

RADIOMETRIC METHODS FOR MEASURING RADIATION FACTORS IN URANIUM PRODUCTION FACILITIES

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Abstract. *This article presents the results of a study to determine the magnitude of the effects of radiation factors of uranium production on the environment, namely, to determine the values - the exposure dose rate of gamma radiation - DER, equivalent to the equilibrium volumetric activity of radon - EEVA in the processing and storage of uranium products, specific activity long-lived alpha-nuclides - DAN in atmospheric air, volumetric activity of radon in the air of the working area and the density of radon molasses from soils in areas of underground leaching - uranium UR.*

Keywords: *uranium object, equivalent equilibrium volumetric activity of radon, radiation factors, specific activity of radionuclides, exposure dose, long-lived alpha-nuclides, volumetric activity of radon, density of radon molasses.*

Introduction. The Republic of Uzbekistan has a law "On Radiation Safety" and regulatory documents - Radiation Safety Standards (NRB-2006) and Basic Sanitary Rules for Ensuring Radiation Safety (OSPORB-2006), the purpose of which is to reduce the levels of exposure of personnel, a limited part of the population, the population and the environment. the environment from the harmful effects of sources of ionizing radiation [1-2].

These regulatory documents oblige to conduct a systematic survey in any man-made objects of uranium production, as a result, to develop and implement ways to reduce the environmental impact of this object on the environment.

One of the operational nuclear-physical methods for the examination of man-made objects for radiation factors is the radiometric method.

The radiation factors present in the air of uranium production - the exposure dose rate of gamma radiation - DER, equivalent to the equilibrium volumetric activity of radon - EEVA, the specific activity of long-lived alpha nuclides, the volumetric activity of radon in the air of the working area and the density of radon molasses from soil areas - PV uranium have a harmful effect on the person, a limited part of the population, the population and the environment [3-5]. Among the radionuclides of the uranium decay chain are ²³⁴U, ²²⁶Ra, ²²²Rn, ²¹⁸Po, ²¹⁴Bi, etc. the most dangerous is radon - ²²²Rn, because radioactive short-lived radionuclides - ²¹⁸Po, ²¹⁴Bi and ²¹⁰Rb are formed from it. These short-lived radionuclides often accumulate in airborne aerosols from uranium objects.

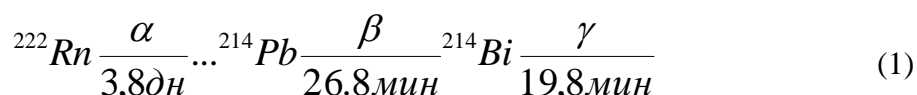
In the air of uranium objects and around it, the presence of radionuclides is everywhere - uranium decay chains - ²³⁴U, ²²⁶Ra, ²²²Rn, ²¹⁸Po, ²¹⁴Bi, etc. forces us to determine their radiation values in order to make decisions and develop measures to protect the population and the environment from the harmful effects of ionizing radiation from these radionuclides [6-8].

On the basis of the above, the determination of the values of radiation factors of uranium production - the exposure dose rate of gamma radiation, equivalent to the equilibrium volumetric activity of radon, the specific activity of long-lived alpha nuclides, the volumetric activity of radon

in the air of the working area and the density of radon molasses from soils areas - uranium IW is an urgent problem of analytical chemistry, applied nuclear physics and radioecology [9-10].

Technique and methods of physical experiment. Determination of the value - the exposure dose rate of gamma radiation was carried out by direct measurement on the device - DKS-96, the value of in the premises for storing uranium products was carried out on the device of the brand - RAA-20P "Poisk", measurements of the volumetric activity of radon in the air of the working area were carried out by the measuring complex "Alpharad plus", the value of the specific activity of DAN is determined by sampling using a sampler - PVP-04 on the filter - AFA (analytical aerosol filter) and measuring on the alpha radiometer - Progress-AR, the value of the density of radon molasses from various surfaces of uranium-bearing rocks is determined by measurement on the device - Alpharad. With express measurement and continuous monitoring of the volumetric activity of radon-222 (^{222}Rn) in the air of the working area, the limit of the permissible relative error is $\pm 30\%$ for this device.

For direct measurement of the volumetric activity of radon, using the device "Alfarad plus" registers the rays of daughter radionuclides occurring by the following reaction:



The daughter short-lived radionuclides ^{214}Pb and ^{214}Bi behave the same as the parent radionuclide ^{222}Rn . Based on this process, the amount of the parent radionuclide ^{222}Rn is directly proportional to the amount of radionuclides ^{218}Po , ^{214}Pb and ^{214}Bi .

