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RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA - BERKELEY

ENGINEERING NOTES

JOB NUMBER	FILE NO.	PAGE
305-10	M12	1

SUBJECT: CALCULATION OF k_∞ IN A URANIUM-GRAPHITE LATTICE

NAME: F. Adelman

DATE: Feb. 8, 1951

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Since the 25 content of the uranium to be used in a MTA multiplying lattice is quite uncertain at present, it is necessary to assume various degrees of depletion in order to estimate the multiplication constant k_∞ and the production of 49 in an infinite uranium-graphite lattice. For these calculations, which are underway at present, a Hanford slug is assumed, and for each rod radius, the slug spacing is varied to give the maximum k_∞. The rod radius will ultimately be chosen on some basis other than multiplication, as the maximum k_∞ increases only very slowly with rod radius in the range of radii of interest. Preliminary calculations indicate:

% 25	.72	.50	.30
$k_{\infty_{max}}$	1.071	.910	.688

Although a .086" water jacket is used for cooling the Hanford slug, this annulus may prove inadequate for the higher average flux in the MTA lattice, depending upon the depletion of the uranium charge. Therefore calculations are being made for 1, $1\frac{1}{2}$, and 2 times the Hanford annulus. Each step decreases k_∞ by about 1%.

The formulae used in this computation are:

(1) Multiplication factor

$$k_\infty = \eta \epsilon p f$$

(2) Number of neutrons produced per thermal neutron absorption in U

$$\eta = \frac{1.305}{\frac{\sigma(25)}{\sigma(U)} \quad \frac{.007115}{R} \quad \frac{1 - R}{.992885} \quad \frac{\sigma(U) - \sigma(25)}{\sigma(U)}}$$

(3) Fast multiplication factor

ϵ is plotted in NAA-SR-90

(4) $$\frac{1}{f_R} = \frac{F(\varkappa_o' r_o)}{N_o \sigma_o' V} \sum_{i=1}^{2} N_i \sigma_i' V_i + E(\varkappa_1 r_g - \varkappa_1 b)$$

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(5) Resonance escape probability

$$p = \exp\left[-\left(\frac{1}{f_R} - 1\right)^{-1}\right]$$

(6) Reciprocal thermal utilization

$$\frac{1}{f} = \frac{F(\mathcal{K}_o r_o)}{N_o \sigma_o V_o} \sum_{i=1}^{3} N_i \sigma_i V_i + E(\mathcal{K}_1 r_g, \mathcal{K}_1 b) \frac{E(\mathcal{K}_1 r_g, \mathcal{K}_1 b) - 1}{1 + \frac{q_1}{q_2}\frac{V_1}{V_2}}$$

$$+ (\mathcal{K}_2 t^2) \frac{(N\sigma V)_1}{(N\sigma V)_2}$$

In these equations the indices 0, 1, 2, 3, represent metal, moderator (graphite), water, and aluminum, respectively; r_o is the rod radius and t is the water annulus thickness, while r_g and b are determined by the volumes per cell V_i of the various materials. σ_i is the thermal absorption cross section of the material in question, while σ_i' and $\mathcal{K}_i'$, which are given in CL-697 Chap. IV, are determined by the uranium resonance integral. q_i is the slowing-down power per cc. $F(\mathcal{K}_o r_o)$, the ratio of the neutron density at the metal surface to the mean neutron density in the metal rod, and $E(\mathcal{K}_1 r_g, \mathcal{K}_1 b) = 1 \frac{\text{excess absorption in the moderator}}{\text{flow of neutrons out of moderator}}$ are plotted in CL-697 Chap. IV. $\sigma(25)$ is the contribution of thermal absorption in 25 to the thermal absorption cross section $\sigma(U)$ of normal U.

Similar computations are being made by North American, using somewhat more refined formulae.