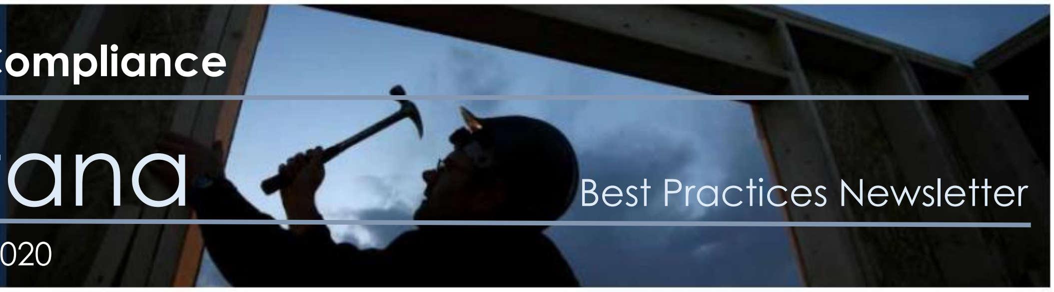
Energy Code Compliance

Montana

Best Practices Newsletter

Winter 2020



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We're here to save the planet. We're here because it's real important for our carbon footprint. And yet they turn out one glass box after another glass box after another glass box. *— Joseph Lstiburek*

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Air Barriers, Vapor Retarders and a Perfect Wall - We're Getting Warmer

Background

Controlling building envelope air leakage is critical in an energy-efficient house or dwelling unit.

In common construction parlance, this is known as "building tight." A house built tight will bring a number of benefits to its occupants, including lower heating bills, fewer drafts, greater comfort, reduced chance of mold and rot, and smaller heating and cooling systems, to name just a few.

To minimize air leakage, the Montana energy code requires that a "continuous air barrier shall be installed in the building envelope." An amendment to the International Energy Conservation Code (IECC) definition of an air barrier adds a requirement that the air barrier *be installed on the warm side of the wall, ceiling, or floor assembly*.

While at first blush, the "warm side" concept seems simple, it's complicated by the fact that envelope assemblies typically contain numerous penetrations for electrical, plumbing, HVAC, and construction intersections of dissimilar materials. These factors can make installation of a continuous, warm-side air barrier challenging.

Regardless of the air barrier's location, the code mandates the efficacy of the air barrier "building tightness" be verified with a blower door test. The current code limits envelope air leakage to 4 air changes per hour @ 50 Pascals (4 ACH50). The code also requires that the home's thermal layer of insulation be fully aligned with (that is, in full continuous contact with) the home's continuous air barrier.

What is an air barrier?

An air barrier is a material or assembly of materials that reduces air flow through or into the building envelope. While the energy code (IECC) addresses the installation of air barriers, the International Residential Code (IRC) addresses vapor retarders. A provision added to the 2018 IECC mirrors the IRC vapor retarder requirement. A primary purpose of both the air barrier and the vapor retarder is to minimize water vapor movement into the building cavities where damage may result. More specifically, the purpose of a vapor retarder is to minimize 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 movement of water vapor into building cavities by air transport. Air movement carries water vapor along with it. Air transport is many times more significant than diffusion in the movement of water vapor. Therefore, the air barrier is critical.

While the residential energy code does not specify any material or assembly of materials that make up an air barrier, the commercial energy code provides an instructive list of 16 materials deemed compliant with a continuous air barrier requirement (Sect. C402.5.1.2.1), provided that "joints are sealed and materials are installed as air barriers in accordance with the manufacturer's instructions."

2018 IECC C402.5.1.2.1 Materials

Materials with an air permeability not greater than 0.004 cfm/ft2 (0.02 L/s • m2) under a pressure differential of 0.3 inch water gauge (75 Pa) when tested in accordance with ASTM E 2178 shall comply with this section. Materials in Items 1 through 16 shall be deemed to comply with this section, provided joints are sealed and materials are installed as air barriers in accordance with the manufacturer's instructions.

