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Atomic Energy Research Department

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The magnetic susceptibility of artificial graphite has been determined as a function of exposure in the MTR. Nine specimens were studied with exposures ranging from \(0.07\) to \(82 \times 10^{18}\) nvt where the nvt refers to members with energy in excess of 1 Mev. These samples were supplied by B. East of the MTR facility. The fluxes were determined by means of X-ray measurements with the exception of the two lower values which were obtained from resistivity measurements. The details regarding the techniques involved in determining these fluxes has been described by Fast (1). The method is similar to that employed by this laboratory in evaluating the damage equivalence between the Hanford cooled test hole and the Brookhaven pile (2).

The measurements were made using the Faraday apparatus described by Henry (3). The susceptibility measurements have a precision of \(\pm 3/4\) per cent or \(\pm 0.03 \times 10^{-6}\) cgs units depending upon which is larger. The samples showed the orientation typical of an extruded type graphite. The value for the virgin sample was \(20.54 \times 10^{-6}\) which is slightly less than the customary value noted for AGOT-4C. The ferrimagnetic impurity present was of the order of 2 ppm, not excessive for artificial graphite. The results of the measurements are shown in Table I. The first column shows the flux as determined by Fast. The second column gives the total susceptibility. The third column gives the ratio of the susceptibility at each exposure with the unirradiated value. It should be noted that this ratio is not the so called Piesirls ratio. In order to determine the true Piesirls ratio it would be necessary to subtract \(f_{\text{ex}}\) from the total susceptibility both a diamagnetic core term and a paramagnetic spin term \((h)\). For the purpose of this report it will be sufficient to use
only the uncorrected ratio of the two susceptibilities. It has been shown that the dependence of this ratio on exposure is independent of graphite type although the initial values may change as much as 2 per cent (5) (6).

The data is presented graphically in Figure I. The ratio of the susceptibilities has been plotted as a function of the square root of exposure. The square root is used primarily because it contracts the scale so that large exposures can be easily plotted. However, in addition one would expect the degeneracy energy to depend on the exposure to the half power.

The features of the curve are similar to those which have been obtained for Hanford exposures. It is interesting to note that either a flattening or a peak occurs in the early damage range; i.e., below .07. A similar peak has been observed in graphitization studies (7) in brom-graphite studies (8) and in annealing data (9).

The curves obtained as a function of Hanford exposure are shown in Figure II (10). By using the susceptibility as a parameter it is possible to determine the equivalence between MTR flux and Hanford MWD/CT. The horizontal lines in Figure II indicate the MTR data. The results are shown in Figure III where the corresponding MWD/CT is shown for each MTR flux value.

The results give a straight line whose slope when squared gives the equivalence factor. This proves to be $2 \times 10^{16} \text{nvt}$ for each MWD/CT.

It is possible to determine the equivalence factor for the Hanford cooled test hole. From the Hanford Special Irradiation Manual, the total thermal neutron flux at any point in the reactor is given as

$$nvt = 2.83 \times 10^{17} \cdot \frac{\varphi}{R} \text{ MMD/AT}$$

where $\frac{\varphi}{R}$ is a rise factor which for the cooled test hole is 1.5 (11). Hence the total thermal nvt at that point is:

$$nvt = 4.24 \times 10^{17} \text{ MMD/AT}.$$  

The ratio of the flux over 1 Mev to the thermal flux is 0.22 as shown by the curves found on page 56 NAA-SR=211 (12). Hence the total integrated neutron...
flux for neutrons with energies in excess of 1 Mev is $9.2 \times 10^{16}$ nvt/MWD/AT.

It would thus appear on the basis of these measurements that the apparent fast flux at MTR is almost five times more damaging than corresponding apparent flux at Hanford. Possible explanations for this phenomena will not be attempted at the present time. It is hoped that future correspondence with the two sites will shed some light on the question.

BIBLIOGRAPHY

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FIGURE 1

DEPENDENCE OF THE MAGNETIC SUSCEPTIBILITY ON EXPOSURE IN THE MTR

\[ [\text{NVT} \times 1.1 \times 10^{-18}]^{\frac{1}{2}} \]
FIGURE II

DEPENDENCE OF THE MAGNETIC SUSCEPTIBILITY ON EXPOSURE IN A MANFRED COOLED TEST HOLE
FIGURE III

EQUIVALENCE FACTOR

MTR Enut (eV/m) x 10^-12 / 2