The Basics of Radon Presentation

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NATIONAL SAFETY COUNCIL ™

Your Safety & Health Leader for 90 Years

Radon is a naturally occurring gas. It can be found in homes, and is the second leading cause of lung cancer. EPA estimates that radon causes between 15,000 and 22,000 lung cancer deaths every years in the United States.

Today I will be giving an overview of:

- Radiation and Radon
- The Health Effects of Radon
- How Radon Exposure Happens
- How to Test You Home, and
- How to Mitigate Your Home, if necessary

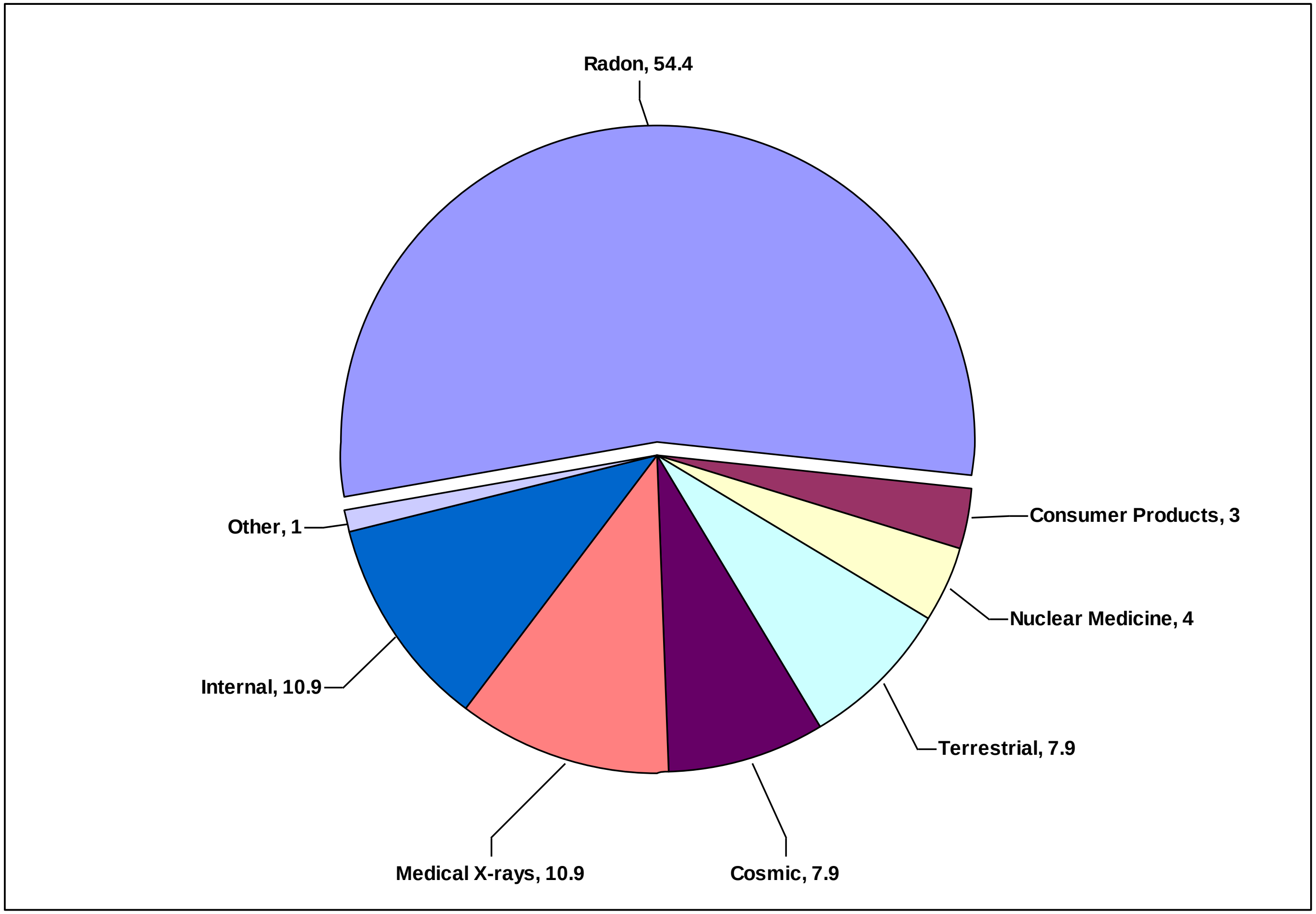
Understanding Radiation and Radon

- Radon is a radioactive gas that is colorless, odorless, tasteless, and chemically inert. Radon atoms are direct descendents from uranium. When atoms of uranium-238 decay, they produce several generations of other radioactive elements. The fifth generation is radium, which in turn decays into radon.

- Though great concentrations of uranium are rare, traces of it are common in ordinary rock and soil throughout much of the United States. Concentrations vary greatly from place to place depending on the underlying geology.

- Radiation is all around us and comes from a variety of natural and man-made sources. It comes from outer space, from the ground, from within the human body, from consumer products, and from x-rays.

Sources of Background Radiation for the U.S. Population



- Radiation dose is measured in REM (Roentgen Equivalent Man). The average person in the United States receives about 360 millirem of radiation per year -- 80% from natural sources and 20% from man-made sources, primarily medical x-rays.

