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NEUTRON LIFETIMES IN THE HANFORD LATTICES

INTRODUCTION

An important parameter which is required in the study of short-term reactor transients is the prompt neutron lifetime. This document presents calculated values for the prompt neutron lifetime in the Hanford IPD lattices under a variety of conditions.

SUMMARY

The calculated values for the prompt neutron lifetimes in the various Hanford IPD lattices are shown in Table I. None of the values shown include any contribution from the neutron slowing down time.

Two different values (l_{01} and l_{02}) are presented for each lattice spacing and condition studied. This arises from an uncertainty about the correct definition of the thermal neutron lifetime. Generally speaking, it is conservative, from a hazards analysis standpoint, to use the shorter values. This has been done in all of the

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kinetics studies concerning the production reactors at Hanford during the last several years. A precise definition and more complete discussion of the values presented are given later in this report.

TABLE I
CALCULATED NEUTRON LIFETIMES
IN VARIOUS HANFORD LATTICES

Lattice and Fuel Type	Condition	Neutron Lifetime (sec)	
		<u>l_{o1}</u>	<u>l_{o2}</u>
OIIN	Hot, Wet, Exposed (400 Mwd/t avg)	1.094x10 ⁻³	1.268x10 ⁻³
OIIN	Hot, Dry, Exposed	1.033	1.315
OIIN	Cold, Wet, Exposed	1.229	1.565
OIIN	Cold, Dry, Exposed	1.192	1.517
OIIN	Hot, Wet, Green	1.123	1.304
OIIN	Hot, Dry, Green	1.079	1.374
OIIN	Cold, Wet, Green	1.248	1.589
OIIN	Cold, Dry, Green	1.211	1.542
OIIE	Hot, Wet, Green	0.968	1.120
OIIE	Hot, Dry, Green	0.917	1.167
CIIN	Hot, Wet, Green	1.118	1.265
CIIN	Hot, Dry, Green	1.074	1.367
KIIN	Hot, Wet, Green	0.889	1.002
KIIN	Hot, Dry, Green	0.847	1.078

DISCUSSION

The thermal neutron lifetimes presented in Table I are defined as,

$$l_{o1} = \frac{\sum_i \phi_i V_i}{\sum_i \phi_i V_i \sum_{a,i} \bar{\nu}_i}, \text{ and} \quad (1)$$

$$l_{o2} = \frac{\sum_i \phi_i V_i (\bar{\nu}_i)}{\sum_i \phi_i V_i \sum_{a,i}}, \text{ where} \quad (2)$$

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ϕ - thermal neutron flux,
 V - volume,
 Σa - macroscopic absorption cross section,
 $\bar{v}$ - $1.128 v_{kT}$, and
 $\left(\frac{\bar{v}}{v}\right) = \frac{1.128}{v_{kT}}$.

The summation was taken over the i regions in the lattice cell.

There is some dissention as to which of the above equations will give the best estimate of the thermal neutron lifetime, the disagreement arising primarily in deciding what method should be used in determining the effective average velocity. In Reference (1) it is indicated that the relationship $\bar{v} = 2(\pi)^{1/2} v_{kT}$ should be used, while in Reference (2) it is concluded that $\left(\frac{\bar{v}}{v}\right) = \frac{2}{\sqrt{\pi} v_{kT}}$ should be used, where

both authors are concerned with only a single medium. The problem at hand is further complicated because the thermal neutron temperature varies in the different regions of the lattice cell.

To establish a base point with a measured value, the neutron lifetime in the French BR-1 Pile⁽³⁾ was calculated. The neutron lifetime as determined by Equation (1) agrees to within one per cent of the measured value when the slowing down time of 1.3×10^{-4} seconds is added to it.

Even this comparison is not strictly valid, however, as the French, in analyzing their experimental data, used the now out-of-date values for the delayed neutron fractions. The lifetime obtained by the French was therefore adjusted to get a value for comparison, and the adjustment used is open to question.

To obtain the quantities required in solving for l_{01} and l_{02} , the IBM 7090 IDIOT⁽⁴⁾ code was used. This code solves for, among other things, the thermal flux, neutron temperature, and macroscopic thermal absorption cross section in each region of the cell. These were then used to determine the values shown in Table I.

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