Physical Agents

Radon in Buildings

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What is radon?

Radon is an invisible, odourless, tasteless, radioactive gas. It is formed by the disintegration of radium, which is a decay product of uranium. Radon emits alpha particles and produces several solid radioactive products called radon daughters or "progeny".

Some amounts of radon gas and radon progeny are present everywhere in the soil, water, and air. Particularly high radon levels occur in regions where the soil or rock is rich in uranium. Radon is emitted by radium in the ground, groundwater and building materials. It can enter the indoor air where it and its decay products accumulate in poorly ventilated areas. Harmful levels of radon and radon progeny can accumulate in spaces with minimal ventilation, such as basements and crawl spaces.

Radon progeny are inhaled with air and deposit in the lungs. The lung absorbs alpha particles emitted by the radon progeny. The resulting radiation dose increases the risk of lung cancer.

What are the health effects of radon?

Radon is classified by International Agency for Research on Cancer (IARC) as Group 1, carcinogenic to humans. Inhaling radon progeny increases the risk of lung cancer. The link between the concentration of radon progeny in the air and the risk of lung cancer was first based on data from a study of lung cancer mortality among uranium miners and other workers exposed to very high levels of radon progeny.

Radon exposure and smoking together significantly increase the risk of lung cancer over radon exposure alone.

What do uranium and radon have in common?

Figure 1 illustrates the radioactive decay chain that produces radon and radon progeny.

Figure 1--Production of radon and radon progeny from uranium

Each radioactive isotope decays at a unique rate described as the half-life of that isotope. This term refers to the time required for half the atoms of a radioactive substance to disintegrate. Radon's half-life is 3.8 days. This time means that, in the absence of its parent radium, the intensity of alpha particles from a given sample of radon will decrease by one-half in 3.8 days; to half the remainder (i.e., one-quarter of the original) in another 3.8 days; to an eighth in another 3.8 days; and so on. However, this decay does not happen indoors because as old radon decays new radon continuously comes out from the decaying radium present in the ground and walls.

Radon progeny have very short half-lives ranging from a fraction of a second to 27 minutes. As a result, radon progeny are present in significant quantities only as long as radon is present. If all the radon gas is removed, the radioactivity of radon progeny will fade away quickly.

What are the units of measuring radon levels?

The concentration of radon in the air is measured in units of picocuries per litre (pCi/L) or becquerels per cubic meter (Bq/m^3). One Bq corresponds to one disintegration per second. One pCi/L is equivalent to 37 Bq/m^3.

The concentration of radon progeny is measured in units of working level (WL) which is a measure of the potential alpha particles energy per litre of air. One WL of radon progeny corresponds to approximately 200 pCi/L of radon in a typical indoor environment. However, the relative concentration of radon and radon progeny may vary from one building to another. In the extreme case, 1 WL corresponds to 100 pCi/L of radon. This situation is called full equilibrium and is extremely unlikely to occur. Occupational exposure to radon progeny is expressed in working level months (WLM) and a working level month is equivalent to the exposure at an average concentration of 1 WL for 170 working hours. Measurement data are reported in either of the above units. For making comparisons between the data from different sources, the following conversion chart may be useful:

> 1 pCi/L = 37 Bq/m^3

> 1 m^3 = 1000 L

> 0.01 WL = 74 Bq/m^3 = 2 pCi/L

> 0.02 WL = 148 Bq/m^3 = 4 pCi/L

> 0.1 WL = 800 Bq/m^3 = 20 pCi/L

The document Quantities and Units of Ionizing Radiation provides more details on the units of ionizing radiation.

How does radon enter buildings?

Radium in the soil directly under a building is normally the major source of indoor radon. Less important sources of radium are groundwater and building materials.

The presence of uranium in soil and rock is an important indicator of places where radium and radon can be present. Because radon is a gas, a fraction of the radon produced in the soil can find its way into a building. The rest is trapped in the soil. In the air, radon decays to radon progeny that are solids, and are present in the building air as fine particles.