Health Effects

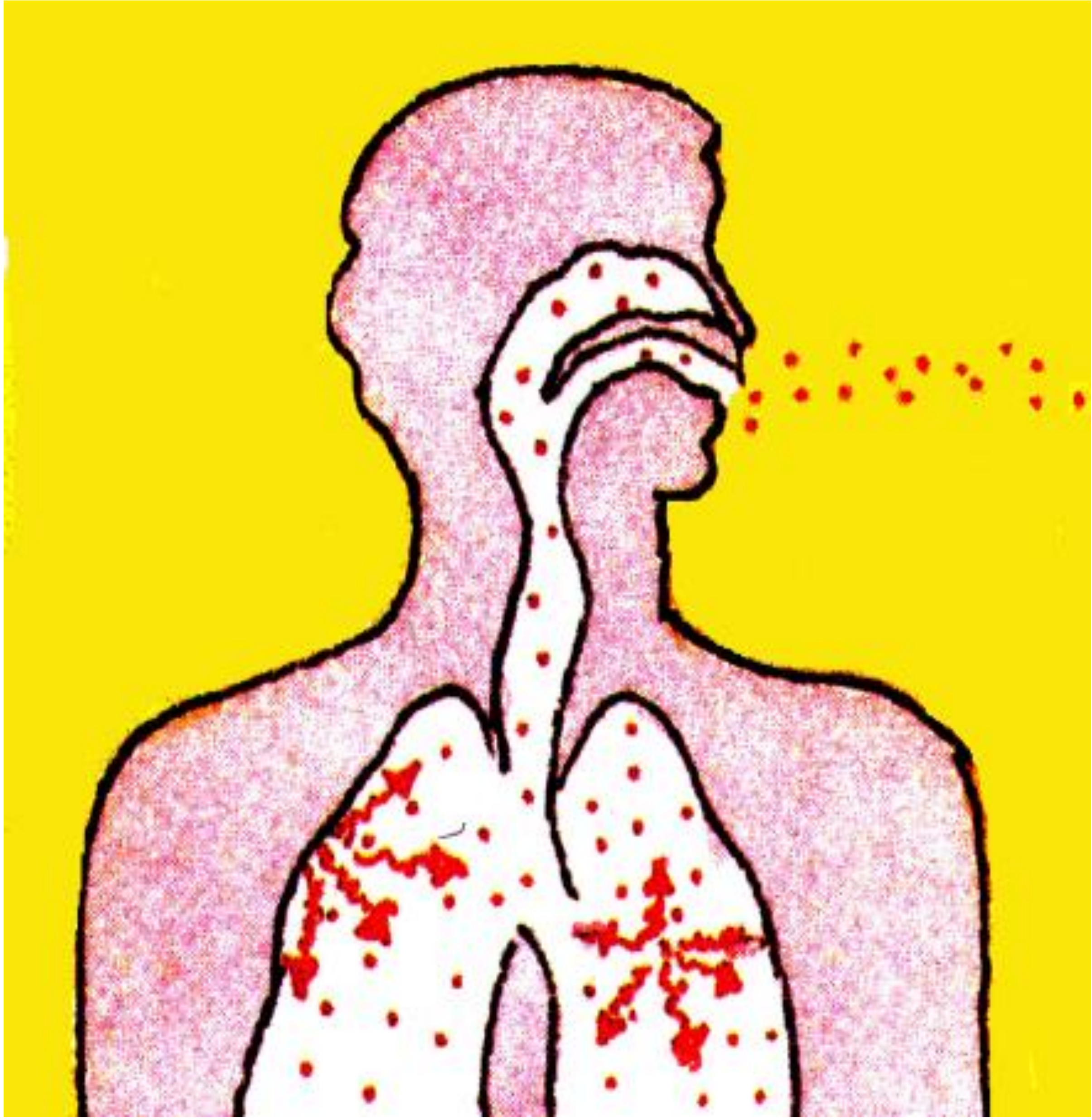
Radiation is a carcinogen, or a cancer causing agent. Most cancers do not appear until many years (10-40 years) after the radiation dose is received.

Radiation may also cause other adverse health effects including:

- genetic defects in the children of exposed parents
- mental retardation in the children of mother exposed during pregnancy.

The risk of developing cancer due to radiation exposure is much higher than the risk of other effects, and the cancer risk increases the more radiation a person receives.

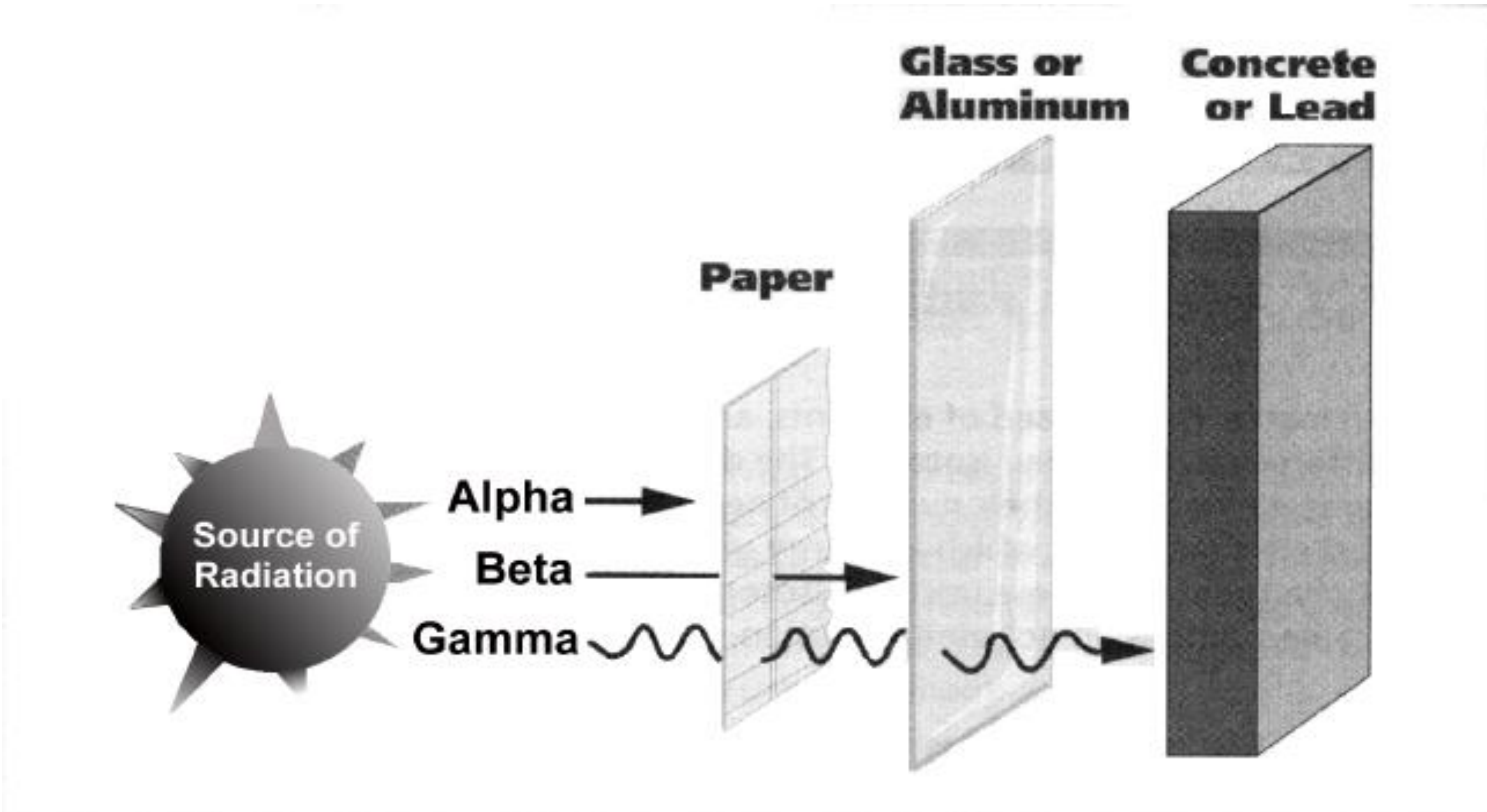
- Though we breathe radon into our lungs, it tends to pass out harmlessly as we exhale. The threat stems from two of radon's decay products, solid isotopes of polonium. Because they revert to solid form, these can be inhaled and can lodge in the lungs, and since their half lives are no more than a few minutes, they tend to "go off" before the lung can clear them.



