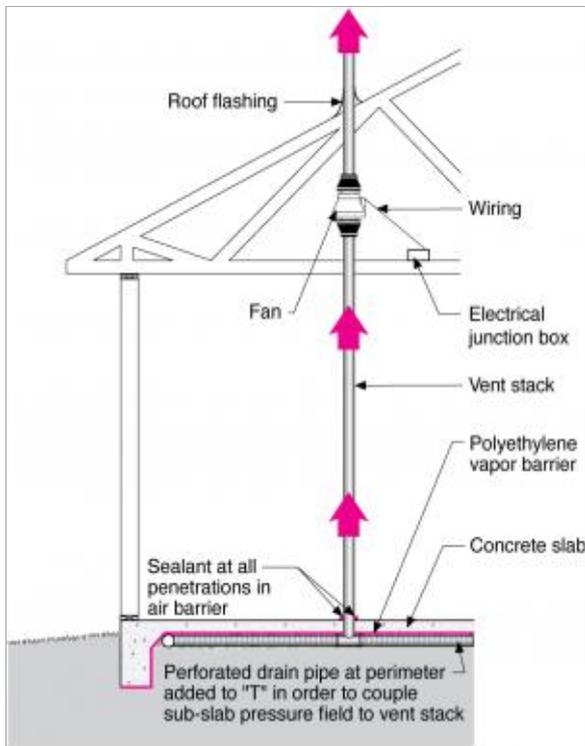


Radon Fan

Last Updated: 01/15/2018

Scope



Install a radon fan or a passive radon vent system to prevent the accumulation of radon and soil gases in the home.

Install an active radon vent system with fan if

- the home is built in EPA Radon Zone 1
- or, the home is tested for radon after construction and shows an indoor radon concentration level of ≥ 4 picocuries/liter, regardless of what radon zone the home is located in ([EPA Indoor airPLUS](#)).

Install an active radon vent system consisting of an in-line fan installed in a vertical vent pipe extending up from a sub-slab collection pipe or mat through the conditioned space of the home and through the roof that uses the fan to pull soil gases up and out of the house.

- Determine vent pipe size and location.
- Lay a perforated pipe or a collection mat around the interior of the foundation perimeter and insert a vertical "T" pipe connect to the pipe or mat.
- Install the concrete slab or polyethylene vapor barrier or both over the ground. Ensure that the slab and/or vapor barrier do not cover the vertical opening of the T connector but are sealed around it.
- Install the vertical pipe.
- Run the pipe up through the interior of the house and through the roof.
- Install an in-line fan.

Install a passive radon venting system if the home is located in Radon Zone 2 or 3. See the guide [Vertical Radon Ventilation Pipe](#).

- Install a passive radon ventilation system consisting of a vertical vent pipe extending up from a sub-slab collection pipe or mat through the conditioned space of the home and through the roof that uses the natural stack effect to pull soil gases up and out of the house.
- Install an electrical outlet in the attic near the vent stack in case a fan needs to be added later.

- Test the home after construction is completed and add an in-line fan if the indoor radon concentration is ≥ 4 picocuries/liter.

See the [Compliance Tab](#) for related codes and standards and criteria to meet the requirements of national programs such as DOE's Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.

Description

Radon is a naturally occurring radioactive gas that is estimated to cause approximately 21,000 lung cancer deaths per year in the United States. The amount of radon in the air is measured in “picocuries per liter of air,” or pCi/L. The average outdoor radon level is 0.4 pCi/L. The average indoor radon level is estimated at 1.3 pCi/L. Roughly 1 out of 15 homes in the United States has elevated radon levels (4 pCi/L or greater).

Radon and other soil gases (water vapor, herbicides, termiticides, methane, etc.) can create an unhealthy indoor environment if they accumulate inside the home. Radon can enter the home through cracks in concrete floors and foundation walls, joints between two or more construction materials, gaps in the materials comprising suspended floors, gaps around foundation penetrations, and cavities inside foundation walls.

The U.S. Environmental Protection Agency publishes a map indicating likely radon levels across the United States (see Climate tab) and has established a maximum exposure limit of 4 picocuries per liter of indoor air. Regardless of individual county radon zone designation, high indoor radon levels have been found in every state, and factors impacting radon infiltration can be complex, including interactions between soil composition, weather, home design and construction, and ventilation from the HVAC system.

Because local radon levels may vary from those shown on the county-level EPA radon map, because the amount of radon that will accumulate in a home can't be determined until the home is built, and because the easiest time to install a radon mitigation system is during initial construction, the best practice recommendation is to install a passive ventilation stack in all new homes, with an electric outlet located in the attic near the vent stack so that it is available to power an in-line fan should post-construction testing dictate that an active radon system is needed to lower radon levels in the home. For more information, see [Vertical Radon Ventilation Pipe](#).

The first step in keeping radon and other soil gases out of the home is to install a continuous vapor barrier under the slab or over the crawlspace floor, and to perform thorough air sealing of floors and below-grade walls. See the following guides for more information on air sealing and vapor barriers for basements and crawlspaces.

