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APPLICATION OF PYLON RADON DAUGHTER STANDARD FOR CALIBRATION OF RADIOMETERS

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Abstract. Radiometers for measurements of radon daughter potential energy used in the surveillance of the work environment need a systematic calibration. This paper presents how a commercially available device produced by the Pylon Company can be applied. This device allows to produce, simply and directly, standard sources of radon daughters, corresponding with the energy, geometry and properties of radiation originated from an air sample. The calibration yielded the results that proved to be in agreement with those obtained previously by means of radon chamber.

Key words:
Radon daughter, Radiometer, Calibration

INTRODUCTION

It is well known that the occurrence of radon and its daughters in different work environments, especially those under the ground, has to be controlled. Therefore, it is necessary to establish relevant control systems to survey these environments, as well as to assess the exposure of workers employed in such conditions. The measuring technique based on passive dosimeters with a track detector still acquires wider recognition; its availability becomes much easier, and it is now recommended as a basic survey method in both work environment and individual exposure [1,2]. There is, however, one drawback of this method, the information is obtained after a relatively long duration of exposure. In the work environment surveillance, it is usually essential to receive the data on concentrations directly at the workplace. Meters based on air samples collected on a filter and the measurements of global alpha activity of collected radon daughter deposits serve this purpose. Based on these measurements, so called the concentration of potential energy of short-lived radon daughters is determined.

Activity is usually measured using a silicon semiconducting detector. Meters are very often used in the most difficult environmental conditions, for example in mines, thus they should be characterized by appropriate technical parameters and should be subjected to systematic metrologic control and calibration in order to ensure their reliability. Flat or point sources of alpha radiation of plutonium and americium isotopes are most commonly used to test the detection system. Nevertheless, they are useless in determining the detection efficiency because of differences in the energy spectrum of alpha radiation from these sources as compared to the energy spectrum originated from the deposit of radon daughters

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plated on a filter during the process of air sampling, and this may lead to some errors.

Since it is not possible to obtain the time constant sources of short-lived radon daughters, in the standardization practice they are created using a radon chamber [3], however, this method is not commonly available. In order to eliminate this difficulties in calibration, the Canadian Company – Pylon Electronic Development – has elaborated a special device to create radon daughter standards. Application of this device and its practical values are presented in this paper.

METHODS

With Pylon daughter standards, the user can solve calibration problems and, in many instances, eliminate the need for large environmental chambers. These devices may deposit a known amount of radon daughter activity on the same type of filter used for collecting samples. Because geometric and spectroscopic errors have been eliminated, the daughter standards provide the most effective calibration technique available.

The basis of the Pylon daughter standards is a small chamber with an embedded radium source as shown in Fig. 1, and which emanates 100% of the gas produced. The chamber is designed such that the daughters will plate uniformly on an filter. The latter becomes a calibration standard with a uniform distribution across the surface. Thus a daughter standard has virtually the same radiation characteristics as that of an air sample.

Daughter standards are calibrated by alpha spectrometry methods against NBS traceable standards. Each unit is individually calibrated to an accuracy of ±4% and labeled. Daughter standards are an excellent means of calibration and alignment of alpha spectroscopic equipment. Because of their high resolution and wide range of peak energies, they are ideal for generating an undergraded spectra of reference energies. The very highest resolution of the energy peaks can be achieved by depositing daughter activity on a metal foil surface or metal disc and then using the disc as the calibration source. Figure 2 shows the

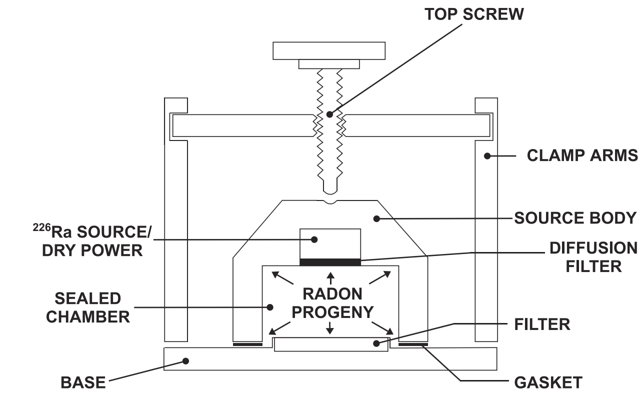

Fig. 1. Diagram of radon daughter deposition standard.

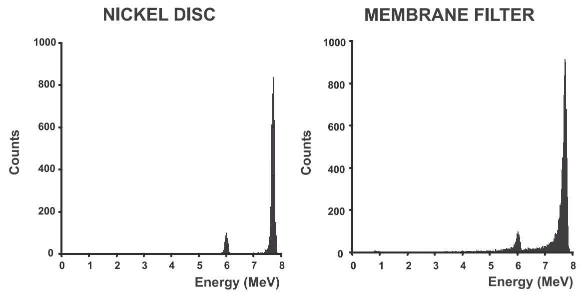

Fig. 2. Comparison of alpha spectrum on nickel disc and on a membrane filter measured in a vacuum.

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A nickel disc proved to be a better base for deposit, because the Sartorius thin membrane filter traversed radiation embedded on its opposite side.

This spectrum was measured after ten minutes from the end of deposit formation and showed high resolution of peak energies for 6 MeV and 7.8 MeV for alpha particles.