When radon undergoes radioactive decay, it emits ionizing radiation in the form of alpha particles. It also produces short-lived decay products, often called progeny or daughters, some of which are also radioactive.

Unlike radon, the daughters are not gases and can easily attach to dust and other particles. Those particles can be transported by air and can also be breathed.

The harm can result when the polonium isotopes emit high-energy, low-velocity particles called alpha radiation. These same alpha particles constantly bombard the body from the outside without harm since most cannot penetrate the dead outer layer of skin. But in the lung, they can penetrate more sensitive and vulnerable lung tissue.


Glass or
Aluminum
Concrete
or Lead
Paper
Alpha
Source of
Radiation
Beta
Gamma

Alpha particles move slowly and deposit their concentrated energy over a shorter distance. When they collide with unshielded lung cells, they can sever strands of DNA’s double helix corkscrew, scrambling its genetic code.

Cells are efficient at repairing breaks in a single strand, but damage from double-strand breaks may be permanent and may be transmitted to the cell’s daughters.

The effects may not be seen for years, or even decades, but ultimately the damage causes cells to lose control over cell division and growth and cancer appears.

Like other environmental pollutants, there is some uncertainty about the magnitude of radon health risks.

However, we know more about radon risks than risks from most other cancer-causing substances. This is because the data on radon come from studies of cancer in people exposed to radon in homes and in mines. Many other substances have test data only from animal studies.

Anyone who breathes is potentially at risk from radon. The risk grows with the level and duration of exposure. The longer your exposure and the higher the concentration, the greater the risk.

EPA estimates that radon causes between 15,000 and 22,000 lung cancer deaths in the United States per year. Although some people debate the number of deaths, it is widely agreed that radon exposure is the second leading cause of lung cancer, after smoking.

Smoking combined with radon is an especially serious health risk. Stopping smoking and lowering a high radon level are the best ways to help minimize your future risk of lung cancer.

