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The Basic Methods for Measurement of Radon Activity in Air

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***Abstract**: The basic methods (track, electret and adsorptive) and devices for measurement of volumetric activity of radon in air are considered.*

Keywords- Radon, volumetric activity, detectable activity, NaI (Tl) detector, decay of radon daughter products; radon reduction; effective dose equivalent

1. INTRODUCTION

The share of radon in the total dose of the population from all sources of ionizing radiation acting on it is 43% [1]. Epidemiological studies have shown an increased risk of developing lung cancer with prolonged exposure to radon and its DPR contained in residential air [2]. In 2009, the International Commission on Radiological Protection (ICRP) established a new benchmark for the volumetric activity of radon (OAR) in residential premises of 300 Bq / m^3 [3].

Methods and techniques for monitoring radon

To determine the average annual concentration of radon in rooms and conduct epidemiological studies to establish the risks of cancer, the exposure of monitors is optimal for 12 months or successive 3 or 6 months throughout the year. A prerequisite for examining a large number of homes on a national or regional scale is the use of methods for measuring radon concentrations that meet the following basic requirements: exposure period from 3 to 12 months; low cost; small size measuring device.

Basic methods

The passive method based on solid state nuclear track detectors (SSNTD) meets all the above requirements and is actively used in research [5]. The formation of tracks in these detectors occurs under the influence of alpha particles emitted during the decay of radon and its DPR. Three polymers are usually used as the detector material: polyallyl diglycol carbonate (PADC), cellulose nitrate film (CN), and polycarbonate (PC). In CN detectors, tracks can be viewed with an optical microscope (manually or automatically), or they can be counted by a spark counter. In PADC detectors, tracks can be counted using automatic systems, using optical microscopes or scanners, as well as a computer with software for image analysis, track identification and counting. The lower detection limit (LLD) for this technique at 3-month exposure is 5-10 Bq / m^3.

The electret method, based on a change in the charge of the electrode (Teflon disk) under the action of air ionization by alpha particles in an ionization chamber (EIC), also has the possibility of long exposure periods and has a small size [6]. As a result of the decay of radon and its DPR in the chamber, ions are formed that fall on a charged electret and reduce its voltage in proportion to the concentration of radon. The exposure time is from several days to 12 months, depending on the thickness of the electret and the volume of the chamber. Unlike track detectors, electrets are sensitive to gamma radiation and therefore require a separate determination of the dose of gamma radiation. The voltage on the electret is measured before and after exposure directly to the site or in the laboratory. This procedure should be carried out as soon as possible to exclude further discharge of the electret charge under the influence of gamma radiation background and radon in the air.

The advantage of these devices is their repeated use, and the disadvantage is the higher cost compared to SSNTD and sensitivity to gamma radiation.

The minimum detectable activity (MDA) of the method depends on the thickness of the electret. For devices of the E-PERM type, with a brief exposure, the voltage drop across the electret is 0.054 Volts per Bq / (m^3 × day) or about 7 Bq / m^3 for 3 days. With prolonged exposure, the sensitivity is worse and is about 0.0045 Volts per Bq / (m^3 × day).

Additional methods.

Passive methods based on a short-term exposure of radon monitors for 2 to 7 days (carbon filters, electrets) are widely used to monitor and quickly identify homes with a potentially high radon content [7].

These devices do not have good integral properties, especially if the concentration of radon changes rapidly during the measurement period. The activity of coal adsorbers is maximum in the last 1-2 days of exposure and depends on temperature and humidity. Therefore, it is recommended to use them indoors in order to maximize the concentration of radon, as well as reduce its level of variation. Before exposure, carbon adsorbers are degassed at a temperature of 110 ° C for several hours. After exposure,

they are tightly closed and quickly delivered to the laboratory for analysis on a gamma spectrometer or liquid scintillation counter. The analysis of exposed carbon adsorbers is usually performed using a gamma scintillation NaI (Tl) detector due to its high efficiency. Spectrum analysis is performed on gamma lines Pb-214 (352 keV) and Bi-214 (609 keV). The background is set using an unexposed adsorber. The registration efficiency is calculated according to the standard, which is a hermetically sealed standard coal adsorber with the addition of a known content of Ra-226.

