Scope

Install a capillary break beneath slab foundations (for example, a slab-on-grade or basement slab foundation) consisting of 4 inches of aggregate stone or 4 inches of sand covered by geotextile matting. Install a vapor barrier over this consisting of

- \( \geq 6 \)-mil polyethylene sheeting lapped 6-12 inches with seams sealed, or
- \( \geq 1 \)-inch extruded polystyrene rigid foam insulation with joints taped.

Seal the sheeting or foam at the joints with foundation walls and around posts or pipes coming up from the ground to provide a continuous vapor barrier.

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

Water gets through the foundation of most houses, either through bulk moisture leaks or through a process called capillary action. Once inside, the water can create significant problems for the home, including structural damage, mold, and poor indoor air quality.

Bulk moisture is the flow of water through holes and cracks and is addressed in the guide *Exterior Surface of Below-Grade Walls*. Bulk water usually moves with gravity down and through foundation walls if large openings or cracks allow it to flow freely into the building. Capillary action occurs when liquid water wicks into the tiny cracks and open spaces of porous building materials such as masonry block, concrete, or wood (see Figure 1 and Figure 2). Capillary suction enables porous materials like concrete to wick water in any direction, including upwards against gravity, for surprisingly long distances. Capillary action in concrete is theoretically capable of pulling water upward as far as 6 miles (Lsiburek, 2014).

*Figure 1* - Capillary action pulls water up through a basement foundation wall that is not protected by a capillary break.

*Figure 2* - A capillary break of aggregate and polyethylene is installed under the slab but no capillary break separates the footing from the stem wall so water can wick up into the house.
To establish a capillary break that will prevent water from wicking up into the basement or slab-on-grade foundation, the U.S. Environmental Protection Agency’s Indoor airPLUS Construction Specifications recommend builders install a drainage pad of either aggregate or sand and geotextile matting. The large spaces between the individual stones prevent capillary action from occurring. The geotextile matting material, which consists of waffle-like or dimpled high-density plastic sheet or a matrix of plastic wire, also has numerous air gaps that prevent capillary action from occurring. Both options are shown in Figure 3.

Figure 3 - A successful capillary break under a basement slab can be created from either aggregate or sand and geotextile matting covered by a vapor barrier of polyethylene or rigid foam.

This base is then covered with a vapor barrier of either polyethylene sheeting or extruded polystyrene rigid insulation (EPA 2015). Polyethylene sheeting is used here primarily as a vapor retarder but it also provides a capillary break. Polyethylene is sometimes used as the vapor barrier between the footing and stem wall to prevent “rising damp,” capillary action that can pull moisture up into the footing walls, as shown in Figure 2.

Rigid foam can also be installed, either over the polyethylene sheeting or directly on the aggregate to serve as a vapor barrier. As with the polyethylene sheeting, if the insulation serves as the vapor barrier, the joints between the insulation panels must be taped and sealed, and the concrete slab should be in direct contact with (poured directly on) the insulation or poly sheeting.

Some builders spray closed-cell spray foam directly onto the gravel base to serve as the vapor barrier, while providing an insulation layer under the slab (DOE 2015).

How to Install a Capillary Break with Aggregate or Sand and Geotextile Matting

1. Level the soil beneath the slab area.
2. Install a bed of ½-inch diameter aggregate gravel to a consistent depth of 4 inches. Or, distribute a 4-inch layer of clean sand evenly across the entire pad area. Lay the geotextile matting in strips across the entire area surface, making sure it is in contact with the foundation edges.
3. Install radon vent pipe in gravel or sand if desired or required.
4. Install a vapor barrier consisting of polyethylene sheeting or polystyrene rigid insulation.

How to Install Polyethylene Sheeting as a Vapor Barrier

1. Select at least 6-mil polyethylene sheeting as a minimum thickness.
2. Place the polyethylene sheeting over the entire foundation area making sure it touches each perimeter wall (see Figure 3 and Figure 4). The polyethylene can be extended to serve as a capillary break under the footing of a slab-on-grade foundation (as shown in Figure 5) or between the footing and the stem wall (as shown in Figure 6).
3. Lay the lengths of sheeting side-by-side and overlap the edges by at least 6 inches. Tip: Overlap the polyethylene sheets by 12 inches to compensate for uneven cut lines.
4. Seal the sheets together at the overlap using either a continuous bead of acoustical sealant, butyl rubber, or butyl acrylic caulk, or with tape manufactured to seal or patch polyethylene such as some builder's tapes and tapes used to repair polyethylene greenhouses (EPA 2015 2015).

