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COMPARATIVE STUDY OF DEPTH DOSE DISTRIBUTION OF FAST NEUTRONS USING SOLID STATE NUCLEAR TRACK DETECTORS

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ABSTRACT

Neutron depth dose distribution in a water phantom for some plastics was measured. The experiment was made with Makrofol, CR-39 and LR-115. The fluence distribution of ^{252}Cf in air and in water phantom were investigated. The measured neutron build up factor for two exposure positions are found to be dependent on the irradiation geometry and in good agreement with the calculated results given in literature.

KEYWORDS

depth dose; dosimetry; fast neutrons; neutron source; phantom; plastic detectors.

INTRODUCTION

The increasing application of ^{252}Cf source in medical therapy gives rise to the read to obtain accurate data about the neutron build up and the tissue attenuation especially at tissue close to the source. Measurements of fast neutron depth dose distribution in a phantom were carried out by several authors (Sayed et al., 1984, 1978, Piesch et a., 1975, 1974, Oliver, 1968).

For accurate analysis of distribution of absorbed dose and equivalent dose, the neutron build-up factor and the attenuation in a phantom were investigated for two source positions. In order to check the different sensitivities of the detectors used for fast neutron, a comparative study of the sensitivity of the three detectors is reported in the present work.

EXPERIMENTAL RESULTS AND DISCUSSION

The measurements were carried out with 50 μg ^{252}Cf neutron source with emission rate of $1.4x10^7$ n/sec at the time of measurements. The phantom used was a prespex box of dimensions 30x30x30 cm^3 which was filled with water. Two different irradiation geometries were considered, source at 30 cm and in contact with phantom surface. The detectors used were: Polymer commercial detector known as CR-39 with a density of 1.32 $gm.cm^{-3}$ and 500 μm thickness, Cellulose nitrate detector manufactured by Kodak Pathe, France, known as LR-115 with 12 μm thickness, and Polycarbonate plastic detector known as Markofol (manufactured by Bayer A.G., West Germany) with a thickness of 300 μm. All measurements were atchived for source in contact with the phantom surface and at 30 cm distance.

The flux distribution of fast neutrons and absorbed dose rate registered in the three detectors as a function of depth in phantom are shown in figures 1 and 2 for the two exposure positions. It is clear that the neutron flux and the absorbed dose rate decreases with increasing depth. The maximum value of the neutron flux for all detectors occurs at the same depth (3.5 cm). As expected, one sees that the flux distribution given by the three detectors and the dose rate when the source in contact with the phantom surface is much higher than that at 30 cm. It is clear that the CR-39 polycarbonate detector is the most sensitive one for fast neutrons followed by LR-115 and then the Makrofol detector.

The variations of the flux ratio ϕ_w/ϕ_a for ^{252}Cf source are shown in Fig. 3 (in contact with the phantom surface). ϕ_w is the fast neutron flux at various depths in water while ϕ_a is the flux measured in free air at the same detector position in empty phantom. Substituting in the following equation,

$$\phi_w/\phi_a = B(x) \exp(-x/\lambda)$$

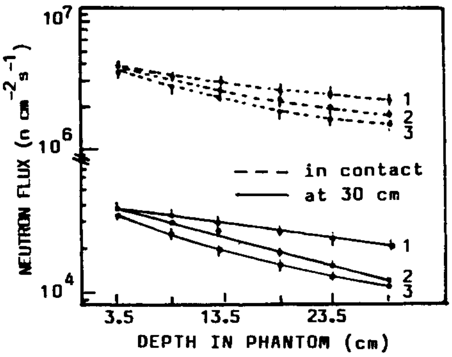

Fig. 1. Dependence of neutron flux on the depth in phantom; 1: CR-39, 2: LR-115, 3: Makrofol.

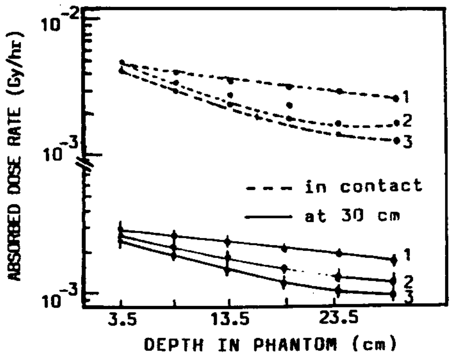

Fig. 2. Dependence of absorbed dose rate on the depths in phantom; 1: CR-39, 2: LR-115, 3: Makrofol.

to obtain the attenuation in the phantom. B(x) is the build-up factor at distance x and λ is the relaxation length. Fig. 4 shows the relation between build-up factor against depth in phantom for the two positions. The measured value for the relaxation length was found to be about 7.1 cm for the three detectors which is in good agreement with 7.25 cm calculated before (Cember, 1985). It is found that the build-up factor increases with depth for 1 cm to 3.5 cm reaching a maximum value 1.4 and 1.7, at 3.5 cm, for the source at 30 cm and in contact with phantom surface respectively and then becomes more or less constant. This shows that the build-up factor depends on the irradiation geometry.

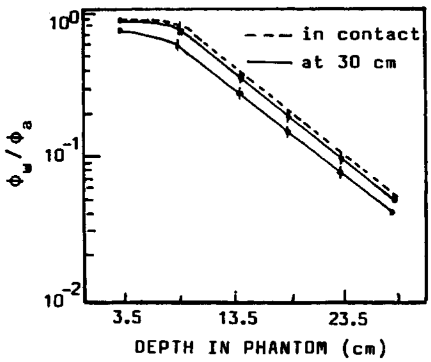

Fig. 3. Ratio of neutron flux measured in water phantom to that in air as a function of depth measured with CR-39, LR-115 and Makrofol track etching detectors (source in contact).

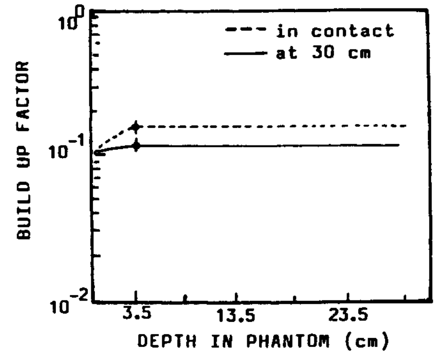

Fig. 4. Buld-up factor of a ^{252}Cf source obtained from experimental depth dose distribution results which were found with CR-39 track etching detector.

CONCLUSION

According to these experimental results the CR-39 polycarbonate polymer has been found to be more sensitive and efficient than the other two detectors. With respect to the application of ^{252}Cf source in medical therapy, there is the need for exact data of the neutron build-up, attenuation in tissue and the corresponding relaxation length. For neutrons, the relaxation length was found to be 7.1 cm in good agreement with 7.25 cm calculated before and the build-up factor reaches ~1.4 and ~1.7 for the source at 30 cm and in contact with the phantom surface respectively.

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