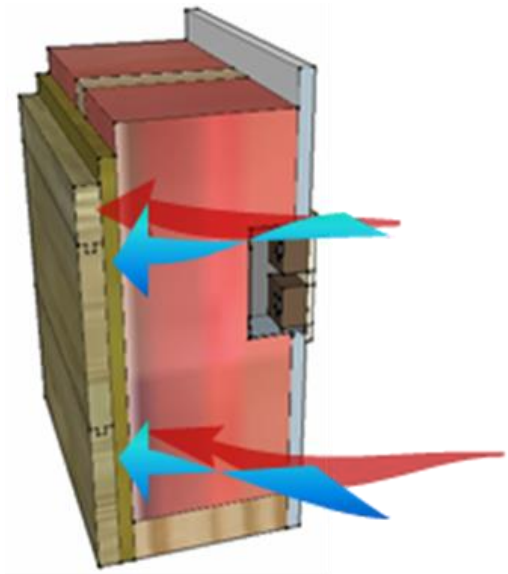
12. Air Barriers and Building Tightness

Air-leakage control is an important but commonly misunderstood component of the energy-efficient house. Tightening the structure with caulking and sealants has several positive impacts. A tight house will have lower heating bills due to less heat loss and fewer drafts to decrease comfort. A tight house reduces the chance of mold and rot because moisture is less likely to enter and become trapped in cavities. Tight homes have better-performing ventilation systems and potentially require smaller heating and cooling equipment capacities. Air leakage is sometimes called *infiltration*, which is the unintentional or accidental introduction of outside air into a building. Whenever there is infiltration, there is corresponding exfiltration elsewhere in the building envelope. In the winter, this can result in warm, moist indoor air moving into cold envelope cavities where condensation can occur, resulting in mold or rot. Infiltration is caused by wind, stack effect, and mechanical equipment such as exhaust fans. The figure below identifies likely points of air infiltration or exfiltration.

Unintentional Air Leaks (Source US EPA)

Air Barriers

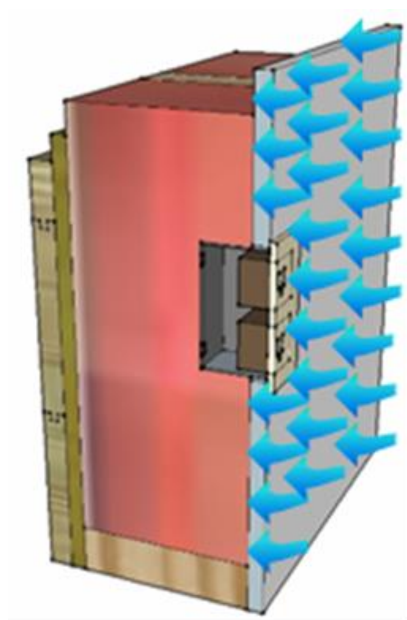
The energy code requires that a "continuous air barrier shall be installed in the building envelope." ***A Montana amendment to the definition of an air barrier further requires that the air barrier be installed on the warm side of the wall, ceiling, or floor assembly.*** An air barrier is a material or assembly of materials that reduces air flow through or into the building envelope. While the energy code addresses the installation of air barriers, the International Residential Code (IRC) addresses vapor retarders. A primary purpose of both the air barrier and vapor retarder is to minimize water vapor movement into the building cavities where damage may result. The purpose of a vapor retarder is to minimize the movement of water vapor into building cavities by diffusion through solid materials such as gypsum board. The purpose of an air barrier is to minimize the movement of water vapor into building cavities by air transport. Air transport is many times more significant in the movement of water vapor. Therefore, the air barrier is critical.



An air barrier prevents the movement of air into the wall via air transport

A variety of materials make good air barriers. Some of the most common are drywall, plywood, polyethylene sheeting, oriented strand board (OSB) sheathing, and rigid foam insulation. Although air cannot leak through these materials, air can travel through openings and seams. The joints in the air barrier must be sealed with tape, gaskets, foam, or caulk as approved by the manufacturer for application to specific materials.