5. Seal around any penetrations through the sheeting such as plumbing or radon mitigation piping.

6. Pour the concrete slab directly over the polyethylene (see Figures 5, 6, and 7) or install rigid foam and then pour the concrete slab (see Figure 4).

Figure 4 - Polyethylene sheeting works with the gravel as a capillary break under the slab and serves as a capillary break between the footing and the stem wall to prevent wicking of water from underneath the slab.
Figure 5. House detail for hot-humid climate showing a slab-on-grade foundation with a capillary break of aggregate and polyethylene which also serves protects the footing.
Figure 6. House detail showing a slab-on-grade foundation with a capillary break of aggregate and polyethylene, which also separates the footing from the foundation wall. 📧
How to Install Polystyrene Rigid Insulation as a Vapor Barrier

1. Lay the polystyrene rigid insulation over the entire foundation area, making sure it touches all perimeter walls. See Figure 8.
2. Tape and seal the joints between insulation pieces.
3. Tape around all piping that comes through the rigid foam insulation (see Figure 9).
4. Pour the concrete slab over the sealed polystyrene insulation.

Figure 7 - Polyethylene sheeting can be seen as cement is poured to create the foundation. Care must be taken when walking on the sheeting to ensure it does not tear or pull apart at the seams.
Figure 8. Rigid foam insulation is installed directly over the aggregate capillary break to serve as a vapor barrier beneath the basement slab in this house detail for the mixed humid climate.

Figure 9. Rigid foam insulation is installed over a drainage pad of aggregate to serve as a capillary break under the basement.
slab. Seams and pipes are sealed with tape and gaskets so foam can serve as a continuous vapor barrier as well.
Ensuring Success

It is critical that care be taken when installing and working around the polyethylene and/or rigid foam prior to pouring the foundation slab to maintain a complete, well-secured, and unbroken vapor barrier over the aggregate or sand and geotextile matting capillary break.
Climate

ENERGY STAR Version 3, (Rev. 08)

Water Management Checklist, Water-Managed Site and Foundation. Capillary break beneath all slabs (e.g., slab on grade, basement slab) except crawlspace slabs using either: ? 6 mil polyethylene sheeting, lapped 6-12 in., or ? 1 in. extruded polystyrene insulation with taped joints. Polyethylene sheeting is not required in Dry (B) climates as shown in 2009 IECC Figure 301.1 and Table 301.1. Polyethylene sheeting is also not required for raised pier foundations with no walls. To earn the ENERGY STAR, EPA recommends, but does not require, that radon-resistant features be included in homes built in EPA Radon Zones 1, 2 and 3. For more information, see EPA’s Indoor airPlus Website.

EPA Indoor airPLUS

The U.S. Environmental Protection Agency Indoor airPLUS Construction Specifications, Item 1.2 Capillary Break Installation. Aggregate or sand and geotextile drainage mat is not required under homes built in dry climates as defined by the 2009 IECC Figure 301.1, areas identified as Group 1 areas 9 in the 2009 IRC Table R405.1), or homes with slab-on-grade foundations. This exception does not apply to homes built in EPA Radon Zone 1, see the Compliance tab or the EPA Indoor airPLUS Construction Specifications for more information.
Training

Right and Wrong Images

Display Image: WM131_Polyoveragg_Right1_BSC.jpg
CAD FILE: WM131_RigidInsulationOverAggregate_CAD_BSC.dwg
PDF: WM131_RigidInsulationOverAggregate_CAD_BSC.pdf

CAD FILE: WM131_PolyethyleneOverAggregate_CAD_BSC.dwg
PDF: WM131_PolyethyleneOverAggregate_CAD_BSC.pdf
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 3.0/3.1, Revision 08), Water Management System Builder Requirements, 1. Water-Managed Site and Foundation, Item 1.3 requires a capillary break beneath all slabs (e.g., slab on grade, basement slab) except crawlspace slabs, using either: ? 6 mil polyethylene sheeting, lapped 6-12 in. or ? 1 in. extruded polystyrene insulation with taped joints(3, 4, 5)

Footnotes

3. Not required in Dry (B) climates as shown in 2009 IECC Figure 301.1 and Table 301.1.
4. Not required for raised pier foundations with no walls. To earn the ENERGY STAR, EPA recommends, but does not require, that radon-resistant features be included in homes built in EPA Radon Zones 1, 2 & 3. For more information, see www.epa.gov/indoorairplus.
5. For an existing slab (e.g., in a home undergoing a gut rehabilitation), in lieu of a capillary break beneath the slab, a continuous and sealed Class I or Class II Vapor Retarder (per Footnote 7) is permitted to be installed on top of the entire slab. In such cases, up to 10% of the slab surface is permitted to be exempted from this requirement (e.g., for sill plates). In addition, for existing slabs in occupiable space, the Vapor Retarder shall be, or shall be protected by, a durable floor surface. If Class I Vapor Retarders are installed, they shall not be installed on the interior side of air permeable insulation or materials prone to moisture damage.

