

Radiation Data, Inc.

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# Radon Measurement Technician

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Review for Continuing  
Education Exam

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## Recap of the Basic Physics of Radon

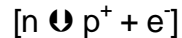
- 1) The basic constituents of atoms and nuclei are:

### Protons, Neutrons, Electrons

**Protons** and **neutrons** are very heavy compared with electrons.

**Protons** have +1 electric charge and mass about 1800 times that of the **electron**.

**Neutrons** have zero electric charge, and mass slightly heavier than the **protons**. The mass of the **neutron** is enough heavier than the **proton** to allow a **neutron** to decay into a **proton** plus an **electron**:



**Electrons** are very light and have  $-1$  electric charge.

The **atomic number** ("Z") equals the number of **protons** inside the nucleus.

The **atomic mass** ("A") equals the number of **protons + neutrons** inside the nucleus.

In an electrically neutral atom, the number of **electrons** equals the number of **protons**.

If an atom is missing one **electron**, it has a net electrostatic charge of +1 and is said to be "ionized."

- 2) Radioactive Decay:

**Alpha Decay.** In this process, the nucleus loses (2 protons + 2 neutrons) which equals one "alpha" particle. The resulting decay product (or "progeny") has atomic number ("Z"), that is, -2 relative to the parent nucleus. The decay product has atomic mass ("A"), that is  $-4$  relative to the parent nucleus. Alpha particles coming from the parent nucleus are very high-energy, typically with 5 MeV of energy. Alpha particles are identical to He-4 nuclei. Alpha particles are heavy, doubly charged (+2), and high-energy. As a result, they are very damaging to whatever they strike. This is especially true if they strike lung tissue.

**Beta Decay:** In this process, the parent nucleus spontaneously emits a "beta" particle, which is identical to the electron. This decay process does not change the atomic mass ("A") of the nucleus, but it does change the electrical charge of the nucleus. "Charge conservation" requires that the single negative charge of the emitted (beta) particle must be compensated by a single +1 increase in the charge of the resulting nucleus. In terms of "A" and "Z," beta decay leaves A unchanged, but Z is

is increased by 1. Beta particles are not nearly as damaging as alpha particles. They are lighter, with lower energy (less than 2 MeV) and singly-ionized.

**Gamma Decay:** Gamma rays are electromagnetic radiation. In nuclear physics, they are treated as particles, not waves. The particles are called “photons.” They are similar to x-rays in that they have no mass and no charge. They are just packets of electromagnetic energy.

X-rays and gamma rays are similar, except for their origins. X-rays come from electron transitions in the orbital electrons surrounding the nucleus. Their energies range from very low (a few hundred electron-volts or so) to 80 KeV or so for heavy elements in the periodic table. Higher energy x-rays can be produced in nuclear labs with electron-accelerators. Gamma rays come from nuclei, and have energies from a low of 14 KeV up to a high of 10 MeV. Gamma ray energies correspond to the energy levels of the parent nucleus. Because gamma rays have no charge and no mass, they are much less damaging than alpha particles. Their damage rates are similar to those of beta particles.

3) Glossary:

**Electron, Proton, Neutron:** defined above.

**Nucleon:** This is a general term covering proton and neutron.

**Beta particle:** An electron created and emitted by a nucleus.

**Alpha particle:** A group of 4 nucleons: 2 protons and 2 neutrons, emitted by a nucleus.

**Isotope:** A specific atomic-mass form of a chemical element. Uranium-238 is one of the “isotopes” of the element uranium. Uranium-235 is another isotope of uranium.

**Nuclide:** Same as “isotope” above.

**Photon:** A particle of electromagnetic radiation. It can be a particle of light, infrared, ultraviolet, or an x-ray or gamma ray particle.

**Radioactive decay:** The natural process by which one element decays into another element (or isotope) by the emission of alpha, beta or gamma rays.

