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A COMPARISON OF THE RESPONSE OF AN ALPHA TRACK DETECTOR EXPOSED IN VARIOUS RADON CALIBRATION CHAMBERS

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ABSTRACT

Data acquired over several years of proficiency and independent quality assurance testing have indicated that the apparent accuracy of the Radtrak® radon monitor may be influenced by the chamber in which the test exposures are conducted. These experiences suggest the existence of an unknown factor associated with the calibration chamber facility that can affect the calibration value relating track density to radon exposure established for alpha track monitors. Landauer, Inc. conducted an experiment in which Radtrak® radon monitors were sent simultaneously to eight calibration facilities which were instructed to expose the monitors to radon using a standard handling procedure. The monitors were manufactured from the same sheet of detector material and, except for those from two chambers, the monitors were processed and analyzed together. In this way analytical variables were minimized. The results demonstrated statistically significant differences in the apparent sensitivity of the monitors among several of the facilities. These differences are large enough to cause unacceptable biases when the monitor system is calibrated in one chamber and tested in another. The causes of the differences are not understood and could be the subject of worthwhile research for organizations interested in radon intercomparisons and calibrations.

INTRODUCTION

The validity of any measurement system is only as good as its calibration. It is common knowledge within the radon measurement industry that one of the most important problems it faces is the lack of a traceable national standard for radon gas. As a substitute, laboratories offering radon in air calibration services calibrate their measurement systems by quantitatively transferring radon gas into their measurement devices by slowly bubbling carrier streams of nitrogen gas through NIST traceable radium solutions.

The quality assurance programs at these calibration laboratories require routine participation in intercomparison programs as a means of validating their primary calibration. The majority of these intercomparisons are performed using radon gas filled scintillation cells. All of the cells within a program are simultaneously filled by the host facility and the cells are returned to the participating laboratories for analysis. The analytical results are compiled and the relative ratio of the participant's measured radon concentration to the host's measured radon concentration calculated.

Using the combination of a radium solution as a primary standard and participation in measurement intercomparisons, it is now believed that the various national laboratories and principal radon calibration laboratories within the United States have a calibration uncertainty on the order of ± 5 percent (Hutchinson et al. 1992).

Landauer, Inc. manufactures the Radtrak® alpha track radon monitor and has been a leading supplier of long term radon measurement devices for over 10 years. Throughout our history, the Radtrak monitor has been tested in many calibration laboratories, including the USDOE Environmental Measurements Laboratory, USEPA National Air and Radiation Environmental Laboratory in Montgomery, Alabama, the USEPA Las Vegas Facility, the USDOE Grand Junction Projects Office Radon Laboratory, and the National Radiological Protection Board in the United Kingdom. These tests were performed as calibration exposures, proficiency tests, research, and as fulfillment of contract quality assurance requirements. In some cases, there is a long history of the Radtrak® monitor's performance in an individual laboratory (Pearson et al. 1992). The data acquired from these tests indicate that the apparent accuracy of the Radtrak® monitor may be influenced by the chamber in which the test exposure was performed.

The purpose of this study was to conduct a calibration laboratory intercomparison using an alpha track radon monitor rather than a gas filled scintillation cell. By controlling the radon exposure, monitor materials, storage, processing, and analysis of the alpha track monitors, a sensitivity factor for the monitor in each laboratory could be calculated and used to compare the monitor's performance between or among laboratories.

MATERIALS AND METHODS

A total of eight calibration laboratories agreed to participate in this study. The participating laboratories are listed in Table 1. Due to Landauer, Inc.'s status as a commercial radon measurement business, the USEPA declined to participate in the study.

Table 1. Participating Calibration Laboratories.

Bowser-Morner, Inc. Dayton, Ohio USA	Bureau of Mines Denver, Colorado USA
Department of Energy Environmental Measurements Laboratory (EML) New York, New York USA	USDOE Grand Junction Projects Office Radon Laboratory Grand Junction, Colorado USA
Landauer, Inc. Glenwood, Illinois USA	National Radiological Protection Board (NRPB) Chilton, United Kingdom
Martin Marietta Inc. Oak Ridge National Laboratory Oak Ridge, Tennessee USA	Swedish Radiation Protection Institute Stockholm, Sweden

The Radtrak® alpha track radon monitor was the device selected to perform the laboratory intercomparison. The monitor consists of a small piece of alpha sensitive poly-allyl-diglycol-carbonate (CR-39) plastic material mounted within an electrically conductive plastic cup. A paper filter covers the opening of the cup to prevent radon decay products from entering the sensitive volume of the device. The normal recommended exposure time period is from 90 d to 365 d, but because it is a true integrating device, the Radtrak® monitor can be exposed for a shorter time period at higher radon concentrations. A single sheet of CR-39 material was used to manufacture all of the monitors used in this study.

