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REMOVAL CROSS - SECTION MEASUREMENTS USING 14 MeV NEUTRONS

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ABSTRACT

14 MeV neutrons from T (d,n) He^4 reaction produced in a neutron generator were used to measure removal cross - sections of iron, lead, ordinary concrete, poliethylene and plexiglass since removal cross - section values provide an easy way for fast neutron flux attenuation calculations. Two different methods were applied and the results were found in good agreement between the error limits.

ÖZET

Nötron jeneratöründe T (d,n) He^4 reaksiyonuyla oluşturulan 14 MeV enerjili nötronlar için, demir, kurşun, beton, polietilen ve plexiglasın görünür soğurulma tesir kesitleri ölçülmüştür. Hızlı nötron akı zayıflamasıyla ilgili hesaplarda önemli olan görünür soğurulma tesir kesitinin ölçümünde iki yöntem uygulanmış ve sonuçlar arasında hata limitleri içinde uygunluk gözlenmiştir.

INTRODUCTION

Removal cross - sections are useful and important particularly at calculations related with shielding against fast neutrons. This comes from the fact that these values provide an easy way for fast neutron flux attenuation calculations in various media consisting of medium and heavy nuclei.

In a hydrogeneous medium, the neutron flux at the location of detector is given by;

$$\varnothing\ (r, T) = \varnothing_H\ (r-T)\ \exp\ (-\Sigma_r T) \qquad (1)$$

where $\varnothing_H$ (r—T) is the neutron flux at the same place without sample, T is the sample thickness and Σ_r is the removal cross section [1,2].

The number of counts N (r, T) and N (r—T) taken from the detector with and without the sample respectively are proportional with corresponding flux values and taking into account the neutron generator flux correction factor, K, the removal cross - section can be evaluated from Eq. 1 as follows,

$$\Sigma_r = K . \frac{1}{T} \ln \frac{N_H (r-T)}{N (r, T)} \tag{2}$$

K is calculated as the ratio of A (r, T) and A (r—T) activities of Cu foils measured around the target, with and without the samples, respectively.

When hydrogeneous medium has been removed the removal cross - section can also be determined from

$$\varnothing (r) = \frac{Q}{4 \pi r^2} \exp [- \Sigma_r (r - r_o)] \tag{3}$$

which represents the flux of primary neutrons at a distance r from a point source. Here, Q is the neutron strength of generator, and $(r - r_o)$ is the total thickness of sample [3].

EXPERIMENT AND RESULTS

The block diagram of the experimental set - up for the first method was given at Fig. 1, where the sample with thickness T, has been placed between the target and hydrogeneous medium made of poliethylene. A small fission chamber lined with U - 235 and placed at a normal distance

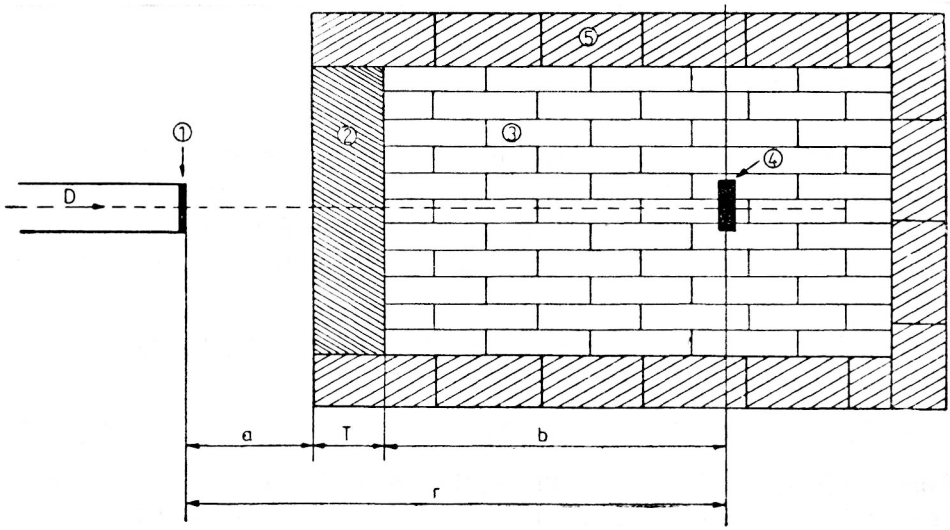

Fig. 1. Experimental set - up for measuring the removal cross - section using the first method. (1) tritium target of the neutron generator, (2) plate sample, (3) polyethylene bricks, (4) fission chamber, (5) polyethylene bricks containing boron.

r away from the target was used in order to monitor the thermal neutrons. In order to reduce the effect of scattered neutrons from the surroundings, the whole system was covered with poliethylene bricks containing boron.

