No Vapor Retarders on Interior Side of Air-Permeable Foundation Insulation

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Scope

In basements or crawlspaces that are insulated along the interior side of the exterior walls with an air-permeable insulation, ENERGY STAR Certified Homes requires that builders do not install a Class 1 vapor retarder on the interior side of the air-permeable insulation. Class I vapor barriers should also not be installed on the interior side of air-permeable insulation in above-grade exterior walls in warm-humid climates (EPA 2015).

- Examples of air-permeable insulation include fibrous insulation like fiberglass batt, blown cellulose, or mineral wool.
- The 2009 IRC defines Class I vapor retarders as a material or assembly with a rating of ≤0.1 perm.
- Examples of Class I vapor retarders include rubber membranes, polyethylene sheeting, glass, aluminum foil, sheet metal, foil-faced insulating sheathing, foil-faced non-insulating sheathing, and vinyl wall paper.
- Class I vapor barriers can be used on the interior side of below-grade walls if air-permeable insulation is not present (for example, foil-faced rigid foam board can be installed on the interior of below-grade concrete foundation walls.
- Open-cell and closed-cell spray foams typically have perm ratings above 0.1 so they can be used unless the manufacturer specifies that a product has a perm rating ≤ 0.1 or so long as the spray foam is not sprayed to a depth that makes it ≤ 0.1 perm.
- Exceptions: Impermeable materials such as ceramic tile may be installed over fibrous insulation at shower and tub walls.
- Mirrors may be used if mounted with clips or other spacers that allow air to circulate behind them.

See the Compliance Tab for related codes and standards requirements, and criteria to meet national programs such as DOE’s Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.
Description

Vapor retarders can be an intrinsic and crucial part of the building envelope. In the right location, they can help manage moisture issues to keep the home dry. However, when vapor retarders are installed on the interior side of air-permeable insulation on below-grade walls, condensation issues can ensue.

Many building scientists recommend insulating the basement or crawlspace walls. The 2012 International Residential Code requires basement insulation in Climate Zones 3 and higher. A sealed, insulated basement or crawlspace is a requirement in the U.S. Department of Energy Zero Energy Ready Home program and the U.S. Environmental Protection Agency Indoor airPLUS program. DOE research shows that insulating the basement is cost effective in any home in climate zones 3 through 8. In cities ranging from St. Louis, MO, to Buffalo, NY, insulating to R-10 yielded annual savings of $250 to $400; insulating to R-20 yielded annual savings of $280 to $450 (Southface and ORNL 2002). However, the insulation must be installed in a way that doesn't trap moisture in the walls.

Concrete is porous and allows moisture transfer. If the below-grade portion of a concrete foundation wall is in contact with damp soil, moisture can wick through the concrete via capillary action. Newly poured concrete also has hundreds of gallons of water to release as the concrete cures. When insulating basements to make them into living space or to meet program requirements, it is a common practice (though not recommended by Building America) to install a wood-framed wall against the concrete then to fill the framed wall cavity with fibrous insulation such as mineral wool, fiberglass, or cellulose insulation. Water vapor can pass through this air-permeable insulation. If the insulation is covered with a permeable layer such as gypsum board and latex paint, the water vapor will pass through that layer as well, allowing the concrete wall to dry to the inside of the home.

Unfortunately, in many areas of the country, builders install polyethylene sheeting, a Class I vapor retarder, over the insulation before installing the drywall. Water vapor can condense on the sheeting (see Figures 1 and 2). When this condensation occurs, the liquid water has no way to dry to the interior of the home. Instead, it will accumulate in the wall cavity. Over time this dampness can lead to ruined insulation, mold, odors, and structural rotting of framing members.

Other Class I vapor barriers, like vinyl wallpaper or the plastic layer installed over blanket insulation in unfinished basements, as shown in Figure 3 (sometimes referred to as diaper insulation) can have the same mold-inducing effect (BSC 2006).
Figure 1 - The plastic vapor barrier on the inside of this foundation wall prevents the wall from drying to the inside, so condensation and mold have begun to form on the inside of the wall cavity.

Figure 2. The polyethylene sheathing installed over batt insulation in this basement wall acted as a Class I vapor retarder, trapping water vapor from the concrete foundation wall, which condensed in the wall cavity providing a breeding ground for mold.
Figure 3. Plastic-covered blanket insulation, the diaper approach to basement wall insulation, will trap moisture coming through the concrete, leading to mold, moisture, and odor problems.

