CONSTRUCTION AND TESTING OF A SIMPLE RADON CHAMBER

Lyle Rathbun
Rathbun.L.C@gmail.com

Abstract

Radon chambers of various sizes and design complexities are used to check the calibration of radon detectors and to study the plate-out of ^{218}Po, (the only one of the radon progeny that is formed as a airborne charged particle and therefore is attracted to surrounding surfaces). If an inexpensive and reliable radon chamber can be shown to be viable for use as supplemental check of radon detector performance, the Quality Assurance program can be enhanced without additional shipping and laboratory costs. The first 300-liter chamber was constructed on a concrete floor with ordinary house bricks and heavy plastic sheeting. Several small slabs of granite and a rock chip containing radium ore were added to enhance the radon level above that provided by the other materials. The intent was to create a consistent radon concentration of 6-10 pCi/L. Due to inconsistencies with the first chamber, a second 300-liter chamber with constructed in a more suitable location and isolated from the concrete floor. The chamber was opened approximately once every seven days to remove electret radon measurement devices and a pocket-sized digital radon monitor (alpha spectrometer). However, one test lasted eight days and another 14 days. Temperature and barometric pressure were recorded. This presentation reports the results for several test periods of the second radon chamber.

Introduction

Radon chambers of various sizes and design complexities have been constructed and tested by several researchers: (Moore, 2005), (Webster, 1992), (George 1983). The radon chamber described here is of a simpler design and relies on natural sources of radon.

Procedure

Two radon chambers were constructed. Each enclosed a 300 liter volume and were constructed in similar fashion: Red clay house bricks (8-in. x 2.25-in. x 4-in)., containing an estimated 1.4 pCi/g of ^{226}Ra each, were stacked to outline a rectangular pattern on a concrete floor and covered with a clear 0.003 in.-thick plastic sheeting material. In the first chamber, the concrete floor was open to the chamber. The plastic sheeting was held against the floor only by the weight of the bricks. The overlaps of the sheeting were not sealed. In the second chamber, bricks were completely enclosed by the plastic sheeting.

The initial sources of radon for the first chamber included the concrete floor (radium content unknown), the clay bricks, and four granite slabs, ¾-in. thick and totaling 1.2 kg with an estimated ^{226}Ra content of 27 pCi/g. When this arrangement failed to produce a radon concentration in the 6-10 pCi/L range, an irregularly-shaped baseball-size, pre-Cambrian metamorphic rock containing uranophane, secondary copper minerals and native silver was added to the chamber. The mass of the rock was 382 g. The uranium content of the rock was estimated at 0.05% $U_{3}0_{8}$ with ^{226}Ra in long-term equilibrium with natural uranium. The radon concentration increased to over 50 pCi/L in less than one day following insertion of the radium ore rock into the chamber. The rock was then removed and a 1-in^2 x 1/4 in-thick chip of the rock was broken off and placed back into the chamber. The radon concentration fell to approximately 10 pCi/L after one week.

When several four-days tests yielded variable results, the first chamber location was abandoned. The bricks, granite and rock chip, along with a new, larger plastic sheet were moved to the garage. The plastic sheeting was placed on the floor and the chamber was built atop it in the same pattern as the initial effort. The loose ends of the sheeting material were pulled tight over the brick "castle," twisted and tied near one end of the chamber. Additional bricks were placed on the plastic atop the bricks forming the outline of the chamber, Figure (1). The radon chamber did not contain an airlock. The tied end (horsetail) had to be loosened to insert and remove measurement devices.

Figure (1): Radon chamber

Methodology

The radon in the chamber was measured with several devices. A pocket-sized digital radon monitor (alpha spectrometer) was placed in the chamber and left there for most of the total three-month testing period. It was calibrated by the manufacturer in March of 2016. The display, which indicated radon concentrations for one day, seven-day, and long term periods, was read through the plastic top of the chamber. Results for the long-term readouts are shown in Figure (2).

An alpha track device was placed in the chamber for a two-month period, removed and sent in for analysis. Results are shown in Figure (3). An activated charcoal device was placed in the chamber at the beginning of testing for a four-day test and two more were likewise tested in the chamber at the end of testing. Results of analyses are shown in Figure (4). Electret devices were placed into the chamber for seven days at a time, removed and read-out. Results are shown in Figure (5).

Results

Device	**Start**	**End**	**Hours**	**Bar. Chg ***	**Temp.+**	**Reading**
** A single pocket-sized digital radon monitor was used through out the testing, except 5/20 through 5/31				(in. Hg)		(pCi/L)
	4/28/16	5/5/16	168.5	-0.30	60ºF	9.7
	5/5/16	5/12/16	336.5	+0.49	60ºF	9.1
	5/12/16	5/20/16	522.5	-0.32	65ºF	9.1
	5/31/16	6/7/16	168	+0.33	65ºF	8.9
	6/7/16	6/14/16	336	+0.48	75ºF	9.2
	6/14/16	6/21/16	504	+0.43	65ºF	9.3
	6/21/16	6/28/16	671.5	+0.26	75ºF	9.3
	6/28/16	7/12/16	1007.5	0.00	75ºF	9.3
	7/12/16	7/19/16	1176.5	-0.24	70ºF	9.4
	7/19/16	7/26/16	1343.5	+0.19	75ºF	9.5
					Average	9.3±0.4

* Net barometer change during 7-day or other test.
+ Average of beginning and ending temperature, rounded to the nearest 5ºF
** Digital radon monitor can be used for official testing everywhere except for U.S. and Canada.