The variation of the dependence of removal cross - section on the sample thickness (T), detector - sample distance (b) and target sample distance (a) was studied to make a spatial optimization to Σ_r as a constant for each kind of sample, then the removal cross - sections of samples were measured.

In the second method, fast neutrons were detected using the threshold reaction ^{63}Cu (n, 2n)^{62} Cu and recording the annihilation radiation. The samples in slab forms, were replaced in normal direction to the target with Cu foils between them to measure the flux distribution (Fig. 2).

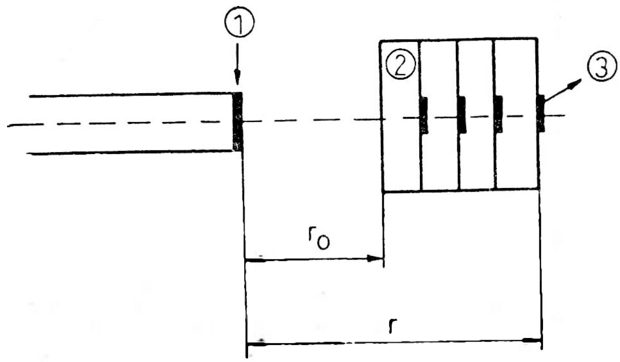

Fig. 2. Experimental set - up for measuring the removal cross - section using the second method. (1) target, (2) slab sample, (3) copper foil.

Eq. 3 may be re - written as;

$$\ln \; [r^2 \varnothing (r)] = -\Sigma_r \; (r - r_o) + \ln \; (Q/4\pi) \qquad (4)$$

Then considering the relation between the activities of irradiated foils and the fast neutron flux and using Eq. 4, the variation of ln $[r^2 \varnothing (r)]$ vs. $(r - r_o)$ was evaluated and plotted in Fig. 3. The slope of the straight line would yield the value of Σ_r.

The measured removal cross - sections for shielding materials by means of two methods were found in good agreement within the error limits. The mean values of these removal cross - sections for iron, lead, ordinary concrete, polyethylene and plexiglass were given in Table — 1

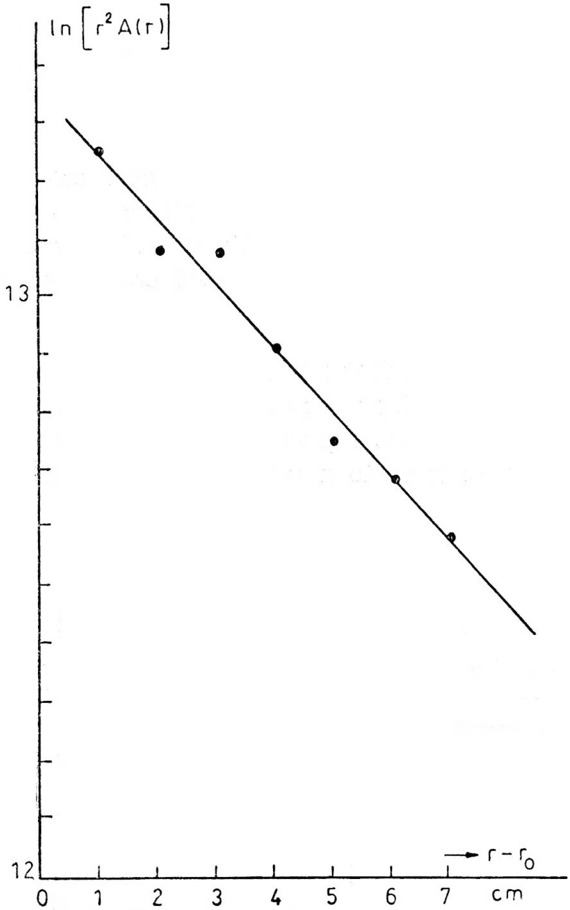

Fig. 3. Activity of the copper foils in iron slabs.

TABLE — 1. Measured removal cross - sections at 14 MeV neutron energy.

Sample	Σ_r (cm^{-1})
Iron	0.115 ± 0.012
Lead	0.091 ± 0.010
Ordinary Concrete	0.069 ± 0.008
Polyethylene	0.059 ± 0.006
Plexiglass	0.059 ± 0.006

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