Radon

Radon (chemical symbol Rn) is a naturally occurring radioactive gas found in soils, rock, and water throughout the U.S. It has numerous different isotopes, but radon-220, and -222 are the most common. Radon causes lung cancer, and is a threat to health because it tends to collect in homes, sometimes to very high concentrations. As a result, radon is the largest source of exposure to naturally occurring radiation.

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The Basics

Who Discovered Radon

The German chemist Friedrich E. Dorn discovered radon-222 in 1900, and called it radium emanation. However, a scarcer isotope, radon-220, was actually observed first, in 1899, by the British scientist, R.B. Owens, and the New Zealand scientist, Ernest Rutherford. The medical community nationwide became aware of the possible extent of a radon problem in 1984. That year a nuclear plant worker in Pennsylvania discovered radioactivity on his clothing while exiting his place of work through the radiation detectors. The source of the radiation was determined to be radon decay products on his clothing originating from his home.

Where does radon come from?

Radon-222 is the decay product of radium-226. Radon-222 and its parent, radium-226, are part of the long decay chain for uranium-238. Since uranium is essentially ubiquitous in the earth's crust, radium-226 and radon-222 are present in almost all rock and all soil and water.

Decay Chains - Uranium Decay
This links provides an illustration of uranium-238 decays through a series of steps to become a stable form of lead.
Uranium
This fact sheet describes the basic properties and uses, and the hazards associated with this radionuclide. It also discusses radiation protection related to it.

What are the properties of radon?

Radon is a noble gas, which means it is essentially inert, and does not combine with other chemicals. Radon is a heavy gas, which accounts for its tendency to collect in basements or other low places in housing. It has no color, odor, or taste. Radon-222 is produced by the decay of radium, has a half-life of 3.8 days, and emits an alpha particle as it decays to polonium-218, and eventually to stable lead. Radon-220, is the decay product of thorium – it is sometimes called thoron, has a half-life of 54.5 seconds and emits an alpha particle in its decay to polonium-216.

Does radon have any practical uses?

Radon has little practical use. Some medical treatments have employed radon in small sealed glass tubes, called seeds, that are specially manufactured to contain the exact amount of radioactivity needed for the application. Radon spas are used extensively in Russia and Central Europe to treat a number of conditions.

Exposure to Radon

How does radon get into the environment?

Radon-222 is the radioactive decay product of radium-226, which is found at low concentrations in almost all rock and soil. Radon is generated in rock and soil, and it creeps through cracks or spaces between particles up to the outside air. Although outdoor concentrations of radon are typically low, about 0.4 picocuries per liter (pCi/l) of air, it can seep into buildings through foundation cracks or openings and build up to much higher concentrations indoors, if the sources are large enough.

The average indoor radon concentration is about 1.3 pCi/l of air. It is not uncommon, though, for indoor radon levels to be found in the range of 5 - 50 pCi/l, and they have been found as high as 2,000 pCi/l. The concentration of radon measured in a house depends on many factors, including the design of the house, local geology and soil conditions, and the weather. Radon's decay products are all metallic solids, and when radon decay occurs in air, the decay products can cling to aerosols and dust, which makes them available for inhalation into the lungs.

Radon easily dissolves in water. In areas of the country that have high radium content in soils and rocks, local ground water may contain high concentrations of radon. For example, underlying rock such as granite, or phosphate rock, typically have increased uranium and radium, and therefore radon. While radon easily dissolves into water, it also easily escapes from water when exposed to the atmosphere, especially if it is stirred or agitated. Consequently, radon concentrations are very low in rivers and lakes, but could still be high in water pumped from the ground. Some natural springs, such as those at Hot Springs, Arkansas, contain radon, and were once considered healthful.

Radon in Water
This site provides informatiom Public Health Standards for Radon in Drinking Water
Radon Home Page
This site provides information about the hazards and management of radon.
EPA Map of Radon Zones
The purpose of this map is to assist National, State, and local organizations to target their resources and to implement radon-resistant building codes.

How does radon change in the environment?