ENERGY STAR also requires that Class I vapor barriers not be installed on the interior side of air-permeable insulation in above-grade exterior walls in hot-humid climates, because warm-moist air entering building cavities through cracks in the exterior wall can condense when it hits the cold back surface of a Class I vapor retarder that is chilled by summertime air conditioning. The condensation can accumulate in the wall cavity creating conditions for mold growth and rot. Examples of Class I vapor retarders that have been incorrectly installed in wall assemblies in hot-humid climates include plastic vapor barrier installed under the drywall or vinyl wallpaper installed over the drywall.

To reduce the risk of condensation, it’s helpful to understand perm ratings so you can select the right wall assembly to reduce condensation risks.

Understanding Vapor Retarders

If water vapor is allowed to pass through the below-grade wall and insulation, it must be allowed to dry to the inside of the home to avoid condensation in the wall cavity. To enable this drying, the wall covering on the interior of the framing must have a relatively high vapor permeability rating.

The vapor permeability (commonly referred to as breathability) is a material’s ability to allow water vapor to pass through it. The moisture vapor transmission rate (MVTR) is the measurement referenced in building codes. The MVTR is measured in a lab using the American Society for Testing and Materials (ASTM) procedure E-96. The test method measures how much moisture vapor is allowed to pass through a material in a 24-hour period (adjusted for vapor pressure across the sample). The resulting number is the moisture vapor permeance (MVP). The unit of measurement for MVP is perms. The higher the perm number, the more moisture vapor the material will allow to pass and the greater its drying potential will be. The water vapor permeability of a material is roughly inversely proportional to its thickness (for example doubling the thickness of spray foam insulation halves the permeability).

Vapor Retarder Code Classifications

The International Residential Code, Section R201, defines vapor retarder classes as follows:

- Class I: 0.1 perm or less
- Class II: 1.0 perm or less and greater than 0.1 perm
- Class III: 10 perm or less and greater than 1.0 perm.

Class I vapor retarders include

- polyethylene plastic sheeting, rubber membranes, glass, aluminum foil, sheet metal, foil-faced insulating sheathings, and foil-faced non-insulating sheathings. This list is not comprehensive. Any material with a perm rating of 0.1 or less should not be used to the interior of air-permeable insulation on the inside of a below-grade wall. However, if the manufacturer’s specifications for a product indicate a perm rating above 0.1, then the material may be used even if it is on this list.

- Examples of Class II vapor retarders include kraft-faced fiberglass batt, low-perm paint, and 1 inch of expanded polystyrene rigid foam.

- Examples of Class III vapor retarders include latex paint, plywood, OSB, and drywall.
For open- and closed-cell spray foams, check manufacturer’s specifications. Open-cell spray foam is generally more permeable. Increasing the thickness of any spray foam layer will decrease its permeability.

The main point to remember when using air-permeable insulation in below-grade walls is that moisture must be allowed to dry to the inside of the building. ENERGY STAR Certified Homes prohibits the use of Class I vapor retarders on the interior side of air-permeable insulation in below-grade exterior walls.

ENERGY STAR recommends using a Class II or Class III vapor retarder. Examples include kraft-faced fiberglass batts in the wall cavity or latex paint on the drywall for below-grade walls.

Foam insulation can be used if the manufacturer’s specifications indicate a perm rating greater than 0.1 and if any wall finishes, such as latex paint, are vapor permeable. ENERGY STAR allows some exemptions to the prohibition on Class I vapor retarders in below-grade walls. These exemptions include:

- Showers and tubs on exterior walls. Class I vapor retarders, such as ceramic tile, may be used at shower and tub walls. The insulation behind the tub or shower should be equivalent to the insulation in the rest of the exterior walls and should be covered with an air barrier of cement backer board, rigid foam insulation, or non-paper-faced drywall that is sealed at the edges and seams to provide a continuous air seal. The recommended backer for exterior walls behind showers and tubs (in both above- and below-grade situations) is cement board. Note that cement board is not waterproof and must be coated with a fluid-applied waterproofing, or a water-resistant barrier must be applied behind it that allows drainage (BSC 2009). The low-perm vapor retarder is allowed due to the high moisture content created by the shower or tub and is used to protect framing and insulation from the excessive moisture.