1. Plywood with a thickness of not less than 3/8 inch (10 mm).
2. Oriented strand board having a thickness of not less than 3/8 inch (10 mm).
3. Extruded polystyrene insulation board having a thickness of not less than 1/2 inch (12.7 mm).
4. Foil-back polyisocyanurate insulation board having a thickness of not less than 1/2 inch (12.7 mm).
5. Closed-cell spray foam a minimum density of 1.5 pcf (2.4 kg/m3) having a thickness of not less than 11/2 inches (38 mm).
6. Open-cell spray foam with a density between 0.4 and 1.5 pcf (0.6 and 2.4 kg/m3) and having a thickness of not less than 4.5 inches (113 mm).
7. Exterior or interior gypsum board having a thickness of not less than 1/2 inch (12.7 mm).
8. Cement board having a thickness of not less than 1/2 inch (12.7 mm).
9. Built-up roofing membrane.
10. Modified bituminous roof membrane.
11. Fully adhered single-ply roof membrane.
12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than 5/8 inch (15.9 mm).
13. Cast-in-place and precast concrete.
14. Fully grouted concrete block masonry.
15. Sheet steel or aluminum.
16. Solid or hollow masonry constructed of clay or shale masonry units.

Most building envelope 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 potentially responsible for significant air leakage:

• Rim joists

• 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 fixture penetrations

• Air leaks between ceiling-mounted duct boots and ceiling drywall

• Poorly weather-stripped attic access hatches

• Air leaks between partition top plates and drywall

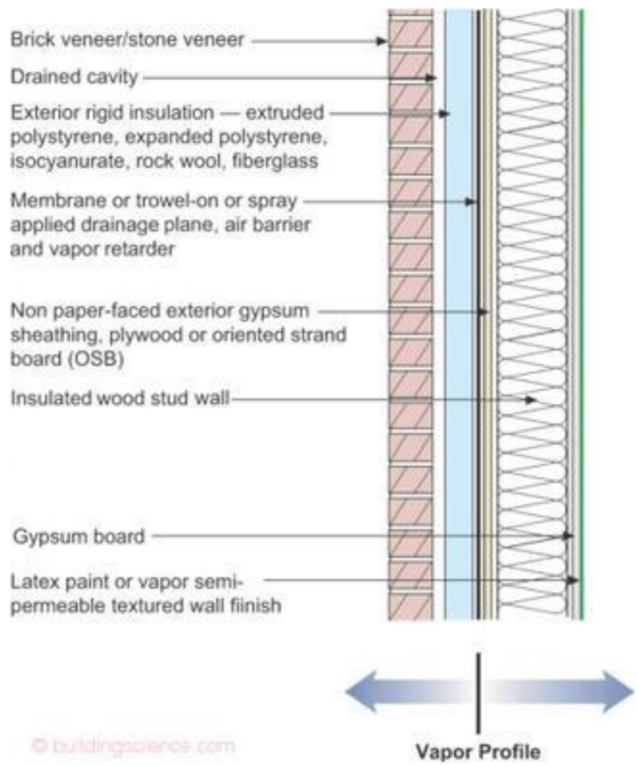
Among its advantages, an exterior air barrier can be easily installed, and detailing related to penetrations and assembly intersections can be minimized. Systems like taped and sealed oriented strand board (OSB), taped and sealed OSB with integrated water-resistant barrier (WRB), fully adhered WRBs, and similar systems installed on the exterior sheathing make sense as the simplest and least labor-intensive solution, but not necessarily the least expensive. While these improved WRBs have other added benefits, assemblies with exterior air barriers would not meet Montana's warm-side air barrier requirement without continuous rigid exterior insulation.

The reason for Montana's warm-side air barrier requirement is that, in our cold climate, the exterior air barrier cannot control the entry of moisture-laden air into insulated wall cavities. However, this concern can be mitigated by insulating the exterior of the wall with rigid insulation to control the condensing surface temperature of the wall structural sheathing. In effect, exterior insulation on the outside of the air barrier moves the warm side of the wall outward in the wall assembly. This is the concept underlying what Building Science Corporation's Joseph Lstiburek calls "the perfect wall."

> "What about this air control thing? Well, air can carry a lot of water and water is bad for the structure. So we have to keep air out of the structure as well because of the air-water thing—or if we let it get into the structure, we have to make sure it does not get cold enough to drop its water. Now, just one other thing tends to be important if you intend on living in the building or working in the building or keeping things safe in the building: We might want to control the interior environment. We especially ought to be concerned about what is in the interior air because when we are in the interior, we tend to breathe it. Well, it turns out that we can't control air until we enclose air. So we need an honest-to-god airtight enclosure in order to provide conditioning such as filtration and air change and temperature and humidity control. And once again, the best place to control this air thing is on the outside of the structure—but under the insulation layer so the air does not change temperature. Presto: the perfect wall. A water control layer, air control layer, and vapor control layer directly on the structure and a thermal control layer over the top of the other control layers." [1]

[1] BSI-001: The Perfect Wall, Joseph Lstiburek, Building Science Corporation, available at https://www.buildingscience.com/documents/insights/bsi-001-the-perfect-wall

Moreover, Lstiburek demonstrates the simplicity of the perfect wall and illustrates that by rotating it horizontally it becomes the perfect roof with the ability to line up the air barriers perfectly in each.



