DETERMINATION OF THE ^{238}U CONCENTRATION IN CONCRETE SAMPLES BY REGISTRATION OF FISSION NEUTRONS

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In the work was to carry out and to improve the fission elements content tests of techniques for the concrete samples analysis of weight up to 0.5 kgs. The basis of this technique is the active analysis. Researched samples were irradiated with flows of neutrons received on the basis of the electron linear accelerator. The neutrons induce fissions in the samples. Experiment was carried out at ELE - 300 NSC KIPT. The technique allowing expressly, with a sufficient degree of reliability is checked up in operation to define the contents ^{238}U in concrete samples. Achieved in the given experiment sensitivity makes ~ 10 g of uranium in a sample.

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INTRODUCTION

For successful performance of the complex of measures for liquidation of consequences of failure on ChNPP Unit 4 it is necessary to solve a number of specific tasks, in particular, on detection of missing fuel, which total amount now makes from 70 up to 150 t by different estimations [1]. One of the reasons for misbalance of fuel in under reactor premises of the 4-th unit could be complicated processes of interaction between the rest of the reactor active zone and concrete constructions that was not foreseen at emergency by the project [2]. Over the last few years, considerable progress has been made in the field of assay techniques for radioactive waste [3-5].

The purpose of the present work was to work out and to test methods for determination of the fission elements content in the concrete samples up to 1 kg in weight.

METHOD AND MEASUREMENTS

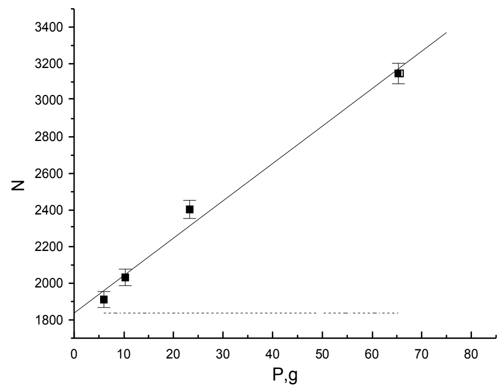
The high density of the samples, as well as their high water content (up to 20%), means that only high-energy neutrons or gamma particles have a high enough range to activate the samples. During the work the samples were irradiated by neutrons from the neutron generator, which was constructed on basis of the electron linear accelerator. The secondary prompt and delayed fission neutrons were registrated by the SNM−11 detector.

The experiment was carried out on the test bed of the linear accelerator LEA-300. The parameters of a beam in the given work were the following: energy E_e = 20 MeV, average current I_e = 2 μA, pulse frequency f = 50 s^{-1}, pulse duration was 1 μs. In details the used experimental technique is described in [6].

At realization of fission neutrons measurements the method of time selection was used, at which the registration circuits are passed the pulses only during some time interval shifted in relation to the accelerator bunch for the time of 5 ms.

It allowed to exclude from registration the pulses resulting from gas ionization in the counter by easy particles at the moment of the accelerator electron bunch and also to get rid of a significant part of background loadings from a primary flow of neutrons.

The researches were carried out on the specially made four concrete samples with the uniformly spread admixture of ^{238}U. The samples contained 6, 10.3, 23.3 and 63.3 g of uranium, accordingly. The size of samples was 8×10×3 cm^3, weight ~ of 500 g. The analogical concrete block without of uranium was used to check influence of the sample matrix.



The dependence of neutrons detector indications (N) on quantity of uranium in a sample (P,g)

EXPERIMENTAL RESULTS

The results of measurements are given on Fig., where the reading numbers of the registered neutrons are shown depending on weight of uranium in a sample. The specified errors of experimental points are statistical. The dashed line in figure specifies a level of a background in measurements. For background the measurements were fulfilled at absence of any sample in flow of neutrons. The results of measurements with a sample matrix only coincided with background measurements within the limits of errors. The additional experiments also have shown that the detector has a sufficient wide-capture aperture of neutron registration and the efficiency of the account did not depend on the sizes of used samples.

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The solid line in figure shows approximation of experimental points by the linear dependence with fitting by the method of least squares:

$$R = AP + B,$$

where P is the weight of uranium, A is sensitivity of the installation, B is level of a background. The results of fitting have given the following values: $A = 18.2 \pm 1.2$; $B = 1817 \pm 34.5$.

From figure it is seen that the experimental points are satisfactorily described by the linear dependence, and this confirms reliability of the measurements.

As the additional control there were carried out control measurements with three gauge samples of refined ^{238}U of weight 4.3, 13.6 and 55 g. The results of measurements of samples from concrete and measurements, using the following formula:

$$P_o = P_к (R_o/R_k)$$

(P_o, P_k - weight of researched and gauge samples, R_o, R_k - number of detector readout of the researched and gauge samples) the estimations of quantity of uranium in researched samples were received. The results of comparison are given in the table where the first column contains the true amount of uranium in concrete samples and all other columns present the values calculated with the help of the given above expression with taking into account weights of the gauge samples. In all cases the statistical errors are taken into account only.

P_u, g (concrete)	P_u= 55 g (gauge)	P_u= 13.6 g (gauge)	P_u= 4.3g (gauge)
65.3	59.9 ± 5.0	44.4 ± 7.6	53.3 ± 13.0
23.3	25.1 ± 3.0	18.6 ± 3.8	--
10.3	6.3 ± 3.0	4.7 ± 2.3	--

From the table it is clear, that the results of estimations satisfactorily coincide with value of the contents of uranium in researched samples. The best consent, as it was necessary to expect, turns out at the greater concentration of uranium both in researched and in gauge samples.

CONCLUSIONS

Thus, the technique allowing expressively, with a sufficient degree of reliability is checked up in operation to determine the ^{238}U content in concrete samples. Achieved in the given experiment sensitivity makes ~ 10 g of uranium in a sample. Now, we concentrate on two areas of importance for application of the present technique to waste assay. First, the enhanced efforts are been taken to decrease the background at measurements and to increase of efficiency of the recording system. Second, we will build and evaluate a prototype assay system scaled up to large sample volumes and based on o experimental setup.

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