- Mirrors. Mirrors are a Class I vapor retarder but may be used if they are mounted over the drywall with clips or other spacers that allow air to circulate behind them. The mirror should not be directly fastened to the wall; if so, it will act as a vapor barrier and condensation will form on the foundation side of the mirror.

Alternative Basement Insulation Methods

Basement insulation methods have been studied extensively by Building America and there are many alternative methods for insulating basements that avoid the Class 1 vapor retarder issue (Aldrich et al. 2012, BSC 2009, Lstiburek 2006, NorthernSTAR 2012, Southface and ORNL 2002, Ueno and Lstiburek 2012). Here are examples of some of these methods. Note, with all of these methods, closed-cell spray foam can be used to insulate the rim joist:

- Attach foil-faced polyisocyanurate to the interior of the concrete wall with mechanical fasteners or construction adhesive, with the bottom 6 inches of wall bare to allow drying or completely seal the polyiso to the full wall with caulk or foam and at seams with foil or polypropylene tape.

- Attach EPS or XPS to the interior of the concrete wall with furring strips. Use the furring strips to attach drywall.

- Attach EPS or XPS to the interior of the concrete wall with construction adhesive. Thoroughly seal the edges and seams of the foam. Install a wood-framed wall interior of the rigid foam. Insulate the cavity with batt or blown fibrous insulation or leave uninsulated. In very cold climates, the cavity insulation R value should not exceed the rigid foam R value.

- Install a 2x4 wood-framed wall set one to two inches in from the foundation wall, then spray closed-cell spray foam directly onto the concrete wall. Finish the interior wall with drywall and latex paint.

- Install rigid foam exterior of the foundation wall.

- Install an ICF foundation wall.

- Install a precast concrete wall system that includes an integrated foam insulation layer sandwiched between two layers of concrete.
Figure 4 - Spray foam insulation with a perm rating greater than 0.1 separates the concrete foundation wall from the interior stud wall, which is uninsulated and contains no Class I vapor barrier. Gypsum board and permeable latex paint, both Class III vapor retarders, allow for drying to the interior.
Figure 5. Rigid foam is installed between the concrete foundation wall and the insulated stud cavity. The permeable rigid foam and lack of a vapor barrier over the cavity wall allow drying to the inside.
Ensuring Success

Confirm that no Class I vapor retarder is installed over permeable insulation in below-grade (i.e., basement) walls.
**Climate**

**ENERGY STAR Version 3, (Rev. 08)**, Water Management System Builder Requirements, Section 1. Water-Managed Site and Foundation, Item 1.6 states “Class 1 vapor retarders not installed on the interior side of air-permeable insulation in exterior below-grade walls.”

Footnote 7. The 2009 IRC defines Class I vapor retarders as a material or assembly with a rating of \( \leq 0.1 \) perm, using the desiccant method with Proc. A of ASTM E 96. The following materials are typically \( \leq 0.1 \) perm and shall not be used on the interior side of air permeable insulation in above-grade exterior walls in warm-humid climates (see the International Energy Conservation Code (IECC) climate map [2009 IECC, Figure 301.1 and Table 301.1]) or below-grade exterior walls in any climate: rubber membranes, polyethylene film, glass, aluminum foil, sheet metal, and foil-faced insulating / non-insulating sheathings. These materials can be used on the interior side of walls if air permeable insulation is not present (e.g., foil-faced rigid foam board adjacent to a below-grade concrete foundation wall is permitted). Note that this list is not comprehensive and other materials with a perm rating \( \leq 0.1 \) also shall not be used. Also, if manufacturers’ specifications for a product indicate a perm rating \( \leq 0.1 \), then it may be used, even if it is in this list. Also note that open-cell and closed-cell foam generally have ratings above this limit and may be used unless manufacturers’ specifications indicate a perm rating \( \leq 0.1 \). Several exemptions to these requirements apply:

- Class I vapor retarders, such as ceramic tile, may be used at shower and tub walls;
- Class I vapor retarders, such as mirrors, may be used if mounted with clips or other spacers that allow air to circulate behind them.