- [Air Sealed, Insulated Basements](#),
- [Unvented, Insulated Crawlspaces](#),
- [Capillary Break Beneath Slab – Polyethylene Sheeting or Rigid Insulation](#),
- [Capillary Break at Crawlspace Floor – Polyethylene Sheeting under Concrete Slab](#),
- [Capillary Break at Crawlspace Floors – Polyethylene Lapped Up Walls and Piers or Secured in the Ground](#),
- [Sump Pump Cover Gasket](#),

Because no vapor barrier is 100% foolproof, a passive or active radon mitigation system should be installed. The easiest time to install this is when the house is under construction, and the sub-slab gravel pad can be easily accessed to lay down a radon collection mat or pipe along the interior perimeter of the home. When this mat or pipe is attached to a vertical vent pipe which extends out through the roof, a negative pressure is created in the pipe, either actively via an in-line fan or passively due to the stack effect. This negative pressure draws soil gases up and out of the house.

How to Install a Radon Fan – Slab-on-Grade Construction

1. Select the location for the ventilation pipe (min. 3” in dia.). It should be installed in a vertical run through a warm part of the house and exhausted through the roof. See Figure 1. The pipe should discharge at least 2 feet above the roof and 10 feet away from any openings in the building to keep the soil gas from re-entering the building.
2. Lay a min. 3-inch-diameter perforated pipe in a gravel trench or a collection mat on top of the gravel around the interior side of the foundation perimeter. Install the pipe in a loop and connect the ends to each side of a vertical “T” pipe connector. The perforated pipe should loop through all sub-slab areas; multiple connection points or interconnections may be required.
3. Place the polyethylene vapor barrier and concrete slab around the vertical “T”; label and cover the open top of the vertical “T” before placing the concrete. Seal the perimeter of the “T” to the concrete to reduce soil gas entry.
4. Install the vertical pipe by connecting it to the vertical “T.” Avoid 90-degree angles in the vertical portion of the pipe; use sweeps if turns are needed. Label the pipe on each floor so it is clear the pipe is not part of the sewer system. If the ventilation pipe extends through an unconditioned attic, insulate the stack to control condensation in the pipe.
5. Run the pipe through the roof and flash it properly. Provide a screened rain cap at the termination to prevent rain entry and nesting animals.
6. Install an electrical junction box for powering the fan and add the fan to the vertical pipe run.

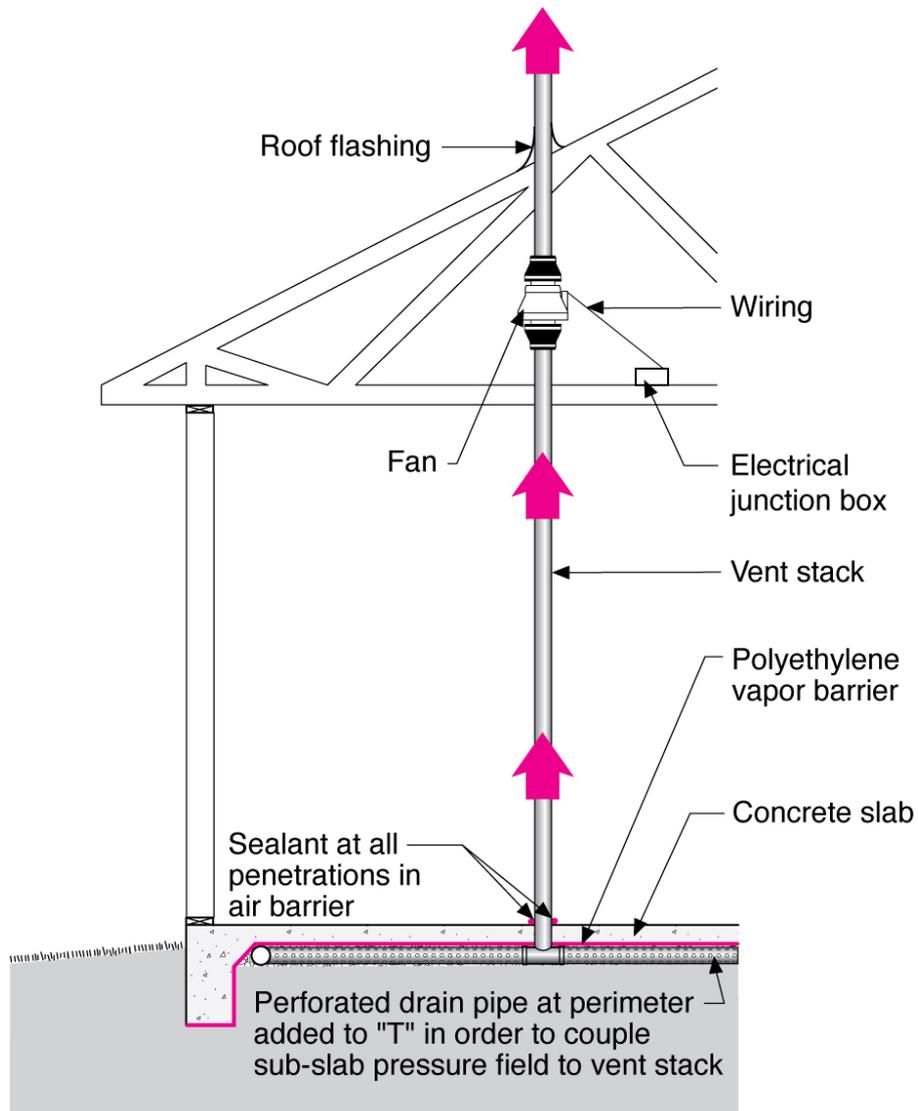


Figure 1. Radon fan - slab-on-grade construction (image courtesy of BSC).

