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A METHOD FOR THE CALIBRATION OF THE TRACK DETECTORS USED IN RADON ENVIRONMENT MEASUREMENT

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Abstract − The measurement of the radon in the environment became during the last years an important field of radiation protection. That is why, the necessity of calibration standards for the radon measuring devices became very important. This paper presents a way of radon track detector calibration wich was developed in the National Institute of R&D for Physics and Nuclear Engineering, Bucharest.

Keywords: radon in environment, track detector

1. INTRODUCTION

Objectives

The main objective of this paper is to present a method for the calibration of the track detectors used in radon environment measurement.

Description

The method wich is proposed for the calibration of the track detectors used in radon environment measurement is based on the utilization of a radioactive source of Ra-Rn at radioactiv equilibrum; it is a relative method to be used in metrology laboratories, for the calibration of the track detectors used for the radon measurement.

The calibration of the track detectors intended to the measurement of the specific activity of environment radon is done in the device from Fig. 1; this device containes a calibrated source of radioactive element Ra-226. This radionuclide undergoes an ∝-desintegration wide leads to another radionuclide, Rn-222, being in gaseous state, but genetical linked to the Ra-226.

After 30 days, the radioactiv equilibrum between Ra-226 and Rn-222 readres a limit of 99,6 % and the instalation can be used for the calibration of the track detectors.

These detectors, unetched, are puted into an alpha monitoring device (Fig. 2), with a filter wich allows to pass only gaseous radon, without its solid descendants.The track detectors will record, on each side, the alpha particles emitted by Rn-222; the track density of the detectors, ρ, is proportional to the specific activity of Rn-222 from the volume v of the device, $C_{A,Rn}$, for an exposure time t_{exp} and to the recording efficiency of the detector, ε_d :

$$\rho[\propto \text{tracks} / \text{cm}^2] = C_{A,Rn} \bullet v \bullet t_{exp} \bullet \varepsilon_d \qquad (1)$$

If one writes now the same equation for a detector irradiated to an unknown specific activity, $C_{A,Rn,x}$, the track density is :

$$\rho_x[\propto \text{tracks} / \text{cm}^2] = C_{A,Rn,x} \bullet v \bullet t_{exp,x} \bullet \varepsilon_d \qquad (2)$$

Methodology

If one use the same ec.(1) for a detector wich was exposed , "x", and then calculates the ratio of the relations, then he obtains the specific activity of the radon in the measuring site, $C_{A,Rn,x}$:

$$C_{A,Rn,x} = C_{A,Rn,c} \bullet (t_{exp,c} / t_{exp,x}) \bullet (\rho_x / \rho_c) \qquad (3)$$

The ecquation (3) allows to determine the specific activities of the radon; for this, the detectors must be etched, to put into evidence the alpha tracks. Then, the tracks are counted using an optical microscope, for each side of the detector.

Calibration facility, called experimental device for track detectors calibration etched wich allows determination radon activity concentrations can be used only after determining radioactive equilibrium between Ra-226 and Rn-222. These radionuclides belongs natural radioactive series U-238 are genetically related. The balance is determined balloon source, Fig 1.1 with tap Fig.1.4. closed on for 30 days at least for which the activities of Rn and Ra becomes0,996. After this period, the calibration can be used either wholly or partially, depending on the number of detectors that we want them calibrated, the concentration of radon is reduced depending on the volume involved in the calibration. Every such use is strictly necessary to be known volume of installation and use of volumes less alpha monitoring devices. .

Throughout the period of exposure alpha (calibration), concentration (volume activity) in radon installation remains constant.

Trace detectors are used CR-39 (Page, England) having dimensions3,5cm·1cm·1mm.

After exposure to radon calibration facility, solid traces detectors are serious chemically NaOH - 30%, 7 hours at 70 oC using etching bath thermostat. After washing with distilled water, dried detectors are the filter paper strip embedded on the microscope and studied by optical

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microscopy, to determine the quantitative density of alpha tracks recorded.

