X, γ, β – SPECTROMETRIC INVESTIGATIONS OF CHERNOBYL "HOT PARTICLES" NUCLIDE COMPOSITION

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Results of investigation of the radionuclide composition of "hot particles" from Chernobyl "Shelter" Object are discussed. An estimate of radionuclide activity of radioactive pollution levels for some premises of "Shelter" is performed.

PACS 28.41.Kw.

It is known [1,2], that considerable part of radionuclides, that have been eject as a result of the incident at the 4th block of Chernobyl APP, is in so called "hot particles" (fine-disperse particles with sizes from fractions of micron to hundreds of microns). The specific activity of such particles for ^{137}Cs can reach 10^6…10^8 Bq/g. Hence the "hot particles" can determine the radiation situation in premises of "Shelter". The high mobility of these particles makes it possible for them to transfer from one premise to another and get out of "Shelter".

There are many types of "hot particles", which are pieces of nuclear fuel, structural materials etc. The radionuclide composition of many of them is not completely investigated, the proportion of radionuclide activities in the particles is not constant. In this regard the investigation of the particles radionuclide composition from the point of view of understanding processes taking place in "Shelter" premises and their influence on the environment are important.

The investigation of radionuclide composition was carried out for 26 samples contained "hot particles" (24 smears and 2 powders) from a number of premises of "Shelter". In addition 2 boring cores from concrete of walls were investigated. The aims of the investigation were: determination of radionuclide composition and activity for substance of the samples, estimation of the radioactive pollution of the premises.

The spectrometric analysis was carried out by means of γ-,X-,β-spectrometers on the base of Ge(Li), Ge and Si(Li) detectors. The energy graduation and registration efficiency of spectrometers was determined by means of standard sources (^{90}Sr, ^{60}Co, ^{134}Cs, ^{137}Cs, ^{152}Eu, ^{238}Pu, ^{241}Am) in the same geometry, in which further on the measurements for investigated samples were carried out. The characteristics of γ-,X-,β-spectrometers are the follows:

- Energy resolution of the γ-spectrometers on the base of Ge(Li) detector at the line of 1333 keV is 2,5 keV;
- Energy resolution of the X-spectrometers on the base of Si(Li) detector at the line of 13,94 keV is 200 eV;
- Energy resolution of the X-spectrometers on the base of Ge detector at the line of 59,5 keV is 590 eV;
- Energy resolution of the β-spectrometers at the K-line of conversion electrons of ^{137}Cs source is 8,4 keV.

The substance of the samples (smears) was contained between two layers of coarse calico in the thin polyethylene package so the absorption effect for γ- and β-radiation in the investigated range of energies was negligible.

At measuring of γ-,X-radiation in the energy range of 10…150 keV, and also β-radiation, a lead screen of 10 mm thick with an hole 10 mm in diameter was put on a sample (further on the measured activity was normalized on the square of this hole). At measuring of γ-radiation in the energy range of 80…2000 keV the screen was not used. In the process of measurement there were determined: activity of fission products (^{90}Sr, ^{125}Cb, ^{134}Cs, ^{137}Cs, ^{154}Eu, ^{155}Eu); activity of activation product (^{60}Co); activity of ^{241}Am. Also activities of Pu isotopes were estimated. The detection limits of radionuclide activities depended mainly on the quantity of substance in the samples. For less active nuclides, which are however important for radiation safety, the upper limits on activity were determined (^{144}Ce, ^{235}U, ^{238}U).

Side by side with γ-radiation of radionuclides in the measured spectra XK-radiation Zr and Nb were observed, that gave evidence for the considerable content of these elements in the substance of samples.

Typical radiation spectra from samples are shown at Figs. 1-3.

The results of radionuclide activity measurements for some premises of "Shelter" are gathered in table.

According to the data of reference [2] a small fraction of "hot particles" containing the fuel is enriched by ^{137}Cs. Probably, particles of this type are maintained in the samples №1 and №3 that were taken in premise №208. In this samples the activity of ^{137}Cs is 5 times higher than that of ^{90}Sr.