How to Install a Radon Fan – Crawlspace Construction

1. Select the location for the ventilation pipe (min. 3" in dia.). It should be installed in a vertical run through a warm part of the house and exhausted through the roof. The pipe discharge should be installed at least 2' above the roof and 10' away from any openings in the building to keep the soil gas from re-entering the building.
2. Lay at least 5' of min. 3" diameter horizontal perforated pipe on the soil at the location where you will run the vertical ventilation pipe and connect it to either side of a vertical "T". See Figure 2.
3. Install a continuous layer of polyethylene vapor barrier with joints taped over the soil. Run the polyethylene sheet up the wall and mechanically attach and seal the edges to the wall. Seal the vertical "T" to the polyethylene to reduce the soil gas entry.
4. Install the vertical pipe by connecting it to the vertical "T." Avoid 90-degree angles in the vertical portion of the pipe; use sweeps if turns are needed. Label the pipe on each floor so it is clear the pipe is not part of the sewer system. If the ventilation pipe extends through an unconditioned attic, insulate the stack to control condensation in the pipe.
5. Run the pipe through the roof and flash it properly. Provide a screened rain cap at the termination to prevent rain entry and nesting animals.
6. Install an electrical junction box for powering the fan and add the fan to the vertical pipe run.

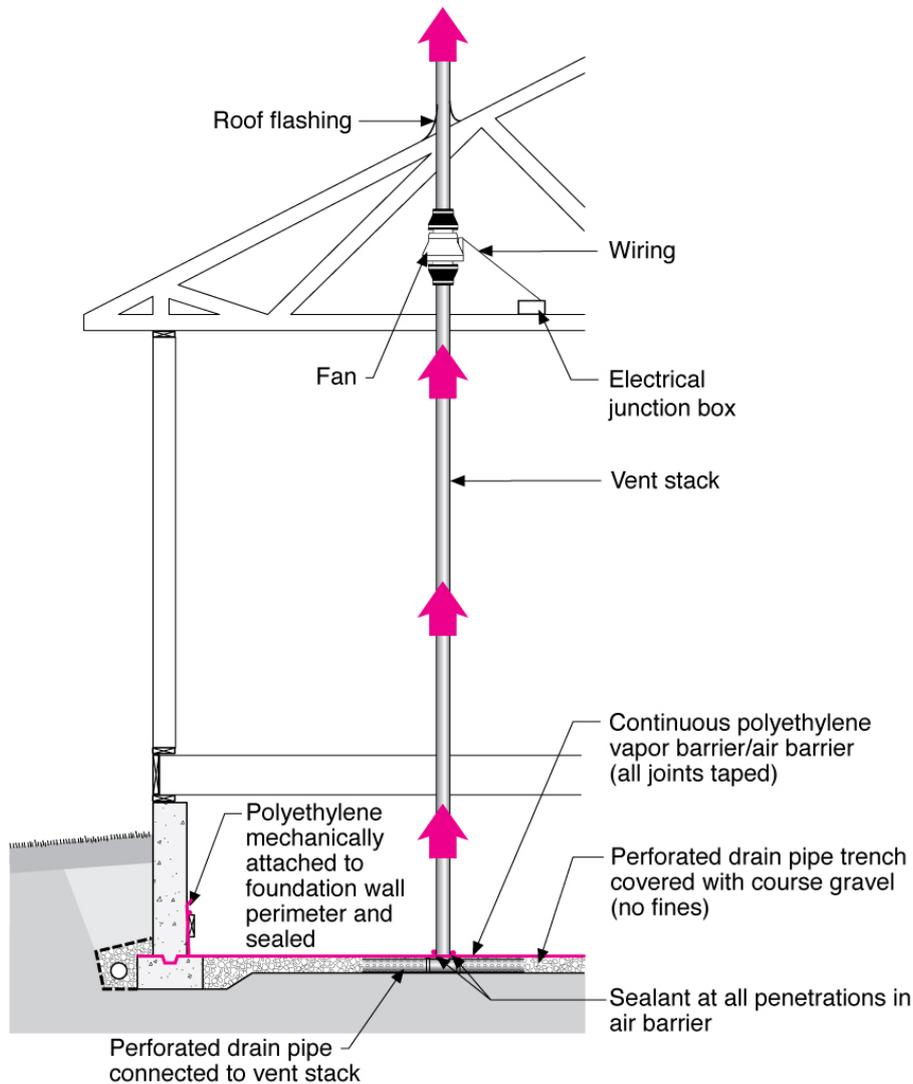


Figure 2. Radon fan - crawlspace construction (image courtesy of BSC).

How to Install Radon Fan – Basement Construction

1. Select the location for the ventilation pipe (min. 3" in dia.). It should be installed in a vertical run through a warm part of the house and exhausted through the roof. The pipe discharge should be installed at least 2' above the roof and 10' away from any openings in the building to keep the soil gas from re-entering the building.
2. Lay a min. 3" diameter perforated pipe in a gravel trench or a collection mat on top of the gravel around the foundation perimeter. Install the pipe in a loop to allow for the soil gas to enter the pipe from two sides and connect it to either side of a vertical "T". Communication to all sub-slab areas is required and multiple connection points or interconnections may be required. See Figure 3.
3. Place the polyethylene vapor barrier and concrete slab around the vertical "T"; label and cover the open top of the vertical "T" before placing the concrete. Seal the perimeter of the "T" to the concrete to reduce the soil gas entry.
4. Install the vertical pipe by connecting it to the vertical "T." Avoid 90-degree angles in the vertical portion of the pipe; use sweeps if turns are needed. Label the pipe on each floor so it is clear the pipe is not part of the sewer system. If the ventilation pipe extends through an unconditioned attic, insulate the stack to control condensation in the pipe.
5. Run the pipe through the roof and flash it properly. Provide a screened rain cap at the termination to prevent rain entry and nesting animals.
6. Install an electrical junction box for powering the fan and add the fan to the vertical pipe run.