Figure (2): Pocket-sized digital radon monitor (alpha spectrometer) results

Device	**Start**	**End**	**Days**	**Temp.**	**Reading**
Track Etch	5/24/16	7/26/16	63	70ºF	10.0±3% (pCi/L)

Figure (3): Alpha track device result for two-month period in radon chamber

Device	**Start**	**End**	**Hours**	**Bar. Chg ***	**Temp+**	**Reading**	**Average**
				(in. Hg)		(pCi/L)	(pCi/L)
Charcoal A	4/28/16	5/2/16	96	-0.20	60ºF	11.0	11.0
Charcoal B	7/24/16	7/28/16	96	+0.15	75ºF	10.4	10.2
Charcoal C	7/24/16	7/28/16	96	"	"	10.0	

* Net barometer change during 4-day test.
+ Average of beginning and ending temperature, rounded to the nearest 5ºF

Figure (4): Charcoal device results for 96 hours in radon chamber

Device	**Start**	**End**	**Hours**	**Bar. Chg ***	**Temp.+**	**Reading**	**Average**
				(in. Hg)		pCi/L	pCi/L
Electret A	4/28/16	5/5/16	168.5	-0.30	60ºF	12.8	12.2
Electret B	4/28/16	5/5/16	168.5	"	"	11.5	
Electret C	5/5/16	5/12/16	168	+0.49	60ºF	11.5	10.8
Electret B	5/5/16	5/12/16	168	"	"	10.1	

Electret A	5/12/16	5/20/16	186	-0.32	65ºF	11.7	10.9
Electret B	5/12/16	5/20/16	186	"	"	10.2	
Electret B	5/24/16	5/31/16	168	0.00	65ºF	8.6	10.8
Electret C	5/24/16	5/31/16	168	"	"	13.0	
Electret C	5/31/16	6/7/16	168	+0.33	65ºF	11.5	11.5
Electret C	6/7/16	6/14/16	168	+0.48	75ºF	10.6	10.6
Electret D	6/14/16	6/21/16	168	+0.43	65ºF	10.3	10.3
Electret D	6/21/16	6/28/16	167.5	+0.26	75ºF	11.3	11.3
Electret E	6/28/16	7/12/16	336	0.00	75ºF	20.2	20.2**
Electret F	7/12/16	7/19/16	169	-0.24	70ºF	14.4	14.4
Electret F	7/19/16	7/26/16	167	+0.19	75ºF	9.4	9.4
						Average	11.2±2.7

* Net barometer change during 7-day or other test.
+ Average of beginning and ending temperature, rounded to the nearest 5ºF
**Two week sample; not included in average or 2-sigma shown

Figure (5): Electret radon device results

Discussion

The average radon level in the passive chamber described here seemed to have little variation based on the digital radon monitor. It was based on long term integrated results and was 9% lower than the average of three types of devices (charcoal device excluded). The alpha track device integrated result was 2% lower than that of the three device average. The electret device average result was 10% higher than that of the three device average. The data for the charcoal devices was not sufficient to establish a trend, but the two average test results were similar to that of the other devices.

The testing design described here was not intended to determine the "true" radon content in the chamber, but rather the degree of agreement between results of different monitoring devices. It was not determined whether variation in results was due to variations in radon levels of the chambers, due to inherent variations within the devices, or due to the relative positions the devices occupied in the chamber.

Additional valuable information could have been obtained had the individual 7-day readings for the digital radon monitor been recorded along with the cumulative average at the end of each 7-day period. However, only the latter was recorded. Future testing will correct this shortcoming Other changes will be made for future testing: A larger radon chamber, with an airlock will be employed. It will be constructed out of a more substantial material than plastic sheeting. A small fan for mixing the air in the chamber will be added. At least two digital radon monitors and two alpha track devices will be placed in the chamber. A sampling port will be added to allow the researcher to obtain grab samples of the radon in the chamber.

The plate-out of radon progeny on the inner surface of the radon chamber was not measured during the current testing. This will be done in future testing to aid in the correlation of results for radon and radon progeny monitoring devices.

Conclusion

While the passive radon chamber shows some promise for use as a secondary QA check of radon monitoring devices, more work needs to be performed to validate these findings.

References

Moore, J.A., Kearfott, K.J., 2005. A Simple Radon Chamber for Educational Use. Health Physics 89(5): S78-84.

Webster, S. T., 1992. Development and Calibration of a Radon Chamber. Master's Thesis. University of Saskatchewan.

George, A.C, Knutsen, E.O., Tu, K.W., 1983. Radon Daughter Plateout--1. Measurements. Health Physics, 45(2) 439-444.