EPA Facts about Radon

What is radon?

Radon is a naturally occurring radioactive gas without color, odor, or taste that undergoes radioactive decay and emits ionizing radiation. Radon comes from the natural (radioactive) breakdown of uranium and thorium in soil, rock, and groundwater and is found all over the U.S. The largest fraction of the public's exposure to natural radiation comes from radon, mostly from soil under homes. (There are three forms of radon, but this document refers primarily to radon-222 and its progeny.)

How does radon change in the environment?

The primary source of radon is from uranium in soils and rocks and in groundwater. Over time, uranium decays into radium, which then decays directly into radon. (See EPA Facts about Radium and Uranium.) Uranium is present naturally in all soil, although quantities differ from place to place. Because radon is a gas and chemically unreactive with most materials, it moves easily through very small spaces, such as those between particles of soil and rock, to the soil surface. Radon is also moderately soluble in water, and it can be absorbed by groundwater flowing through rock or sand. Radon undergoes radioactive decay, when it releases ionizing radiation and forms "daughter" elements, known as decay products. It is the release of radiation from this decay process that leads to exposure and health risks from radon.

During the decay process, radiation is released in the form of alpha particles, beta particles, and gamma rays. Alpha particles can travel only short distances and cannot penetrate human skin. However, when inhaled, they can penetrate the cells lining the lungs. Beta particles penetrate skin, but cannot pass through the entire body. Gamma radiation can travel all the way through the body. The health risk associated with each type of radiation is a function of how and what parts of the body are exposed.

The time required for a radioactive substance to lose 50 percent of its radioactivity by decay is known as the half-life. The half-life of uranium-238 is about 4.5 billion years. The half-life of radon is 3.8 days.

How are people exposed to radon?

Outside air typically contains very low levels of radon (about 0.4 picoCuries per liter [pCi/L] of air). But it can build up to higher concentrations in indoor air from soil under foundations of homes, schools, and office buildings, where it can seep into buildings. EPA estimates that the national average annual indoor radon level in homes is about 1.3 pCi/L of air. However, more than 6 percent of all homes nationwide have elevated levels at or above EPA's voluntary action level of 4 pCi/L. Levels greater than 2,000 pCi/L of air have been measured in some homes.

Although radon in indoor air from soil gas typically accounts for the bulk of the total radon risk to individuals, people may also be exposed to radon and its daughters through use of

drinking water from groundwater that contains radon. Radon gas escapes from the water and goes into the air when water that contains radon is used in the home for showering, washing dishes, and cooking. Radon in domestic water generally contributes only a small proportion (about 1 to 2 percent) of the total radon in indoor air. Radon levels in air and groundwater will generally be higher in areas of the country with rock types that contain high amounts of uranium and radium, such as phosphate or granite.

How does radon get into the body?

Radon and its radioactive daughters can enter the body through inhalation and ingestion. Inhaling radon is the main route of entry into the body, with most of the radon being exhaled again. However, some radon and its daughter products will remain in the lungs, where radiation released during the decay process passes into the lung tissues, causing damage. Radon is also produced in the body from parent radium deposited in the body.

Is there a medical test to determine exposure to radon?

Radon in human tissue is not detectable by routine medical testing. However, several of its decay products can be detected in urine, in lung and bone tissue, and by breath tests. These tests, however, are not generally available to the public. They are also of limited value since they cannot be used to determine accurately how much radon a person was exposed to, nor can these tests be used to predict whether a person will develop harmful health effects.

How can radon affect people's health?

Exposure to radon and its daughters increases the chance that a person will develop lung cancer. The increased risk of lung cancer from radon primarily results from alpha particles irradiating lung tissues. Most of the damage is not from radon gas itself, which is removed from the lungs by exhalation, but from radon's short-lived decay products (half-life measured in minutes or less). When inhaled, these decay products may be deposited in the airways of the lungs, especially if attached to dust particles, and subsequently emit alpha particles as they decay further, resulting in damage to cells lining the airways.

Radon is considered a known human carcinogen based on extensive studies of exposure to human beings. In two 1999 reports, the National Academy of Sciences (NAS) concluded that radon in indoor air is the second leading cause of lung cancer in the U.S. after cigarette smoking. The NAS estimated that the annual number of radon-related lung cancer deaths in the U.S., is about 15,000 to 22,000. NAS also estimated that radon in drinking water causes about 180 cancer deaths each year in the United States. Approximately 89 percent of these cancer deaths are caused by lung cancer from inhalation of radon released to indoor air from the water, and about 11 percent are a result of cancers of internal organs, mostly stomach cancers, from ingestion of radon in water.

What recommendations has the U.S. Environmental Protection Agency made to protect human health?

Please note that the information in this section is limited to recommendations EPA has made to protect human health from exposure to radon. General recommendations EPA has made to protect human health at Superfund sites (the 10^{-4} to 10^{-6} cancer risk range), which cover all radionuclides including radon, are summarized in the fact sheet "Primer on Radionuclides Commonly Found at Superfund Sites."

EPA has established a limitation to exposure to radon-222 and radon-220 decay products of less than 0.02 Working Levels (WL) for uranium mill tailings sites, where radon poses the major health threat. These regulations under 40 Code of Federal Regulations (CFR) Part 192.12(b) are often Applicable or Relevant and Appropriate Requirements (ARARs) at Superfund sites with either radium- or thorium-contaminated soil.

In 1988, EPA and the U.S. Surgeon General issued a health advisory recommending that all homes below the third floor be tested for radon and fixed if the radon level is at or above 4 pCi/L, EPA's national voluntary action level. EPA and the Surgeon General also recommend that schools nationwide be tested for radon. (Exposure to 5 pCi/L of radon-222, or 7.5 pCi/L of radon-220, corresponds to an approximate annual average exposure of 0.02 WL for radon decay products in the home.) For more details, see EPA's "A Citizen's Guide to Radon," September 1994, USEPA #402-K92-001, and "Consumer's Guide to Radon Reduction," August 1992, USEPA 402-K92-003. For copies, contact the National Radon Hotline (800) 767-7236 or EPA's web site http://www.epa.gov/iaq/pubs/index.html.

There is currently a proposed Maximum Contaminant Level (MCL) for radon in drinking water from community water systems using groundwater. The Safe Drinking Water Act directs EPA to set both an MCL for radon in drinking water, as well a higher alternative maximum contaminant level accompanied by a multimedia mitigation program to address radon risks in indoor air. This approach reflects radon's unique characteristics: that radon released to indoor air from soil under homes and buildings in most cases is the main source of exposure, with radon released from tap water being a much smaller source of radon exposure. For more information, contact the Safe Drinking Water Hotline at (800) 426-4791 or visit EPA's web site at http://water.epa.gov/drink/index.cfm.

For more information about how EPA addresses radon at Superfund sites

Contact Stuart Walker of EPA:
(703) 603-8748 or walker.stuart@epa.gov,
or visit EPA's Superfund Radiation Webpage:
http://www.epa.gov/superfund/resources/radiation/