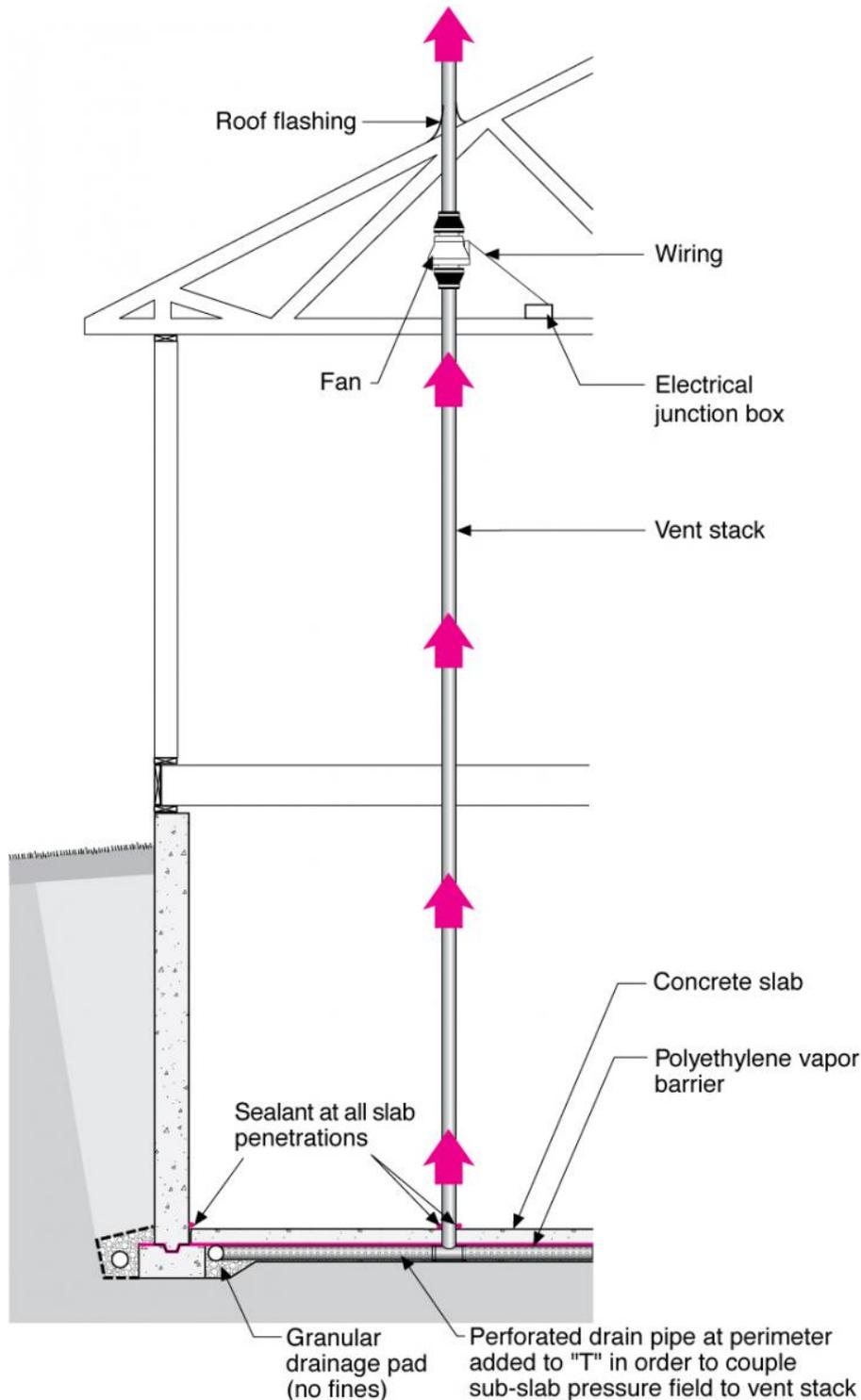


Figure 3. Radon fan - basement construction (image courtesy of BSC).

How to Install Vertical Ventilation Pipe – Retrofit Basement Construction

1. Select the location for the ventilation pipe to be installed in a vertical run through a warm part of the house and exhausted through the roof. The pipe discharge should be installed at least 2' above the roof and 10' away from any openings in the building to keep the soil gas from re-entering the building.
2. Lay down the drainage mesh over the existing concrete slab to create a soil gas collection space. Place an inverted toilet flange at the selected location and secure it to the slab.
3. Place the polyethylene vapor barrier over the drainage mesh and seal it to the flange with sealant and tape.
4. Install rigid foam insulation over the polyethylene and seal the gap between the insulation and the flange with expanding foam. Lay down the subfloor over the insulation. Insulation under the slab is not required by the building code; therefore, it is up to the homeowner to decide whether or not insulating the slab should be part of the retrofit. Types of rigid insulation appropriate for this use include extruded polystyrene (XPS) and expanded polystyrene (EPS). See Figure 4.

