Heavy Water

The considerations which were applied above lattices of uranium-containing aggregates in graphite can also be applied to such lattices contained in certain slowing down media with the exception of media in which hydrogen is the slowing agent.

If heavy water is used as a slowing agent in place of graphite, it is of interest to know the ratio of the weights of heavy water to uranium which is equivalent to agiven ratio of carbon to uranium in the sense that a lattice of a given uranium-containing aggregates has the same resonance absorption in both cases. We obtain equivalent systems if we replace eight carbon atoms by about one molecule of heavy water; i. e., four carbon atoms by one atom of deuterium and a half atom of oxygen. Expressed in terms of weights this means that for equivalent lattice systems, the weight ratio of heavy water to uranium has to be about 4.8 times smaller than the weight ratio of graphite to uranium ~~in the equivalent lattice~~.

This statement concerning the equivalent amounts of carbon and heavy water for equal resonance absorption is derived from a scattering cross section of deuterium for resonance neutrons having a value between 3 and 4 (about 3.3) and from a scattering cross section for carbon of $\frac{4.8}{1.18}$ & 4. The slowing down per collision of carbon and deuterium is determined by the masses of the carbon and the deuterium atoms. The number of collisions needed to slow down the neutron from E_2 to E_1 is for carbon

$$k(C) \approx 6.5 \ln \frac{E_2}{E_1}$$

The same number for collisions with deuterium is

$$k(D) \sim 1.4 \ln \frac{E_2}{E_1}$$

The ratio of the corresponding numbers of atoms of carbon and deuterium is accordingly

$$\frac{3.3}{1.4} \Big/ \frac{4.8}{1.18}\,\frac{1}{6.5} \sim 3.8$$

However, if deuterium is used in the form of heavy water , a slight correction is to be applied to take into account the slowing down by oxygen so that 4 may be taken for the ratio of the equivalent number of atoms of carbon to deuterium.

Since carbon has a thermal absorption cross section of about 0.005 and the thermal absorption of heavy water per deuterium atom may be taken for the purpose of the present discussion to be about 0.003, it follows that of the two systems which have equal resonance absorption, the one in which the slowing down is due to deuterium is more favorable. It may, therefore, be stated that if a given lattice in graphite is capable of maintaining, in a sufficiently large mass, a chain reaction, the eqiuvalent lattice in heavy water is also capable of maintaining a chain reaction in a sufficiently large mass. If we take a lattice element of uranium metal which is close to the most favorable case in graphite, then a heavy water system which is equivalent to the most favorable graphite system can be made potentially chain reaction with a quantity of about 20 tons of heavy water.

Heavy Water

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REPLACEMENT IX

Heavy Water

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