The main steps in applying this method are:

- the calibration of the Ra-226;
- the calibration of square optical network in order to know exactly the area of the studied surface of the detector;
- the counting of the tracks on each side of the detector
- Measurement of source (2082 ± 150) Bq was

determined with an uncertainty of 7,2% for confidence level of 99,73%. After setting the radioactive equilibrium between Ra-226 and Rn-222, calibrated source of Ra-226, Rn-222 generates a constant flow equal to the source activity. Radioactive equilibrium after 30 days is made up to 99,56% after 40 days in the proportion of 99,93% after 50 days at the rate of 99,98% and after 60 days at the rate of 99,99% [5].

Can be considered that the concentration of radon activity is constant throughout the trace detector calibration in the calibration tightly closed

- Square-optic network, located in one of the binocular through calibration allows determination of the area studied for traces of the detector and so, finally, determine the density of alpha tracks in the detector [alpha track /cm^2].

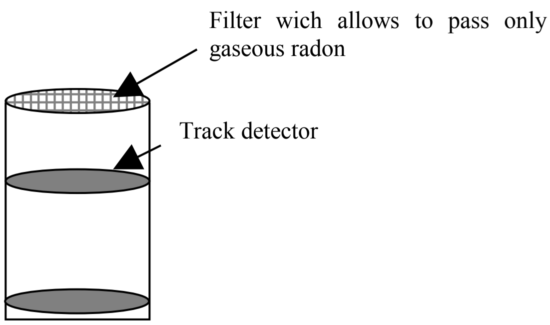

Fig. 2. Alpha monitoring device

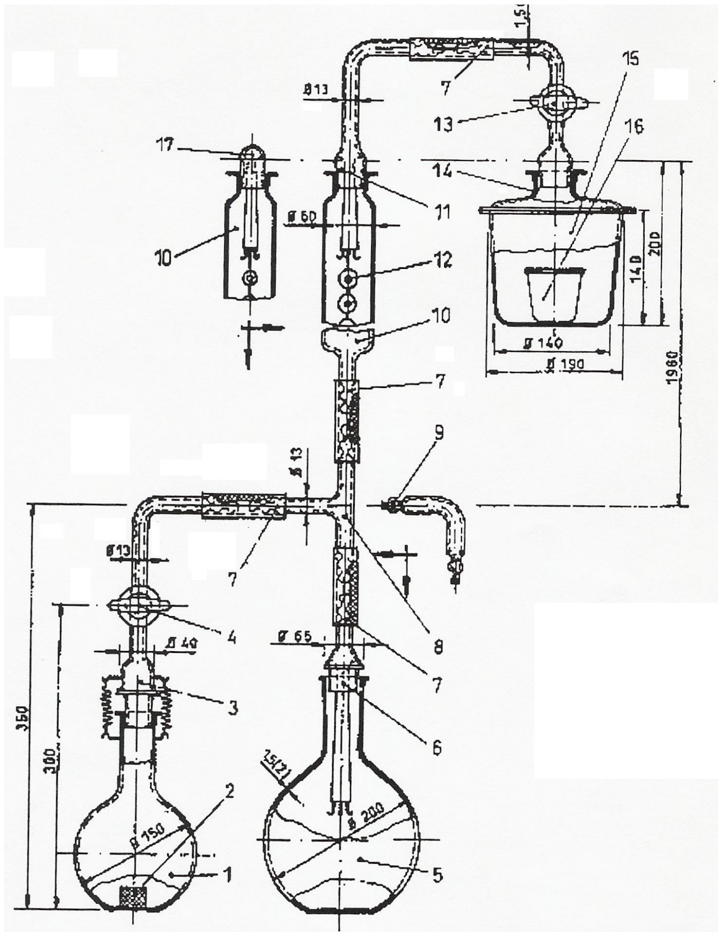

Fig.1. Experimental device for track detectors calibration with ^{226}Ra-^{222}Rn source

1.glass balloon; 2. ^{226}Ra – ^{222}Rn source; 3. stopper; 4.tap; 5.glass balloon;12. alpha monitoring device ; 13. tap; 14. lid

Experimental results

Processing of experimental data is made according to the latest recommendations of international legal metrology.