5. Install the vertical pipe by cementing it to the flange. Avoid using 90-degree angles in the vertical portion of the pipe; use sweeps if turns are needed. Label the pipe on each floor so it is clear the pipe is not part of the sewer system. If the ventilation pipe extends through an unconditioned attic, insulate the stack to control condensation in the pipe. See Figure 5.
6. Run the pipe through the roof and flash it properly. Provide a screened rain cap at the termination to prevent rain entry and nesting animals.
7. Install an electrical junction box for powering the fan and add the fan to the vertical pipe run.

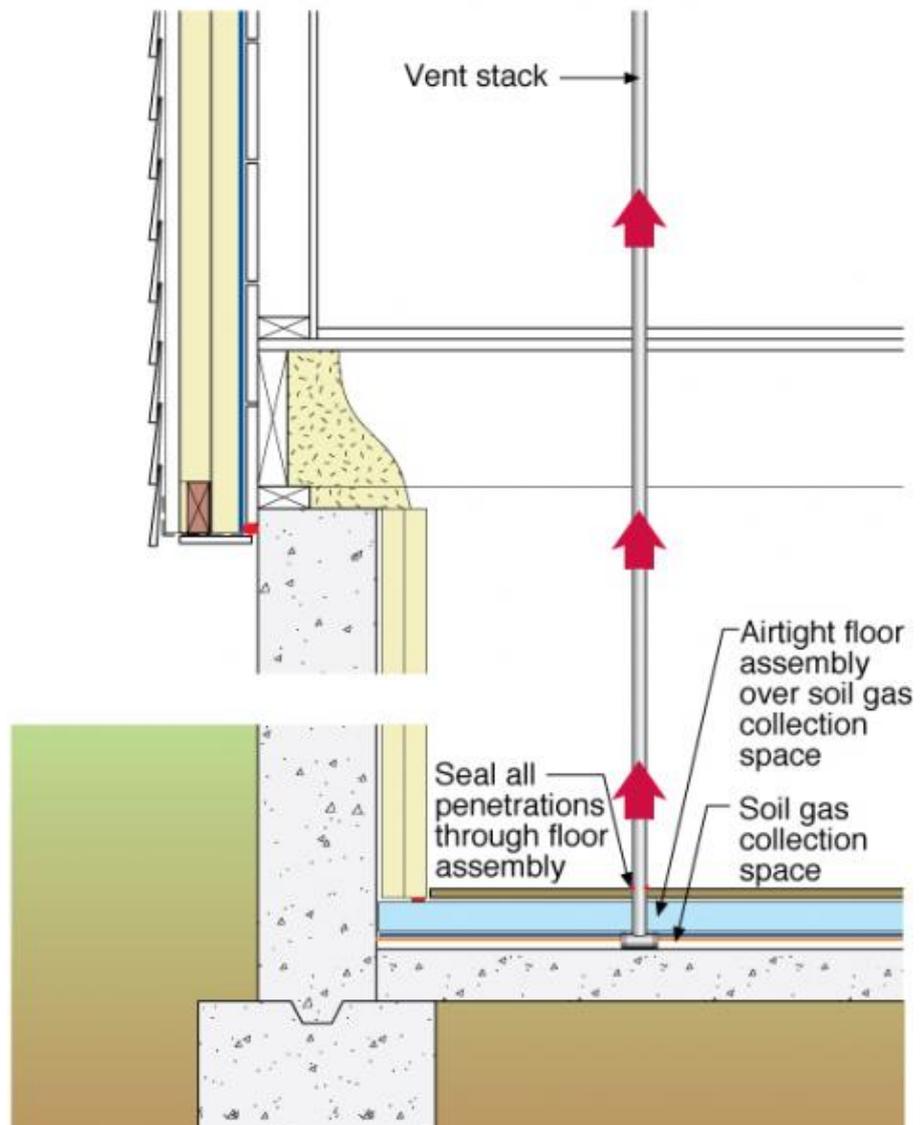
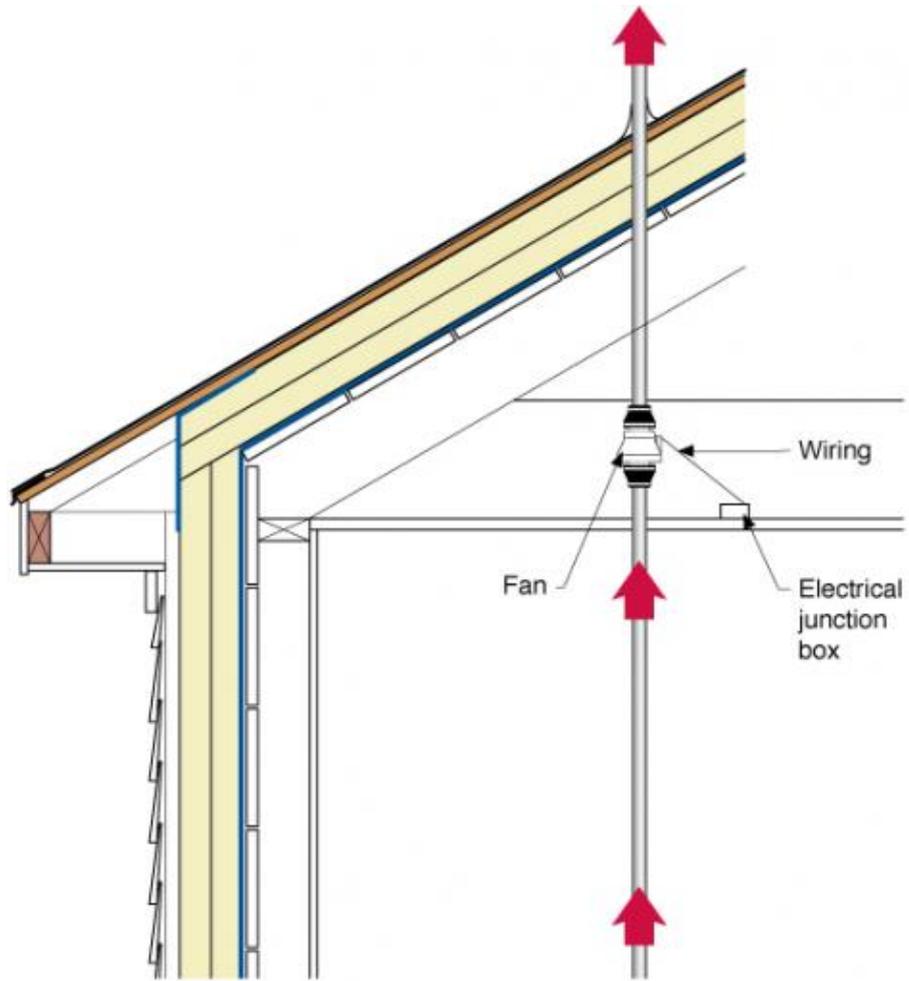


