

LETTERS TO THE EDITORS

The Transfer Function of a Water-Boiler Reactor

The purpose of this note is to point out an inconsistency in the usual assumptions of the space-independent kinetic equations for a water-boiler reactor as shown in Skinner and Hetrick (1).

The specific equations of interest were given as the following:

$$\frac{dP(t)}{dt} + \frac{\beta_{\text{eff}} - \rho(t)}{l} P(t) - \sum_{j=1}^m \lambda_j C_j(t) = 0 \quad (1.1)$$

$$\rho(t) = \rho_1(t) + \alpha T(t) + \phi V(t) \quad (1.5)$$

For simplicity, we ignore the delayed neutron terms, and find

$$\frac{dP(t)}{dt} = -\frac{\beta_{\text{eff}} - \rho(t)}{l} P(t)$$

Strictly speaking, this equation is applicable only to reactors operating at fixed values of ρ_1 , T , and V . The values may be changed from run to run, but not during the run. If P is a function of ρ , T , and V as Skinner and Hetrick have found, then with full mathematical rigor we may write

$$\frac{dP(t)}{dt} = \left. \frac{\partial P}{\partial t} \right|_{v,T} + \left. \frac{\partial P}{\partial V} \right|_{t,T} \dot{V} + \left. \frac{\partial P}{\partial T} \right|_{t,v} \dot{T} \quad (1)$$

We now argue that by definition, and by actual experimental practice

$$-\frac{\beta_{\text{eff}} - \rho(t)}{l} P(t) \equiv \left. \frac{\partial P}{\partial t} \right|_{v,T}$$

We therefore claim that it is incorrect to assume that Eq. (1.1) is complete without specifying the conditions under which the additional terms may be neglected. It is not mathematically sufficient to argue that because Eq. (1.5) does not contain terms in \dot{V} , or \dot{T} , Eq. (1.1) should not contain terms in \dot{V} . In a derivation proceeding from fundamental principles, the term in \dot{V} does not enter Eq. (1.1) through Eq. (1.5).

It is believed that the application of Eq. (1) is extremely important for a wide class of reactor kinetic problems (2). Furthermore, some of the statements of Skinner and Hetrick should be reviewed in the light of the approximations which they have made. For example, the statement on page 591, "From a pragmatic viewpoint, the range of validity of the space-independent kinetic equations may be extended by regarding the parameters K , α , γ , G , ϕ , and σ as functions of the equilibrium power, with all other external experimental parameters constant, as measured from very experimental transfer function." is strictly true only for very small values of both $(\partial P/\partial V)_{t,T} \dot{V}$ and $(\partial P/\partial T)_{t,v} \dot{T}$.

Another way to arrive at Eq. (1) is through the de-

pendence of "power" on the "effective" neutron generation time as follows:

$$\begin{aligned} \dot{P} &= \left. \frac{\partial P}{\partial t} \right|_l + \left. \frac{\partial P}{\partial l} \right) \dot{l} = \left. \frac{\partial P}{\partial t} \right|_l \\ &+ \frac{\partial P}{\partial V} \left[\left. \frac{\partial l}{\partial V} \right|_{T,t} \dot{V} + \left. \frac{\partial l}{\partial T} \right|_{V,t} \dot{T} + \left. \frac{\partial l}{\partial t} \right|_{V,T} \right] \\ &= \frac{\partial P}{\partial t} + \frac{\partial P}{\partial V} \dot{V} + \frac{\partial P}{\partial T} \dot{T} \end{aligned}$$

if $\partial l/\partial t = 0$.

REFERENCES

1. R. E. SKINNER AND D. L. HETRICK, *Nuclear Sci. and Eng.* **3**, 573-594 (1958).
2. R. L. MOORE, *Trans. Am. Nuclear Soc., Nuclear Sci. and Eng. Suppl.*, **1**, No. 2, 92 (1958); and to be published.

RICHARD L. MOORE

*Richard L. Moore Consultants
Los Angeles, California
Received January 8, 1959*

Multigroup Diffusion Calculation of k_∞ for D_2O Lattices¹

In the usual method of calculating the criticality of lattice reactors the actual lattice cell is replaced by a cylindrical cell of the same area. The infinite multiplication constant is then calculated from the four-factor formula, $k_\infty = \eta \epsilon p f$. When the factors are calculated using standard recipes (1), it is usually found that the values of k_∞ obtained are greater than experimental values. To correct for this, various semi-empirical formulae have been devised to modify the values of one or more of the four factors (2).

In an attempt to calculate k_∞ from basic data, we have developed a multigroup procedure for a single reactor cell. This method yields not only k_∞ but also a consistent set of the four factors. The definitions of ϵ and p are different from those usually employed. In particular, ϵ is defined as the ratio of the total neutron production to the thermal production and p is defined as the ratio of the thermal absorption to the total absorption in the cell. However, since the definitions of η and f are the usual ones the product ϵp conforms to the usual definition, $k_\infty/\eta f$.

¹ Work performed under Subcontract 1295 of U. S. Atomic Energy Commission Contract AT(38-1)-193, with Sargent & Lundy Engineers.