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The $O^{16}(n,p)$ N^{16} Reaction Cross Section

The $O^{16}(n,p)$ N^{16} reaction produces the principal radioactivity in the coolant during operation of water-cooled reactors. High energy gamma rays accompany the decay of N^{16}. The cross section for this reaction has been the subject of several experimental investigations, the results of which have at times been in apparent agreement and at other times in apparent disagreement. It is the purpose of this note to summarize a review (*1*) of the available information concerning the cross section for this reaction with regard to application to water-cooled reactors.

The reaction cross section averaged over the fission neutron spectrum has been deduced from activation measurements obtained using water circulated through a reactor. The activation flux used by Henderson and Tunnicliffe (*2*) in arriving at a cross section of 18.5 ± 1.5 μb is determined from a calculation of the average path length of a fission neutron in the cooling water channel of the reactor fuel element. Honeck has calculated this average path length using Monte Carlo techniques which account for self-shielding in the fuel element, thereby obviating the need for an assumed angular distribution of the neutrons entering the coolant channel. The results, as reported by the Neutron Cross Section Evaluation Group (*3*), are about one half as large as Henderson's, and would increase the cross section by about 2. When the integral activation cross section, of 19 ± 5 μb, reported by Roys and Shure (*4*) is adjusted for the more recent information on the yield of 0.74 high energy gamma rays per N^{16} disintegration and the improved confidence of the magnitude of the $Al(n,\alpha)$ cross section which had been used as a monitor of the activation flux, the $O^{16}(n,p)$ value becomes 21 ± 4 μb.

Martin (*5*) had measured the excitation function of the $O^{16}(n,p)$ N^{16} reaction from 12.4 to 18 Mev. DeJuren, Stooksberry, and Wallis (*6*) have extended the range of the measurements, covering the region from 11 to 19 Mev with improved energy resolution. Their more accurate technique for monitoring the irradiation flux gives results lower than those of Martin by about a factor of 2. Their results exhibit a prominent resonance near 11.8 Mev previously unobserved. Similar measurements have been made between 12.6 and 16.3 Mev by Seeman and Moore (*7*).

In averaging the excitation function, it is important that the absolute value and shape of the fission neutron spectrum within several Mev of the reaction threshold of 10.23 ± 0.01 Mev be used. In the energy region above 10 Mev, experimental information on this spectrum is scanty. The results of Watt (*8*) and of Frye and Rosen (*9*) are given in Fig. 1 with arbitrary normalization at 7 Mev, with consistency noted even above 10 Mev. Also seen in Fig. 1 is the shape of the Watt spectrum ($e^{-E} \sinh \sqrt{2E}$) and that of the Cranberg spectrum ($e^{-E/0.965} \sinh \sqrt{2.29E}$), both normalized to the experimental results in the 3–4 Mev range. These shapes are consistent with the available experimental information in this region, with the Watt spectrum providing a somewhat better fit. The relative number of neutrons with energies greater than 10 Mev predicted by these representations differs by about 17%.

When the results of DeJuren, Stooksberry, and Wallis are weighted with the Watt spectrum, the average cross section is 19 μb. When weighted with the Cranberg spectrum, the average cross section is 16 μb. These results agree with the adjusted integral activation cross section of Roys and Shure, 21 ± 4 μb, to within the uncertainties of the experimental information.

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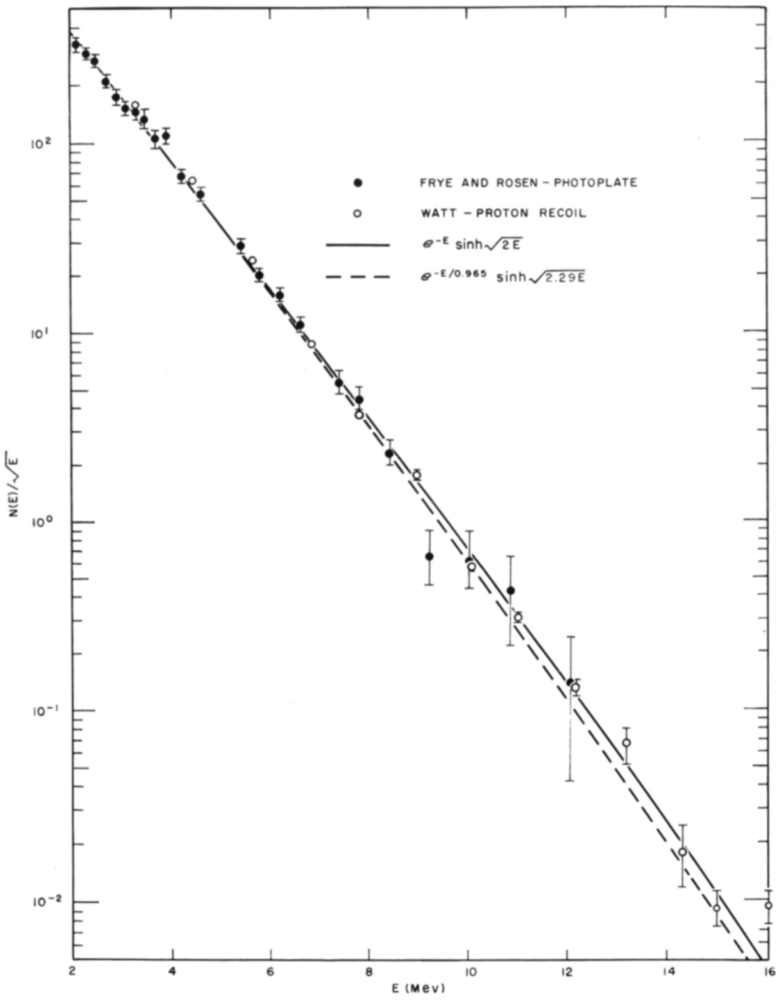

FIG. 1. Neutron spectrum from thermal fission of U^{235}

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Cadmium Ratios of U^{235} Fission in Slightly Enriched Uranium, Light Water Moderated Lattices*

The initial conversion ratio of multiplying assemblies containing U^{238} can be inferred from measurements of the ratio of epicadmium to subcadmium capture in U^{238} (ρ_{28}), expressing the contribution of the U^{235} epicadmium fission either in terms of the ratio of epicadmium to subcadmium fission in U^{235} (δ_{25}), or in terms of the cadmium ratio in gold (CdR_{Au}) (*1*).

Work performed at BNL in slightly enriched uranium, water moderated lattices (*1, 2*), has shown a discrepancy between conversion ratios deduced from ρ_{28} and CdR_{Au} measurements, and those deduced from ρ_{28} and δ_{25} measurements. Since in ref. *2* it was stated that the gold cadmium ratios measurements were probably the most reliable ones, the values of δ_{25} seeming systematically low, some by as much as a factor of two, the cadmium ratios for U^{235} fission of some of these lattices have been remeasured, using a technique similar to that tried at WAPD (*2*).

The method originally used at BNL, and described in ref. *1*, consisted of counting the fission product β activity of high purity Al catchers, which had been irradiated, one bare and one cadmium-encased, between sections of fuel rods in miniature lattices. Miniature lattices (18 in. tall) were preferred to exponential assemblies because of their ease of operation and of the higher flux attainable, previous work having indicated that the use of a reduced size assembly does not have appreciable effects on the values of the measured parameters.

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