Radon Resistant New Construction

Connecticut Department of Public Health
Radon Program

Radon Overview

- Radon is a radioactive gas which causes lung cancer
- It is naturally-occurring, and comes from the breakdown of uranium and radium
- Radon can be found all over the U.S.
- It cannot be detected with the 5 senses
- It enters homes primarily from the soil below
- Radon is the second-leading cause of lung cancer in the U.S., and there are simple and affordable actions the public can take to reduce exposure to radon.
- Nearly one out of every 5 homes in Connecticut is estimated to have a radon level above the EPA's action level of 4.0 pCi/L

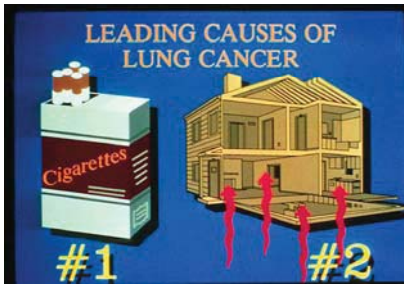
Radon and Its Health Effects

- There are no immediate health effects
  - Radon causes **no** symptoms
- Radon and radon decay products are inhaled into lungs and remain
- Radiation is emitted when radon breaks down.
- The Alpha radiation damages tissue DNA and leads to increased risk of lung cancer.
- There is no known safe level of radon

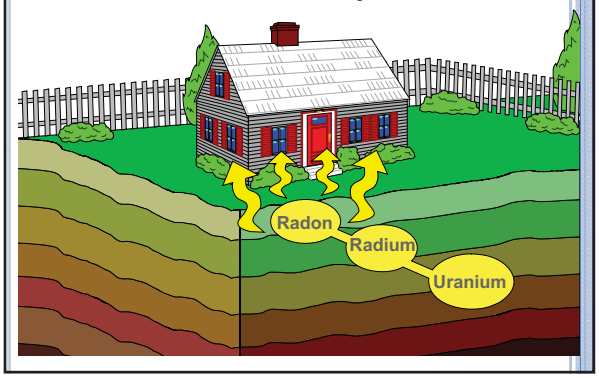
#1 Cause of Lung Cancer

#2 Cause of Lung

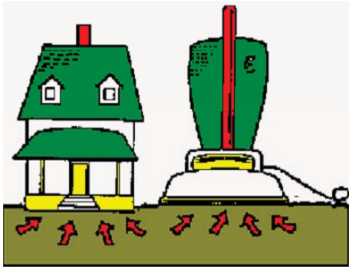
However, Radon is ***leading*** cause of lung cancer among **non**-smokers



Uranium Decay Chart



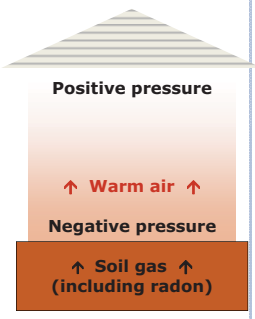
Why It Enters the Home



A home acts like a vacuum drawing gases inside

Air pressure differences
Stack effect

- Heated indoor air rises and escapes through cracks and holes at top of home
  - Creates positive air pressure at top of home
  - Creates negative air pressure (vacuum) at bottom
- Vacuum draws in soil gas, including radon
- Effect is greatest during coldest months
- Thermal bypasses increase effect



Air pressure differences
Mechanical systems

Heating, ventilation, and air conditioning (HVAC) systems
- Air distribution blowers
- Furnaces
- Boilers
- Wood-burning fireplaces
- Woodstoves
- Other combustion systems

Home exhaust systems
(vent air to outside)
- Clothes dryers
- Exhaust fans in bathrooms, kitchens, or attics
- Central vacuum cleaners

Any type of home can have elevated radon levels

1 in 5 Connecticut homes has a radon concentration at or above the action level of 4 pCi/L
- Old or new
- Drafty or well sealed
- With or without a basement

EPA and DPH Action Level - AIR

The Environmental Protection Agency (EPA) recommended action level for radon in air is

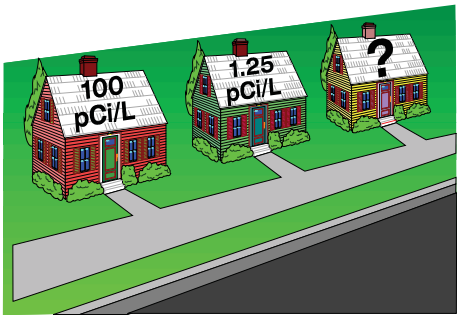
4.0 pCi/L

This action level **is not** a health-based standard!