The energy code requires compliance with the Air Barrier and Insulation Installation Table (the so-called *visual checklist*) shown later in this article. The energy code also requires that air barrier effectiveness be tested with a blower door test. Passing a blower door test help confirm that the air sealing requirements have been met. The energy code requires that the house pass the test with a result of 4 air changes per hour at 50 Pascal pressure (ACH 50) or less. The blower door test result must be provided to the building code official, who may require that the test be performed by an approved party.



A vapor retarder prevents the movement of air into the wall via diffusion.

It is recommended that builders and designers develop an air-sealing plan. Begin by setting a tightness goal, reviewing the building plans, and identifying potential areas of air leakage. The plan should include the types of materials that will be used to create the air barrier. The residential energy code does not identify specific air barrier products but does require that the materials allow for expansion and contraction while also following the manufacturer's instructions.

To achieve the energy code air tightness requirements, a pre-construction meeting with trades that share responsibility such as the building contractor, framing contractors, insulation contractors, and the person who will conduct the tightness testing is recommended. Conducting a preliminary blower door test early in the construction process is advisable if the builder is unfamiliar with house tightening techniques. A preliminary blower door test can be performed once windows, doors, and ceiling are installed. The primary purpose of this early test is to identify the location of air leakage sites while they are still accessible. A thermal infrared camera can also help locate air leaks.

Mold at the Rim Joist. Below are two examples of mold behind rim joists in a basement and in a crawl space insulated with only fiberglass batts. Water vapor in house air can travel through the fiberglass batt and, in cold weather, condense on the rim/band joist to cause mold.

Mold in Walls. Both photos, below, show mold behind unsealed electrical boxes. The energy code Air Barrier and Insulation Installation Table details code-required air barrier practices that would have prevented this problem from occurring. Because localized air leakage problems can occur, both the Air Barrier and Insulation Installation Table and building tightness testing is required by the energy code.


Air Barrier and Insulation Installation	
Component	**Criteria**
Air barrier and thermal barrier	A continuous air barrier installed in the building envelope. Exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier sealed. Air-permeable insulation not be used as a sealing material.
Ceiling/attic	The air barrier in any dropped ceiling/soffit aligned with the insulation and any gaps in the air barrier sealed. Access openings, drop-down stair, or knee wall doors to unconditioned attic spaces sealed.
Walls	Corners and headers insulated and the junction of the foundation and sill plate sealed. The junction of the top plate and top of exterior walls sealed. Exterior thermal envelope insulation for framed walls installed in substantial contact and continuous alignment with the air barrier. Knee walls sealed.
Windows, skylights, and doors	The space between window/door jambs and framing and skylights and framing sealed.
Rim joists	Rim joists insulated and include the air barrier.
Floors (above-garage and cantilevered floors)	Insulation installed to maintain permanent contact with underside of subfloor decking.
Crawl space walls	Where provided in lieu of floor insulation, insulation permanently attached to the crawlspace walls. Exposed earth in unvented crawl spaces covered with a Class I vapor retarder with overlapping joints taped.
Shafts, penetrations	Duct shafts, utility penetrations, and flue shafts opening to exterior or unconditioned space sealed.
Narrow cavities	Batts in narrow cavities shall be cut to fit, or narrow cavities shall be filled by insulation that on installation readily conforms to the available cavity space.
Garage separation	Air sealing shall be provided between the garage and conditioned spaces.
Recessed lighting	Recessed light fixtures installed in the building thermal envelope shall be air-tight, IC-rated, and sealed to the drywall.
Plumbing and wiring	Batt insulation shall be cut neatly to fit around wiring and plumbing in exterior walls, or insulation that on installation readily conforms to available space shall extend behind piping and wiring.
Shower/tub on exterior wall	Exterior walls adjacent to showers and tubs shall be insulated and the air barrier installed separating them from the showers and tubs.
Electrical/phone box on exterior walls	The air barrier installed behind electrical or communication boxes or air sealed boxes installed.
HVAC register boots	HVAC register boots that penetrate building thermal envelope sealed to the subfloor or drywall.
Fireplace	An air barrier installed on fireplace walls. Fireplaces have gasketed doors.

Air Barriers Q & A

What materials make good air barriers?

