the poly air/vapor barrier to the box's wide flange.

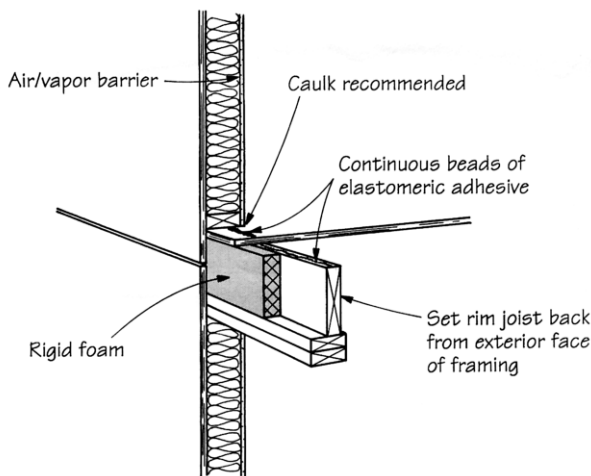
Another option for new construction is to use a plastic electrical box with a flange, such as those made by Nu-Tek Plastics (#25 11151 Horseshoe Way, Richmond, BC V7A 4S5, Canada) or R&S Enviro Products (1 Church St., Unit 10, Keswick, ON L4P 3E9, Canada; 416/476-5336). The Nu-Tek boxes have a foam-gasketed flange that is meant to press up against the back of the drywall and provide a tight seal without a plastic air/vapor barrier. The R&S electrical boxes have an ungasketed flange and a secondary ring that snaps over the perimeter of the box to pin the poly to the flange. Both boxes have a piece of closed-cell foam over the power line openings that is slit and then caulked after the line is run in.

R&S Enviro also makes a rubber insert box that fits into existing outlet, switch, and ceiling boxes to seal leaks (left). Again, the small gaps around the incoming power lines must be caulked.

Recessed light fixtures. Because the lights are hot they act like small chimneys to draw moist air into the ceiling cavity. Several companies, including Juno (2001 S. Mt. Prospect Rd., Des Plaines, IL 60017; 800/323-5068), Halo (400 Busse Rd., Elk Grove Village, IL 60007; 800/323-8705), Lightolier (100 Lighting Way, Secaucus, NJ 07096; 800/223-0726), and Scientific Component Systems (2651 Dow Ave., Tustin, CA 92680; 714/730-3555) make airtight ceiling fixtures. These are IC-rated so you can pack insulation close around them, and are sealed so they have a very low air leakage rate. Scientific Components also makes a replacement fixture that can be easily retrofit to an existing opening.

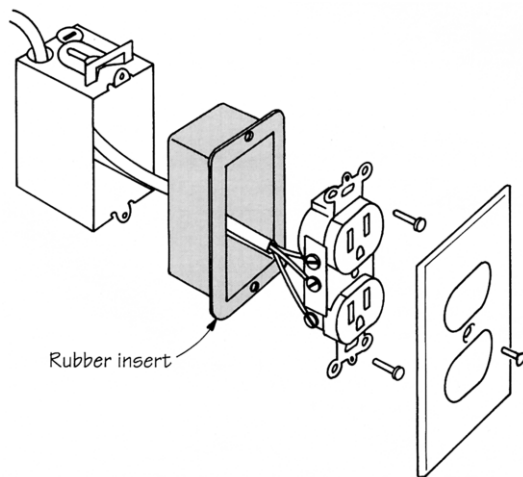
— JLC

Sealing the Rim Joist



Instead of wrapping the vapor barrier around the band joist, you can insulate the band with rigid foam so that it's not prone to condensation.

Tight Outlets



The R&S Enviroseal allows you to seal existing metal outlet boxes with a rubber insert and caulk.

Where Does the Dew Drop?

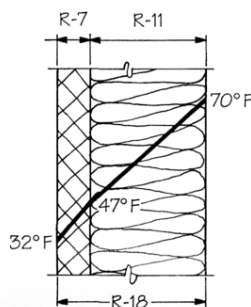
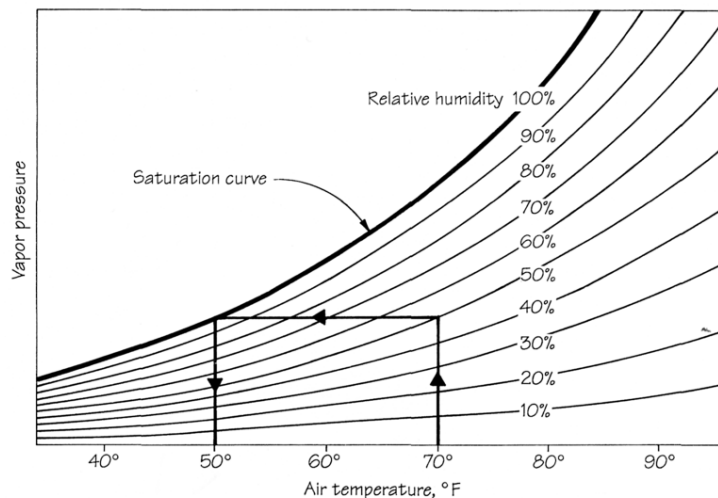
To figure out how much insulating foam sheathing you should install on the exterior of a building, you need to know the dew point of the interior air during winter.