No level of radon is considered "safe"

The EPA recommends that radon levels of ≥ 4.0 pCi/L be reduced to decrease risk of developing lung cancer.

Testing Is The Only Way To Know



Radon Potential Map

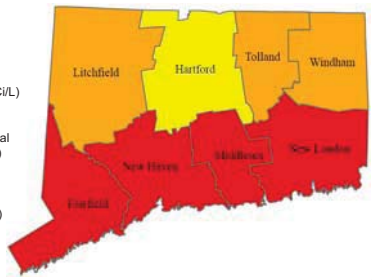
- Radon is found in high levels in homes in ALL regions of the state
- Purpose of map:
  - Developed to assist building officials in deciding to build radon-resistant new construction (homes and schools)

Radon Potential Map of CT

Zone 1: High Potential (greater than 4 pCi/L)

Zone 2: Moderate Potential (from 2 to 4 pCi/L)

Zone 3: Low Potential (less than 2 pCi/L)

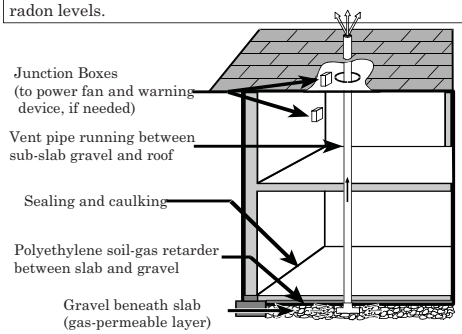


Radon-Resistant New Construction

- EPA recommends that all new homes in Zone 1 regions be built radon resistant
- Build features into a home during its construction
- Low up-front cost versus retro-fitting a home after it is built
  - Radon-resistant cost: $350-$500
  - Installing system afterward: $1,000-$2,500

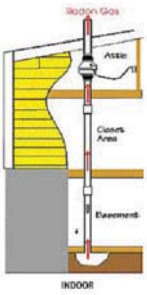
Cost-Effectiveness of RRNC

RRNC involves the installation of a passive radon vent stack (no fan), that can be upgraded if necessary by adding a fan to further reduce radon levels.



Simple Steps to Building Radon-Resistant New Housing

- Install a passive system
  - 4 inch layer of ½-inch or ¾ inch gravel
    - Insert venting pipe in gravel bed with TEE-fitting or loop
  - Plastic sheeting on top of gravel
  - Seal sumps and other openings
  - Run PVC piping through home to roof
  - Label piping "Radon Vent Pipe"
  - Install unswitched electrical junction box within 6 feet of where the fan may be installed if the passive system must be activated



Major components of a passive system

Install Layer of Gas Permeable Material

4 to 6 inch layer of clean, coarse gravel is used beneath the slab to allow the soil gas to move freely underneath the house.

Gravel is 10-1000 times more air permeable than sand

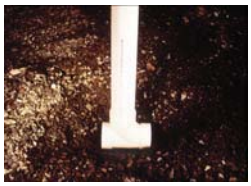
Install Soil-Gas Collection System

Bury a perforated 3-4 inch diameter PVC pipe in gravel layer

Slope pipe towards collection point

Centrally locate non-perforated tee assembly

Label visible interior pipe "Radon Vent System "



Install a Sealed Polyethylene Membrane

6-mil thick or 3-mil cross laminated polyethylene sheeting is placed on top of the gas permeable layer and subslab pipes to help prevent the soil gas from entering the home.

Radon System Piping

A 3 or 4-inch PVC pipe runs from the gas permeable layer through the house and roof to safely vent radon gases above the house.

Killingly High School

Electrical Junction Box

An electrical junction box is wired in case an electric venting fan is needed later to activate the system.

