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INFORMATION CATEGORY

Unclassified

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REFERENCE

PURPOSE

It has been assumed* that the same effectiveness may be assigned to each delayed neutron group when employing the in-hour equation to the reactivity associated with a stable positive period. The purpose of this report is to evaluate this assumption.

DISCUSSION

Given the stable positive period, τ , the reactivity (in dollars) is obtained from the in-hour equation:

$$\rho(\$) = \frac{K_{eff} - 1}{K_{eff} \beta_{eff}} = \sum_{i=1}^6 \frac{a_i}{1 + \lambda_i \tau} + \frac{l^*}{\tau K_{eff} \beta_{eff}}$$

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where: a_i = fractional delayed group yield
 λ_i = delayed group decay constant
 l^* = prompt neutron lifetime
 β_{eff} = effective delayed neutron fraction

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* WANL-TNR-158, "Preassembly Experiment (PAX) In Support of NRX-A2"

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The second term of this equation involving λ^* is negligible for periods that are usually considered and the relationship can be reduced to:

$$\rho(t) = \sum_{i=1}^6 \frac{a_i}{1 + \lambda_i \tau} \quad (1)$$

where $a_i = \frac{\beta_i \gamma_i}{\beta \gamma} \quad (2)$

in which γ_i is the effectiveness of the i th delayed neutron group. If all groups are assumed to have the same effective, γ , then Equation (2) is reduced to

$$a_i = \frac{\beta_i}{\beta} \quad (3)$$

In order to verify this assumption Equation (1) is evaluated using both (2) and (3) for a_i

In order to evaluate the ratios γ_i/γ , the adjoint flux at the center of the reactor was obtained from a 40-group radial DTK* with PAX composition and geometry. Figure 1 shows the relative adjoint flux, ϕ^* , for the center and the edge of the core. Since the central curve is more rapidly varying, it should give the largest variation in effectiveness and was used to evaluate γ_i/γ by the equation:

$$\frac{\gamma_i}{\gamma} = \frac{\phi_i^*}{\bar{\phi}^*} \quad \text{where} \quad \bar{\phi}^* = \frac{\sum_{i=1}^6 \phi_i^* \beta_i}{\beta}$$

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* One dimensional transport theory calculations.

The results of this calculation as well as other delayed neutron data used is tabulated in Table I.

Finally, the reactivity, $\rho(t)$, was evaluated using Equation (1) with both Equations (2) and (3) used for a_i for several periods. The results are shown in Table II. Since the discrepancy is less than 1.0%, it is concluded that the assumption is valid.

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FIGURE 1
RELATIVE ADJOINT FLUX AS A
FUNCTION OF ENERGY

TABLE I
DELAYED NEUTRON DATA *

Group	E-Mev	β_i	β_i/β	$\lambda_i(\text{sec}^{-1})$	γ_i/γ
1	.25 $\pm$ .06	.000243	.038	0.0127	1.037
2	.56 $\pm$ .06	.001363	.213	0.0317	.996
3	.43 $\pm$ .06	.001203	.188	0.115	1.012
4	.62 $\pm$ .06	.002605	.407	0.311	.989
5	.42 $\pm$ .06	.000819	.128	1.40	1.014
6	-----	<u>.000166</u>	<u>.026</u>	3.87	<u>1.0</u>
		.0064	1.000		$\bar{\rho}^* = 2.566$

* Data of Keepin, Wimmett, and Ziegler

TABLE II

Period τ (sec)	REACTIVITY - ρ (\$)		% Difference
	$\sum_{i=1}^6 \frac{\beta_i \gamma_i / \beta \gamma}{1 + \lambda_i \tau}$	$\sum_{i=1}^6 \frac{\beta_i / \beta}{1 + \lambda_i \tau}$	
0	1.000	1.000	0.0
50	.160638	.160017	0.39
100	.096979	.096512	0.48
1000	.012390	.012307	0.67