RESPONSE OF A BF_3 COUNTER WITH TWO PARAFFIN MODERATORS FOR NEUTRON DOSE EQUIVALENT RATES

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1. INTRODUCTION

For the measurement of dose equivalent rates of neutrons with energy range of epithermal to fast, a method using a BF_3 proportional counter with two kinds of paraffin moderator (two-moderator method)(1) has been employed in the JAERI. Errors in the actual measurement by the two-moderator method are sum of the errors due to ambiguity of energy response of the detector and the errors in the theoretical derivation of the relation between the dose equivalent rate and count rates measured. In order to examine the accuracy of the method for slowed down neutrons, response of this method was compared with those of three types of rem counter.

2. TWO-MODERATOR METHOD

The two-moderator method utilizes two kinds of cylindrical paraffin moderator placed in turn over a BF_3 counter.

Generally, the spectrum of neutrons having slowed down component is given as a linear combination of source spectrum and 1/E spectrum. Dose equivalent rates due to a neutron spectrum represented as a linear combination of two components are given as a linear combination of the count rates with each moderator. Based on the fact described above, the dose response by the two-moderator method is determined as

$$\dot{H}\ (\text{mrem/hr}) = K_1 N_1 + K_2 N_2 \qquad (1)$$

where $\dot{H}$ is dose equivalent rate and N_1 and N_2 the count rates in cpm of the counter with moderator 1 and moderator 2 respectively, and K_1 and K_2 are constants.

In the two-moderator method, a combination of two paraffin moderators of 8.5 cm and 4.5 cm in thickness was chosen so that the detectors have sufficient sensitivities for a wide energy range and have an appropriate difference between their energy responses. The paraffin moderators used in the experiment are shown in Fig. 1. The effective volume of the BF_3counter is 11.7cm, and the pressure of BF_3 gas (^{10}B enriched to 96 per cent) is 200 mmHg. Based on the energy responses of the counters with 8.5 cm and 4.5 cm thick paraffin moderators (1) respectively and the ICRP response curve(2), $K_1$and K_2 were determined as 13.5×10^{-3} mrem/hr/cpm and -6.77×10^{-3} mrem/hr/cpm, respectively,for the Am -Be source spectrum.

3. EXPERIMENTAL METHOD

Response obtained by this method and those of three types of rem counter to slowed down neutrons were measured using Am - Be neutron sources and concrete walls which were arranged as shown in Fig. 2. The rem counters used in the experiment were Andersson-Braun type, Bonner type and JAERI type (four BF_3 counters are placed in a cylindrical paraffin moderator)(3) rem counters.

The spectrum of neutrons incident to the detector consists of two components (source spectrum and 1/E spectrum) as described in Section 2, and the fraction of 1/E component varies with position of neutron sources.

If one expresses the neutron spectrum $\phi(E)$ by

$$\phi(E) \approx C_1\phi_1 \quad (E) + C_2\phi_2 \quad (E) \tag{2}$$

where $\phi_1(E)$ is the Am - Be source spectrum and $\phi_2(E)$ is the 1/E spectrum, the total fluxes of which are normalized to be unity, and C_1 and C_2 are constants, then a fraction of 1/E component (f) is given by

$$f = \frac{C_2}{C_1 + C_2} \tag{3}$$

For various arrangements of the neutron sources, count rates of the detectors one by one were measured. In the two-moderator method dose equivalent rate was obtained using Eq. (1). The dose equivalent rates by the rem counters were obtained using the count rates measured and the conversion factors (mrem/hr/cpm) for the Am - Be source spectrum.

4. RESULTS

Relative responses of the three types of rem counter to the present method are shown in Fig. 3. It is seen from Fig. 3 that all the responses of the three rem counters and of the detector of present method are consistent within $\pm$ 40 per cent in fractions of 1/E component up to 0.7.

The dose equivalent rates obtained by present method agreed well with the measured dose equivalent rates of the Andersson-Braun type and Bonner type rem counters corrected for the dose equivalent rates based on the reported energy responses(4),(5) and the ICRP response curve (2).

From the results it was concluded that the two-moderator method has enough precision to measure the dose equivalent rates due to the slowed down neutrons.

REFERENCES

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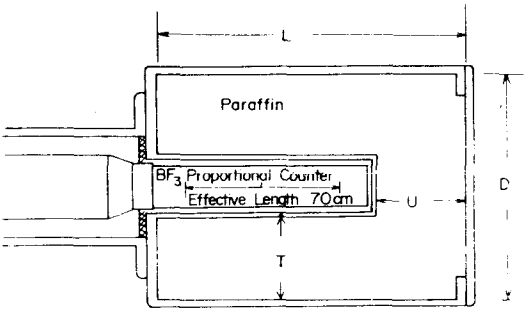


Dimensions (in mm)	Moderator No	
	1	2
D	190	110
L	220	180
T	85	45
U	85	45

The moderator is covered with a 1 mm thick cadmium case.

Fig. 1 BF_3 proportional counter with a cylindrical paraffin moderator.

Arrangement	Position		
	A	B	C
1	S1, S2	—	—
2	S2	S1	—
3	—	—	S1, S2

S1 : Am-Be 5Ci , S2 : Am-Be 1Ci

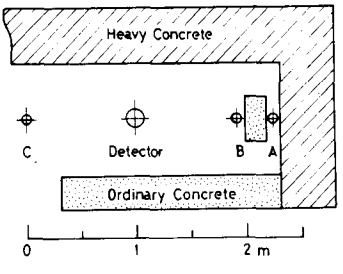
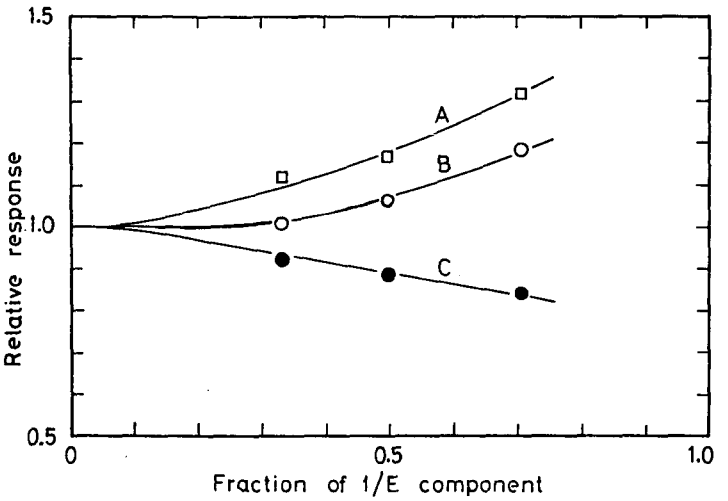


Fig. 2 Experimental arrangement of detector, neutron sources and concrete walls.



Curve A : Bonner type rem counter
Curve B : Andersson-Braun type rem counter
Curve C : JAERI type rem counter

Fig. 3 Relative responses of the rem counters to the two-moderator method.