![International Energy Conservation Code (IECC) Climate Regions](image-url)
Training

Right and Wrong Images
None Available
Compliance

The Compliance tab contains both program and code information. Code language is excerpted and summarized below. For exact code language, refer to the applicable code, which may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

ENERGY STAR Certified Homes

ENERGY STAR Certified Homes (Version 3/3.1, Revision 08), Water Management System Builder Requirements

1. Water-Managed Site and Foundation:

1.6 Class I vapor retarder not installed on interior side of air permeable insulation in exterior below-grade walls.\(^7\)

Footnotes:

(7) The 2009 IRC defines Class I vapor retarders as a material or assembly with a rating of \(\leq 0.1\) perm, using the desiccant method with Proc. A of ASTM E 96. The following materials are typically \(\leq 0.1\) perm and shall not be used on the interior side of air permeable insulation in above-grade exterior walls in warm-humid climates or below-grade exterior walls in any climate: rubber membranes, polyethylene film, glass, aluminum foil, sheet metal, and foil-faced insulating / non-insulating sheathings. These materials can be used on the interior side of walls if air permeable insulation is not present (e.g., foil-faced rigid foam board adjacent to a below-grade concrete foundation wall is permitted). Note that this list is not comprehensive and other materials with a perm rating \(\leq 0.1\) also shall not be used. Also, if mfr. spec.'s for a product indicate a perm rating \(\leq 0.1\), then it may be used, even if it is in this list. Also note that open-cell and closed-cell foam generally have ratings above this limit and may be used unless mfr. spec.'s indicate a perm rating \(\leq 0.1\). Several exemptions to these requirements apply:

- Class I vapor retarders, such as ceramic tile, may be used at shower and tub walls;
- Class I vapor retarders, such as mirrors, may be used if mounted with clips or other spacers that allow air to circulate behind them.

Builders Responsibilities: It is the exclusive responsibility of builders to ensure that each certified home is constructed to meet these requirements. While builders are not required to maintain documentation demonstrating compliance for each individual certified home, builders are required to develop a process to ensure compliance for each certified home (e.g., incorporate these requirements into the Scope of Work for relevant sub-contractors, require the site supervisor to inspect each home for these requirements, and / or sub-contract the verification of these requirements to a Rater). In the event that the EPA determines that a certified home was constructed without meeting these requirements, the home may be decertified.

ENERGY STAR Revision 08 requirements are required for homes permitted starting 07/01/2016.

DOE Zero Energy Ready Home

Exhibit 1: Mandatory Requirements. Certified under ENERGY STAR Qualified Homes Version 3.

ASTM E96/E96M-15

Standard Test Methods for Water Vapor Transmission of Materials. Available from ASTM. The standard covers the test methods to determine water vapor transmission of materials through which the passage of water vapor may be of importance, such as paper, plastic films, other sheet materials, fiberboards, gypsum, etc.

2009, 2012, 2015, and 2018 IECC

Tables R402.1.2 and R402.1.4 provide basement and crawlspace wall insulation R- and U-values by climate zone. R402.2.9 "Basement walls" states that basement walls should be insulated from the top of the wall down 10 feet or to the basement floor, whichever is less, and that walls in unconditioned basements don’t need to be insulated if the floor overhead meets required insulation levels. R402.2.11 "Crawl space walls" allows crawlspaces to be insulated if unvented by installing insulation along the crawl space wall to grade level and then down or out an additional 24 inches.


Section R101.4.3 (Section R501.1.1 in 2015 and 2018 IECC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)


Section R702.7 Vapor Retarders. Class I or II vapor retarders are required on the interior side of frame wall in Climates Zones 5-8 and Marine 4, except on basement walls and below-grade portions of any wall.


Section N1101.3 (Section N1107.1.1 in 2015 and 2018 IRC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)
Appendix J regulates the repair, renovation, alteration, and reconstruction of existing buildings and is intended to encourage their continued safe use.
Case Studies

1. **Interior Foundation Insulation Upgrade - Madison Residence Madison, WI**
   - **Author(s):** ORNL
   - **Organization(s):** ORNL
   - **Publication Date:** October, 2013
   - Case study of a basement retrofit of a 1916 home in Madison, Wisconsin, home that involved installing dimple drain mat and closed-cell spray foam on interior of basement wall and an interior footing drain to manage moisture before finishing an existing basement.

2. **Interior Foundation Insulation Upgrade—Minneapolis Residence (524KB)**
   - **Author(s):** ORNL
   - **Organization(s):** ORNL
   - **Publication Date:** April, 2017
   - Case study describing a basement remodel of a 1928 Minneapolis home that involved installing dimple drain mat and closed-cell spray foam on interior of basement wall and an interior footing drain to manage moisture before finishing an existing basement.