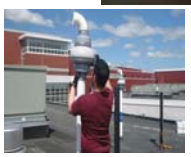
Every Home Must be Tested for Radon After Occupancy

- An average radon test result will determine if the passive system is adequately reducing radon levels to below 4.0 pCi/L
- Test in the colder months when radon tends to be highest
- A fan will have to be installed to activate the radon reduction system if levels are not below 4.0 pCi/L

Activating the Passive System
Installing a Fan

Attic installation (unoccupied)

Outside the house



Radon Resistant New Construction Makes Sense

- Low-cost
  $350-$500 per home
  Versus $1,000-$2,500 to retrofit
- Simple - uses common building materials
- Effective - reduces radon levels by about 50%
- Other benefits include moisture control and energy savings
- RRNC protects families

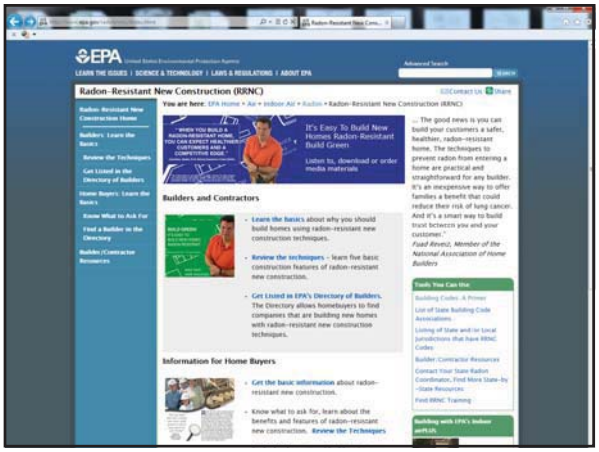
Radon Laws Pertaining to RRNC in Connecticut

- **Chapter 173 Public School Building Projects**
- **Sec. 10-291. Approval of plans and site.**

b) The Department of Education shall not approve a school building project plan or site, as applicable, if: (1) The site is in an area of moderate or high radon potential, as indicated in the Department of Environmental Protection's Radon Potential Map, or similar subsequent publications, except where the school building project plan incorporates construction techniques to mitigate radon levels in the air of the facility;…

For more information

- www.ct.gov/dph/radon
- www.epa.gov/radon



Radon Mitigation Professionals

Radon Mitigation Professionals take specialized courses, pass an exam and maintain a national membership with one of these national certification programs.

Radon Mitigation Professionals are registered as Home Improvement Contractors with the Connecticut Department of Consumer Protection.

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Click on the links below to find out more about radon:

RADON BASIC FACTS

DECEMBER 2010

WHAT IS RADON?

Radon is an invisible, odorless and tasteless radioactive gas. It is formed from the radioactive decay of radium and uranium, which occur naturally in bedrock worldwide. Radon is measured in units of radioactivity in both air and water as "picoCuries per liter" (pCi/L).

The U.S. Environmental Protection Agency (EPA) has set an *action level* of 4.0 pCi/L for radon in indoor air. The *action level* is a level at which EPA recommends action be taken. Radon levels in a home should be reduced if they are equal to or greater than the 4.0 pCi/L action level. More recent studies show an increased risk for lung cancer at average radon concentrations in indoor air of approximately 3.0 pCi/L. The EPA recognizes that radon exposure at any level poses some health risk; therefore, a homeowner may want to consider reducing radon levels that are between 2.0 pCi/L and 4.0 pCi/L.

WHERE IS RADON FOUND?

Radon is commonly found in soil, rock and water. Higher concentrations are possible near certain types of bedrock (granite, shale) that have high uranium content. This would suggest that radon potential in Connecticut could be predicted based upon the type of bedrock and soil in an area. However, test data indicate that high radon concentrations can occur sporadically in all parts of the state. <u>The only way to know if you have an indoor air radon problem is to test your home.</u>

SHOULD I BE CONCERNED ABOUT RADON IN MY HOME?

Yes, the U.S. Surgeon General has warned that exposure to elevated levels of radon in indoor air is the leading cause of lung cancer in nonsmokers. In 2005, the University of Iowa conducted the largest North American residential radon study to date. Data showed compelling, direct evidence of an association between lung cancer and prolonged residential radon exposure. The EPA estimates that approximately 25,000 lung cancer deaths each year in the United States are attributed to radon in indoor air. Breathing radon over prolonged periods can present a significant health risk. If you smoke and reside in a home with high radon levels, your risk of developing lung cancer is especially high.