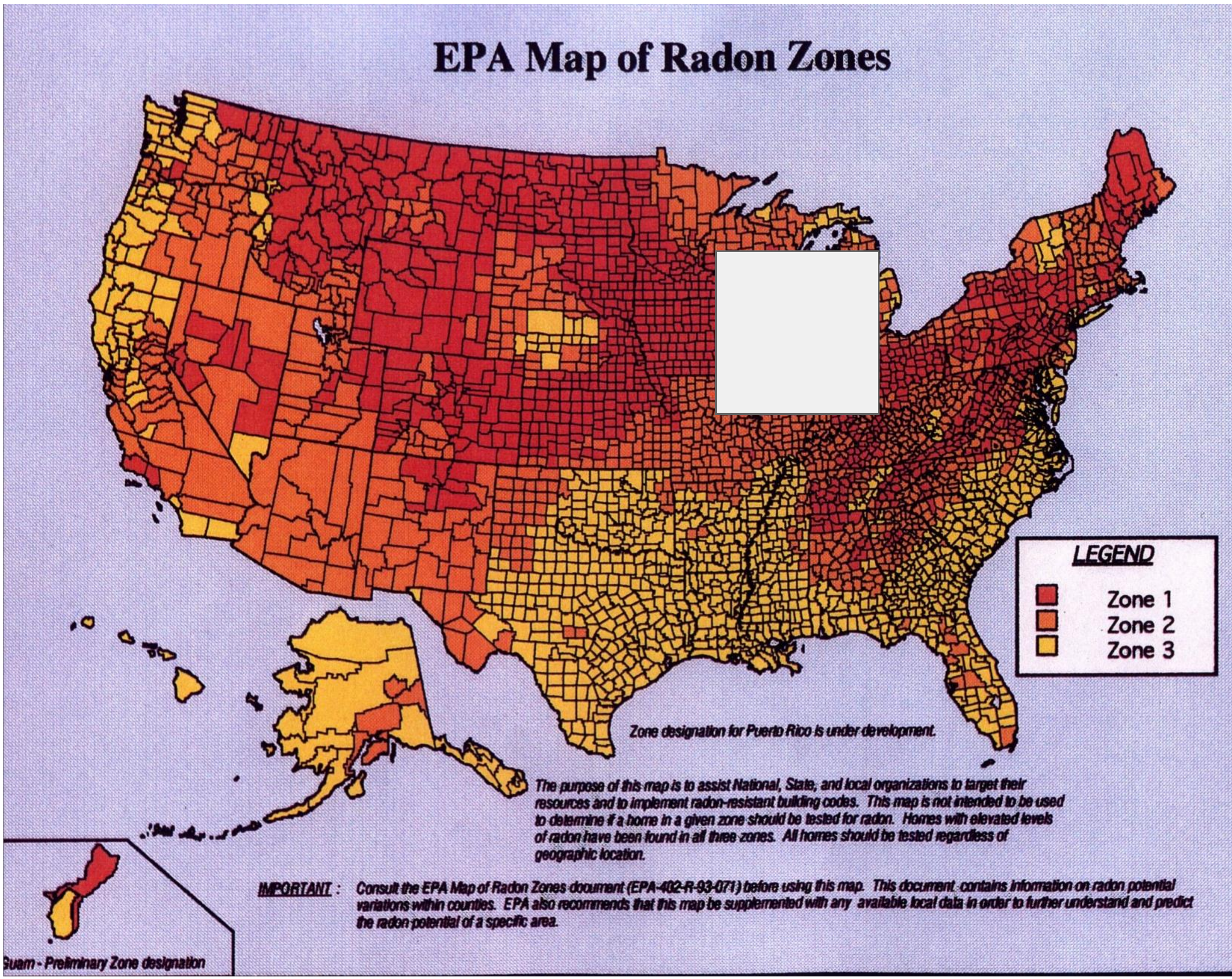
Your chances of getting lung cancer from radon depend mostly on the following factors:

- How much radon is in your home
- The amount of time you spend in your home
- Whether you are a smoker or former smoker

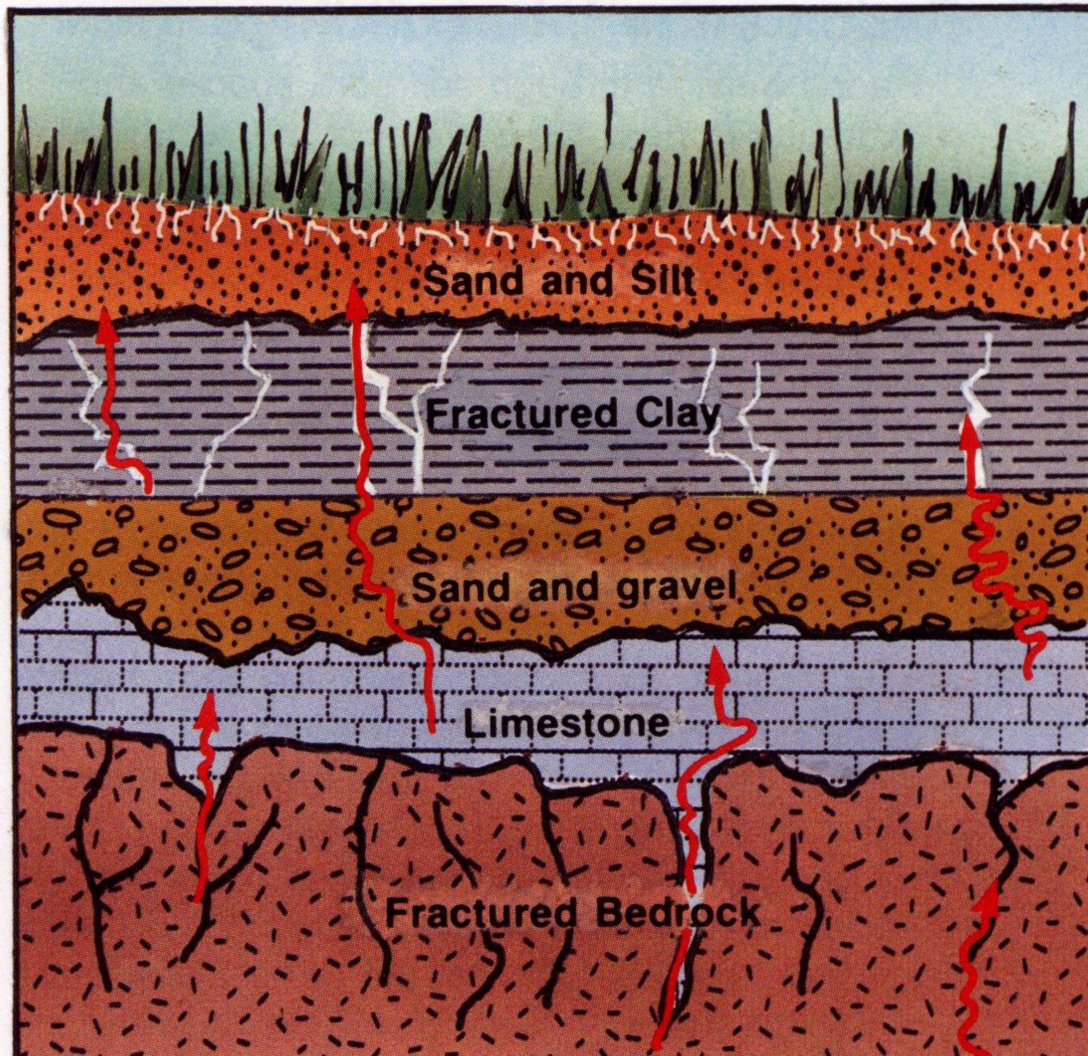
How Exposure Happens

Radon is measured in picocurie (pCi), which is the rate of radioactive decay of radon. Four picocuries per liter of air (4 pCi/L) is the EPA’s recommended action level. That is the level that EPA recommends that homeowners take action to reduce radon levels in the home.

