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NEUTRON FLUX MEASUREMENTS IN THE HANFORD TEST IRRADIATION FACILITIES

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May 12, 1965

NEUTRON FLUX MEASUREMENTS
IN THE HANFORD TEST IRRADIATION FACILITIES

P. R. Prevo
M. H. Montgomery

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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NEUTRON FLUX MEASUREMENTS
IN THE HANFORD TEST IRRADIATION FACILITIES

I. INTRODUCTION

In the past, in-reactor testing of materials was restricted to gross sorting. This kind of testing required only a qualitative estimate of in-reactor exposure. It has consequently been the practice to report the exposure of a sample by relating the exposure to the heat energy released by the nearby uranium fuel, usually reported in the familiar MWD/AT (megawatt day per adjacent ton) unit. This is a useful and convenient method of determining gross exposure. The measurement is not complicated by the kind of material, geometry factors of the samples, or loading conditions of the reactor. However, these very facts limit the usefulness of the measurement. Current materials programs require refinement beyond the gross sorting phase, and many tests are now aimed at studying the effects of trace amounts of elements upon the structural properties of materials. This type of test requires a more quantitative determination of exposure than the MWD/AT estimate can provide.⁽¹⁾

Therefore, a better definition of the neutron flux in the Hanford Irradiation Facilities is required in order to facilitate analyses of irradiation experiments and to accurately predict irradiation conditions for proposed experiments.

II. OBJECTIVE

The objective of this program is to define the neutron flux at various positions of a representative number of the irradiation facilities. To date, data has been collected, reduced, and partially analyzed for two side-to-side test facilities. This interim report concerns this work. A report on the whole program will be issued upon completion of the experimental work.

III. SUMMARY & CONCLUSIONS

The most important result of these tests was the verification of the existence of a large flat zone on the near-to-far thermal neutron flux distribution. A perturbation in fast and thermal neutron flux was observed in the region between the center line of two adjacent lattice units. The presence of thoria in a process tube has a pronounced effect on the fast flux.

Encouraging results of this preliminary set of measurements accentuate the desirability of proceeding with the remainder of the proposed program.

IV. DISCUSSION

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(1) RL-REA-1017, Flux Measurement Program, P. R. Prevo, April 7, 1965.

Facilities

The two side-to-side K Reactor test facilities, 2B-KE and 2A-KW, which contain multiple tube water cooled facilities, were used in the tests (see Figure 3). In these facilities, the cooling water flows inside the 3.25" ID outer tube and outside seven inner tubes. The facility is located in a 4 1/16" square channel and penetrates the full width of the reactor. The reactor loading for the tube rows immediately above and below the test holes, and horizontal control rod positions in the vicinity of the test holes, are shown in Figures 1 and 2. The capsules containing the flux wire were charged into one of the smaller outer tubes.

Capsules

Standard K Reactor magazine capsules were used to contain the flux wire (see Figure 3).

Flux Wire

Aluminum wire 0.02" OD, containing 0.1% by weight cobalt-59, was used as the thermal (<0.414 meV) neutron flux monitor. Type 270 nickel in the form of 0.02" OD wire was used for the fast (>0.18 meV) neutron flux monitor. After irradiation, the wires were removed from the capsules, cut into various lengths and counted.

Counting

The $\text{Co}^{59} (n, \gamma) \text{Co}^{60}$ reaction was used in determining the magnitude of the thermal flux and the $\text{Ni}^{58} (n, p) \text{Co}^{58}$ reaction in evaluating the fast flux.

The irradiated wires were analyzed for gamma activity by the Analytical Laboratory Operation of the Chemical Processing Department.

Data Reduction

The count data in disintegrations per second per milligram (dps/mg) were reduced to neutron flux data using the methods described in Reference 2. The thermal neutron flux reported here refers to gross thermal neutrons, since corrections were not made for epithermal flux activation. A correction was made for thermal neutron burnout of the product isotope Co^{60} . A value of 38.0 ± 0.7 barns was used for the cross section for the $\text{Co}^{59} (n, \gamma) \text{Co}^{60}$ reaction. A value of 0.0123 barns was used for the cross section for the $\text{Ni}^{58} (n, p) \text{Co}^{58}$ reaction.

Results

The B test facility is near the centerline of the reactor and the A test facility is upstream from it. Since the reactor has a near-cosine neutron flux distribution, the B test facility is nearer to the peak flux than the

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- (2) HW-81367, Foils: A Program For Computing Neutron Exposures From Foil-Activation Data, W. C. Morgan, April, 1964.

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A test facility. The measured values of the neutron flux in the A and B test facilities correspond closely to a cosine distribution. The flat zone of thermal neutron flux from the near side to the far side of the reactor is easily confirmed by these measurements. One might expect that the flat zone should be contained symmetrically between the enrichment rings, which are located in rows 49 and 50 on the near side, and row 90 on the far side. However, Figure 2 shows that the flat flux zone is not as well defined on the near side as on the far side of the reactor. This is due to the fact that the horizontal control rods (HCR's) enter the reactor from the near side and tend to perturb the flux on that side of the reactor. Normally, the near side of the reactor is loaded with more enrichment than the far side, thus effectively compensating for the perturbing effect of the HCR's, as shown in Figure 1. The additional enrichment causes the neutron flux to be locally peaked in the near side E ring. The use of No. 18 HCR aids in eliminating some peaking in the region; even so, this peak in the neutron flux is about 20% higher than the rest of the flat zone.

The special distributions of thermal and fast flux within the lattice is difficult to establish, but it is felt that these measurements have been able to define the distributions with reasonable accuracy. The flux, for several lattice units, was determined at six equidistant positions per lattice. The resulting measurement indicates a peaking of thermal neutron flux in the graphite region between the process tubes, and a depression immediately under the process tube. This perturbation is of the order of + 5 per cent. This effect is illustrated in Figure 2 between lattice units 67 and 72.

At the time of measurement, a thorium blanket occupied lattice units 62, 68, 80, and 86 of Figure 1. There is an expected sharp perturbation in the fast flux in the area of these process tubes since a source of fast neutrons has been removed.

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LATTICE SPACES (1)

FIGURE 1
THERMAL NEUTRON
2A KW REACTOR
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FIGURE II

CROSS SECTION OF
IRRADIATION FACILITY

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MAGAZINE CAPSULE

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