The advantages of activated carbon detectors are their simplicity, multiple use and low maintenance (when using a gamma-ray spectrometer). The disadvantages include a short exposure time (preferably less than 7 days), the influence of humidity and temperature. The MDA for this type of detector is 4-8 Bq / m^3 in the measurement time interval up to 4 days after exposure, depending on the type and size of the adsorbers and the characteristics of the gamma-ray spectrometer. MDA of carbon detectors using a liquid scintillation counter for counting is about 5 Bq / m^3 in the measurement interval up to 2 days after exposure.

Active methods using air pumping through measuring devices can be used in continuous exposure for a relatively long time. However, the instruments used are expensive and large in size, which limits the possibility of their use for large-scale studies and, therefore, they are usually used for calibration and quality control of measurements of other methods.

Typical levels of specific radon activity in calibration chambers used in the calibration of devices for measuring radon concentration in residential premises are from several hundred kBq / m^3 ×h (for example, 220 kBq / (m^3 × h) corresponds to 100, 50, and 25 Bq / m^3 for exposure periods of 3, 6 and 12 months, respectively) up to several thousand kBq / m^3 × h (for example, 6500 kBq / (m^3 × h) corresponds to approximately 3000, 1500, and 750 Bq / m^3 for the exposure period 3, 6 and 12 months, respectively).

It should be noted that in Uzbekistan until now there is no systematic monitoring of radon in the air of residential premises, regulated by international and national regulatory documents. A comparative analysis allows us to conclude that the use of activated carbon detectors is the most suitable for a quick and mass assessment of the radon safety of housing.

We used coal to determine the content of radon in water as a sorbent of a 100% absorbing substance. The silver sorbent is heated to 130 ° C in a special muffle furnace and completely freed from radon. For the measurement of water samples are taken twice a month during the year. Measurement and obtaining of the results is carried out in the following order: the preparation of the sorbent (in our case, coal) is first heated to 130 ℃ in order to free completely from radon, then by weighing it determines the mass of the sorbent. For the experiment, it is required to specially prepare the rooms, so that there should be no air exchange with the environment in the room. Then it's convenient to install a tripod in the room and hang silver charcoal so that it is 1-1.5 m from the floor, 1.5 m from doors and windows. After that, the silver sorbent is stored for 1-3 days in the room. The mass of the sorbent that enveloped the radon is determined and introduced into the ASW program. After half an hour, the sorbent is placed on a single-crystal NaI (TI) detector and then its activity increases.

Table 1. The table below shows a seasonal change in the volumetric activity of radon living rooms population

month	VAR Bq / m^3	Temperature	Humidity
November	138,6 ± 22	10	85
	157,4 ± 16		
December	199,9 ± 21	-4	87
	170,9 ± 34		
January	203,2 ± 27	10	33
	169,2 ± 26		
February	69,4 ± 12	2	45
	79,4 ± 14		
March	107,8 ± 40	15	72
	113,1 ± 29		
April	45,8 ± 16	20	40

	54,1 ± 8,3		
May	45,6 ± 8	25	35
	52,9 ± 14		
June	41,2 ± 17	29	35
	43,9 ± 13		
July	36,8 ± 16	37	19
	46,6 ± 19		
August	<22	38	18
	<21		
September	61,7 ± 31	29	15
	67,1 ± 21		
October	96,7 ± 29	14	84
	100,7 ± 35		

CONCLUSION

From the foregoing, it can be seen that the maximum and minimum content of the SAR in the room depends on the days of the season. There is a fascination with the content of the SAR for the winter period, but on the contrary, the summer time decreases. Relative to enthusiasm, the activity of radon is observed in the morning and evening time. Radon as a radioactive gas, its content inside the building depends on the air circulation of the building. It has been experimentally proven that, in the presence of the best air revolutions of a building, the variation of radon corresponds to atmospheric air.

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