EPA estimates that nearly 1 out of every 15 homes in the United States has radon levels above the action level. Radon problems have been identified in every state. 1 in 3 homes in Minnesota have radon levels above the action level.


EPA Map of Radon Zones
LEGEND
Zone 1
Zone 2
Zone 3
Zone designation for Puerto Rico is under development.
The purpose of this map is to assist National, State, and local organizations to target their resources and to implement radon-resistant building codes. This map is not intended to be 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.
IMPORTANT : Consult the EPA Map of Radon Zones document (EPA-402-R-93-071) before using this map. This document contains information on radon potential variations within counties. EPA also recommends that this map be supplemented with any available local data in order to further understand and predict the radon potential of a specific area.
Guam - Preliminary Zone designation

Unlike its ancestors, uranium and radium -- which are in solid form -- radon is a gas, and therefore very mobile. The slightest fissure in surrounding rock is enough to allow radon gas to be released from its “prison” in the earth. It can percolate through the soil and move to the surface.


Sand and Silt
Fractured Clay
Sand and gravel
Limestone
Fractured Bedrock

Radon moves more readily through permeable soils, such as coarse sand and gravel, than through impermeable soils, such as clays. Fractures in any soil or rock allow radon to move more quickly. So homes built on highly permeable soils and bedrock are more likely to have higher levels of radon.

In the open air, most radon dilutes into insignificant concentrations. Current estimates are that the average outdoor background level of radon is 0.4 pCi/L.

When radon is trapped and allowed to concentrate in a house or other building, it becomes a serious health threat. The average home in the United States contains about 1.25 pCi/L.

In combination, three factors determine the potential for high radon levels in homes:

1. normal to high uranium concentrations
2. soil characteristics that allow gas movement to the surface
3. access for uranium's decay products into homes

Differences in type of foundation construction, as well as local geologic and soil characteristics, can result in great differences in radon levels for homes located in the same neighborhood.

Weather can also have an affect on radon levels in your home.

Radon gas escapes to the surface the easiest way it can -- through crack and other openings.

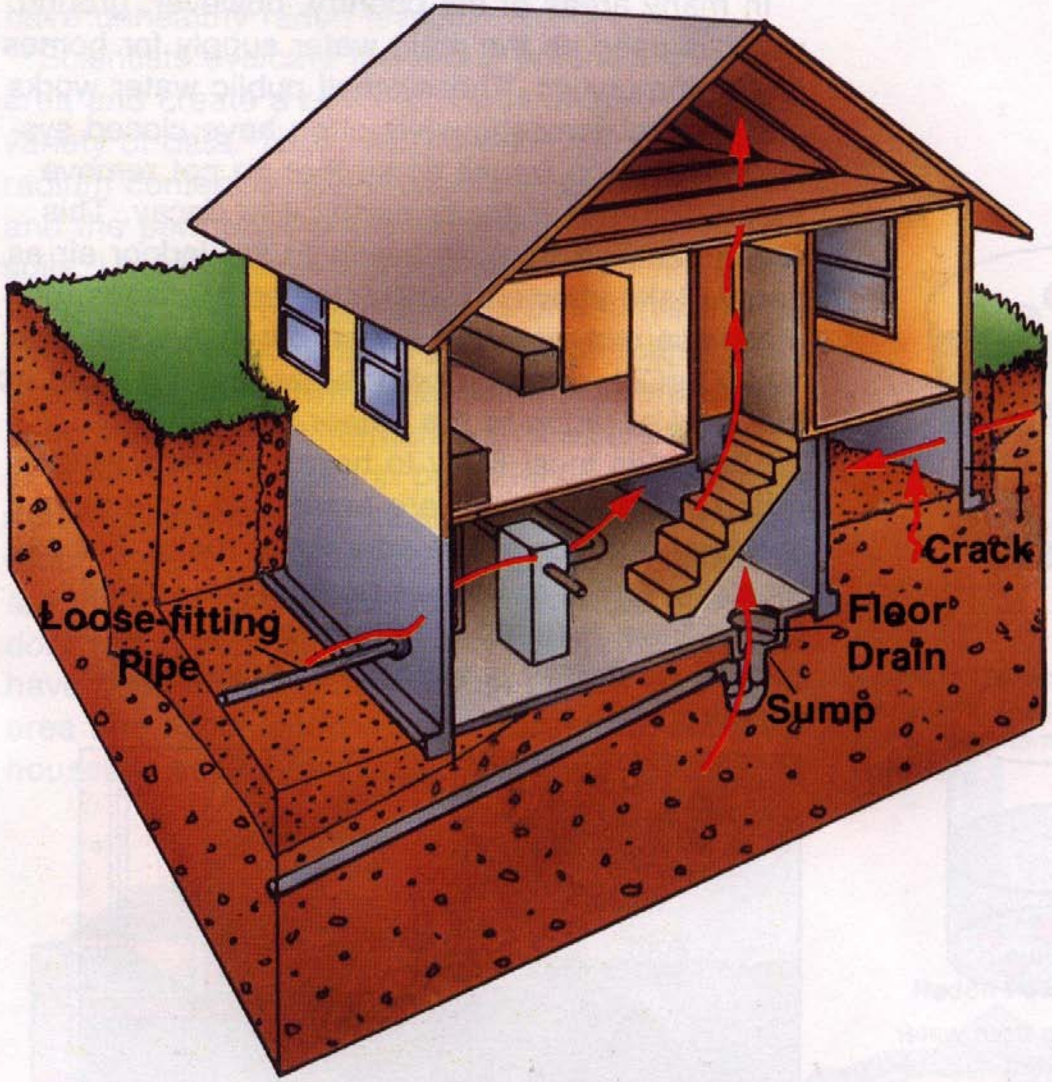
- **Rain and snow** can create a covering that can deter the radon from making it to the surface and it may find an easier path into your home
- **Cold weather** can make a difference because warm air is lighter and rises, creating a low pressure vacuum effects that can pull more radon from the ground. Also during cold weather we keep our windows and doors closed, creating fewer ways for the radon to escape.