A presence of ^{241}Am is noticed in the samples №1, №4 and №5 taken in premise №360. The ^{241}Am activity in this samples is 5…17 Bq/cm^2. For other samples with a considerable ^{137}Cs activity the upper limit of the ^{241}Am activity is estimated.

Also activity of plutonium isotopes is estimated for samples with marked ^{137}Cs content.

According to the obtained results, premises №3,9, №206/2 and №006/2 are least polluted among

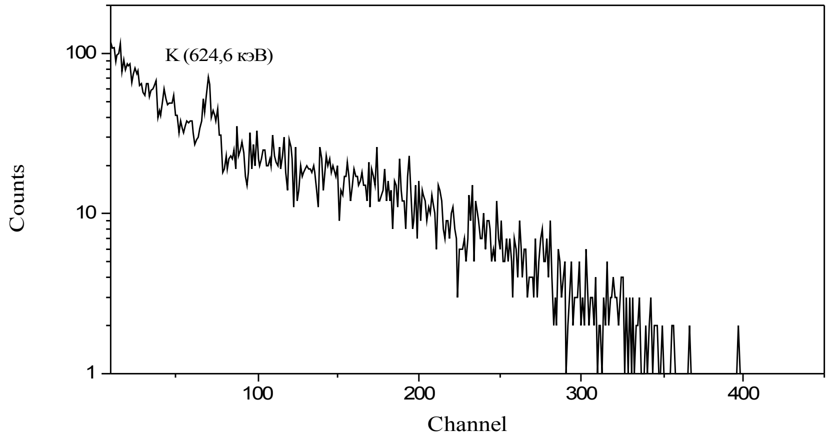

Fig. 1. *The β-spectrum of a "hot particles" sample was obtained by of the β-spectrometers. Premise №360, sample №4*

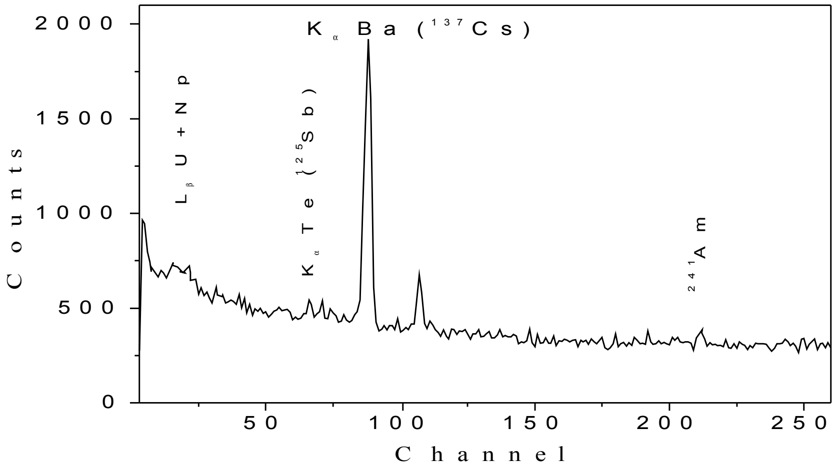

Fig. 2. *The X-,γ-spectrum of a "hot particles" sample was obtained by of the Si(Li)-spectrometers. Premise №360, sample №4*