First look at the chart to figure out what the dew point is for a given air temperature and relative humidity. Say you have an indoor relative humidity of 50% at 70°F. On the horizontal scale, locate the temperature and move up to the curve that represents 50% relative humidity, as shown. Then move left to the saturation curve, and down to find the dew point temperature — 50°F in this case.

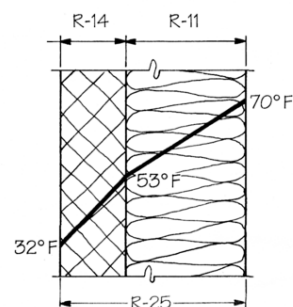
Moisture must condense on a solid surface (it won't condense in midair and is unlikely to condense in fiberglass), and the inside surface of the sheathing is where the condensation is most likely to occur. The objective is to put enough foam on the wall so its inside surface remains *above* the dew point (in this case, above 50°F) for the average winter temperature at the site.

You can find the temperature at any point inside the wall if you know the R-values of the wall insulations you are using. The temperature change through the wall is in direct proportion to that R-value. For example, for an average outdoor winter temperature of 32°F, the temperature inside the 1-inch foam sheathing in Wall A will be $\frac{7}{18}$ (R-7 over R-18) of the way from 32°F to 70°F, or 47°F. This is below the dew point, so condensation is likely to form on the inside of the foam sheathing.

In Wall B, with 2 inches of foam, the temperature at the inside sheathing surface is $\frac{14}{25}$ of the way, or 53°F — safely *above* the dew point. This thicker insulating sheathing would be your safest bet in climates with an average winter temperature of 32°F or less.



Wall A



Wall B

vapor barrier only in an addition?
Only in the ceiling?

A. If a modern addition has modern insulation, it ought to have modern air and vapor barriers. As for ceiling-only vapor barriers, it's not something we recommend for new construction. But since the ceiling — particularly cathedral ceilings — are one of the most likely places to have moisture problems, ceilings are the best place to concentrate your air and vapor sealing efforts. Ceilings and attics are more vulnerable to moisture damage than walls because convection currents carry lots of warm, moist air into those spaces.

The bottom line: When you add on, add a vapor barrier throughout — not just in the ceiling.

Q. Are vapor barriers needed below slabs? Will the barrier inhibit the curing of concrete? What if the vapor barrier gets ripped when the concrete is placed?

A. In a new home, it's a good idea to install a vapor barrier beneath an enclosed slab since ground moisture evaporating up through a slab is a major source of indoor humidity. Here the plastic sheeting is functioning as a capillary break, keeping moisture from wicking into the slab.

Poly under a slab may cause the slab to dry more slowly, which can be a benefit to curing but can also delay finishing. Drying may also be uneven since the slab can only dry upward. This will affect the rates of hydration in the top and the bottom of the slab. Since the top is likely to dry more quickly than the bottom, the slab can curl.

Preventing slab curl is easy. Add a 2-inch layer of sand over the poly before you place the slab. The sand will absorb some water downward to equalize the rate of hydration. In addition, it is important to temporarily cover the top of the slab with poly, water, or a curing agent to slow the evaporation of water from the surface (see "Curing Concrete," 3/93).

Don't worry about punctures or small tears since, as we said, a vapor barrier that covers 90% of the surface is 90% effective. The layer of sand will help cushion the poly to prevent small punctures. For best results use a heavy-duty poly made for below-grade use, such as Cross-Tuff (Manufactured Plastics and Distribution, 2162 Market St., Denver, CO 80205; 303/296-3516), Dura-Tuff (Yunker Plastics, 200 Sheridan Springs Rd., Lake Geneva, WI 53147; 800/236-3328), and Tu-Tuff

(StoCote Products, Drawer 310, Richmond, IL 60071; 800/435-2621).

The bottom line: Put a vapor barrier below slabs in new construction.

Q. Are vapor barriers needed in crawlspaces? Do you have to seal the edges to the foundation?

A. A vapor barrier is essential on the dirt floor of a crawlspace to keep moisture in the soil and out of the house. Even if the soil appears dry, a lot of moisture evaporates up into the house, particularly if the water table is high. Moreover, a wet crawlspace with no ground cover and inadequate ventilation can spawn all manner of fungi on the floor structure because you've got the two conditions necessary for rot: damp wood and warm temperatures. This can happen in any climate that has warm weather part of the year.

No, you don't have to seal the edges of the poly to the foundation because of the 90% rule stated above. A layer of sand or gravel over the poly will make it a lot easier to move around in the crawlspace.

The bottom line: Always put a ground cover in a crawlspace.

Q. Do vapor barriers contribute to

moisture problems or air quality problems inside a home?

A. No, but air barriers might, since a good air barrier will prevent moisture and indoor toxins from dissipating. Remember, however, that the best way to reduce moisture problems in the walls is to reduce excess moisture in the home or vent it directly at its source. That means you should install good bathroom and kitchen exhaust fans; vent the dryer outside; eliminate uncovered crawlspaces; and don't air-dry laundry or store firewood indoors. Similarly, the best way to reduce air quality problems is to keep strong toxins out of the home or ventilate them directly. For example, avoid products with a high formaldehyde content, such as cheap wood paneling, and ventilate hobby areas, such as a photo darkroom, directly outdoors.

With very tight construction, a whole-house ventilator, such as an air-to-air heat exchanger, might be required.

The bottom line: Build tight and ventilate right. The tighter the home, the more you'll need to reduce moisture and pollution sources and add mechanical ventilation. ■