Figure 4. Radon fan - retrofit basement construction. (BSC).

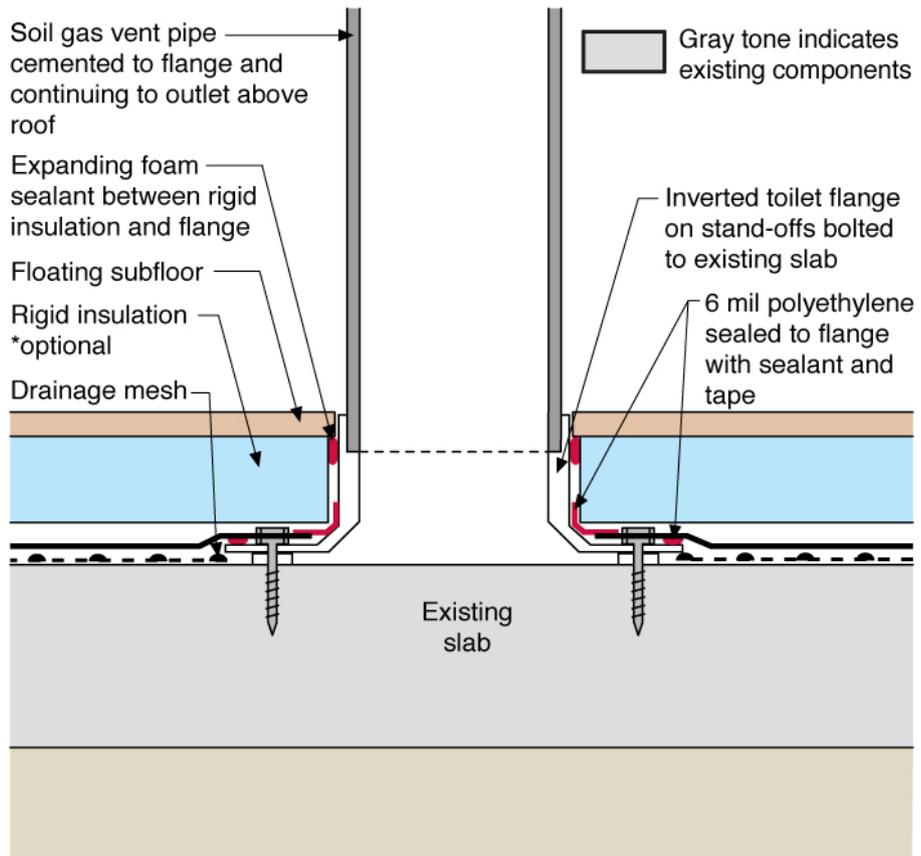


Figure 5. Detail showing connection of a radon vent stack to an existing basement slab. (BSC).