Because radon is a chemically inert (unreactive) gas, it can move easily through rock and soil and arrive at the surface. The half-life of radon-222 is 3.8 days. As it undergoes radioactive decay, radon-222 releases alpha radiation and changes to polonium-218, a short-lived radioactive solid. After several more decay transformations, the series ends at lead-206, which is stable.

Radon dissolves in water, and easily leaves water that is exposed to the atmosphere, especially if the water is agitated. Consequently, radon levels are very low in rivers and lakes, but water drawn from underground can have elevated radon concentrations. Radon that decays in water, leaves only solid decay products which will remain in the water as they decay to stable lead.

How are people exposed to radon?

Most of the public's exposure to natural radiation comes from radon which can be found in homes, schools, and office buildings. EPA estimates that the national average indoor radon level in homes is about 1.3 pCi/l of air. We also estimate that about 1 in 15 homes nationwide have levels at or above the level of 4 pCi/l, the level at which EPA recommends taking action to reduce concentrations. Levels greater than 2,000 pCi/l of air have been measured in some homes.

Radon is also found in the water in homes, in particular, homes that have their own well rather than municipal water. When the water is agitated, as when showering or washing dishes, radon escapes into the air. However, radon from domestic water generally contributes only a small proportion (less than 1%) of the total radon in indoor air in most housing. Municipal water systems hold and treat water, which helps to release radon, so that levels are very low by the time the water reaches our homes. But, people who have private wells, particularly in areas of high radium soil content, may be exposed to higher levels of radon.

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How does radon get into the body?

People may ingest trace amounts of radon with food and water, However, inhalation is the main route of entry into the body for radon and its decay products. Radon decay products may attach to particulates and aerosols in the air we breathe (for example, cooking oil vapors). When they are inhaled, some of these particles are retained in the lungs. Radon decay products also cling to tobacco leaves, which are sticky, during the growing season, and enter the lungs when tobacco is smoked. Smoke in indoor environments also is very effective at picking up radon decay products from the air and making them available for inhalation. It is likely that radon decay products contribute significantly to the risk of lung cancer from cigarette smoke.

What does radon do once it gets into the body?

Most of the radon gas that you inhale is also exhaled. However, some of radon's decay products attach to dusts and aerosols in the air and are then readily deposited in the lungs. Some of these are cleared by the lung's natural defense system, and swallowed or coughed out. Those particles that are retained long enough release radiation damaging surrounding lung tissues. A small amount of radon decay products in the lung are absorbed into the blood.

Most of the radon ingested in water is exhaled in hours. There is some risk from drinking water with elevated radon, because radioactive decay can occur within the body where tissues, such as the stomach lining, would be exposed. However, alpha particles emitted by radon and its decay product in water prior to drinking quickly lose their energy and are taken up by other compounds in water, and do not themselves pose a health concern.

Health Effects of Radon

How can radon affect people's health?

Almost all risk from radon comes from breathing air with radon and its decay products. Radon decay products cause lung cancer. The health risk of ingesting radon, in water for example, is dwarfed by the risk of inhaling radon and its decay products. They occur in indoor air or with tobacco smoke. Alpha radiation directly causes damage to sensitive lung tissue. Most of the radiation dose is not actually from radon itself, though, which is mostly exhaled. It comes from radon's chain of short-lived solid decay products that are inhaled on dust particles and lodge in the airways of the lungs. These radionuclides decay quickly, producing other radionuclides that continue damaging the lung tissue.

There is no safe level of radon--any exposure poses some risk of cancer. In two 1999 reports, the National Academy of Sciences (NAS) concluded after an exhaustive review that radon in indoor air is the second leading cause of lung cancer in the U.S. after cigarette smoking. The NAS estimated that 15,000-22,000 Americans die every year from radon-related lung cancer.

When people who smoke are exposed to radon as well, the risk of developing lung cancer is significantly higher than the risk of smoking alone.