- **Hot weather** again can cause a higher concentration because we seal the home to make the air conditioning more effective.

- **Strong winds** blowing across the top of a home can create an overall suction in the house which draws more radon gas in from the soil beneath the foundation.

The major source of radon is beneath the home in soil or rock that contains uranium -- granite, shale, phosphate, and pitchblende. The decaying radon particles in that soil or rock can enter a home or building through:

- cracks in floors and walls
- gaps in suspended floors
- openings around sump pumps and drains
- cavities in walls
- joints in construction materials
- gaps around utility penetrations (pipes and wires)
- crawl spaces that open directly into the building


Loose-fitting
Pipe
Crack
Floor
Drain
Sump

Indoor levels depend on the rate of entry and the rate at which it is removed by ventilation. A home with little indoor and outdoor air exchange is more likely to have higher radon levels than a home with great ventilation.

People living above the second floor generally need not be as concerned about residential radon because radon dilutes as it moves upward within a building.

Testing and Mitigating

Measuring for radon is easy and generally quite reliable. For most people, use of a short-term kit or measuring device over a period of two to seven days is an effective way to begin understanding potential individual radon risks. Short-term tests offer the quickest way to test a home. However, because radon levels in a home fluctuate widely over time, long-term readings over the course of several seasons provide the most reliable indication of annual radon levels.

Radon levels within a building often change on a day-to-day basis. Highest indoor levels are often found during winter months. Weather conditions and opening/closing of windows and doors are among the factors that cause these patterns.

EPA recommends that for homes, initial measurements be short-term tests placed in the lowest lived-in level. If you are doing a short-term test, close your windows and outside doors and keep them closed as much as possible during the test. If testing for just 2-3 days, be sure to close windows and outside doors at least 12 hours before beginning the test. Long-term tests remain in your home for more than 90 days. The closer the long-term measurement is to 365 days, the more representative it will be of annual average radon levels.

Two groups of devices are commonly used for short-term testing:

- **Passive devices** do not need power to function and include alpha tract detectors, charcoal canisters, and charcoal liquid scintillation detectors. Passive devices are returned to a lab for analysis.
- **Active devices** require power to function. This group consists of different types of continuous monitors. Some of the active monitors can provide data on the range of variation within the test period. Some are designed to detect and deter interference. However, they usually require operation by trained testers and are more costly.

EPA recommends that testing be done in the lowest level of the home suitable for occupancy. This typically represents an area where greatest radon level may occur. Ideally, the test should be conducted in a regularly used room on that level, such as a living room, playroom, den, or bedroom.

Avoid testing in a kitchen, bathroom, laundry room, or hallway. High humidity and drafty conditions can bias results from some test devices.

Do not disturb the devices while they are sampling. Doing so may alter their results, so they should be placed out-of-the-way.

If the lowest occupied level is not used much, consider also testing a higher-use area. This may help you to better estimate your long-term exposure.

Because most indoor radon comes from naturally occurring radon in the soil, high indoor levels are more likely to exist below the third floor. This is why EPA recommends testing all homes below the third floor. In some cases, high radon levels have been found at or above the third floor, due to radon movement through elevators or other air shafts in the building. If you are concerned about this possibility, you may decide to test for radon.

If the result of an initial short-term measurement is below 4 pCi/L, a follow-up test is not necessary. However, since radon levels change over time, you may want to test again sometime in the future, especially if use patterns change and a lower level of the building becomes occupied or used more often. Renovations, changes in ventilation, earthquakes, settling of the ground beneath the building, and other changes may cause indoor radon exposures to change.

EPA recommends a follow-up measurement be used to confirm whether radon levels are high enough to warrant mitigation. There are two types of follow-up measurements that may be conducted. The choice depends, in part, on the results of the initial test.

An initial measurement result of 10 pCi/L or greater should be quickly followed by a second short-term test under closed-building conditions. If the average of the initial and second short-term results is equal to or greater than 4 pCi/L, radon mitigation is recommended. If the average of the short-term test results is less than 4 pCi/L, consider testing again sometime in the future.

If the result of the initial measurement is between 4 pCi/L and 10 pCi/L, the follow-up test may be made with either a short-term or a long-term method. If a long-term follow-up test result is 4 pCi/L or higher, EPA recommends remedial action. If the long-term follow-up test result is less than 4 pCi/L, consider testing again sometime in the future.