The results obtained and their discussions. The values of the DER of gamma radiation are the main factor showing the magnitude of the impact of uranium objects on the radiation situation of the area in the area of uranium production. To assess the obvious impact of uranium production on the radiation situation at more than 40 observation points, the value of the exposure dose rate - DER located at different distances from the radiation source was measured. More than 200 measurements of DER, EEVA and DAN values were carried out at observation points. Some results of measurements of values - DER, EEVA and DAN at observation points, the influence of uranium production are given in Table. 1.

From some measurements of values - DER, ERVA and DAN given in tab. 1. It can be seen that uranium production enterprises have a moderate radiation impact on the environment. Obtained as a result of monitoring observation points, carried out for more than 10 years, show that all the values - DER, ERVA and DAN turned out to be at the level of the background value for the area. This fact shows that the current uranium production does not have a clear impact on the environment, and its influence does not leave its territory.

Table 1

Some results of measurements of values - DER, EEVA and DAN at observation points the impact of uranium production

№	DER, mkZv/h	EEVA, Bk/m ³	ДАН, Bk/m ³
1	0.11	10	0.92
2	0.12	12	1.53
3	0.11	9	1.97
4	0.09	8	2.21
5	0.10	12	1.52

6	0.12	12	0.97
7	0.11	4	2.19
8	0.13	6	1.36
9	0.12	3	1.20
10	0.10	9	1.90
11	0.12	8	2.46
12	0.13	9	1.49
13	0.11	9	2.67
14	0.13	7	2.50
15	0.12	6	3.20

To assess the radiation situation and assess the state of the technogenic object itself, a number of measurements were made - DER, EEVA and DAN in various objects, such as uranium IW sites, uranium waste tailings and off-balance ore dumps. The results obtained are shown in table. 2.

Table 2

**The results of measurements of values - DER, EEVA and DAN in uranium IW sites,
 uranium waste tailings and off-balance ore dumps**

№	DER, mkZv/h	EEVA, Bk/m³	DAN, Bk/m³
The results of measurements in the areas of uranium PV			
1	2.00	28	15.55
2	1.70	32	9.97
3	2.00	57	21.60
4	2.40	68	21.50
5	2.20	82	4.58
Results of measurements in tailings dumps			
6	3.20	31	9.95
7	3.65	46	10.77
8	3.23	64	32.80
9	3.05	56	7.32
10	4.22	38	4.61
Results of measurements in off-balance ore dumps			
11	10.8	56	22.91
12	5.60	68	24.40
13	6.80	65	11.85
14	4.65	55	6.73
15	4.35	90	64.40

As can be seen from the results given in Tab. 2., the value - DER, ERVA and DAN in various technogenic objects differs from each other. In uranium IW sites, the value of MED, EEDA, and DAN is relatively less than in uranium waste tailings and off-balance ore dumps. But despite this value, DER, ERVA and DAN are several times higher than at the observation points. The obtained results of the conducted monitoring show that the value - DER, ERVA and DAN is always less than in the established norm in SanPiN No. 0196-06. On the basis of this fact, it can

be concluded that the radiation situation in the territory of uranium production complies with all established International and Republican standards for radiation safety.

On the basis of given in tab. 1 results of measurements of values - DER, EEVA and DAN at observation points, the influence of uranium production and tab. 2 results of measurements of values - DER, EEVA and DAN in uranium IW sites, uranium waste tailings and off-balance ore dumps, it is possible to calculate the annual effective dose for the population, a limited part of the population and for personnel working in these facilities.

Table 3

Results of measurements to determine RSA and physical parameters of the environment

№	RSA, Bk/m³	Temperature, °C	Humidity, %	Atmospheric pressure, mm Hg
1	23	25	44	728
2	25	24	43	735
3	21	27	41	729
4	24	28	41	732
5	23	25	44	728
6	28	24	43	735
7	20	27	41	729
8	27	28	41	732
9	20	25	44	728
10	25	24	43	735
11	23	27	41	729
12	26	28	41	732
13	28	25	44	728
14	21	24	43	735
15	24	27	41	729

In the atmospheric air of rooms where radioactive ores and radioactive products are stored – uranium chemical concentrates, uranium nitrous oxide, etc., radon is present in a certain amount - a member of the uranium decay chain that negatively affects the health of personnel and the environment. To determine the value of the equivalent equilibrium volume activity of radon in the storage rooms of uranium products showed that the longer the radioactive product is stored in closed rooms, the more radon accumulates.

Some results of the volumetric activity of radon – OAR and the physical parameters of the environment determined in localities are given in Tab. 3.