The NAS also estimated that radon in drinking water causes an additional 180 cancer deaths annually. However almost 90% of those projected deaths were from lung cancer from the inhalation of radon released to the indoor air from water, and only about 10% were from cancers of internal organs, mostly stomach cancers, from ingestion of radon in water.

Is there a medical test to determine exposure to radon?

Several decay products can be detected in urine, blood, and lung and bone tissue. However, these tests are not generally available through typical medical facilities. Also, they cannot be used to determine accurate exposure levels, since most radon decay products deliver their dose and decay within a few hours.

The best way to assess exposure to radon is by measuring concentrations of radon (or radon decay products) in the air you breathe at home.

Protecting People from Radon

How do I know if there is radon in my home?

You cannot see, feel, smell, or taste radon. Testing your home is the only way to know if you and your family are at risk from radon. EPA and the Surgeon General recommend testing for radon in all rooms below the third floor. EPA also recommends testing in schools.

The EPA Citizen's Guide to Radon describes commonly available tests for measuring radon concentrations in the home. (See "What is EPA Doing About Radon?".)

Radon testing is inexpensive and easy--it should only take a few minutes of your time. Millions of Americans have already tested their homes for radon. Various low-cost, do-it-yourself test kits are available through the mail and in hardware stores and other retail outlets. You can also hire a trained contractor to do the testing for you.

What can I do to protect myself and my family from radon?

The first step is to test your home for radon, and have it fixed if it is at or above EPA's Action Level of 4 picocuries per liter. You may want to take action if the levels are in the range of 2-4 picocuries per liter. Generally, levels can be brought below 2 pCi/l fairly simply.

The best method for reducing radon in your home will depend on how radon enters your home and the design of your home. For example, sealing cracks in floors and walls may help to reduce radon. There are also systems that remove radon from the crawl space or from beneath the concrete floor or basement slab that are effective at keeping radon from entering your home. These systems are simple and don't require major changes to your home. Other methods may be necessary.

People who have private wells should test their well water to ensure that radon levels meet EPA's newly proposed standard.

Radon in Drinking Water
This page provides information on regulations, studies, and state contacts related to radon in drinking water.
Radon
This page provides access to a wide variety of information and publications on radon and preventing exposure to radon.
National Radon Hotline:
800.767-7236

What recommendations has the federal government made to protect human health from radon?

In 1988, EPA and the U.S. Surgeon General issued a Health Advisory recommending that all homes be tested below the third floor for radon. They also recommended fixing homes with radon levels at or above 4 picocuries per liter (pCi/L), EPA's National Voluntary Action Level. EPA and the Surgeon General also recommend that schools nationwide be tested for radon.

EPA Radon Publications, including:
- EPA's "A Citizen's Guide to Radon
- "Consumer's Guide to Radon Reduction

What is EPA doing about radon?

EPA has established a voluntary program to promote radon awareness, testing, and reduction. The program sets an 'Action Level' of 4 picocuries per liter (pCi/l) of air for indoor radon. The action level is not the maximum safe level for radon in the home. Instead it is the

point at which the cost to the homeowner for fixing the problem (taking action) is warranted by the risk from the radon. However, the lower the level of radon, the better. Generally, levels can be brought below 2 pCi/l fairly simply.

In addition to working with homeowners, EPA is working with home builders and building code organizations. The goals are to help newly constructed homes be more radon resistant and to encourage radon testing when existing homes are sold.

Radon Resistant New Construction
This page provides information on radon resistant homes.
Radon and Real Estate
You will find a number of tools and resources use by the real estate community that EPA and its radon partners has developed.

The 1988 Indoor Radon Abatement Act authorizes EPA to provide grants to states to support testing and reducing radon in homes. With various non-governmental and public health organizations, EPA promotes awareness and reduction of indoor radon. Partners include the American Lung Association, the National Environmental Health Association, the American Society of Home Inspectors, and the National Safety Council. The Radon Publications page provides a list of EPA-sponsored publications in English and Spanish.

EPA has also proposed a standard for the maximum amount of radon that may be found in drinking from community water systems using ground water.

Proposed Radon Rule
to set maximum contaminant levels in drinking water.