

CALIBRATION OF THE SOLID STATE NUCLEAR TRACK DETECTOR CR-39 FOR RADON MEASUREMENTS

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ABSTRACT

Solid state nuclear track detectors (SSNTD) are widely used for radon measurements and CR-39 is one of the most popular SSNTD. In this work it was determined the calibration factor for radon concentration measurements through the passive method with CR-39 detectors. The detectors were put in a proper device (an adapted Lucas cell) and exposed to the standard radon concentration through the Pylon Model RN-150 flow through radon gas source. After exposure, the detectors were etched for 5.5 hours in a KOH solution at 80° C in a bath at a constant temperature. The track density was read in an Axiolab – Zeiss optical microscope, with nominal magnification of X10 connected to a video camera and to a personal computer. The calibration factor was obtained through the relation between standard radon concentration, track density and exposure time.

1. INTRODUCTION

The natural radioactivity is the main component to human exposure. Radon (^{222}Rn) and their short lived decay products are recognized as the most important contributors to committed effective dose received by population due to natural sources [1].

The environmental radon concentration is a function of time and climate conditions. The techniques for the collection and measurement of ^{222}Rn in air can be subdivided into active (requiring power to collect a sample) and passive (requiring no power) methods. Active methods are usually used for short-term measurements of radon. Passive methods are more suitable for the assessment of radon exposure over long time scales and can be used for large-scale surveys at moderate cost [2].

Solid state nuclear track detectors, known as passive method, are widely used for radon measurements. Radon concentrations are determined by measuring the emitted alpha particles, which causes damage in the detector surface (latent track). Because of its good ionization sensitivity and stability against various environmental conditions and high degree of optical clarity, CR-39 has become the state-of-the-art track detector for environmental radon monitoring [3].

In order to calculate the radon concentration, it is necessary to know the track density (track per cm^2 in detector surface), the exposure time and the calibration factor that converts the track density to radon concentration. The aim of this work is to determine the calibration factor for radon concentration measurements through the passive method with CR-39 solid state nuclear track detectors.

2. MATERIALS AND METHODS

The CR-39 detector was put in a proper device (an adapted Lucas cell) and exposed to the standard radon concentration through the Pylon Model RN-150 flow through radon gas source (Fig.1) during approximately four days. The RN-150 contains a solid radium (^{226}Ra) source, which provides 100% emanation to radon gas when the ambient temperature is between -20°C and 50°C and pressure is between 0 and 3 atmospheres [4]. At equilibrium, the Pylon source dispenses a standard concentration of $15.2\text{ kBq}\cdot\text{m}^{-3}$ into the adapted Lucas cell with a CR-39 detector. The Rn-150 is operated with a vacuum hand pump. A precision manometer is provided to perform a cross calibration with the vacuum gauge under different atmospheric pressures.

After exposure, the detector was etched for 5.5 hours in a KOH solution at 80°C in a bath at a constant temperature in order to visualize the trails of the registered alpha particles. After the etching, the trails became tracks which were visible by optical microscope. The track density was read in an Axiolab – Zeiss optical microscope, with nominal magnification of X10 connected to a video camera and to a personal computer.

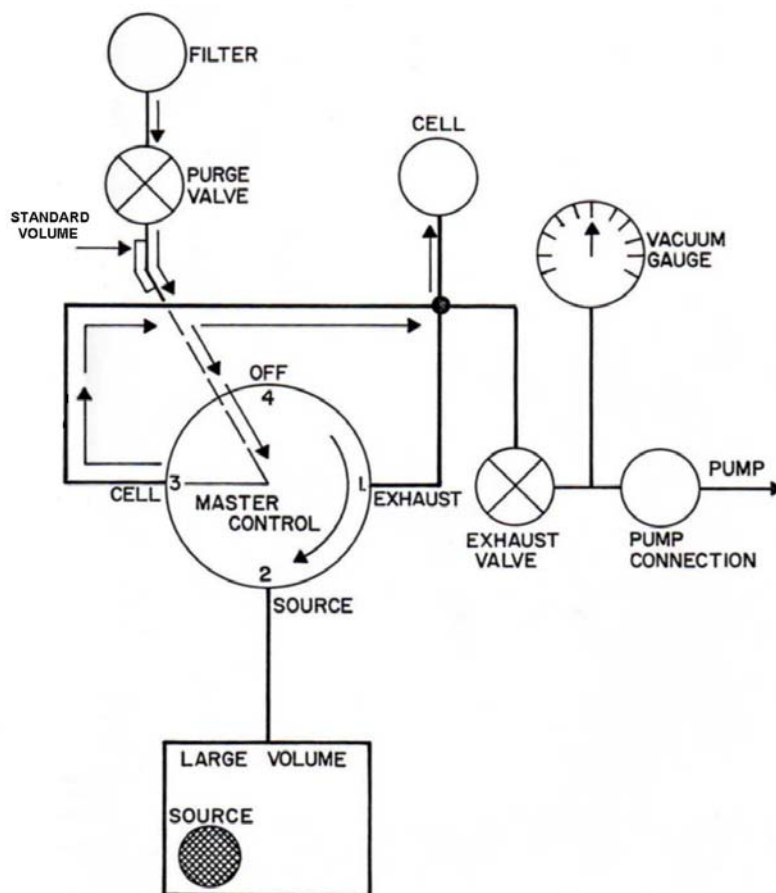


Figure 1. Working diagram of Pylon RN-150 calibrated radon source

The calibration factor was determined through the following expression [5]:

$$k = \frac{D}{C \cdot t} \quad (1)$$

where:

k - calibration factor ($\text{tr}\cdot\text{cm}^{-2}$ per $\text{Bq}\cdot\text{m}^{-3}\cdot\text{d}$)

C - standard radon concentration ($\text{Bq}\cdot\text{m}^{-3}$)

D - track density ($\text{tr}\cdot\text{cm}^{-2}$)

t - exposure time (d)

3. RESULTS

The calibration factor for CR-39 detector was calculated using equation (1). Three detectors were exposed to the standard radon concentration; the average value and its standard deviation are presented at table 1.

Table 1. CR-39 average calibration factor

Detector	k ($\text{track}\cdot\text{cm}^{-2}$ per $\text{Bq}\cdot\text{m}^{-3}\cdot\text{d}$)
CR-39	$2.758 \cdot 10^{-2} \pm 4.495 \cdot 10^{-3}$

4. CONCLUSIONS

The calibration factor depends on the active volume of alpha monitoring devices, the type of track detector and the track detector etching conditions. The results obtained until now show a good data reproducibility and are in accordance with other literature values [6, 7] for the same type detector. At the moment, it was made three exposures for the calibration factor determination. Afterwards, more detectors will be exposed to the radon source in order to corroborate the calibration factor.

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