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ANALYSIS OF THE FLUCTUATIONS OF THE AVERAGE MONTHLY ACTIVITY AT A NUCLEAR POWER PLANT WITH AN RBMK-1000 REACTOR

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The results of an analysis of the fluctuations of the relative activity of gaseous (inert) and the specific activity of volatile (iodine) fission products in the technological medium of the power-generating units of the Kursk and Smolensk nuclear power plants in 1996 and 1997 are presented. It is shown that these quantities behave in time as fluctuation bursts against a quasistationary background. Using a large set of statistical data, it is shown that this character of the activity is a consequence of two processes: the appearance of leaks in the fuel elements and the unloading of fuel assemblies containing unsealed fuel elements. A relation, which is the same for all power-generating units, between the number of bursts per year and the number of unloaded fuel assemblies is found. The amplitude distribution functions of the bursts, indicating the existence of groups of defects in RBMK-1000 fuel elements, are obtained. The results obtained are discussed and conclusions are presented. 3 figures, 1 table, 1 reference.

The tightness of the sealing fuel elements is an important indicator of the operational safety of power-generating units. The activity of the fission products and its variation in time in a technological medium can contain helpful information about the dynamics of defect formation and about the leakage of radionuclides from unsealed fuel elements, characterizing the effective size of a defect. For the computer codes that calculate the activity under the jackets of sealed or unsealed fuel elements as well as in the technological medium of a reactor, specifically, for the FPR_RBMK.03 code developed jointly with the Russian Science Center “Kurchatov Institute,” a leak determined computationally or experimentally is important. In the present paper, a large amount of data on the average monthly total relative activity of gaseous fission products in the vapor of drum-separators, the specific activity of $^{131}$I and $^{134}$I in the water in drum-separators, and the total specific activity of iodine in the coolant of a multiple forced circulation loop (MFCL) is analyzed. The instantaneous measurements of these quantities and their averaging over each month of operation of power-generating units were performed by a team at the Kursk and Smolensk nuclear power plants. Our attention was drawn to the fluctuation of the average monthly values of the indicated quantities. As far as we know, such an analysis has never been performed previously on a large set of statistical data.

The initial data were analyzed using a graphical representation for the dependences. This makes it possible to find the temporal correlations and to estimate the character of the variation of these quantities. As an example of the initial data, Fig. 1 shows the time dependence of certain average monthly quantities obtained on the third power-generating unit of the Kursk nuclear power plant in 1997. The relative activity of the gaseous fission products in the vapor of the 4th drum-separator was calculated from the average monthly measurements of the radiation from the condensate of the vapor. The average monthly total specific activity of iodine isotopes at sampling point 19 in the MFCL and the specific activity of $^{131}$I and $^{134}$I was calculated from the activity, respectively, in the MFCL water (point 19) and each drum-separator.

Fig. 1. Time variation in months of the specific activity of iodine isotopes at sampling point 19 in the MFCL (a), average specific activity of $^{134}\text{I}$ (b) and $^{131}\text{I}$ (b) in the water in drum-separators, and average relative activity of gaseous fission products in the vapor of the drum-separators (d): ●, ○, Δ, □ 1st, 2nd, 3rd, and 4th drum-separators, respectively.

As a result, the following conclusions were drawn for the power-generating units analyzed:

- The changes in the specific activity of iodine and the relative activity of gaseous fission products have the form of fluctuation bursts against a quasistationary background.

- The relative fluctuation of the average monthly total specific activity of iodine at point 19 in MFCL is much smaller than the relative fluctuation of the specific activity of $^{131,134}\text{I}$ in water and the relative activity of gaseous fission products in the vapor of the drum-separators, so that the measurements performed at point 19 were excluded from the analysis.

In this paper, it is assumed that the fluctuation character of the specific activity is due to the temporal dynamics of two processes: the appearance of defective fuel elements in some fuel assemblies (increase of the specific activity) and unloading of fuel assemblies with unsealed fuel elements (dropoff of specific activity).

It follows from the fluctuations of the average monthly values that the real time scale of their variation is 1 month, which is longer than the half-life of $^{131,134}\text{I}$ and the gaseous fission products. Under these conditions, an approximately linear dependence of the specific activity of a radionuclide and its leakage into the coolant through a defective fuel element,* which follows from the continuity equations, is realized. For example, for a drum-separator with water mass $M$ this dependence has the form

$$k_i = q_i M (1 + K_i/\lambda_i),$$

where $k_i$ is the leakage from the fuel element or the rate at which the $i$th radionuclide enters the drum-separator through a defect, $1/$sec; $q_i$ is the specific activity, $1/(\text{sec-kg}); K_i$ is the total rate of removal of the radionuclide (in this case, by vapor), $1/$sec; $\lambda_i$ is the decay rate of the radionuclide, $1/$sec. Thus, the change in the specific activity in time can be interpreted as the dynamics of

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