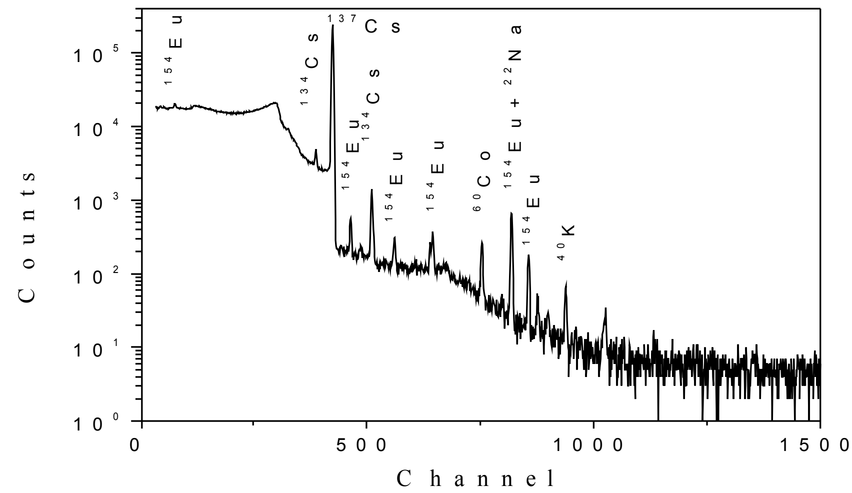

Fig. 3. *The γ-spectrum of a "hot particles" was obtained by of the Ge(Li)-spectrometers. Premise №012/6, sample №1*

inspected premises of “Shelter”. Premises №208/9 and №360 are most polluted, however for those strong activity variations for the samples (smears) are typical.

The powdery samples picked in premises №012/6 and №304/3 possess considerable specific activity, have the same radionuclide composition and contain products of fission of nuclear fuel. It must be noted that in the sample substance the 90Sr activity a few times exceed that of 137Cs.

Presence of 134Cs and 137Cs was observed in the point on external surface of boring cores from concrete of walls. Radionuclides of fuel substance were not observed in the depth of these samples.

By analyzing results collected in the table we can make conclusion that the radionuclide composition and relations between radionuclide activities are approximately equal for various premises of “Shelter”. The fact is probably explained by transport of the pollution from one premise to another during visitation of personnel.

The results of measuring of the radionuclides activity

№ premise and № sample	**The radionuclides activity in the samples Bq/cm²**											
	^{90}Sr	**^{125}Sb**	**^{144}Ce**	**^{137}Cs**	**^{134}Cs**	**^{60}Co**	**^{154}Eu**	**^{155}Eu**	**^{235}U**	**^{238}U**	**^{238,239,240}Pu**	**^{241}Am**
№3,9 №1	<15			9								
№3,9 №2	<20			2								
№3,9 №3	45	<1	<20	25	0,2	0,1		<7	<3	<8	<25	<2
№360 №1	1500	12	<30	1400	9	1,5	8	10	<10	<30	<150	15
№360 №2	20	<3	<3	35				<1	<4	<7	<50	<2
№360 №3	40	<3	<3	37	0,2			<1	<4	<7	<50	<2
№360 №4	2000	20	<30	1500	11	2	11	10	<7	<30	<135	17
№360 №5	510	9		400				<5	<4	<30		5
№006/2 №1	<25			26								
№006/2 №2	20			32								
№006/2 №3	25			22								
№006/2 №4	20			72								
№006/2 №5	50	1	<7	75	0,6	0,2	1	<2	<3	<20	<15	<2
№006/2 №6	35			20								
№206/2 №1	25	<2	<10	35				<1	<2	<5		<2
№206/2 №2	<15	<1	<7	8				<2	<2	<10		<1
№206/2 №3	<15	<2	<5	10				<1	<2	<10		<1
№206/2 №4	50	<1	<5	17				<2	<3	<10		<1
№206/2 №5	<15	<1	<10	60	0,45	0,1	0,1	<2	<3	15	<35	<2
№208/9 №1	100	<2	<13	590				<3	<4	<45	<25	<2
№208/9 №2	<10		<5	40				<1	<3	<5		<1
№208/9 №3	90		<15	510	3,5			<2	<4	<30		<2
№208/9 №4	<10		<5	10				<1	<2	<5		<1
№208/9 №5	<25		<4	15				<1	<2	<7		<1
№012/6№1	115400*			28000*	180*	6*	900*	460*			1100*	360*
№304/3№1	108500*			30000*	240*	3*	1000*	500*			2100*	540*

Note- the value of activity is shown in Bq/mg.*

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