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# Letters to the Editor

## A Generalized Resonance Integral Correlation for Uranium Rods

In a previous paper[1], a resonance integral correlation was presented which agreed well with Hellstrand's data for both uranium metal[2] and $UO_2$ isolated rods[3] as a function of size and temperature[4]. The same correlation was shown to match many of the early experiments using homogeneous mixtures of uranium[5,6]. It was predicted that the correlation should be general enough to predict the resonance integral for other types of uranium fuel, such as UC.

Experimental data for UC rods have recently been published[7]. These results provide a useful check on the generality of the previously published resonance integral correlation.

Table I compares the calculated resonance integrals for the UC rods to the experimental values. The experimental errors were quoted as "typically ± 1.5%." This is approximately the maximum difference between the calculated and experimental resonance integrals.

These results confirm that the resonance-integral correlation is general and can be extrapolated with some confidence to other uranium compounds or mixtures.

The generalized uranium resonance-integral correlation is reviewed below:

Excluding 1.08 b for $1/v$ absorption, the correlation is

TABLE I

Comparison of Calculated and Experimental Resonance Integrals for UC Rods

| Rod Diam (cm) | $S/M$ ($cm^2/g$) | Resonance Integral (non $1/v$) In barns | |
|---|---|---|---|
| | | Experimental | Generalized Correlation |
| 0.99 | 0.295 | 17.8 | 17.71 |
| 1.29 | 0.226 | 16.1 | 16.01 |
| 1.49 | 0.196 | 14.9 | 15.16 |
| 1.79 | 0.163 | 13.9 | 14.15 |
| 1.99 | 0.147 | 13.5 | 13.59 |
| 2.52 | 0.116 | 12.4 | 12.43 |
| 3.09 | 0.094 | 11.4 | 11.48 |

$$RI^{28} = 2.16x + 1.48 + (0.0279x - 0.0537)\, T_{eff}^{1/2},$$

where

$T_{eff}$ is in degrees Kelvin

$$x = \left(\frac{\Sigma_{s0}^{f}}{N_0^{28}} P_0 + \frac{D_{eff}}{\ell_0 N_0^{28}}\right)^{1/2},$$

where

$\Sigma_{s0}^{f}$ is the scattering cross section of the fuel. The microscopic scattering cross sections to be used are 10.7 b for uranium, 3.8 b for oxygen, and 4.7 b for carbon

$N_0^{28}$ is the $^{238}U$ number density in the fuel region

$\ell_0$ is the mean chord length in fuel ($\ell_0 = 4\, V_0/S_0 = 2R_0$ for fuel rod)

$P_0 = 1 - P_c$, where $P_c$ is tabulated[8] collision probability and a function of $\Sigma_{s0}^{f} R_0$

$D_{eff}$ is the effective shielding factor for close packed lattices and can be calculated by the method of Sauer[9]. For the isolated rods considered in Table I, its value is unity.

It can be seen from the above correlation that the equivalence parameter used is

$$\sigma^* = \sigma_p P_0 + (\ell_0 N_0^{28})^{-1},$$

where the potential scattering ($\sigma_p$) includes the scattering of the absorber atom (implying the narrow resonance approximation).

The factor $P_0$ has been included in the volume term to account for the flux dip within the fuel rod. The volume absorption is assumed to be due to neutrons that enter the fuel from the moderator, at energies just above the resonance energies, and then are scattered into a resonance line in the fuel. The term $P_0$ accounts for the depression of this flux within the fuel rod; from the reciprocity relation, $P_0$ is the ratio of average fuel flux-to-surface flux for neutrons entering the fuel rod. Although this form of the equivalence parameter is somewhat heuristic, it appears to correlate the experimental data better than other forms proposed earlier[10,11].

*L. E. Strawbridge*

Westinghouse Electric Corporation
Advanced Reactors Division
Box 355
Pittsburgh, Pennsylvania

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