Ensuring Success

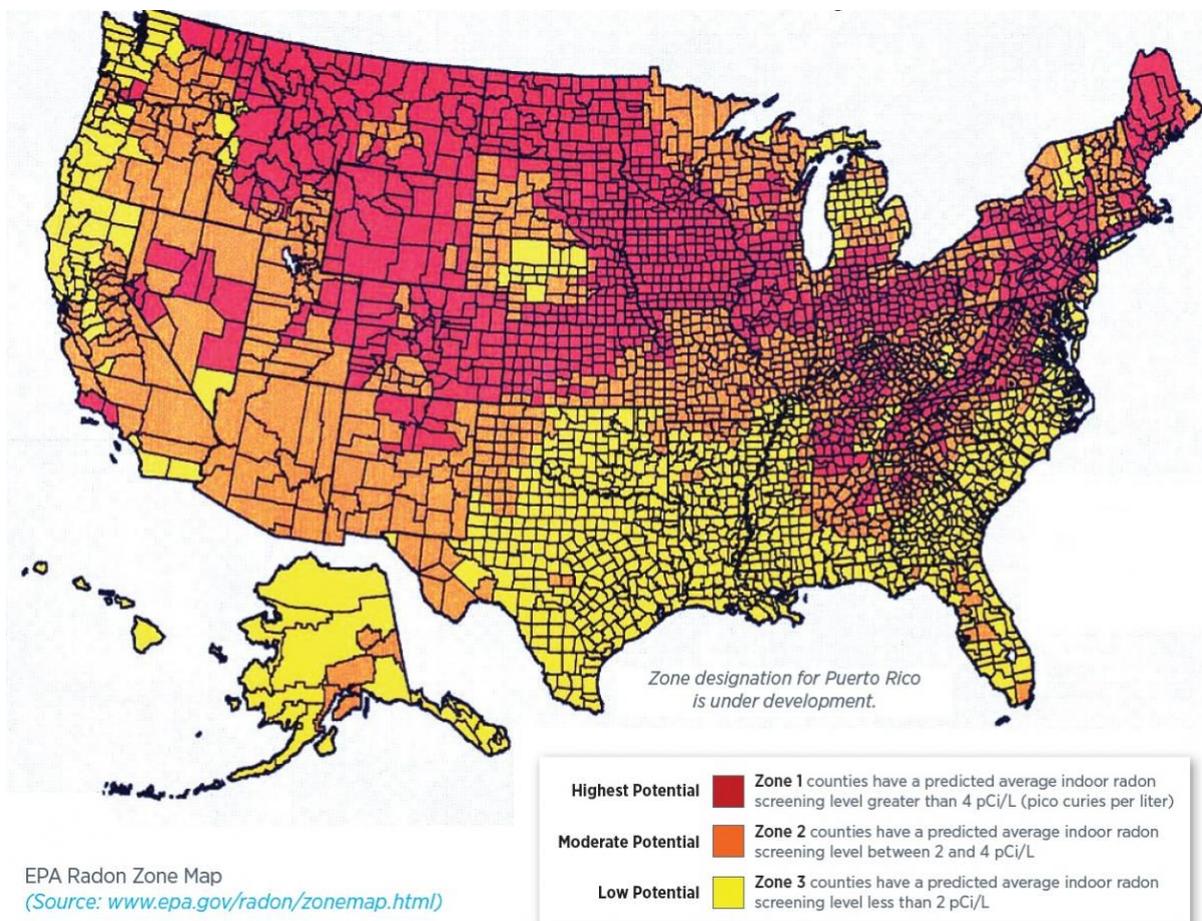
The home can be tested with a short-term or a long-term radon test kit that can be obtained through the mail or at local hardware stores. The short-term tests remain in the home between 2 and 90 days and the long-term tests remain for longer than 90 days. If the radon level is higher than 4 picocuries per liter of air (pCi/L) the radon mitigation fan should be installed and activated. The installation instructions for the radon mitigation system should be followed carefully as improper installation of the system can actually increase radon levels in a home.

Climate

In cold climates, the vertical ventilation pipe should be located inside a heated space. The vertical ventilation pipe should not be placed in an exterior wall as it will reduce the natural thermal stack effect and may prohibit the installation of the fan in the future.

In hot climates, the wind, a hot attic, or heat from the sun could all impact the effectiveness of a passive vent stack.

EPA recommends that the radon mitigation system be installed in high radon potential areas (Zone 1). The [list of Zone 1 counties can be found on the EPA website](#).



EPA Radon Zone Map
(Source: www.epa.gov/radon/zonemap.html)

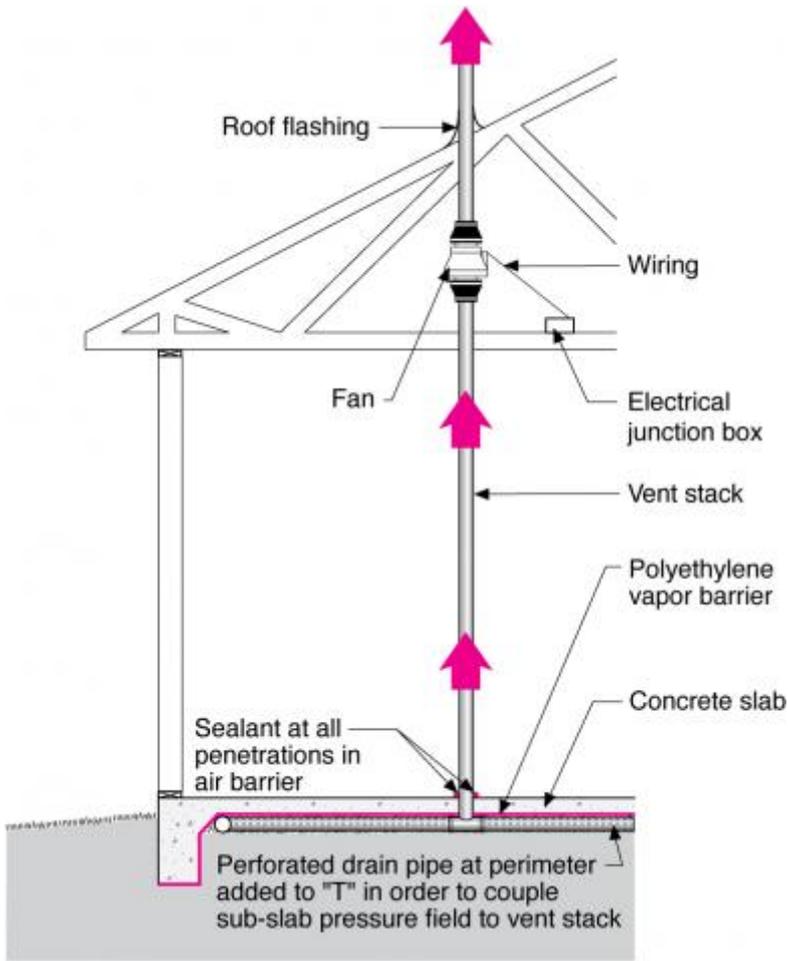
EPA Radon Zone Map

Training

Right and Wrong Images



Display Image: [DS112_RadonFan-Wrong_BSC.jpg](#)



Display Image: [DS112_RadonFan-1_Slab BSC.jpg](#)

CAD

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.