7. The 2009 IRC defines Class I vapor retarders as a material or assembly with a rating of ? 0.1 perm, using the desiccant method with Proc. A of ASTM E 96. The following materials are typically ? 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 ? 0.1 also shall not be used. Also, if mfr. spec.’s for a product indicate a perm rating ? 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 ? 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.

DOE Zero Energy Ready Home National Program Requirements

The U.S. Department of Energy (DOE) Zero Energy Ready Home National Program Requirements requires (Exhibit 1, Items 1 and 6) that all homes meet ENERGY STAR Certified Homes Version 3 or 3.1 and the U.S. Environmental Protection Agency Indoor airPLUS Construction Specifications.

EPA Indoor airPLUS

The U.S. Environmental Protection Agency (EPA) Indoor airPLUS Construction Specifications requires homes to meet the ENERGY STAR Certified Homes requirements. Additional requirements include the following.

1.2 Capillary Break Installation

Under the polyethylene sheeting or extruded polystyrene (XPS) insulation installed to meet ENERGY STAR Water Management System Builder Checklist Item 1.3:

- Install a 4 in. layer of 1/2 in. diameter or greater clean aggregate; OR
- Install a 4 in. uniform layer of sand, overlain with either a layer of geotextile drainage matting throughout or strips of geotextile drainage matting along the perimeter installed according to the manufacturer’s instructions.

Exceptions to the aggregate or sand requirement (Not applicable in EPA Radon Zone 1):

- Dry climates, as defined by 2009 IECC Figure 301.1.
- Areas with free-draining soils – identified as Group 1 (Table R405.1, 2009 IRC) by a certified hydrologist, soil scientist, or engineer through a site visit.
• Slab-on-grade foundations.

Alternative path for gut-rehabs:

• For an existing slab in a home undergoing a gut rehabilitation in Radon Zones 2 and 3, the alternate slab treatment in the ENERGY STAR Water Management System Builder Checklist, footnote 5, shall apply as an alternative to polyethylene and aggregate or sand under the slab. Homes undergoing gut rehabilitation in Radon Zone 1 must also install an active radon system utilizing sub-slab depressurization, and radon levels shall be verified upon final inspection to be below the EPA action level (4pCi/l) to receive qualification.

Note: In EPA Radon Zone 1 (see Specification 2.1):

• Polyethylene sheeting must be installed and overlapped by 6 to 12 in. at the seams.
• ENERGY STAR staking method for poly sheeting may not be used in crawlspaces with no slab.
• ENERGY STAR exceptions for capillary break (polyethylene) under slabs do not apply. Poly is required in Radon Zone 1.

Advisory: 10 mil polyethylene is recommended if crawlspace floors are not covered with a concrete slab.

2.1 Radon-Resistant Construction

NOTE: Completion of the ENERGY STAR requirements now satisfies the following Indoor airPLUS requirement:
Air seal all sump covers (Builder-W 1.7).

Additional Indoor airPLUS Requirements:

• Construct homes in EPA Radon Zone 1 (see www.epa.gov/radon/zonemap.html) with radon-resistant features to conform to ASTM E1465; or IRC, Appendix F; or NFPA 5000, Chapter 49. Consult EPA’s “Building Radon Out” (EPA 402-K-01-002) for general guidance on installing radon-resistant features.

Visually verify the following requirements:

• Capillary break installed according to Specification 1.2, irrespective of climate zone.
• A 3 or 4 in. diameter gas-tight vertical vent pipe, clearly labeled to conform with the radon-resistant standard used, e.g., “Radon Reduction System” or “Radon Pipe” or “Radon System.” The vent pipe shall be connected to an open T-fitting in the aggregate layer (or connected to geotextile drainage matting according to the manufacturer’s instructions) beneath the polyethylene sheeting, extending up through the conditioned spaces and terminating a minimum of 12 in. above the roof opening. For crawlspaces, install at least 5 ft. of horizontal perforated drain tile on either side of the T-fitting, attached to the vertical radon vent pipe beneath the sheeting and running parallel to the long dimension of the house.
• Radon fan installed in the attic (i.e., an active system) OR an electrical receptacle installed in an accessible attic location near the radon vent pipe (i.e., a passive system) to facilitate future fan installation if needed.
• Foundation air sealing with polyurethane caulk or the equivalent at all slab openings, penetrations and control or expansion joints.


