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MASTER

A CRITICAL MASS SURVEY OF THE

U²³⁵-U²³⁸-C SYSTEM*

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A critical mass survey of the homogeneous uranium graphite system has been made for the entire range of enrichments and moderator ratios using an 18 group set of cross sections. For most of the calculations an age-diffusion code (FIRE)¹ was used, but for small sized assemblies S_4 transport calculations were made for comparison. At 40% enrichment the two agreed within 1% in radius down to 30 cm ($C/U^{235} = 10$) but the diffusion results were 5% larger for $C/U^{235} = 3$ (19.71 cm) and $C/U^{235} = 1$ (16.26 cm).

The basic cross section set was that of Mills² with the resonance absorption for both U^{235} and U^{238} treated according to Bell³. He defined the effective cross section as

$$\tilde{\sigma}_r = \frac{\int_{E_1}^{E_2} \frac{\sigma_r(E)}{\sum_t^{NR}(E)} \frac{dE}{E}}{\int_{E_1}^{E_2} \frac{1}{\sum_t^{NR}(E)} \frac{dE}{E}}$$

where $\sum_t^{NR}(E)$ is the total cross section minus the scattering cross section for the elements for which the resonance width exceeds the maximum neutron energy loss. Numerical integrations were performed using appropriately either the infinite mass or narrow resonance approximations.

Results for various energy groups were obtained as a function of σ_p , the total scattering cross section per atom of resonance absorber. The energy dependent cross sections at 300°K were derived from experimental resonance parameters by J. Devaney.⁴ For each mixture, the appropriate resonance cross sections were computed for U^{235} in groups 10 to 13 (36 to 1.13 ev)

and for U^{238} in groups 9 to 12 (419 to 3.06 ev).

The results for bare spheres with $\rho(c) = 1.65$ g/cc and $\rho(U^{235}) = 18.75$ g/cc are shown in Fig. 1. The strongest effect of the resonance absorption appears for $10^2 < C/U < 10^3$ at enrichments below 20%. The enrichment necessary to make an infinite medium critical is shown in Fig. 2 as a function of moderator ratio.

Calculations of reflected cores show a region of infinite reflector savings as proposed by Marchuk.⁵ This occurs in the resonance region for enrichments of about 9% and is effectively a special case of the more familiar lumping effect.

FIG. 1

Critical Radii of homogeneous uranium graphite spheres of various enrichment. $\rho(c) = 1.65 \text{ g/cc}$, $\rho(\text{U}^{235}) = 18.75 \text{ g/cc}$. Curves are labeled by the enrichment in per cent.

FIG. 2

The enrichment required for criticality in an infinite homogeneous uranium-graphite mixture.

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