[DOE Zero Energy Ready Home](#)

The DOE Zero Energy Ready Home program requires that builders comply with EPA Indoor airPLUS. The Indoor airPLUS checklist (Item 2.1) notes that completion of the ENERGY STAR checklists now satisfies the Indoor airPLUS requirement that builders air seal all sump covers (WMS 1.7). The Indoor airPLUS checklist specifies additional requirements that are outlined below.

[Indoor airPLUS Construction Specifications](#)

Construct homes in [EPA Radon Zone 1](#) 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.
- 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.

Note: Consult local building codes to determine whether additional radon requirements apply. In January 2013 ANSI-AARST published a standard of practice for "[Reducing Radon in New Construction of 1&2 Family Dwellings and Townhouses \(CCAH-2013\)](#)."

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 [EPA's radon website](#) 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 [EPA's radon website](#) 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.

[ENERGY STAR Certified Homes \(Version 3, Rev. 08\)](#)

Per the ENERGY STAR Certified Homes, Ver 3, Rev. 08, National Program Requirements Water Management System Builder Checklist, footnote 4 ... 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](#).

[ASTM](#)

ASTM E1465–08a: Standard Practice for Radon Control Options for the Design and Construction of New Low-Rise Residential Buildings

This practice provides the design details and construction methods for two built-in soil depressurization radon control and reduction systems appropriate for use in new low-rise residential buildings. Depending on the configuration of the radon vent stack installed, the radon system's operation may have a pipe route appropriate for a fan-powered radon reduction system, or have a more efficient pipe route appropriate for passively operated radon reduction systems. This practice covers special features for soil depressurization radon reduction systems including (1) slab-on-grade, basement and crawlspace foundation types with cast concrete slab and membrane ground covers, (2) sub-slab and sub-membrane gas-permeable layers and their drainage, (3) radon system piping, (4) radon discharge separation from openings into occupiable space, (5) radon fan installation, (6) electrical requirements, (7) radon system monitor installation, (8) labeling, (9) radon testing, and (10) system documentation.

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

None Available

References and Resources*

1. [A Citizen's Guide to Radon: The Guide to Protecting Yourself and Your Family from Radon](#)
Author(s): U.S. Environmental Protection Agency
Organization(s): EPA
Publication Date: May, 2012
Report telling consumers the risks of radon, how radon gets into a home, and steps consumers can take to reduce radon exposure in their homes.
2. [ASTM E2121-13, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings](#)
Author(s): ASTM International
Organization(s): ASTM
Publication Date: March, 2013
Standard describing methods for installing radon mitigation systems in existing homes.
3. [Builder's Guide to Cold Climates](#)
Author(s): Lstiburek
Organization(s): Building Science Corporation
Publication Date: January, 2006
Book presenting the best techniques for energy and resource efficient residential construction in the colder climates of North America.
4. [Building Radon Out, A Step-by-Step Guide On How To Build Radon-Resistant Homes](#)
Author(s): U.S. Environmental Protection Agency
Organization(s): EPA
Publication Date: April, 2001
Document detailing how to build radon-resistant homes.
5. [Consumer's Guide to Radon Reduction: How to Fix Your Home](#)
Author(s): U.S. Environmental Protection Agency
Organization(s): EPA
Publication Date: January, 2016
Report telling consumers how radon gets into a home and how to reduce radon entry into a home.
6. [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.
7. [ENERGY STAR Certified Homes, Version 3 \(Rev. 07\) Inspection Checklists for National Program Requirements](#)
Author(s): U.S. Environmental Protection Agency
Organization(s): EPA
Publication Date: June, 2013
Standard document containing the rater checklists and national program requirements for ENERGY STAR Certified Homes, Version 3 (Rev. 7).
8. [Indoor airPLUS Construction Specifications Version 1 \(Rev. 03\)](#)
Author(s): U.S. Environmental Protection Agency
Organization(s): EPA
Publication Date: October, 2015
Document outlining specifications that were developed by the U.S. Environmental Protection Agency (EPA) to recognize new homes equipped with a comprehensive set of indoor air quality (IAQ) features.
- 9.

[Mass Save Deep Energy Retrofit Builder Guide](#)

Author(s): Pettit, Neuhauser, Gates

Organization(s): Building Science Corporation

Publication Date: July, 2013

Guidebook providing useful examples of high performance retrofit techniques for the building enclosure of wood frame residential construction in a cold and somewhat wet climate.

10. [Radon-Resistant New Construction Builder/Contractor Resources](#)

Author(s): U.S. Environmental Protection Agency

Organization(s): EPA

Publication Date: June, 2013

Website with information about radon-resistant construction techniques and other radon resources for builders, contractors and homebuyers.

11. [Soil Gas Control](#)

Author(s): Building Science Corporation

Organization(s): Building Science Corporation

Publication Date: May, 2009

Information sheet about soil gas control strategies for foundations.

*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.

Contributors to this Guide

The following authors and organizations contributed to the content in this Guide.

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[Advanced Energy Corporation](#)

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