Results are expressed by the average corrected by measuring the $Ni + c$ (correction) and the calculation of uncertainty, $U = k \cdot u_c$, which will take into account the uncertainties of type A and B, $u_c^2 = u_A^2 + u_B^2$, errors made by all the quantities involved, systematic, random and aberrant (rugged). For expansion factor, k, a correction that uncertainty provides a level of confidence of ~ 95% is considered k = 2 (actually 1,96).

The number of the alpha tracks coresponding to the witness detectors are presented in

Tab. 1:

Witness	The number of alpha tracks ± σ	Medium
MAR	149 ± 20	143.5 ± 25
	138 ± 15	
MAR 2	157 ± 16	159.5 ± 23
	162 ± 16	
M	198 ± 23	193 ± 28
	188 ± 16	
M2	144 ± 16	147 ± 23
	150 ± 16	
M(T)	176 ± 17	175 ± 21
	174 ± 12	
M(C)	194 ± 18	194 ± 18

Medium : 169 ± 20

$3\sigma_n = 60 \Rightarrow$ Limiting values ($\pm 3\sigma_n$) = (109 ÷ 229)

For the detectors used in this experiment, we also checked the repetability and the reproducibility.

Condition of reproducibility of the method requires that individual differences between values measured from the average of 10 measurements was within 3σ.

$$\Delta\rho_i = (\rho_i - \rho_{mediu}) \leq 3\sigma$$

The results of these tests are :

Tabel 2. Reproducibility

Detector	The number of alpha track / cm^2	Background
C1	777 ± 28	608 ± 34
C2	918 ± 31	749 ± 37
C3	863 ± 30	694 ± 36
C4	771 ± 28	602 ± 34
C5	803 ± 29	634 ± 35
C6	736 ± 39	567 ± 44
C7	758 ± 30	589 ± 36
C8	669 ± 26	500 ± 33
C9	738 ± 27	569 ± 34
C10	727 ± 27	558 ± 34

Medium: 607 ± 68, $3\sigma_n = 204 \Rightarrow$ Limiting values (403 ÷ 811)

Tabel 3. Repeatability
Set I

Detector	The number of alpha track / cm^2	Improved background
E	637 ± 36	468 ± 41
X	431 ± 29	262 ± 35
	629 ± 36	460 ± 41
III	565 ± 34	396 ± 39
A	706 ± 37	537 ± 42
T	517 ± 38	348 ± 43

$|\Delta| < 3\sigma$ Medium$_{set\,I}$: 412 ± 89 $|\Delta| = 38$

Tabel 3. Repeatability
Set II

Detector	The number of alpha track / cm^2	Improved background
II	432 ± 29	263 ± 35
I	615 ± 41	446 ± 46
Δ	434 ± 29	263 ± 35
IV	404 ± 29	235 ± 35
V	545 ± 33	376 ± 39
Z	592 ± 35	423 ± 40

$|\Delta| < 3\sigma$ Medium$_{set\,II}$: 335 ± 84 $|\Delta| = 39$

Medium$_{set\,(I+II)}$ = 374 ± 122

$\Rightarrow$ Limiting values = (252 ÷ 496)

2. CONCLUSIONS

The results obtained during this scientific work confirm that the method wich we propose for the calibration of the track detectors used for radon environment measurement is adequated and offers some good performances :

- precision
- repetability
- reproducibility

So, this method can be succesfully used in many activity fields, as :

- radon environment measurement, for public health;
- nuclear medicine studies concerning the radon effects on human being;
- scientific research concerning radon environment;
- the presence of radon in buildings for domestic or social activities;
- the pollution’s evaluate when geothermal energy is used and the mine’s water.

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