THORON GAS MEASUREMENTS

By Bill Brodhead
www.wpb-radon.com
wmbrodhead@hotmail.com

Elements are defined by both the atomic mass which is the total number of protons and neutrons in the nuclei (center of the atom) and by the atomic number which is the total of just the protons in the nuclei. The atomic number (# of protons) actual determines the atoms name (radon, polonium, bismuth etc). Atoms with the same proton number but different total mass numbers because of varying numbers of neutrons are consider isotopes (kind of like a cousin). Radon actually has two naturally occurring isotopes – radon (Rn222) and thoron (Rn220). Both have 86 protons but they have different numbers of neutrons which gives them different atomic mass numbers. The parent isotope for thoron is Th232, a primordial element which is widely spread in soils and rocks and has a half-life of 14.1 billion years This half life is a lot longer than the parent of radon which is uranium 238 with a half life of 4.5 billion years. See the chart below for the decay chain of thoron and the decay chain of radon at the end of this paper.

Decay Chain of Thorium 220

Element &Mass Number	Atomic Number	Emitted Radiation	Half Life
Thorium 232	90	α, γ	4.5 billion yrs
Radium 224	88	α	3.62 days
Thoron/Radon	86	α	55.6 seconds
Polonium 216	84	α	0.15 seconds
Lead 212	82	β, γ	10.6 hours
Bismuth 212	83	β, γ	60.6 minutes
Polonium 212	84	α	300 nano seconds
Lead 208	82		stable

α = alpha emission β = beta emission γ = gamma emission

Note that thoron itself has only a 55.6 second half life compared to radon's 3.825 days. Thoron like radon is also a noble gas, which means it is a free agent in the soil and can easily move out of the soil into our homes. The difference however is while radon has plenty of time to meander up through the soil once it is produced by radium's decay in the soil; thoron has literally a few minutes to make it. When thoron decays it becomes a solid reactive particle that will easily cling to dirt in the soil or dust in the air. The first decay product of thoron, polonium 216, has a fairly long half life of 10.6 hours so it is likely to be breathed into the lungs if it is air borne. But because of its long half life compared to radon decay product half life the lungs may be able to push it back out before it decays. These two factors of not having enough time to get out of the soil and into a home and the long decay life of the first decay product has generally placed thoron in the low risk category for inducing lung cancer.

There is some potential of over-estimating the amount of radon(Rn222) in a measurement by inadvertently including the decays from thoron (Rn220) and its decay products. Radon sniffing diagnostic measurements taken close to a radon entry route with a scintillation cell detector are particularly sensitive to this problem. In my research projects in New Jersey and Pennsylvania I have on numerous occasions found that there is predominately thoron in the soil and in the stone wall foundations. Many times the thoron concentration is over 90% of the measured radioactivity. This can be easily determined with a scintillation type detector and a decay counting interval of 60 seconds. Since thoron has a 55 second half life, a sample of air drawn directly from a radon exhaust pipe or from the soil or close to a stone foundation will have increasing decay activity until the pump for the monitor is turned off. At that time the sample trapped inside the cell will have rapidly falling decay counts if there is thoron in the sample or slightly increasing counts if the sample contains only radon.

In general it is thought that passive radon detectors and passive radon continuous monitors will not be affected by thoron concentrations in the room because of the transit time into the passive detector chamber. If there are significant concentrations of thoron in the room there can be small influences that could cause the detector to overestimate the radon concentration. The E-Perm technology

http://www.radelec.com/

has a thoron measuring methodology that uses an E-Perm chamber with large paper filtered openings into the chamber to allow quick movement of radon and thoron into the chamber. Standard E-Perm chambers are exposed at the same time. The difference between the two detector measurements determines the thoron concentration at the measurement location.

Keep in mind that measurements of thoron will vary over short distances. Radon's longer 3.8 day half life allows it to spread uniformly around a basement so that the radon detector placement location is not that critical. Thoron detector placement is very critical because of its 55 second half life.

Monitors that measure radon decay products (measured in the United States in units of working level - WL) will collect both radon decay products and thoron decay products on the filter. The long lived thoron decay products in the air (polonium 216 - 10.6 hours and lead 212 - 60.6 minute half life) will cause working level continuous monitors to read higher. A continuous working level monitors manufacturered by Eberline and used in the 1990's had a built-in correction for subtracting the thoron decay products and listing the percentage that was collected. This correction was made by measuring the decay activity for an additional four hours after the pump had turned off at the end of the measurement period. Unfortunately most of these monitors are no longer available for measurements to determine thoron's presence in the air.

The Pylon AB5 continuous radon monitor, http://www.pylonelectronics.com/index.html, has an available attachment for measuring radon decay products. This attachment could be used to make a 10 minute grab sample and then measure the activity on the filter after the radon decay products have mostly decayed away.

As you can see making an accurate thoron or thoron decay product measurement is not easily done. Determining the health risk from this exposure is also difficult but fortunately it is generally considered a very small risk compared to radon because it is unlikely that much thoron will make it to the primary living areas.

Decay Chain of Radon 222

Element &Mass Number	**Atomic Number**	**Emitted Radiation**	**Half Life**
Uranium 238	92	α, γ	4.5 billion yrs
Thorium 234	90	β, γ	24.1 days
Protactinium 234	91	β, γ	1.14 min
Uranium 234	92	α, γ	248,000 yrs
Thorium 230	90	α, γ	80,000 yrs
Radium 226	88	α, γ	1,620 yrs
Radon 222	86	α	3.825 days
Polonium 218	84	α	3.05 min
Lead 214	82	β, γ	26.8 min
Bismuth 214	83	β, γ	19.7 min
Polonium 214	84	α	0.0016 sec
Lead 210	82	β, γ	25 yrs
Bismuth 210	83	β	4.85 days
Polonium 210	84	α, γ	138 days
Lead 206	82	none	Stable