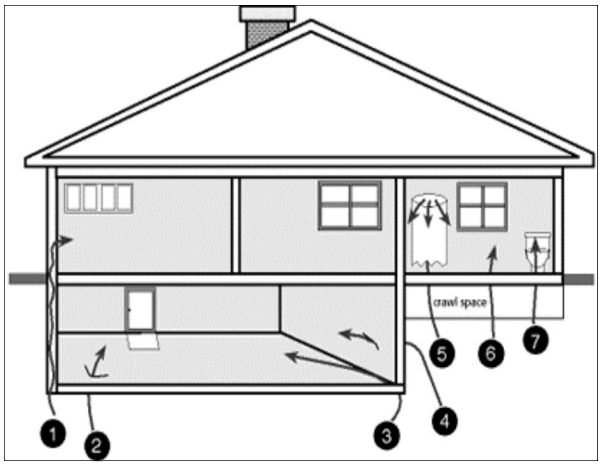
ARE THERE ANY SYMPTOMS ASSOCIATED WITH RADON EXPOSURE?

No, exposure to radon does not cause any symptoms. Long-term exposure to high levels increases a person's risk for developing lung cancer. This cancer can take up to 30 years to develop. Because radon does not have an odor and does not cause symptoms, you may not know you are exposed. Therefore, all homes should be tested and action should be taken to reduce high levels.

HOW DOES RADON ENTER THE HOME?

Radon is drawn into the home through cracks and other openings (e.g., sump pits) in the foundation. Air pressure inside the home is usually lower than the pressure in the soil around the foundation. This pressure difference draws radon gas into the home, especially during the colder months of the year when the heating system is on and the home is closed-up. Therefore, radon levels may be much higher in the winter months.

Radon may also be present in well water and can be released into indoor air during tap water use, such as showering, laundering clothes, and dishwashing. The transfer ratio for radon from well water to indoor air has been estimated as follows: 10,000 pCi/L in water may increase the level of radon in the air by 1 pCi/L.



How Radon Enters A Home

1. Cavities inside walls
2. Cracks in solid floors
3. Construction joints
4. Cracks in walls
5. The water supply
6. Gaps in suspended floors
7. Gaps around service pipes

SHOULD I TEST MY HOME FOR RADON?

Yes. All homes should be tested for radon in indoor air. This includes newly constructed homes built with radon resistant new construction (RRNC) features. The EPA recommends that homes be tested for radon in air prior to being placed on the market. This will provide time to have the home fixed or "mitigated" to reduce elevated radon levels. Testing for radon in water is not recommended unless the property is served by a private well. After the air testing has been completed, a homeowner should consider testing the water for radon.

HOW IS A HOME TESTED FOR RADON?

There are two testing procedures: a short-term test (lasting 2-90 days) and a long-term test (lasting 91 days-1 year). According to EPA protocol, testing during a real estate transaction varies slightly from testing one's own home. Short-term testing is usually conducted during real estate transactions, because it provides a quick result for potential buyers to make an informed decision. Testing involves the simultaneous placement of two test devices or one electronic continuous radon monitor to measure radon in the air. All windows and doors in the house must be closed 12 hours prior to beginning the test and remain closed throughout the entire testing period, except for normal entry and exit. The protocol for real estate transactions is to test in the lowest level suitable for occupancy, which a buyer could use for living space. Both the potential buyer and radon measurement professional make the determination for test placement based on the buyer's intended use of the space. Test devices must be left in place for a minimum of 48 hours. Multiple-round testing is not compliant with EPA protocol for a real estate transaction. The average result of two short-term tests or the result of a continuous radon monitor is adequate to make an informed decision on whether to mitigate a home. It is recommended that a qualified radon measurement professional conduct testing for a real estate transaction (refer to the CT DPH Radon Program website for a list of measurement professionals).

The protocol for testing a home that is not involved in a real estate transaction is as follows: A homeowner should test in the lowest lived-in area of the home. If the basement is not occupied more than three hours per day, then radon testing should be done on the first floor of the home. Long-term testing is an option that will provide radon test results that more accurately reflect year-round airborne exposure to radon for occupants of a home. The average result of two short-term tests or one long-term test should be compared to the EPA action level of 4.0 pCi/L.

WHAT DO THE RESULTS MEAN?

For Short-Term Testing Conducted in a Home During a Real Estate Transaction:

1. If the average of two short-term tests or a continuous radon monitor radon test result is below 4.0 pCi/L, then follow-up testing is not necessary at this time. However, radon levels fluctuate and may change over time. A homeowner may want to test in the future, especially if living patterns change (e.g., a lower level of the home is renovated and used more frequently). Radon testing should be performed during the colder months. If initial testing was performed during the spring or summer, retesting during the heating season is recommended.

2. If the average result of a short-term test is equal to or greater than 4.0 pCi/L, then it is recommended that a homeowner or homebuyer reduce the levels of radon in the home by having a radon reduction (mitigation) system installed by a qualified mitigation professional (refer to the CT DPH Radon Program website for a list).