Advisories:

1. Elevated levels of radon have been found in homes built in all three zones on EPA’s Map of Radon Zones. Consult your state radon program for current information about radon in your area. Go to www.epa.gov/radon/wherelyoulive.html and click on your state for contact information.
2. EPA recommends, but does not require, that all homes built with radon-resistant features in EPA Radon Zone 1 pre-emptively include a radon vent fan. EPA also recommends, but does not require, radon-resistant features for homes built in EPA Radon Zones 2 and 3. EPA further recommends that all homes built in EPA Radon Zones 2 and 3 with radon-resistant features be tested for radon prior to occupancy. A radon vent fan should be installed when the test result is 4 pCi/L (the EPA action level) or more.
3. The U.S. Surgeon General and EPA recommend that all homes built in Radon Zones 1, 2 and 3 be tested for radon. Provide buyers with EPA’s Citizen’s Guide to Radon, encourage them to test for radon and refer them to www2.epa.gov/radon for more information.
4. If soil or groundwater contamination is suspected on or near the building site (e.g., former industrial sites), volatile chemical contaminants from soil gas or vapor intrusion into a building may pose an IAQ risk. In such cases, EPA recommends radon-resistant features consistent with Specification 2.1, which can minimize or prevent the vapor intrusion into a house. See the EPA Vapor Intrusion Primer or ASTM E2600 for more information. You should also consult your state, tribal, or local environmental regulatory agency for information on the location of contaminated sites, including those subject to Superfund (CERCLA), Resource Conservation and Recovery Act (RCRA) cleanup requirements, or the Brownfields program. Visit EPA’s “Where You Live” for more information.

**2009, 2012, 2015, and 2018 IRC**

Section R506.2.3 Vapor retarder. A 6 mil polyethylene (or other approved) vapor retarder to have joints lapped not less than 6 inches must be placed between the concrete slab and the base course or prepare subgrade if no base course exists. Exceptions: Detached garages, utility buildings, other unheated accessory structures, unheated storage rooms less than 70 square feet, carports, driveways, walks, patios, and other flatwork not likely to be later enclosed or heated, and where approved by the building official.

**2009, 2012, 2015, and 2018 IECC**

This is not specifically addressed in the 2009, 2012, or 2015 IECC.


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.
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 Studies

1. **DOE ZERH Case Study 2015: BrightLeaf Homes, McCormick Avenue, Brookfield, IL**
   - Author(s): Gilbride
   - Organization(s): PNNL
   - Publication Date: October, 2015
   - Case study on a 2015 Housing Innovation Award-winner built by BrightLeaf Homes in Brookfield, Illinois.

2. **DOE ZERH Case Study 2015: Greenhill Contracting, Green Acres #20, #26, #28, New Paltz, NY**
   - Author(s): Gilbride
   - Organization(s): PNNL
   - Publication Date: October, 2015
   - Case study on a 2015 Housing Innovation Award-winner built by Greenhill Contracting in New Paltz, New York.

References and Resources*

1. **BSI-011: Capillarity - Small Sacrifices**
   - Author(s): Lstiburek, Joseph
   - Organization(s): Building Science Corporation
   - Publication Date: May, 2014
   - Article describing correct ways to eliminate water damage by incorporating a sacrificial layer to foundation walls and footings.

2. **DOE Zero Energy Ready Home National Program Requirements**
   - Author(s): Department of Energy
   - Organization(s): DOE
   - Publication Date: May, 2019
   - Standard requirements for DOE's Zero Energy Ready Home national program certification.

3. **ENERGY STAR Certified Homes, Version 3/3.1 (Rev. 09) National Program Requirements**
   - Author(s): U.S. Environmental Protection Agency
   - Organization(s): EPA
   - Publication Date: September, 2018
   - Webpage with links to Document outlining the program requirements for ENERGY STAR Certified Homes, Version 3 and 3.1 (Rev. 09).

4. **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.

5. **Residential Buildings: Foundations**
   - Author(s): Department of Energy
   - Organization(s): DOE

6. **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.

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

8.
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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