As can be seen from the results in Tab. 3. The volume activity of radon – OAR in populated areas has slightly less values than in certain values in various man-made objects such as - in dumps, tailings dumps and in areas of PV uranium shown in Figure 1 graphical dependence.

In addition to the above radiation factors in the area where uranium production operates, graphical dependences of the radon molasses density in various technogenic objects were found – in dumps, tailings dumps and in areas of uranium PV with the values of radon volumetric activity. Fig. 1. shows the graphical dependence of the OAR on the density of radon syrup and atmospheric pressure of the environment.

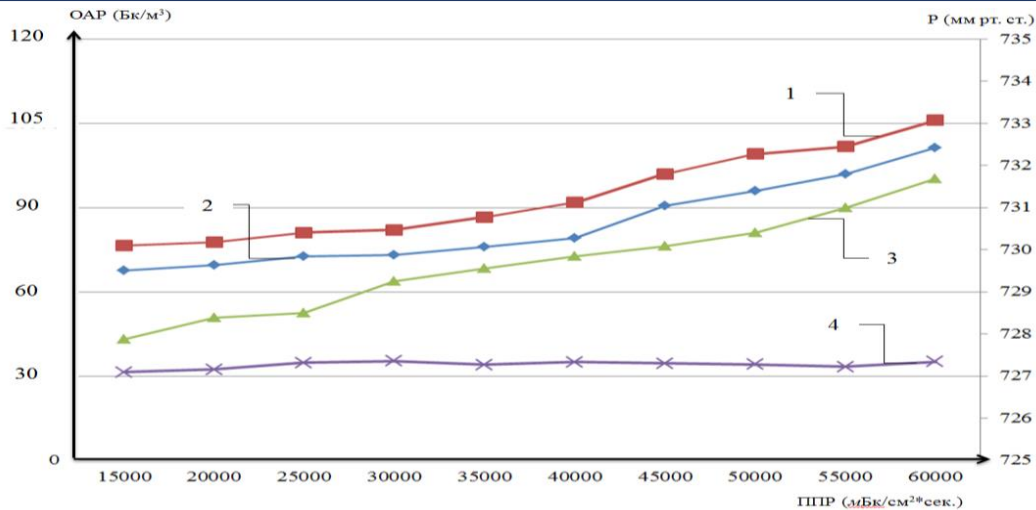


Fig. 1. Graph of the dependence of the value of the volumetric activity of radon in the air on the density of radon molasses from the rocks of uranium dumps, tailings dumps and sites of uranium PV.

1 – the line of dependence of the value of the volumetric activity of radon in the air on the density of radon molasses from the rocks of uranium dumps.

2 – the line of dependence of the value of the volumetric activity of radon in the air on the density of radon molasses from the rocks of tailings.

3 – the line of dependence of the value of the volumetric activity of radon in the air on the density of radon molasses from the rocks of the uranium PV sites.

4 – line changes in atmospheric pressure values during measurements of the volumetric activity of radon in the air and the density of radon molasses from the rocks of uranium dumps, tailings dumps and sites – PV of uranium.

Based on the results obtained and the constructed graph, it is established that the values of the OAR directly depend on the density of radon molasses coming out of the soil of these objects. With a change in the density of radon molasses coming out of the soil from 15 000 MBq/cm² *sec to 60 000 MBq /cm²*sec, the value of the OAR in the air will change from 40 Bq/m³ to 110 Bq/m³. Under these conditions, the atmospheric pressure values will not change significantly from 727 mmHg to 728 mmHg. The dependence of the values of the volumetric activity of radon in the air on the density of radon molasses from the rocks of uranium dumps will change more intensively than the changes in the values of the volumetric activity of radon in the air on the density of radon molasses from the rocks of the sites – PV uranium.

Conclusion. On the basis of the conducted studies to determine the magnitude of the effects of radiation factors – the power of the exposure dose of gamma radiation - MED, equivalent to the equilibrium volumetric activity of radon – EROA in the processing and storage of uranium products, the specific activity of long-lived alpha-nuclides – DAN in atmospheric air, the volumetric activity of radon in the air of the working area and the density of radon molasses from soils underground leaching sites – From the soils of uranium dumps and from the soils of tailings of uranium waste, it can be concluded that the value of these factors and the specific activity of radionuclides in the studied object corresponds to the established norms and does not exceed the values established in SanPiN-0193-06.

The data obtained show that the radiation situation in and around this technogenic uranium object is in satisfactory condition and do not have a clear negative harmful effect on the health of the population, a limited part of the population, personnel and the environment.

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