References and Resources*

1. **Air Barriers - Tub, Shower and Fireplace Enclosures**
   - **Author(s):** Building Science Corporation
   - **Organization(s):** Building Science Corporation
   - **Publication Date:** May, 2009
   - Brochure about creating an air barrier at tub, shower and fireplace walls.

2. **Basement Insulation Technology Fact Sheet**
   - **Author(s):** Southface Energy Institute
   - **Organization(s):** Oak Ridge National Laboratory
   - **Publication Date:** January, 2002
   - *Publication dates are shown for formal documents. Dates are not shown for non-dated media. Access dates for referenced, non-dated media, such as web sites, are shown in the measure guide text.*

3. **DOE Zero Energy Ready Home National Program Requirements**
   - **Author(s):** Department of Energy
   - **Organization(s):** DOE
   - **Publication Date:** April, 2017
   - Standard requirements for DOE's Zero Energy Ready Home national program certification.

4. **Durable Interior Foundation Insulation Retrofits for Cold Climates, Cloquet, Minnesota**
   - **Author(s):** NorthernSTAR
   - **Organization(s):** NorthernSTAR
   - **Publication Date:** April, 2015
   - Case study describing foundation wall moisture studies at a research facility in Minnesota run by Building America team NorthernSTAR.

5. **ENERGY STAR Certified Homes, Version 3 (Rev. 08) National Program Requirements**
   - **Author(s):** U.S. Environmental Protection Agency
   - **Organization(s):** EPA
   - **Publication Date:** December, 2015
   - Webpage with links to Document outlining the program requirements for ENERGY STAR Certified Homes, Version 3 and 3.1 (Rev. 08).

6. **More Info.**
   - Access to some references may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.
Case study describing novel technique for installing exterior spray foam on foundation walls that uses high-pressure water sprayer and a “hydro vac” to remove dirt along the foundation wall.

7. **How to Insulate a Basement Wall**
   - **Author(s):** Holladay
   - **Organization(s):** Green Building Advisor
   - **Publication Date:** June, 2012
   - Blog entry describing methods for insulating basement walls on the interior or exterior.

8. **Info 511: Basement Insulation**
   - **Author(s):** Building Science Corporation
   - **Organization(s):** Building Science Corporation
   - **Publication Date:** May, 2009
   - Information sheet describing techniques for insulating basements.

9. **Measure Guideline: Basement Insulation Basics**
   - **Author(s):** Aldrich, Mantha, Puttagunta
   - **Organization(s):** CARB, National Renewable Energy Laboratory, Steven Winter Associates, SWA
   - **Publication Date:** October, 2012
   - Document describing good practices for insulating basements in new and existing homes.

10. **Measure Guideline: Hybrid Foundation Insulation Retrofits**
    - **Author(s):** Ueno, Lstiburek
    - **Organization(s):** Building Science Corporation
    - **Publication Date:** May, 2012
    - Document providing information on basement insulation, air sealing and water management retrofits.

11. **Technical Guidance to the Indoor airPLUS Specifications**
    - **Author(s):** U.S. Environmental Protection Agency
    - **Organization(s):** EPA
    - **Publication Date:** October, 2015
    - Website providing technical guidance to help home builders and their subcontractors, architects, and other housing professionals understand the intent and implementation of the specification requirements of the IAQ labeling program.

12. **Understanding Basements**
    - **Author(s):** Lstiburek
    - **Organization(s):** Building Science Corporation
    - **Publication Date:** October, 2006
    - Information sheet with methods for constructing or retrofitting basements to reduce moisture issues.

13. **Understanding Vapor Barriers**
    - **Author(s):** Lstiburek
    - **Organization(s):** Building Science Corporation
    - **Publication Date:** October, 2006
    - Information sheet describing the function of a vapor barrier, and methods to retard the migration of water vapor.

14. **Upgrading Below Grade Spaces**
    - **Author(s):** NorthernSTAR
    - **Organization(s):** NorthernSTAR, University of Minnesota
    - Presentation for residential energy efficiency stakeholder meeting.

15. **Water Management System Builder Checklist Guide**
    - **Author(s):** U.S. Environmental Protection Agency
    - **Organization(s):** EPA
    - **Publication Date:** February, 2011
    - Guide describing details that serve as a visual reference for each of the line items in the Water Management System Builder Checklist.
Contributors to this Guide
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