Measurements of the Temperature Dependence of Thermal Neutron Diffusion Parameters in Water and Dowtherm A

Using the pulsed source technique, the absorption cross section, diffusion coefficient, and diffusion cooling constant of water and Dowtherm A (26.5 weight % diphenyl, 73.5 weight % diphenyl oxide) were measured as a function of temperature. The measurements were performed with the 250-kev neutron generator and 25-channel time analyser constructed by Beckurts (*1*). The experimental arrangement was similar to that of von Dardel and Sjöstrand (*2*), Antonov *et al.* (*3*), and Dio (*4*).

The decay constant λ of the fundamental mode of the neutron distribution was measured as a function of buckling. Fitting the decay constants to a parabola

$$\lambda = (\Sigma_a v) + DB^2 - CB^4$$

the parameters $(\Sigma_a v)$, D, and C were obtained, the bucklings ranging from $B^2 = 0.11$ cm^{-2} to $B^2 = 0.75$ cm^{-2} in the case of water and from $B^2 = 0.025$ cm^{-2} to $B^2 = 0.26$ cm^{-2} in the case of Dowtherm A.

The values of B^2 were calculated from the geometry. The transport mean free path used for the extrapolation length was taken from the measured values of D by an iteration procedure.

Tables I and II show the results with the statistical errors. Systematic errors from background, backscattering, dead time, and temperature inaccuracy are small compared with these.

TABLE I

Diffusion Parameters of Thermal Neutrons in Dowtherm A

Temperature [°C]	20°	80°	140°	180°
Density ρ [g cm^{-3}]	1.062	1.013	0.963	0.928
$(\Sigma_a v)$ [sec^{-1}]	2870 ± 50	2740 ± 90	2600 ± 150	2530 ± 170
D [cm^2 sec^{-1}]	49200 ± 800	60700 ± 1300	74300 ± 2400	83800 ± 2900
C [cm^4 sec^{-1}]	11900 ± 2700	12200 ± 4400	17700 ± 9100	22300 ± 11400

TABLE II

Diffusion Parameters of Thermal Neutrons in Water

Temperature [°C]	22°	40°	60°	80°
Density ρ [g cm^{-3}]	0.998	0.992	0.983	0.972
$(\Sigma_a v)$ [sec^{-1}]	4780 ± 160	4820 ± 100	4640 ± 140	4660 ± 360
D [cm^2 sec^{-1}]	35400 ± 700	36800 ± 500	40500 ± 700	43100 ± 1700
C [cm^4 sec^{-1}]	4200 ± 800	3300 ± 600	5500 ± 800	5800 ± 2000

By proper averaging of the $(\Sigma_a v)$ values, the absorption cross section of hydrogen is obtained from the water measurements as $\sigma_a^H = 326 \pm 6$ mb, and from the Dowtherm A measurements as $\sigma_a^H = 333 \pm 5$ mb, the Dowtherm A being of technical purity only.

Using the work of Nelkin (*5*, *6*), Sjöstrand (*7*), and Gelbard *et al.* (*8*) errors due to

(a) the neglection of a B^6-term,

(b) the neglection of the energy dependence of the extrapolation length, and

(c) the use of diffusion theory

were estimated. All these effects gave corrections smaller than the statistical errors of the diffusion parameters.

Taking the energy dependence of the diffusion coefficient from its temperature dependence, the mean square energy loss per collision in the thermal region was obtained from (C), according to Nelkin (*5*). The results indicate a strong hindrance of the rotations in water in the measured temperature region. The thermalization properties of Dowtherm A turned out to be a little better than those of water.

The details of experimental procedure and discussion of results will be published in "Nukleonik."

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