For Testing a Home NOT Involved in a Real Estate Transaction:

1. If the long-term or short-term test result is below 2.0 pCi/L, then a follow-up test is not necessary. However, radon levels change over time. A homeowner may want to test in the future, especially if living patterns change (e.g., a lower level of the home is renovated and used more frequently).

2. If the initial short-term test result is equal to or greater than 2.0 pCi/L, a follow-up test should be performed in the same location within one month. If the average of the initial and follow-up test is between 2.0 pCi/L and 3.9 pCi/L, a homeowner may want to consider mitigation because exposure to radon at any level poses some health risk.

3. If the average of the initial and follow-up test is 4.0 pCi/L or greater, a homeowner should reduce the levels of radon in the home by having a radon reduction (mitigation) system installed by a qualified mitigation professional (refer to the CT DPH Radon Program website for a list).

HOW CAN RADON BE REDUCED IN A HOME?

A homeowner should hire a qualified radon mitigation professional to decrease airborne radon levels to well below 4.0 pCi/L. Ideally, the level can and should be reduced to below 2.0 pCi/L. A radon mitigation contractor takes steps including, but not limited to, installing ventilation systems, sealing entry routes for radon gas and installing sub-slab depressurization systems to reduce radon levels in homes. CT DPH compiles a list of qualified mitigation professionals who can evaluate properties and install radon reduction systems. These contractors have attended specialized courses, passed an examination provided by the National Environmental Health Association (NEHA) or the National Radon Safety Board (NRSB) and also maintain a Home Improvement Contractors registration through the CT Department of Consumer Protection. The list of contractors can be found on the Radon Program website under the “Radon Professionals” heading.

IS RADON IN DRINKING WATER A CONCERN?

Drinking water that contains radon is not believed to be a significant health risk compared to inhaling radon in air. The concern with radon in tap water is that some radon can enter the air and be inhaled, contributing to airborne radon levels. Radon in air is a much greater health risk than radon in water. Therefore, water testing should not occur until after radon in the air has been tested.

CT DPH recommends testing a home's water for radon when the following two conditions are met:

1. the home is served by a private well; and
2. the indoor air has already been tested for radon.

The water sampling technique is critical in obtaining accurate results and should be performed by a qualified radon measurement professional (see the CT DPH Radon Program website for a list). The water sample must be analyzed by a laboratory that is approved by the CT DPH Environmental Laboratory Certification Program to test for radon in the water. Results reported by laboratories that are not approved by CT DPH are not considered valid results.

At What Level Should Action Be Taken for Radon in Water and How Is Radon In Water Reduced?

CT DPH has set a *guideline* of 5,000 pCi/L for radon in water. A homeowner should consider reducing radon levels in their well water if the average of two or more tests is equal to or greater than 5,000 pCi/L. Two systems are currently available for reducing radon levels in private wells: the granular activated carbon (GAC) filter system and the aeration system.

The GAC will effectively treat radon in water at levels between 5,000 and 10,000 pCi/L. This system uses special charcoal filters to remove radon from the water. These filters must be changed every 12 to 18 months (or according to manufacturer's recommendations) to avoid a decrease in filter efficiency. The average cost of a GAC system is between $1,500 to $3,000.

The aeration system will reduce radon levels that are above 10,000 pCi/L. This system bubbles air through the water so that the radon is released into the air and vented away from your home. It is recommended that the aeration system be cleaned annually. The average cost of an aeration system is between $3,000 to $6,000.

Both of these systems are under constant development and a number of variations of each system are on the market. Radon mitigation contractors listed on the CT DPH Radon Program website are trained to install and maintain radon reduction systems for drinking water.

Does Connecticut Have Laws That Require Radon Testing And Mitigation?

No. The EPA and CT DPH recommend that all homes be tested and mitigated for radon if elevated levels are found. The same recommendation applies for homes involved in real estate transactions. The cost of mitigation during a real estate transaction is often negotiated between the buyer and seller.

For More Information:

CT Department of Public Health
Radon Program
450 Capitol Avenue, MS# 51-RAD
Hartford, CT 06134-0308
860-509-7367
http://www.ct.gov/dph/radon

U.S. Environmental Protection Agency:
http://www.epa.gov/iaq/radon

Fact Sheet

March 2012

Connecticut Department of Public Health
Environmental Health Section
Radon Program

Radon Resistant New Construction (RRNC)

Radon is a naturally occurring, radioactive gas and is the leading cause of lung cancer in non-smokers. Radon resistant new construction methods can be effective in improving indoor air quality and reducing radon entry into buildings. Read this fact sheet to learn more about building healthy homes.

