LETTERS TO THE EDITOR

WHAT TO BELIEVE ABOUT XENON

Dear Sir:

It is perplexing to discover that there is a wide variety of values, reported in current textbooks, for the maximum reactivity effect of equilibrium xenon. For example, for a highly enriched system containing ^{235}U, Glasstone and Sesonske[1] report a maximum xenon reactivity effect of $\rho = 0.052$ (≈\$7.30), whereas other authors, for example, Lamarsh[2] or Isbin,[3] arrive at the value $\rho = 0.026$ (≈\$3.70). To obtain their answer, Glasstone and Sesonske and nearly all of these other authors, with the notable exception of Zweifel,[4] neglect the effect of the poisoning on the thermal nonleakage factor. The purpose of this Letter is to show that an error has been made by Glasstone and Sesonske, and that the value of the other authors is unchanged when the effect of poisoning on leakage is considered.

Glasstone and Sesonske compute the reactivity effect from the expression

$$\rho = \frac{k' - k}{k'} \approx \frac{f' - f}{f'} \approx \frac{-\Sigma_p}{\Sigma_U + \Sigma_m} \quad , \tag{1}$$

where Σ_m comprises the absorption of all materials except xenon, Σ_p, and fuel, Σ_U. This treatment obviously neglects the effect of xenon on the thermal nonleakage factor. Glasstone and Sesonske then state that for highly enriched systems $\Sigma_U \gg \Sigma_m$, and thus $f \approx 1$, or

$$\rho \approx \frac{-\Sigma_p}{\Sigma_U} \quad . \tag{2}$$

This second assumption is clearly incompatible with the first, as now one has

$$k \approx k_\infty \approx f\eta \approx \eta \quad ; \tag{3}$$

since $\eta = 2.06$, the reactor cannot be initially critical. If the second assumption is not made, the result of most other authors is obtained, i.e.,

$$\rho \approx -f\frac{\Sigma_p}{\Sigma_U} \approx -\frac{1}{\eta}\frac{\Sigma_p}{\Sigma_U} \quad . \tag{4}$$

We now show, in a manner somewhat different from Zweifel's, that the result of Eq. (6) can be obtained without neglecting the leakage effect. Let

$$\rho = \frac{k' - k}{k'} = \frac{f'P_{\text{th}}' - f\,P_{\text{th}}}{f'P_{\text{th}}'} \quad , \tag{5}$$

where

$$P_{\text{th}} = (1 + L^2B^2)^{-1}$$

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Assuming only that $D = D'$ gives

$$\rho = \frac{-\Sigma_p}{\Sigma_U + \Sigma_m + DB^2} = \frac{-\Sigma_p}{\Sigma_U}\,f\,P_{\text{th}} \approx -\frac{1}{\eta}\frac{\Sigma_p}{\Sigma_U} \quad . \tag{6}$$

ACKNOWLEDGMENT

I should like to acknowledge the valuable comments of John R. Lamarsh, who (doubtless along with many others) discovered the error long before I.

REFERENCES

1. S. GLASSTONE and A. SESONSKE, *Nuclear Reactor Engineering*, pp. 260-264, Van Nostrand, New York (1967).

2. J. R. LAMARSH, *Introduction to Nuclear Reactor Theory*, pp. 467-470, Addison-Wesley Publishing Co., Reading, Massachusetts (1966).

3. H. S. ISBIN, *Introductory Nuclear Reactor Theory*, p. 582, Reinhold Publishing Co., New York (1963).

4. P. F. ZWEIFEL, *Reactor Physics*, pp. 179-186, McGraw-Hill Book Co., New York (1973).

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REPLY TO "WHAT TO BELIEVE ABOUT XENON"

Dear Sir:

In our discussion concerning the effect of poisons on reactivity, we use the poisoning ψ, defined as the ratio of the number of thermal neutrons absorbed by the poison to those absorbed in the fuel, and do assume that the effect on the thermal diffusion length is small. Where k_{eff} is unity, we show that

$$\rho = -\psi\frac{z}{1 + z} \quad ,$$

where $z/(1 + z) = f$, the thermal utilization. As pointed out by L. Ruby, and by others since our book was published in 1963, our assumption that the thermal utiliza-