The concentration of radon and radon progeny in the indoor air depends on:

- the amount of radium in the soil and

- the ease with which the radon it produces can move through soil and building walls where it can then mix with the room air.

Because radon is a gas, changes in the atmospheric pressure also affect its emission from the ground and its accumulation in the building air.

The concrete floor and walls in the basement slow down the movement of radon from the soil into the building. However, cracks in the floor, wall slab joints, and the drainage system allow radon to enter a building.

Indoor radon concentrations are almost always higher than outdoor concentrations. Once inside a building, the radon cannot easily escape. The sealing of buildings to conserve energy reduces the intake of outside air and worsens the situation. Radon levels are generally highest in cellars and basements because these areas are nearest to the source and are usually poorly ventilated.

What workplaces are at risk of radon exposure?

Exposure to radon can happen in a variety of workplaces and industries, including:

- underground mines
- tunnelling and underground workings
- oil and gas production
- water treatment plants
- fertilizer manufacturing
- fish hatcheries
- metal recycling facilities

What are the exposure limits for indoor radon?

There are several sources of exposure limits to note.

The Canadian Nuclear Safety Commission (CNSC) sets two types of radiation exposure limits. One is for occupationally exposed persons as defined by the *Nuclear Safety and Control Act* as a nuclear energy worker, which “means a person who is required, in the course of the person’s business or occupation in connection with a nuclear substance or nuclear facility, to perform duties in such circumstances that there is a reasonable probability that the person may receive a dose of radiation that is greater than the prescribed limit for the general public”. The occupational exposure limit is an effective dose of 50 mSv (milli-Sievert) for a one-year dosimetry period and an effective dose of 100 mSv for a five-year dosimetry period. This limit means over 5 years, the annual average effective dose limit is 20 mSv, and exposure cannot exceed 50 mSv in a single year. The limit for pregnant workers, once the pregnancy has been declared, is 4 mSv for the remainder of the pregnancy. The annual exposure limit t for the general public is an effective dose of 1 mSv. Thesevalues are found in the *Radiation Protection Regulations* (SOR/2000-203, Section 13(1)).

Some occupational health and safety jurisdictions have adopted values for workers (in general) or for workers in a specific industry (e.g., underground mines, mines and mining plants). The Carex Canada summary document on Radon lists these values. You can also contact your local occupational health and safety jurisdiction to determine what values may apply in your situation.

Although there is currently no regulation that governs an acceptable level of radon in Canadian homes, Health Canada, in partnership with the provinces and territories, has developed a guideline.

Acceptable levels of radon in "dwellings" which includes homes or public buildings (schools, hospitals, long term care facilities and correctional facilities) is 200 Becquerels per cubic metre (200 B/m^3) based on the Government of Canada Radon Guideline.

What do we know about indoor radon levels?

Indoor concentrations of radon vary across the country but are usually greatest in areas with higher levels of uranium in the underlying rock and soil. Radon can be found in nearly all homes in Canada.

The only way to know for sure if your home or workplace has levels of radon higher than the guidelines is to conduct testing in each home or workplace of concern.

How are radon levels detected?

Indoor radon levels are measured by air sampling and by alpha dosimetry using radon track etch dosimeters. A number of companies manufacture and sell measuring instruments.

Since radon levels vary greatly from day to day, Health Canada recommends long-term sampling (at least 3 months) to get a more accurate reading.

Testing can be done by professionals or by using testing kits that can be purchased online or from some home improvement stores. To get accurate values, be sure to follow the testing kit's instructions carefully.

What can I do to reduce indoor radon levels?

In many cases, a method called sub-slab depressurization is used. A pipe is installed through the basement sub-flooring that leads to an outside wall or to the roof. A small fan draws the radon from below the house and exhausts the radon before it can enter the home. Other methods include to increase ventilation, or to seal major entry routes into the home. Effectiveness of each method will depend on how high the radon levels are, and the characteristics of each home.

Health Canada refers to the Canadian National Radon Proficiency Program (C-NRPP) for a list of certified service providers who can help reduce the level of radon in your home.

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