Why Build With RRNC Methods?

Homes built with RRNC methods can be effective in reducing radon levels by venting radon away from the home. It is easier and less costly to install features during construction than after the home is built. All of these techniques and materials are commonly used in construction. No special materials are required.

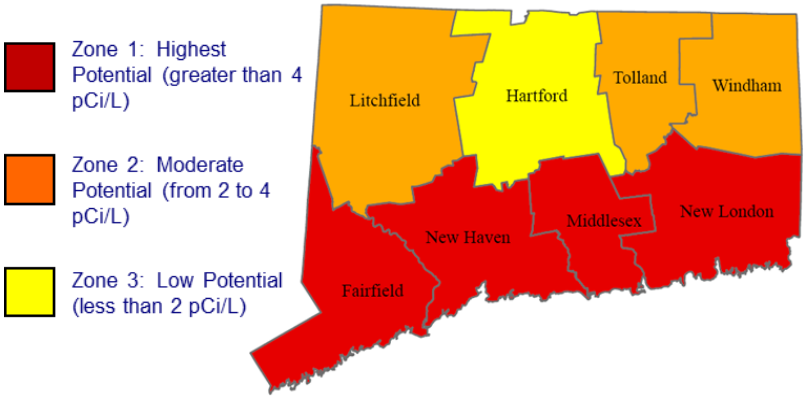
Is My Region in a High Risk Area For Radon?

This map shows the radon potential by county in Connecticut. High radon level areas are called Zone 1 areas. The United States Environmental Protection Agency (EPA) and the Connecticut Department of Public Health (CT DPH) recommend builders and architects use RRNC methods in both Zone 1 and Zone 2 areas.

Is Radon a Significant Health Risk?

The EPA estimates that radon gas causes over 21,000 lung cancer deaths per year in the U.S. The EPA set an *action level* for radon at 4 picocuries per liter (pCi/L). "Picocuries per liter" is a unit of measure for radiation. It is recommended that homeowners take steps to reduce radon levels in indoor air to below 4 pCi/L.

Connecticut Radon Potential Map



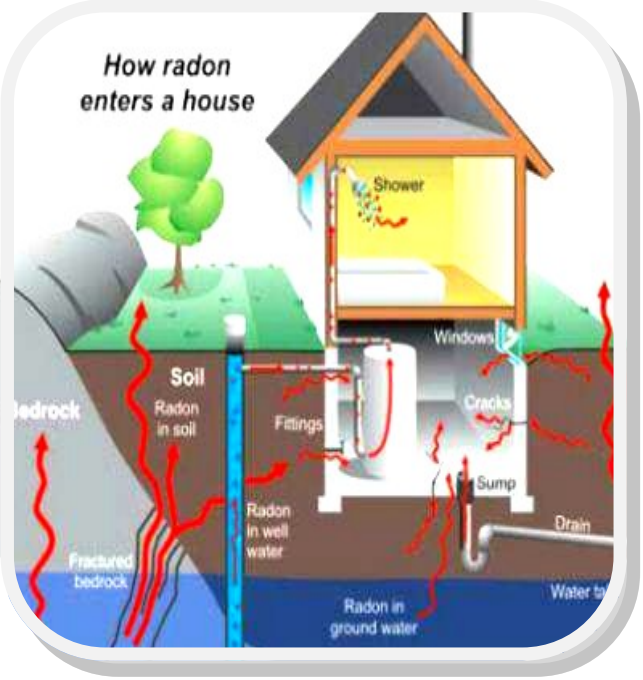
This map is not used to determine if a home in a given zone should be tested for radon. Homes with elevated levels of radon have been found in all three zones. All homes should be tested regardless of geographic location.

How Does Radon Enter a Home?

Can be drawn into a house from the soil as a result of air pressure differences through:

- √ Cracks in foundation
- √ Cavities inside walls
- √ Joints between floor and wall
- √ Gaps around service pipes and in suspended floors

As warm air rises, the "stack effect" causes unconditioned replacement air to enter the lower portion of the house.



What are the Steps to Building Radon Out?

There are 4 basic steps to building radon out.