Ten test monitors and five control monitors were sent to each participating laboratory. The monitors were individually packaged in radon proof sealed foil pouches. The following instructions accompanied each set of monitors.

1. The test monitors are to receive between 222 $kBq.h.m^{-3}$ and 444 $kBq.h.m^{-3}$ (250 $pCi.d.L^{-1}$ and 500 $pCi.d.L^{-1}$) total radon exposure in a 4 to 7 day exposure.

2. The radon chamber conditions should be approximately 20°C and 50% relative humidity.

3. At the conclusion of the exposure, the control monitors are to be removed from their foil pouches and combined with the exposed test monitors.

4. The monitors are allowed to off-gas from 16 h to 24 h in a low radon environment.

5. A foil seal is then placed on each monitor and the monitors returned to Landauer, Inc. for processing.

Upon receipt of the monitors from an individual laboratory, they were stored in a nitrogen atmosphere until all of the laboratories returned their monitors. All of the returned monitors were placed into the same 5.5 N NaOH etch batch and etched for 15.5 h at 70°C. Each monitor chip was then read using a semi-automatic image analysis system to determine the total number of etched tracks in 32 mm^2.

Monitors from laboratories numbered 2 and 7 in Table 2, were not received in time to be etched with the other laboratory monitors due to logistical problems. The track densities for the monitors from those two laboratories were adjusted for etching variability by using standard control monitors in all etching processes. The process control monitors were all manufactured from the same sheet of CR-39 plastic and exposed at the same time in the Landauer radon chamber. The monitors from all the laboratories were analyzed at the same time using the same instruments.

The total track density for each monitor was calculated in tracks/mm^2. The mean track density of the five control monitors for each laboratory was considered as the background track density for that set of monitors and subtracted from each test monitor exposed at the same laboratory. A sensitivity factor for each monitor was calculated by dividing the total delivered exposure by the net track density. The mean laboratory sensitivity factor was used to compare the performance of the alpha track monitor among calibration laboratories.

Table 2. Calibration Laboratory Sensitivity Factors.

Laboratory	Total Exposure $kBq.h.m^{-3}$	Sensitivity Factor $kBq.h.mm^2.m^{-3}$
1	294.8	33.2 +/- 1.2
2	674.1	28.8 +/- 0.9
3	319.2	34.6 +/- 2.6
4	402.7	33.4 +/- 1.5
5	485.7	33.0 +/- 2.0
6	236.2	31.4 +/- 1.6
7	308.1	38.5 +/- 2.8
8	364.0	34.9 +/- 1.4

RESULTS

Table 2 lists the calculated sensitivity factors for each laboratory. The sensitivity factors ranged from 28.8 $kBq.h.mm^2.m^{-3}$ to 38.5 $kBq.h.mm^2.m^{-3}$, approximately a 25% difference between the highest and lowest laboratory. The variation at one standard deviation within each exposure set ranged from 4% to 8%. This level of variation was expected and agrees with the errors corresponding to counting statistics at the track densities observed.

An analysis of variance was performed on the sensitivity factors and indicated that the sensitivity factors observed for Laboratories 2, 6, and 7 were significantly different from at least one other laboratory at a 95% confidence level. The sensitivity factors for Laboratories 1, 3, 4, 5, and 8 were found to be not significantly different from one another.

CONCLUSIONS

This study demonstrates a significant difference in sensitivity factors obtained from various calibration laboratories when intercompared using an alpha track device. In February, 1991 the United States Environmental Protection Agency (USEPA) revised its Radon Measurement Proficiency Program (RMP). Currently, this program requires the individual relative error of each test monitor be less than or equal to 25% of a target value (USEPA 1991). Given the apparent sensitivity differences of ≈25%, it would be possible to fail an USEPA RMP style proficiency test by selecting the wrong combination of calibration and testing laboratories. These results emphasize the fact that the performance of a measurement system is only as good as its calibration.

The causes of the observed laboratory differences are not clearly understood at this time and are an area needing further research.

REFERENCES

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