Real Time Neutron Dosimeter Response Calculations

A. Seghour and F.Z. Dehimi

Laboratoire de Dosimétrie des Rayonnements. Centre de Radioprotection et de Sûreté. 02, Bd Frantz Fanon. B.P. 1017. 16000 Alger. Algeria.

Abstract

The response of a real time neutron dosimeter using a thin LiF target sandwiched between two parallel surface barrier semiconductor detectors is studied for different neutron distributions and different angles of incidence. Calculations of the response function defined for a simultaneous detection by the two detectors of the particles emitted when the reaction $^6Li(n,t)\alpha$ occurs in the target are fulfiled by geometrical considerations of the reaction kinematics and the differential cross section variations. Finally, the efficiency of the studied detection system is analysed for dosimetric uses.

Introduction

A good neutron dosimeter will present good sensitivity and a known neutron energy response. These conditions are generaly fulfiled by neutron spectrometers, reason for which many neutron dosimeters derive directly from neutron spectrometer designs. Recently [1], a neutron spectrometer using a thin LiF target and two surface barrier detectors has been studied, designed, and applied to determine neutron energy distributions at different irradiation sites in a nuclear reactor. This design is easily modified to serve as a neutron dosimeter.

Dosimeter description

Two surface barrier detectors which active surfaces face each other are used to detect charged particles from $^6\mathrm{Li(n,t)}\alpha$ reactions occuring in a thin LiF layer sandwiched between the two diods. The response of a neutron dosimeter based on the use of such a detection assembly is strongly dependent on the kinematics of the $^6\mathrm{Li(n,t)}\alpha$ reaction and the geometrical considerations of the emission and the detection of the charged particles. In this work, the attention is focused on the detection assembly in order to calculate the response function of the neutron dosimeter.

Response function calculations

Neutron fluxes are generally contaminated by γ. In order to realize a neutron dosimeter only suitable for neutrons in a mixed $n-\gamma$ field, a coincidence detection mode is used. In the first approach, it seems that such a detection assembly will have a poor detection efficiency for intermediate and fast neutrons. Nevertheless, it has been shown in another work [1], that the charged particles issued from the reaction $^6Li(n,t)\alpha$ are emitted in an angle greater than 140^0 for neutron energies as important as the fission neutron energies (17 $\sim$ 20 MeV).

The total number of the particles detected with the coincidence condition is :

$$N(E_n) = N_0\ \Phi(E_n)\ G(E_n) \qquad (1)$$

where the geomerical function $G(E_n)$ is defined as :

$$G(E_n) = \int_0^e dx \int_0^R r dr \int_0^{2\pi} d\phi \int_0^{\theta_{max}} \int_{\beta_{min}(\theta,\phi)}^{\beta_{max}(\theta,\phi)} \frac{d\sigma(\cos\theta)}{d\cos(\theta)}\, P\, R(\beta)\, d\beta\, d\cos(\theta) \qquad (2)$$

whith :

N_0 : target nuclei number, $\Phi(E_n)$: neutron flux of an energy E_n, e : ^{6}LiF target thickness, R : detector active surface radius, P : coincidence detection condition : P = 1 if the detection coincidence is fulfiled, P = 0 if the detection coincidence is not fulfiled, and R(β): the ratio of the detected particles emitted within a solid angle $d\Omega = d\beta\, d\cos(\theta)$ to the total emitted particles.

Results of calculations of 78 neutron energy groups are reported in Fig.1.a. were the response functions for normal and lateral incidences, i.e. 0^0 and 90^0. It can be seen that geometrical function follows 1/E form for neutrons below 1 keV and the dosimeter angular dependence is only sensitive to fast neutrons.

The neutron energy response of the dosimeter is calculated using several well known neutron distributions. Calculations are fulfiled taking into account the energy detection resolution of diods (fwhm $\simeq$ 15 − 20keV). This conduct to express the total number of the detected particles of a neutron incident energy E_n as :

$$N(E_n) = N_0 \int_{E_n-\Delta E_n}^{E_n-\Delta E_n} \Phi(E)\ R(E_n - E)\ dE \qquad (3)$$

with:

$$R(E_n - E) = \frac{1}{\sqrt{2\pi}\,\sigma} G(E)\ \exp{(E_n - E)^2/2\sigma^2} \qquad (4)$$

Results of the neutron dosimeter responses for : 1/E distribution, fission distribution and reactor distribution (moderated 1/E plus fission) are reported on figures 1.b.c. and d.

Conclusion

For neutron energies below 1 keV, the response of the real time neutron dosimeter has a 1/E form independently of the angle of incidence and the neutron distribution. Whereas, for fast neutrons it is found that the dosimeter is sensitive to angle and energy variations.

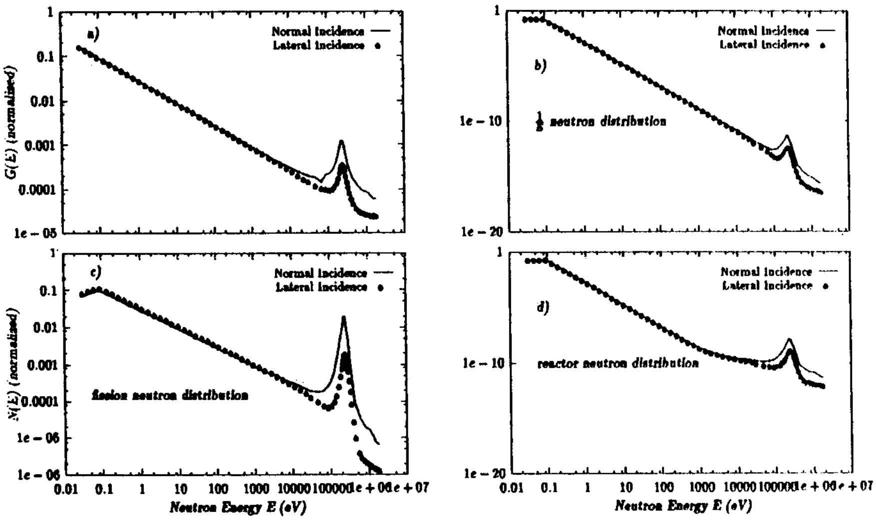

Fig1. a) The geometrical function. Neutron response functions for : b) 1/E distribution. c) fission distribution. d) reactor distribution.

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References

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