**Half life:** The time during which exactly half of any radioactive species will decay away.

**Radiation dosage:** The quantitative measure describing the effect of radiation on whatever it strikes. The units are in Roentgen, RAD, and REM. Roentgens are used to measure dosage in gases (including air). RADs are for dosage to liquids and solids, including people. REMs are RADs corrected for the effectiveness of various forms of radiation. Alphas are 20 times as damaging as betas or gammas.

**Radioactivity:** A term having two meanings. The dictionary meaning is simply the process of radioactive decay. The scientific meaning is quantitative: “How much radioactivity is in a particular sample?” is a question to be answered quantitatively.

The unit of radioactivity is the Curie, and it specifies how many radioactive decays per second occur in the sample.

**Curie:** The Curie (“Ci”) is equal to  $3.7 \times 10^{10}$  disintegrations per second.

**Microcurie:** One millionth of a Curie.

**Picocurie:** One millionth of a microcurie.

**Concentration:** The concentration of radon in air is measured in picocuries per liter (“pCi/l”).

4) How Radon-222 is created—the decay of U-238

Uranium-238 is the principal isotope (about 95% natural abundance) of the element uranium. U-238 decays according to this:

U-238 → Th-234 → Pa-234 → U-234 → Th-230 → Ra-226 → Rn-222 → Po-218 → Pb-214 → Bi-214 → Po-214 → Pb-210

Details of the decay of Radon-222:

Ra-226

☺ Alpha, 1600 years

Rn<sup>222</sup>

☺ Alpha, 3.8 days

Po<sup>218</sup>

☺ Alpha, 3 minutes

Pb<sup>214</sup>

↻

Bi<sup>214</sup>

↻

Po<sup>214</sup>

Beta/Gamma

Beta/Gamma

☺

Alpha 0.1 millisecc

Pb<sup>210</sup>

5) Measuring radon and radon progeny:

Radon gas is measured in picocuries per liter (“pCi/l”).

Radon progeny are measured in what is called Working Level (“WL”). The physical definition of 1 WL is 130,000 MeV per liter of air.

6) Secular equilibrium:

Since radon has a much longer half-life than any of its progeny, it is possible to have what is called secular equilibrium between radon and its decay products. In secular equilibrium, the concentration of radon and its progeny are fixed. Their ratio is determined by the physics of their respective half-lives.

In practice, we never have perfect secular equilibrium. The decay products escape before they die naturally during radon’s 3.8 day half-life. The result: The actual concentration of decay products is lower than theory would predict. In practice, the

assumption is that the equilibrium ratio is 50%. In other words, the concentration is assumed to be half of what the physics of the decay scheme would predict.

## Further Review

Please refer to the NJDEP Study Guide for the remaining items.

- 8) Methods of measuring Radon Gas (pages 13 – 18)  
  
Activated charcoal canisters  
Alpha Track detectors  
Electric Ionization Chambers (“E-Perms”)  
Continuous radon monitors  
Radon gas grab-samplers
- 9) Methods of measuring Radon Progeny (page 18 and EPA Protocols)  
  
RPISUs  
Continuous working level monitors  
WL grab samplers (Kusnetz method)
- 10) The mathematical relationship between pCi/l, WL and Equilibrium Ratio (page 26)
- 11) Radon in water (pages 9-10)  
  
General Discussion  
Removal Methods

## Miscellaneous Topics

See the attachment for a detailed discussion.

- 12) Sources of radon: Radon in various geologies
- 13) How radon gets into the home: Three factors affect indoor radon concentration.
- 14) Radon mitigation methods:  
  
What are the means of entry and how to affect them  
Sealing and sub-slab depressurization
- 15) Radon measurement according to EPA Protocols (refer to EPA 402-R-92-004)  
  
Where to place tests  
Where not to place them  
When to place tests  
When not to place them

- 16) Rules by NJDEP
- Who may deploy test kits
  - Who may retrieve them
  - Who may not deploy or retrieve tests
  - Who may receive test reports
  - Who must receive them
  - Who may not receive them
- 17) How to deal with closed house conditions
- If windows are open upon deployment
  - If windows are open upon retrieval
- 18) Tampering
- Tampering is a risk with any short-term measurement
  - Ways to detect signs of tampering
  - Ways possibly to counter tampering or to detect it
  - Warning the buyer of the risks
- 19) Fluctuations in readings
- Weather conditions affect readings
  - Statistical fluctuations
- 20) The NJ statute licensing home inspectors
- Excerpts from the 1998 statute
  - Current status of the statute

## References

This course requires the you have a copy of the NJ Study Guide and the EPA Protocols. These publications are provided to all students who take the Radiation Data 2-day course. Radiation Data can provide copies for a small fee if you have lost yours.