1. Install a 4" layer of clean gravel or aggregate beneath the slab;
2. Lay polyethylene sheeting on top of the gravel layer;
3. Include a gas-tight venting pipe from the gravel layer through the building to the roof; and
4. Seal and caulk the foundation thoroughly.

Radon Resistant New Construction Basic Features

You and your builder can design your new home to keep radon out. Both gravel and plastic sheeting are already required under Connecticut Building Code. For a small additional cost, you can make your new home radon resistant. Have your builder take these four steps.

Step 1: Sub Slab Layout

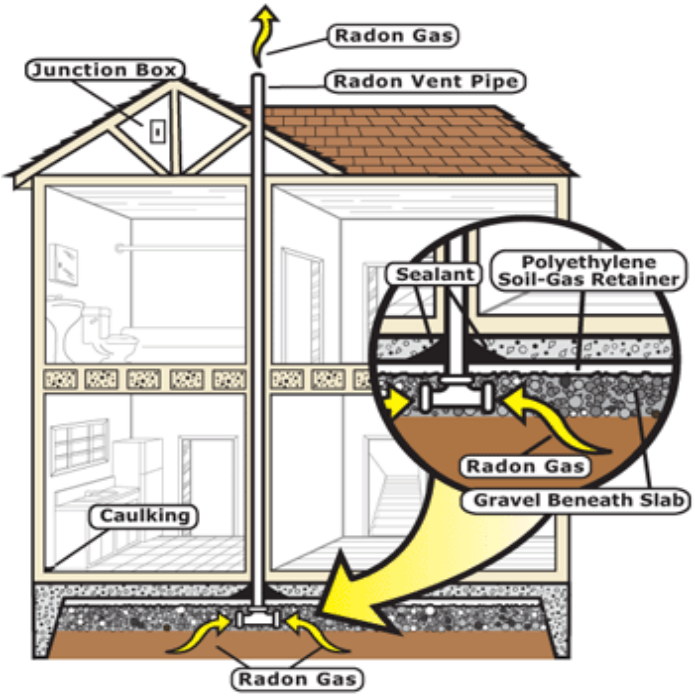
1. **Install Gravel Layer** (creates a permeable layer)
   - √ Aggregate size: 1 - 1½ inch diameter, no fines
   - √ Place 4-6 inches thick in a uniform layer
2. **Install Soil-Gas Collection System**
   - √ Bury a perforated 3-4 inch diameter PVC pipe in gravel layer
   - √ Slope pipe towards collection point
   - √ Keep subslab pipe ends uncapped
   - √ Centrally locate non-perforated tee assembly
   - √ Protect exposed pipe end from concrete mix while pouring foundation
   - √ Label visible interior pipe "Radon Vent System"
3. **Install a Sealed Polyethylene Membrane** (acts as a vapor barrier)
   - √ Use 6-mil thick or 3-mil cross laminated polyethylene
   - √ Place sheeting on top of gravel and subslab pipes
   - √ Overlap seams 12 inches & seal with duct tape
   - √ Run sheeting 12 inches up side walls and secure prior to pouring foundation

Step 2: Radon System Piping

1. **Pipe From Sub-Slab Gravel Through Roof** (vents radon gas above the home)
   - √ Run 3-4 inch diameter schedule 40 PVC pipe vertically through the building floors
   - √ Support pipe every 6 feet in horizontal runs; every 8 feet in vertical runs
   - √ Label all portions of visible pipe "Radon Vent System"
2. **Vent Stack Pipe Discharge**
   - √ Terminate vent stack pipe 12 inches above roof
   - √ Locate vent stack pipe 10 feet away from windows or other openings including furnace flue

Step 3: Electrical Wiring

1. **Install Electrical Outlet** (allows for future Installation of fan)
   - √ Install unswitched electrical junction box in attic
   - √ Locate within 6 feet of the vent pipe
   - √ Label circuit breaker



A "*Passive Radon Control System*" relies on natural air pressure to draw the radon out of the house.

Step 4: Fan Installation

1. **Every Home Must Be Tested for Radon After Occupancy**
   - √ An average radon test result will determine if the passive system is adequately reducing radon levels.
   - √ You may need to have a fan installed to activate the radon reduction system to reduce radon levels to below 4 pCi/L.

For more information about RRNC, call your Local Health Department/District
or
visit the Connecticut Department of Public Health
Radon Program website:

www.ct.gov/dph/radon