DETERMINATION OF SPONTANEOUSLY FISSIONING ACTINIDE ACTIVITY BY NEUTRON CORRELATION METHOD

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Approximate models have been developed and experimentally verified for the activity of spontaneous fission of actinide elements by neutron correlation method.

Introduction

Non-destructive methods of actinide spontaneous fission activity determination are widely used in measuring practice. They comprise calorimetric methods, techniques based on detection of fission instantaneous γ-radiation, and fission neutron time correlation methods. The latter seem more preferable due to high penetrating ability of neutrons, expressness and relative simplicity of their implementation. Methods are being developed along the lines of improving the measurement means for neutron correlation analysis as well as developing the models, that most adequately describe the dependence of a device response on the actinide spontaneous fission activity, correct accounting of the affecting factors and a search of calibration procedures, providing the improvement of determination accuracy without the loss of expressness.

The models that most adequately characterize a measuring device response by the Monte-Carlo method in different approximations, accounting for the real distribution of the multiplicity of actinide spontaneous fission neutrons and the influence of the multiplication effect thereon in the neutron intrinsic field have been developed. Approximate models that make it possible to obtain calibration dependences as analytical expressions have been developed as well for specific types of compositions assayed. The serviceability of the models developed has been experimentally shown and various error components have been estimated.

Specific examples of implementation of the methods developed are given as applied to Pu metal and oxide specimens of different isotopic compositions, U–Pu metal oxide fuel (MOX) as well as isotope production on \(^{238}\)Pu dioxide and \(^{252}\)Cf base. The possibilities of \(^{244}\)Cm spontaneous fission activity determination are considered.

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The relative error of determination varies in the range from 0.1 to 3.0%, depending on the compound type, isotopic and chemical composition, etc.

**Experimental and discussion**

The needs of the nuclear physical methods developed set forth the goal of developing and certifying the measuring means from spontaneous fission activity of the main transuranium nuclides. The most suitable nuclides are $^{240}$Pu, $^{244}$Cm and $^{252}$Cf$^{1,2}$.

To settle this problem, SP-1 and SP-2 specimens have been manufactured from metal Pu containing about 90% of $^{240}$Pu and less than 0.3 mass % of impurities.

Jointly with Mendeleev All-Union Scientific Research Institute of Metrology, we carried out a long-term study of the SP-1 and SP-2 specimens. These specimens were then certified as the working standard of $^{240}$Pu spontaneous fission activity$^3$ for the first time in the world practice.

The working standard of the radionuclide spontaneous fission activity unit SRS 6–16–88 represents a set of reference standards and is meant for maintaining and transferring the radionuclide activity unit from the activity unit state primary standard SPS 6–84 to reference and working measuring means in order to improve the accuracy and ensure the uniformity of measurements of the radionuclide spontaneous fission activity. The standard comprises the following measuring means: (1) radionuclide spontaneous fission activity standards — SP-1 and SP-2 sources on the $^{240}$Pu base with known isotopic composition, and (2) the comparator-radiometric counter of neutron coincidences NCC-1$^4$ meant for transferring the spontaneous fission activity unit to the 1st reference grade standards of radionuclide spontaneous fission activity.

Spontaneous fission activity standards (SP-1 and SP-2 sources) are meant for maintaining and transferring the spontaneous fission activity unit from the working standard to 1st grade reference (working) standards of spontaneous fission activity via the NCC-1 comparator in the range of $20–2 \times 10^6$ Bq, as well as to 1st grade reference (working) devices of spontaneous fission activity measurements in the range from 20 to $2 \cdot 10^6$ Bq by the direct method of measurements.

The methodological error of the activity unit transfer via the NCC-1 comparator varies in the range from 0.5% to 1.5% at a confidence level of 0.95, depending on nuclide composition, shape and mass of the sources certified. The relative error of certification of the 1st grade reference standards and devices of spontaneous fission activity is measured in the range from 4.0 to 8.0% and from 0.5 to 2.0%, respectively, at a confidence level of 0.95.

Reference standard means of spontaneous fission activity measurements are used