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In cold climates such as ours, exterior rigid insulation works to achieve the goals of the Montana warm-side air barrier rules: reducing condensation problems in wood-framed walls and eliminating or reducing thermal bridging.

Traditional vapor retarder installations, such as sealed and caulked drywall and sealed polyethylene, reduce the condensation potential by limiting the amount of humid interior air that can contact the interior surface of the exterior sheathing. However, these attempts at air sealing are never perfect, and gaps and imperfections in the air barrier can lead to condensation problems. As previously discussed, rigid insulation on the exterior of the wall assemblies keeps the exterior sheathing warmer and reduces condensation potential. In fact, this benefit is recognized in the code, and as discussed, sufficient exterior rigid insulation can allow the warm side air barrier to be moved outward.[2] Unfortunately, installation of exterior continuous insulation can also increase construction costs for materials and additional labor costs of detailing around windows and doors.

What About Two Air Barriers?

The Montana residential energy code requires a continuous air barrier on the warm side of an envelope assembly. There is nothing in the code that would prevent the installation of an additional air barrier on the exterior side of the wall as well. If both a warm side and an exterior air barrier is to be installed, it is critical that the wall be able to dry to either the inside or outside. Another way of saying that is, "There should not be Class I vapor retarders on both the warm side and

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[2] Measure Guideline: Incorporating Thick Layers of Exterior Rigid Insulation on Walls Building America Report – 1406 November 2014 (rev2. 04/2015) Joseph Lstiburek and Peter Baker

the exterior of the assembly." It becomes imperative that the designer understand the vapor permeability of the two air barriers to be sure that the wall can dry to either the interior or the exterior.

Where Is the Warm Side?

Montana builders and designers wanting to incorporate Lstiburek's perfect wall system must convince inspectors that there is enough insulation on the exterior walls to ensure the air barrier remains on the warm side of the wall. This is the most important detail of this system. Too little insulation will cause the sheathing to become cold, creating a condensing surface on the interior side of the exterior sheathing, resulting in wet interior assemblies.

The obvious question is how much exterior insulation is enough to keep condensation from occurring on the warm side of the exterior sheathing? The 2018 IRC Table R702.7.1 allows a Class III vapor retarder on interior side of the wall based on the R-value of exterior insulation sheathing. A Class III vapor retarder is semi-permeable and is minimally affective at preventing vapor diffusion. That table requires exterior rigid insulation R-values of 7.5 or greater for a 2x4 wall and R-11.25 or greater for a 2x6 wall.

In any case, the designer or builder incorporating continuous rigid exterior insulation with an exterior air barrier, should design walls specifically with the goal to keep the interior surface of the sheathing warm enough to prevent most condensation. It is also important to keep in mind that, while the code's minimum requirements for Climate Zone 6 should be adequate, it is not unusual for many places in Montana to fall well below 0°F and stay there for weeks at time. To understand how much "vapor drive" a building will experience during this time, designers and builders should read BuildingScience.com's *BSI-031: Building in Extreme Cold.* This short article addresses the importance of a perfect, fully adhered, impermeable membrane on all six sides of the building envelope (four walls, the floor and the ceiling). All mechanical penetrations are on the inside of assemblies, rigid exterior insulation is installed on all six sides with no insulation in the walls, ceiling, and floor building cavities. This strategy ensures the assembly dries to the inside.[3]

As is always the caveat, use of an exterior air barrier with rigid exterior insulation should be discussed with your local code enforcement official before construction to ensure a mutual understanding and compliance with Montana's unique warm-side air barrier requirement.

DEQ Montana Department of Environmental Quality

For questions, suggestions, or to be removed from the newsletter distribution list, email: carll@ncat.org

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Energize Montana Energy Code Website:
http://deq.mt.gov/Energy/EnergizeMT/EnergyCode

[3] BSI-031: Building in Extreme Cold, Joseph Lstiburek https://www.buildingscience.com/documents/insights/bsi-031-building-in-extreme-cold