## Attachment A. Discussion Points

The numbers below refer to paragraph numbers in the text.

**Para 12:** Radon in geological formations.

Radon-222 comes from the radioactive decay of Radium-226. That element is present in most geological formations as a radioactive decay product of Uranium-238. Radium-226 has a half-life of 1600 years. Radon-222 has a half-life of only 3.8 days, so it is important that there be a relatively easy (short and quick) path for it to reach the basement before it decays. In simple terms, Ra-226 must be located within “easy commuting distance” of the basement in order for Rn-222 to be able to get there.

It is of historical interest to note that Ra-226 was discovered by Mme. Curie, and the unit of radioactivity, the “curie” ( $3.7 \times 10^{10}$  disintegrations per second) happens to be the activity contained in 1.0 gram of Ra-226.

Almost all geological formations can contain Ra-226, and therefore generate radon gas. Among the list of possible sources are clay and shale (especially the black-color variety), sand, sandstone, dolomite, limestone, marble, and granite. The formations unlikely to contain Ra-226 include lava and diatomite.

**Para 13:** Radon gets into the home through openings in the foundation and floor. The three factors affecting indoor radon concentration are: the concentration of radon in the soil gas, the driving force (i.e., the pressure differential between the soil gas and the basement air), and the impedance (the number and size of cracks in foundation and floor, and the concrete porosity).

**Para 14:** The main method used for radon mitigation consists of sealing all obvious openings, and installing a sub-slab depressurization system.

**Para 15:** Placements must be done according to EPA Protocols.

Placed in the lowest livable level.

Not in direct drafts, near sources of heat, nor near exterior walls or windows or doors.

Not in kitchens, bathrooms or laundry rooms.

Do not place during periods of extreme weather, nor if extreme weather conditions are predicted.

**Para 16:** Who?

Kits may be placed only by licensed measurement professionals or by homeowners.

Kits may NOT be placed by unlicensed persons, including buyers or realtors.

Homeowners are not permitted to retrieve kits and mail them if the test was contracted by the buyer and the kits were placed by a certified radon professional.

Reports may only be sent to the owner and to the buyer if he or she paid for the test.

**Para 17: Closed House Conditions:**

If the house is not closed at the time of placement, the test may proceed, but only if the house is closed at the time, and the testing period is extended to a minimum of 4 days.

If the house is open at the time of retrieval, the condition must be reported to the owner if available, and in writing on the chain of custody form sent to the lab. In such cases, the Measurement Specialist will determine whether to issue an “estimate only” assay report or to reject the test outright.

**Para 18: Tampering**

Sellers often do things to lower the radon readings, and it is almost impossible to detect. Tamper-resistant things like breakable window-seals, etc., can be used, but they can always be easily circumvented. There is a great risk in using anti-tampering devices if it lulls the buyer into believing that the short-term test is certified. It is not, and the buyer should be warned.

Tricks to detect or foil tampering:

- Tell the seller that you will return to retrieve the test on Friday, but show up a day early.
- Cruise by the home several times during the test to look for open windows.
- Place a second test kit not in plain sight.

**Para 19: Fluctuations in readings**

All short-term radon tests are subject to fluctuations on account of varying weather conditions.

Low barometric pressure increases the “driving force” thereby increasing the radon concentration in the basement. Conversely, high pressure leads to lower radon levels.

Protracted rain or freezing can obstruct the flow of radon into the outdoors and increase the indoor levels. Such conditions can lead to anomalies in the concentrations, both high and low readings.

**Para 20:** A summary of the home inspector licensing statute is shown on the page following this paragraph.