ANALYSIS OF THE SECONDARY PARTICLE PENETRATION EXPERIMENT

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The penetration of secondary neutrons and photons produced from the 21.5-mm-thick graphite target irradiated by 52-MeV protons has been measured in graphite, iron, water and concrete. Both the source spectra(1) and the spectra transmitted through these four matters(2) have been measured with a 2-in x 2-in-dia. liquid organic scintillator, NE213, using the n-γ discrimination techniques. The dimensions and the atomic densities of the matters are shown in the table, and the experimental setup is illustrated in Fig. 1. Lower limits of the energies of the measured spectra are 2MeV for neutrons and 0.6MeV for photons. The measured spectra were analyzed by the discrete ordinate transport calculation and the multi-group Monte Carlo calculation. For the former, the ANISN code was used without the buckling correction by approximating the experimental arrangement to one-dimensional slab. For the latter, the multi-group Monte Carlo code has been developed including the point-detector estimation and the angular sampling method by Straker(3).
In both calculations, DLC-58 group constants(4) (neutrons of 47 groupes from thermal to 60MeV and gamma rays of 21 groups from 0.01MeV to 14MeV) and the measured source spectra are used.

The neutron spectra calculated by these two codes agree well each other and also with the measured ones both in the spectral shapes and in the absolute values, excluding that the ANISN result is greater than the Monte Carlo result in case of neutron penetration through the 101-cm-thick water, since one-dimensional approximation neglects the leakage from the lateral surfaces of the finite slabs. The attenuation profiles of the neutron fluences ($E_n \geq 2$MeV) are shown in Fig. 2.
The calculated results are in good agreement with the experimental results, and the differences are less than 10% in the slopes of the curves (the attenuation coefficients).

The attenuation of photon fluence were calculated only with ANISN. The calculated results agree with experimental ones in case of graphite and water, but attenuate faster than the experimental ones in case of iron and concrete. This discrepancy may be caused from that, in DLC-58, the photon production by non-elastic collision with neutrons of energy higher than 14.9MeV is ignored and that the fractions of photons produced by the non-elastic collisions with neutrons are less than 20% in graphite and water, but dominant in iron and concrete.

References

(1) T. Nakamura, et al, Nucl. Instr. Methods, 151, 493(1978)
(2) K. Shin, et al, Bull. Inst. Chem. Res., Kyoto Univ., 57, 102(1979)
(3) E.A. Straker, et al, ORNL-4585(1970)
(4) R.G. Alsmiller, Jr., et al, ORNL/TM-6486(1978)

Table Dimensions and Atomic Densities of the Matters

Matter width(cm) x height(cm)	Thickness (cm)	Atomic Density Used in Calc. (atom cm-3)
graphite 90x54	21.5 43.0 64.5	C 8.43+22
iron 52x50	19.3 38.6 57.9	Fe 7.70+22
water 80x55	60.0 101.0	H 6.68+22 O 3.34+22
concrete 75x60	46.0 69.0 115.0	H 5.95+21 O 4.48+22 Si 2.00+22 Ca 1.52+21 Fe 7.38+20

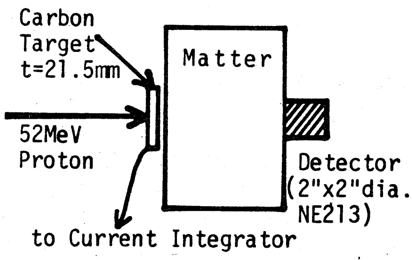

Fig.1 Experimental setup for the measurements of the secondary particle penetration.

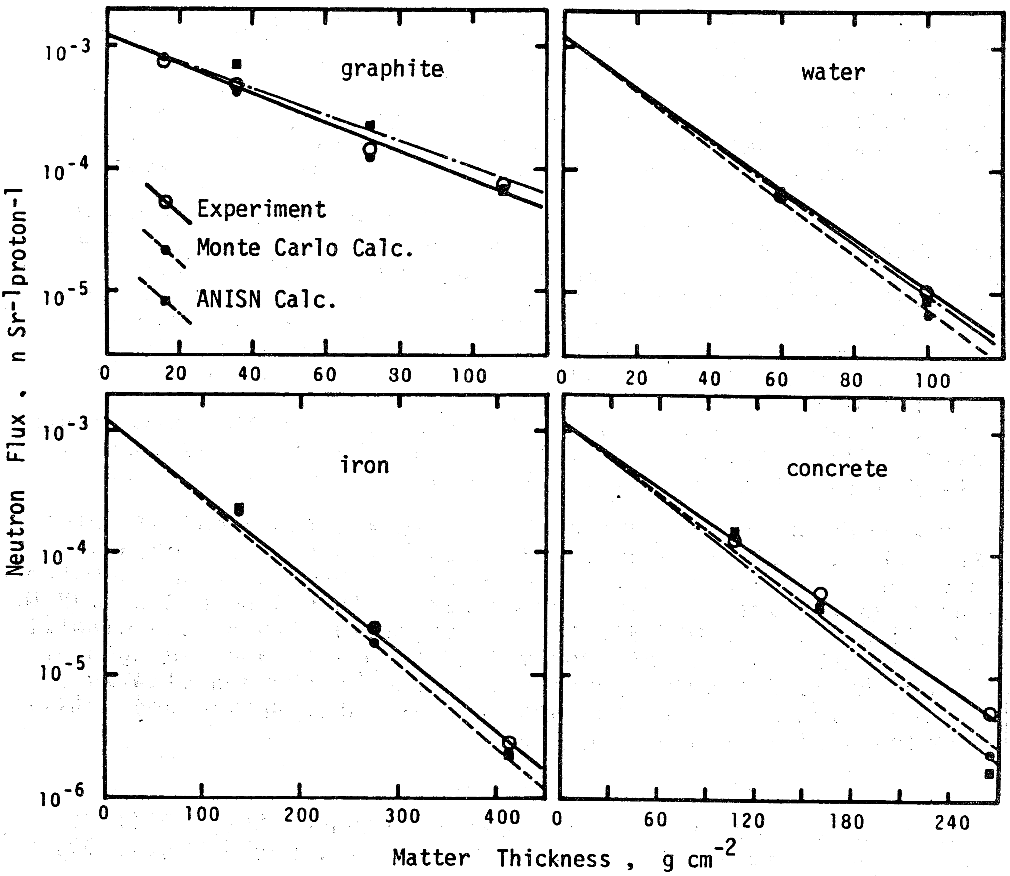

Fig.2 Attenuation of measured and calculated neutron fluxes integrated above 2 MeV