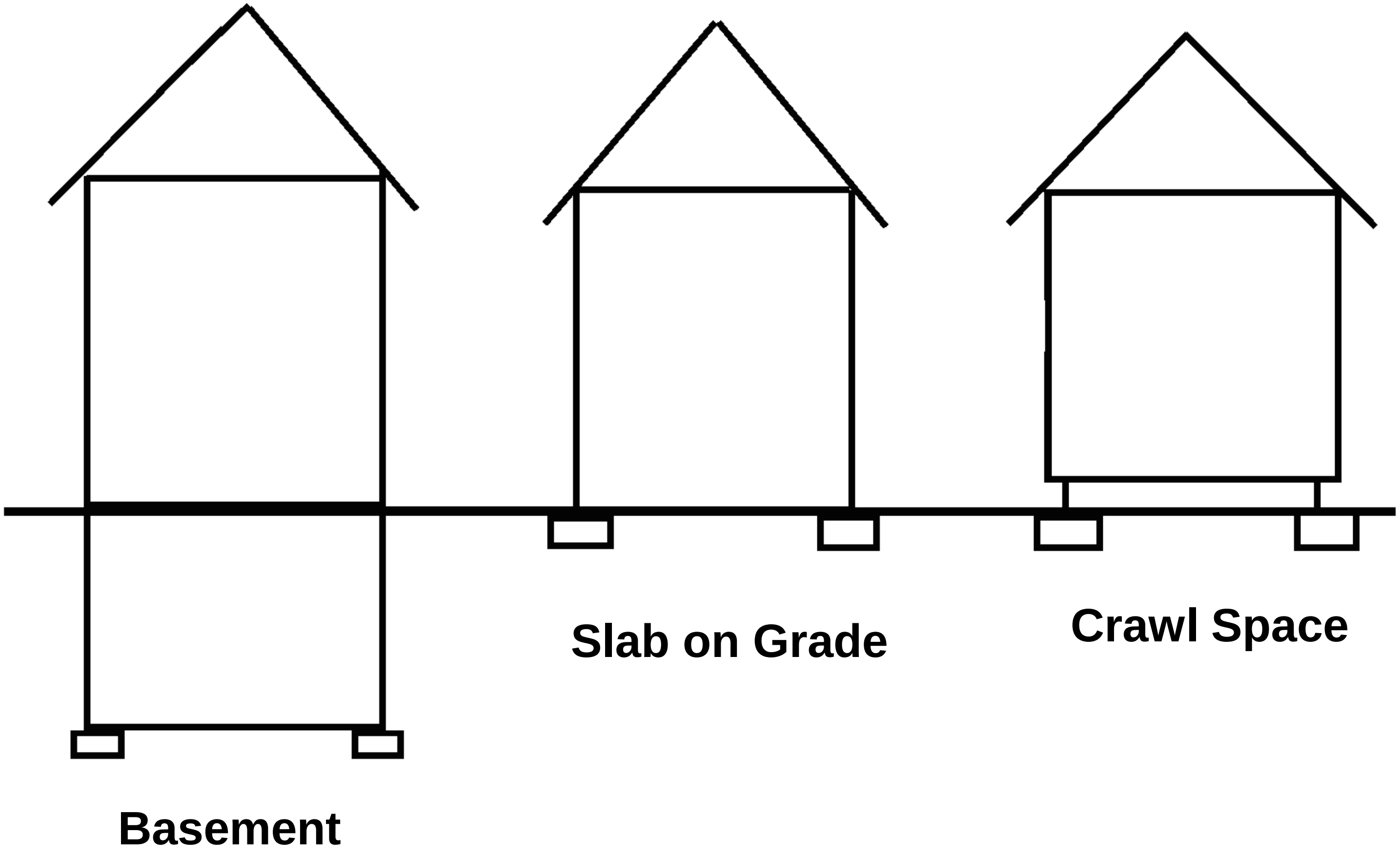
If a short-term follow-up test is done and the result is 4 pCi/L or higher, radon mitigation is recommended. If the average of the initial and follow-up short-term tests is less than 4 pCi/L, consider testing again sometime in the future.

In certain instances, such as may occur when measurements are performed in different seasons or under different weather conditions, the initial and follow-up tests may vary by a considerable amount. Radon levels can vary significantly between seasons, so different values are to be expected.

A radon mitigation system is any system or steps designed to reduce radon concentrations in the indoor air of a building.

Your house type will affect the kind of radon reduction system that will work best. Houses are generally categorized according to their foundation design, for example, basement, slab-on-grade (concrete poured at ground level), or crawlspace (a shallow unfinished space under the first floor).

House Foundation Types



Some houses have more than one foundation design feature. For instance, it is common to have a basement under part of the house and to have a slab-on-grade or crawlspace under the rest of the house. In these situations a combination of radon reduction techniques may be needed to reduce radon levels to below 4 pCi/L.

There are several methods that a contractor can use to lower radon levels in your home. Some techniques prevent radon from entering your home while others reduce radon levels after it has entered.

In many cases, simple systems using underground pipes and an exhaust fan may be used to reduce radon. Such systems are called "sub-slab depressurization," and do not require major changes to your home. These systems remove radon gas from below the concrete floor and the foundation before it can enter the home. Similar systems can also be installed in houses with crawl spaces. Radon contractors use other methods that may also work in your home. The right system depends on the design of your home and other factors.

Short-term Actions

EPA considers the following reduction strategies as only temporary or partial measures, but they can be used in combination with others to reduce radon levels:

- ***Sealing cracks*** and other openings in the foundation to limit the flow of radon into the home (although sealing cracks alone has not been shown to lower radon levels significantly or consistently).
- ***House pressurization*** involves blowing air from upper floors or outside into the lowest level of the house (typically the basement) to prevent radon from entering the house.
- ***Natural ventilation*** reduces radon levels by mixing radon with outside air, but it typically is only a temporary measure because of substantially increased heating and cooling costs.
- A ***heat recovery ventilator*** (HRV or air-to-air heat exchanger) can increase ventilation. This increases heating and cooling costs, too, but not as much as natural ventilation.

Long-term Actions

Several different methods are used to reduce radon levels in homes over the long term.

For houses with a basement or a slab-on-grade foundation, radon levels usually can be reduced with one of the following methods.

- ***Subslab suction*** (or subslab depressurization) is the most common method. Pipes are inserted through the floor slab or below the slab from outside the house into the crushed rock or soil underneath. A fan connected to the pipes draws the radon from below the house and releases it into the outdoor air.

- ***Drain tile suction*** can be used in houses where perforated drain pipes have been installed to direct water away from the foundation, but only when the tiles form a complete loop around the foundation.

- ***Sump hole suction*** can be used in houses with basements and sump pumps. The sump can be capped so that it can continue to drain water and also serve as the location for a radon suction pipe.

- ***Block wall suction*** can be used to remove radon from hollow spaces in basement concrete block walls.

For houses with crawl spaces, the following methods can be used.

- ***Ventilating*** can be done passively (without a fan), or actively (with a fan).