A. Most air barriers are an assembly or system of several materials. Sheet polyethylene and gypsum board are the most common elements of most air barriers. A gypsum board-based air-barrier system requires no polyethylene. Polyethylene is classified as a Class I vapor retarder and will prevent a wall from drying. A wide variety of materials can make up an air-barrier system, including wood, poured concrete, glass, some rigid foam insulations, some spray foams, plywood, and peel-and-stick rubber membranes. Although air can't leak through these materials, it can leak at penetrations, edges, and seams. When these materials are used to form an air barrier, additional materials such as tape, gaskets, or caulk are required to complete a code-compliant air barrier. To make a good air barrier, a material not only must stop air flow, but it also must be durable.

If house wrap has been installed under the house siding, is that a code-compliant air barrier?

A. No. The primary purpose of house wraps is to provide a water-resistant barrier to protect against moisture that penetrates the siding or cladding. In other words, house wraps protect the wall sheathing from wind-driven rain that gets past the siding. The Montana energy code requires that an air barrier be installed on the warm side of the wall, not under the siding on the wall's exterior. There are certainly benefits from installing a house wrap, but a house wrap does not meet code requirements for an air barrier.

If a house has sheet polyethylene installed under the drywall, is the polyethylene an air barrier?

A. That depends. The sheet polyethylene would have to be sealed at all edges, seams, and penetrations to fulfill the code requirements for a continuous air barrier. To act as an effective air barrier, however, polyethylene needs to be installed with careful attention to a long list of details, including the use of non-hardening sealant at all seams and the use of airtight electrical boxes.

Where are the most common air barrier defects located?

A. Most air leaks occur at the joints between different materials: for example, where floors meet walls and where walls meet ceilings. Although gaps around windows and doors occasionally contribute to air leakage, the most significant air leaks are usually in hidden areas. Here's a list of some of areas that are often poorly sealed, and therefore responsible for significant air leakage:

- Basement rim joist areas
- Cracks between finish flooring and baseboards
- Utility chases that hide pipes or ducts
- Plumbing vent pipe penetrations
- Kitchen soffits above wall cabinets
- Fireplace surrounds
- Recessed can light penetrations
- Cracks between ceiling-mounted duct boots and ceiling drywall
- Poorly weather-stripped attic access hatches

What's the best way to identify air leaks in the air barrier?

A. Tracking down air leaks can be a challenge, especially for builders not familiar with tight building practices. The best way to test the integrity of a home's air barrier is to perform a blower door test. While the blower door fan is exhausting air from the house, an infrared camera, infrared thermometer, or smoke stick is used to find air leaks. It surprises many builder that significant air leakage paths can occur through interior partitions located far from exterior walls.

Plan Review

1. Verify that submitted construction documents identify location (warm side of wall) and details of continuous air barrier installation, including specification of how joints in materials will be sealed. The code required air barrier installation details are included in Table R402.4.1.1 Air Barrier and Insulation Installation.

2. Verify that the construction documents specify a tested envelope tightness of 4 ACH50 or tighter.

Field Inspection

1. Verify installation of continuous air barrier in accordance with Table R402.4.1.1 Air Barrier and Insulation Installation.

2. Verify that all joints and penetrations in the air barrier are sealed.

3. Verify that all air barrier materials are installed per manufacturer's instructions.

4. Verify that the building envelope has been tested by an approved entity to a tightness of 4 ACH50 or tighter.

Code References

R202 General Definitions

Air Barrier. Material(s) assembled and joined together to provide a barrier to air leakage through ***or into*** the building envelope. An air barrier may be a single material or a combination of materials. *(Note: A Montana amendment added the words "or into." The intent of the amendment was that an air barrier is to be installed on the warm side of the exterior thermal envelope assembly and that is the correct interpretation.)*

R402.4 Air Leakage (Mandatory). The building thermal envelope shall be constructed to limit air leakage in accordance with the requirements of Sections R402.4.1 through R402.4.4.

> **R402.4.1 Building Thermal Envelope.** The building thermal envelope shall comply with Sections R402.4.1.1 and R402.4.1.2. The sealing methods between dissimilar materials shall allow for differential expansion and contraction.
>
> **R402.4.1.1 Installation.** The components of the building thermal envelope as listed in Table R402.4.1.1 shall be installed in accordance with the manufacturer's instructions and the criteria listed in Table R402.4.1.1, as applicable to the method of construction. Where required by the code official, an approved third party shall inspect all components and verify compliance.

Resources

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