The RN-190 radon daughter standard is adjusted to two typical filter sizes: 25 and 47 mm. For each of these sizes two maximum values of deposit activity are available: 4000 dpmcm^{-2} and 20 000 dpmcm^{-2}. These values are adequate to the state of radioactive equilibrium in the chamber.

Taking advantage of short time necessary to keep the equilibrium between radon and its daughters, optional radon activities can be obtained through selecting appropriate time of deposit formation (Fig. 3). According to the producer's recommendations a minimum time for deposit formation is 24 h.

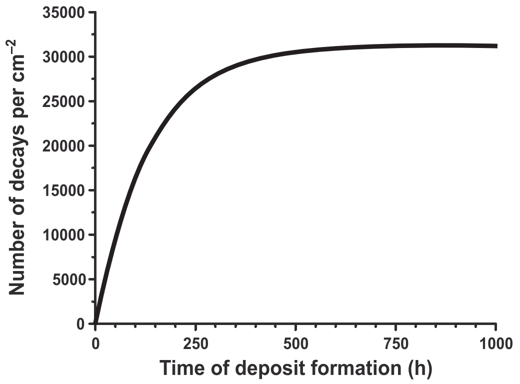

Fig. 3. Time-dependent growth of deposit activity.

In Poland, routine measurements to assess the work environment in mines are performed using a RGR-13 mining radiometer of Polish production. After collecting a 10 l air sample, the radiometer measures alpha global activity of the filter within 8–10 min after filtration according to Markov method [4]. The radiometer is equipped with the control source with isotope ^{239}Pu, but its use for calibration is not recommended by the producer. Energy spectrum of alpha radiation from this source shows the energy peaks within the range of 4–5 MeV, which is considerably different from the energy of radon daughter alpha particles (Fig. 4).

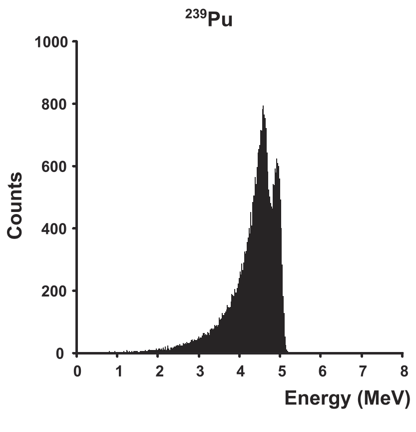

Fig. 4. Energy spectrum of alpha radiation of the control source with ^{239}Pu isotope.

RESULTS

A device of RN-190 type, with the filter diameter of 25 mm was used in the radiometer calibration. The radon daughter deposit was plated on nickel disc, placed during

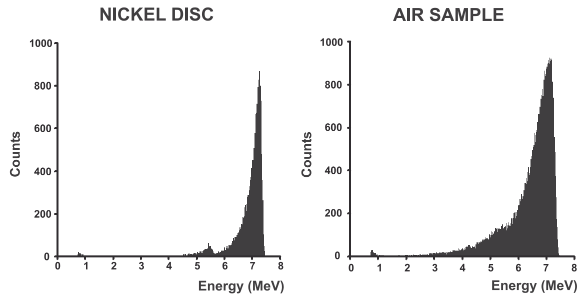

Fig. 5. Comparison of alpha radiation energy spectra from the established standard and air samples at normal atmospheric pressure.

the measurements in the radiometer filtration head. Since the calibration and air sample measurements were conducted in the conditions of normal pressure, alpha radiation energy spectra from the established standard and air samples were compared, taking account of these conditions (Fig. 5).

Energy peaks for these measurements have the same value, but a left-sided broadening of the radiation spectrum line on the filter was observed, which means that particles of lower energies, stopped in deeper pores of membrane filter, are registered. The broadening is slight and with insignificant impact on the detection efficiency. For better calibration, several standard sources were produced at different intervals of deposit formation. Figure 6 presents the relationship between the number of the detector counts and the theoretical number of decays of deposit-forming alpha particles. This relationship forms a calibration curve and allows for determining calibration coefficient of 0.19 that remains in good agreement with coefficients determined earlier by means of radon chamber.

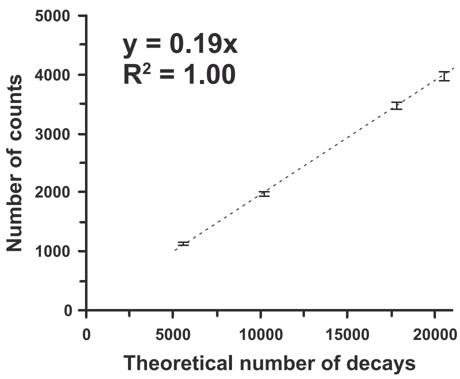

Fig. 6. The calibration relationship for the radiometer tested.

CONCLUSIONS

Commercially available devices of RN-190 type, produced by the Pylon Company, are very useful in calibration of instruments used in measuring concentrations of alpha radiation potential energy. Handling of these devices is very simple. They are reliable and help to avoid complicated calibration procedures typical of radon chamber. Application of these devices does not require to establish a specialist laboratory for calibration. Taking account of difficult conditions in the environments surveyed and a possible impact of these conditions on the radiometer parameters, it should be stressed that the devices in question allow for introducing at any time appropriate corrections and ensure the reliability of the results.

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