- ***Submembrane depressurization*** involves covering the earth floor with a heavy plastic sheet and using a vent pipe and fan to draw the radon from under the sheet.

The cost of making repairs to reduce radon is influenced by the size and design of your home and other factors. Most homes can be fixed for about the same cost as other common home repairs, like painting or having a new hot water heater installed. The average cost for a contractor to lower radon levels in a home is about $1,200, although this can range from $500 to about $2,500. Your costs may vary depending on the size and design of your home and which radon reduction methods are needed.

New Construction

New homes can be built with radon-resistant features that minimize radon entry routes and allow for easier remediation of problems that may occur later. These features cost less if installed during construction than if added to an existing house, adding an estimated $350 to $500 to the cost of a new home compared to $800 to $2,500 to retrofit an existing home (1991 dollars).

Radon-resistant construction practices fall into three categories:

- ***Sealing entry routes*** is a basic element in radon mitigation and includes many practices similar to those used for controlling moisture and for energy conservation. Vapor barriers, caulks, and foams can seal radon entry routes in foundation and floor areas.
- ***Soil ventilation systems*** are sometimes referred to as soil depressurization or sub-slab depressurization systems. They are used to create a suction on the soil so that radon is removed as a soil gas before it enters the house. Some of these systems use fans (active systems) and some do not (passive systems).
- ***Mechanical house ventilation systems*** may be designed to provide extra outside air dilution or to maintain higher pressure inside the building relative to outside, preventing radon from entering, although less is known about such systems so far.

The techniques vary for different foundations and site requirements, but the basic elements of radon-resistant features are:

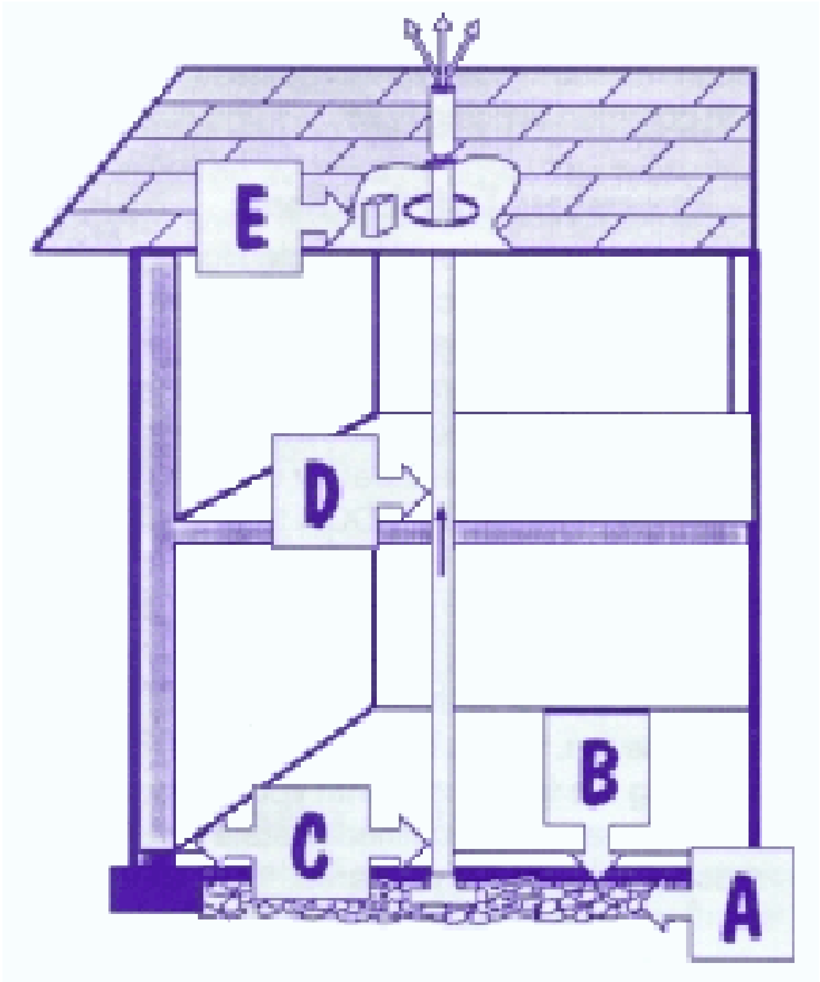
A. Gas Permeable Layer - This layer is placed beneath the slab or flooring system to allow the soil gas to move freely underneath the house. In many cases, the material used is a 4-inch layer of clean gravel.

B. Plastic Sheeting - Plastic sheeting is placed on top of the gas permeable layer and under the slab to help prevent the soil gas from entering the home. In crawlspaces, the sheeting is placed over the crawlspace floor.

C. Sealing and Caulking - All openings in the concrete foundation floor are sealed to reduce soil gas entry into the home.

D. Vent Pipe - A 3- or 4-inch gas-tight or PVC pipe (commonly used for plumbing) runs from the gas permeable layer through the house to the roof to safely vent radon and other soil gases above the house.

E. Junction Box - An electrical junction box is installed in case an electric venting fan is needed later.



If you are planning to make any major structural renovation to an existing home, such as converting an unfinished basement area into a living space, it is important to test the area for radon before you begin the renovation.

If your test results indicate a radon problem, radon-resistant techniques can be inexpensively included as part of the renovation.

Because major renovations can change the level of radon in any home, always test again after work is completed.

If you decide to have a professional test your home, or if mitigation become necessary, you should call your state radon contact.

For More Information

- National Radon Hotline (800) 76707236
- National Radon Helpline (800)557-2366
- Radon Fix-It Helpline (800) 644-6999
- National Safety Council Web site, www.nsc.org/ehc/radon.htm
- Environmental Protection Agency Web site, www.epa.gov/iaq/radon/index.html
- Links to State Radon Office, www.epa.gov/iaq/contacts.html