

Evaluation of the sensitivity of the gas-discharge gamma-counters to the concomitant neutron radiation

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Abstract. In the fields of gamma-neutron radiation the accuracy measurement of gamma-ray doses depends on their sensitivity to concomitant neutron radiation. In this connection, verification results of gamma-dosimetry on the installation with isotope cobalt or cesium sources are not always adequate to measurement results in real gamma-neutron fields. The data prove, that the sensitivity coefficients of gas-discharge gamma-dosimeters at PRIZ-M reactor is 1.23 larger as compared to Co^{60} source, due to the effect of the concomitant neutrons on their indications. The error due to the neutrons effect can be significantly reduced or eliminated completely, if gamma-dosimeters calibrated in the field of gamma-neutron radiation, adequate spectral and dose characteristics to radiation fields in which they are used.

1. Introduction

Gas-discharge gamma-counters produced domestically are applied in dosimetric and radiometric devices for recording hard beta and gamma radiation. Widespread of counters is explained by their high sensitivity due to secondary ionization effect, simple design, high output power, low cost, wide operating temperature range and not strict requirements to supply voltage stability.

In the fields of gamma-neutron radiation, the accuracy measurement of gamma-ray doses depends on their sensitivity to concomitant neutron radiation, which is registered by the counter recoil nuclei and nuclear reactions products occurring in the counter case and gas. In this connection, verification results of gamma-dosimetry on the installation such as SPGU-1, KIS-NRD or UDG-AT130 [1, 2] with isotope cobalt or cesium sources are not always adequate to measurement results in real gamma-neutron fields. Besides, under real measurement conditions the neutrons contribution to the indication of gamma-dosimeter cannot be always estimated as the pulses generated by the counter under the impact of gamma-rays and neutrons are not identified to pulse shape or their energy. In consequence of this effect reduction, caused by neutrons, from electronic devices is not feasible. The result is an unaccounted systematic error due to gamma-dosimeter sensitivity to concomitant neutrons.

The motive to conduct special experiments on evaluation of neutron effect on the indication of gas-discharge gamma-counters is the insufficient information concerning this problem in published papers.

Purpose of work is evaluation of the sensitivity of the gas-discharge gamma-counters to the concomitant neutron radiation.



2. Evaluation

The studies were conducted in standard fields of PRIZ-M reactor gamma-neutron radiation and in the field of standard cobalt gamma-ray source. Using standard fields in experimental studies should be regarded as one of the ways to improve the accuracy of measurement results, since the radiation parameters in these fields are previously investigated with the help of standard measurement tools, and measurement results are “tied” to the indications of the reactor monitor channel based on fission chamber KNT-5.

The absorbed dose of gamma-ray in standard field was measured at the metrological certification of the installation with a set of ionization chambers out of the composition of the military standard VE-19PDN-2 [3] at an error of 9.5%. The objects of investigation are gas-charged gamma-counters produced domestically.

The coefficients (K) of sensitivity to gamma-rays are determined experimentally, their values are equal to the ratio of counter indication (N) to the absorbed dose of gamma-rays (D_γ) in a standard tissue. By the same algorithm the values of sensitivity coefficients to gamma-ray of Co^{60} standard source have been determined. The average sensitivity coefficient values of gamma-dosimeters (on the results of three measurements) are given in the table 1 at an error of 10% at confidence probability 0.95.

Table 1. Sensitivity coefficients of gas-discharge gamma-dosimeters produced domestically in the fields of different radiation sources: E_γ and E_n are the average energy of gamma-ray and neutrons, respectively; K is the sensitivity coefficient.

Radiation source	E_γ , MeV	E_n , MeV	K 10^{-10} , imp/Gr
PRIZ-M reactor	1.66	0.67	0.76
Co^{60}	1.25	—	0.62

The data from table 1 prove, that the sensitivity coefficients of gas-discharge gamma-dosimeters at PRIZ-M reactor is 1.23 larger as compared to Co^{60} source, $K_{\text{PRIZ-M}}/K_{\text{Co}^{60}} = 1.23$, due to the effect of the concomitant neutrons on their indications. The results of radiation parameters analysis under real conditions of using dosimeters prove that the contribution of concomitant neutron on gamma-dosimeters indications might have even more value than obtained in this experiment, as K-value depends on not only spectral neutron composition, but on the ratio of neutron and gamma-ray doses D_n/D_γ .

The error due to the neutrons effect can be significantly reduced or eliminated completely, if gamma-dosimeters calibrated in the field of gamma-neutron radiation, adequate spectral and dose characteristics to radiation fields in which they are used [4].

To solve this problem at PRIZ-M reactor the model field of gamma-neutron radiation was created by variety of materials, transforming the radiation parameters to the desired values. The criterions of similarity are the energy spectra of neutrons and ratio of neutron and gamma-ray doses in real radiation field characteristic of the zone of spectral-angular balance forming in the open area at a distance from sources more (3–4) λ [5], where λ —the average length of neutron runs in the air. Radiation parameters in a model field were investigated by the calculated and experimental methods by means using ROZ-6.5 program. The maximum divergences of neutron density flux in different energy groups do not exceed 12%, which indicates the satisfactory reproduction of the given neutron spectrum in the model field. The D_n/D_γ ratio equal to 0.88 (in the modeling field) and 0.96 (in the test field) is also quite close.

Our results indicate that the error of measurement gamma-ray dose in real gamma-neutron fields is two times lower at the dosimeter calibration in model field than in a cobalt source.

3. Conclusion

The sensitivity of gas-discharge gamma dosimeters to radiation at PRIZE-M reactor is 1.23 larger as compared to Co⁶⁰ source, due to effect of the concomitant neutrons on their indications.

References

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