Effective Resonance Integral for Uranium Carbide*

Recent advances in the theory of resonance integrals (*1*) have established the dependence of the effective integral on a parameter $\zeta = S/(4VN\sigma_0)$, where S and V are the lump surface and volume, N is the absorber number density, and σ_0 is the energy-independent or potential cross section (10 barns for uranium). For mixtures or compounds containing an extra scattering cross section σ_m per absorber atom, ζ becomes

$$\zeta = \frac{S}{4VN\sigma_0} + \frac{\sigma_m}{\sigma_0}.$$

This holds for all resonances, provided (*2*):

$$(1 - \alpha_m)E \gg \Gamma_{pr}$$

i.e., provided the energy loss in a moderator collision at resonance energy is large compared with the practical width of the resonance. This criterion is fairly well satisfied for U^{238} resonances when oxygen or carbon is the moderator. The possible exception is the 6.7 ev resonance, where $(1 - \alpha_0)E$ is only 1.28 times Γ_{pr}.

Although calculations based on measured resonance parameters have led to somewhat high values of the effective resonance integrals (*3*), the above formulation permits transforming experimental data on one type of fuel element to apply to another type. Since experimental data on uranium carbide are not yet available, application of this method to obtain the carbide integral from the oxide and pure metal measurements gives a useful estimate of the carbide integral.

Using only the dependence on the parameter ζ, it is found that from a measurement of the effective integral I in a lump of uranium metal with surface-to-mass ratio $(S/M)_U$ one predicts the same value of I for a uranium carbide lump with surface-to-mass ratio

$$(S/M)_{UC} = 0.952\ (S/M)_U - 0.046.$$

Similarly, a uranium oxide lump with $(S/M)_{UO_2}$ is equivalent to a carbide lump

$$(S/M)_{UC} = 1.08\ (S/M)_{UO_2} + 0.027.$$

Figure 1 shows the experimental points of Hellstrand (*4*) plotted according to the above scheme. A measurement by Davis (*5*) is also included. The square of I is plotted versus $(S/M)_{UC}$, in accordance with the theoretical prediction (*3*) of an improved empirical fit from the formula $I = a\sqrt{S/M + b}$. The points are found to be consistent with the above theoretical prediction and the empirical fit $I = 28.5\sqrt{S/M + 0.08}$ is shown.

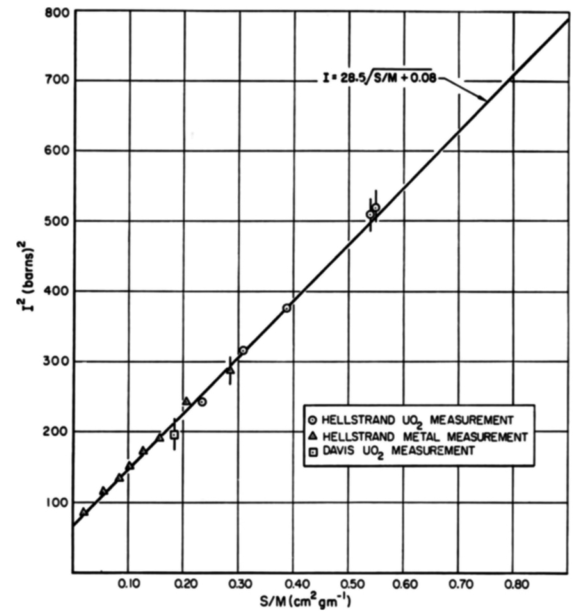

FIG. 1. Effective resonance integral in uranium carbide.

A rough estimate of the temperature effect can be obtained from theoretical results (*3*). Recent revisions (*6*) in the measured resonance parameters, however, necessitate a revision of these results. This work is now in progress.

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