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Thermal Neutron Flux in the Thermal Column of the NRL Reactor

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ABSTRACT

In certain nuclear reactor experiments it is necessary to know how the thermal-neutron flux and the cadmium ratio vary within the exposure cavity of the thermal column.

The neutron flux in the thermal column of the NRL reactor was measured with gold detectors. The thermal flux in a cavity in the graphite had a maximum value of 10^{10} neutrons/cm^2-sec at 1 MW power and a cadmium ratio of 470 for the gold detector. The flux was determined at points along the vertical axis of the cavity.

PROBLEM STATUS

This is a final report on the problem; unless otherwise notified. The problem will be considered closed 30 days after the issuance of this report.

AUTHORIZATION

NRL Problem H01-01
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THERMAL NEUTRON FLUX IN THE THERMAL COLUMN OF THE NRL REACTOR

INTRODUCTION

The NRL reactor has a thermal column which provides a source of thermalized neutrons necessary for some experiments in which interfering effects are produced by fast neutrons. For example, in the determination of small amounts of sodium in the presence of large amounts of aluminum, the reaction of the fast neutrons with ^{27}Al produces ^{24}Na by the (n, α) reaction. This interferes with the determination of sodium from thermal neutron capture by ^{23}Na.

The thermal column is an extension of the graphite reflector and is shaped like a rectangular parallelopiped constructed of graphite stringers. Some of the stringers are removable, thereby providing some flexibility in the choice of configurations available for experiments. Access to the neutron flux is made through an opening in the top. The configuration currently in use permits access to a cylindrical cavity 3 in. in diameter and extending nearly 3 ft into the graphite, as shown schematically in Fig. 1. A thermal neutron flux of about 10^{10} neutrons/cm^2-sec is available at the bottom of the cavity for irradiating small samples. A series of measurements was made to determine the variation of the thermal neutron flux in the cavity in a vertical direction and in a void in the reactor shield just above the cavity shown in Fig. 1.

EXPERIMENTAL METHOD

The relative neutron flux was computed from the activity of gold foils which were exposed along the vertical center line of the cylindrical cavity in the graphite (Fig. 1). Circular gold disks of 0.155-in.^{2} area and 0.001-in. thickness were used, each placed with a diameter along the vertical direction and with the normal to the circular surface pointing horizontally in the vertical symmetry plane common to both the thermal column and the reactor-core grid plate.

The activity of the gold foils exposed in the region of the greatest neutron flux near the bottom of the cavity was measured with a calibrated, 4π γ-ray ionization chamber (1) and provided a flux value at one point to which the other points were compared. The relative activities of the other foils were then compared using the observed intensity of the 412-keV gamma ray of ^{198}Hg associated with the 2.7-day beta decay of ^{198}Au, as determined by a Ge(Li) solid-state detector of 6-cm^3 volume and a 512-channel pulse-height analyzer.

Cadmium ratios for gold were determined by comparing the activities of gold foils exposed to the flux while covered by 0.015 in. of cadmium with the activities of bare gold foils, the cadmium ratio for a gold detector being the ratio of the activity of a bare gold foil to that of a covered one. The cadmium ratio was found to be greater than 450; therefore, the activity of the bare foil determines the thermal neutron flux (neutron energy less than about 0.2eV) with sufficient accuracy.

Two thin gold foils (1.2 mg/in.^{2}) were exposed to determine whether the effect of foil thickness could be observed in the determination of the flux. The activity was measured with the calibrated Ge(Li) detector. The results showed no difference between the value of the neutron flux determined by the thin foils and that obtained with the regularly

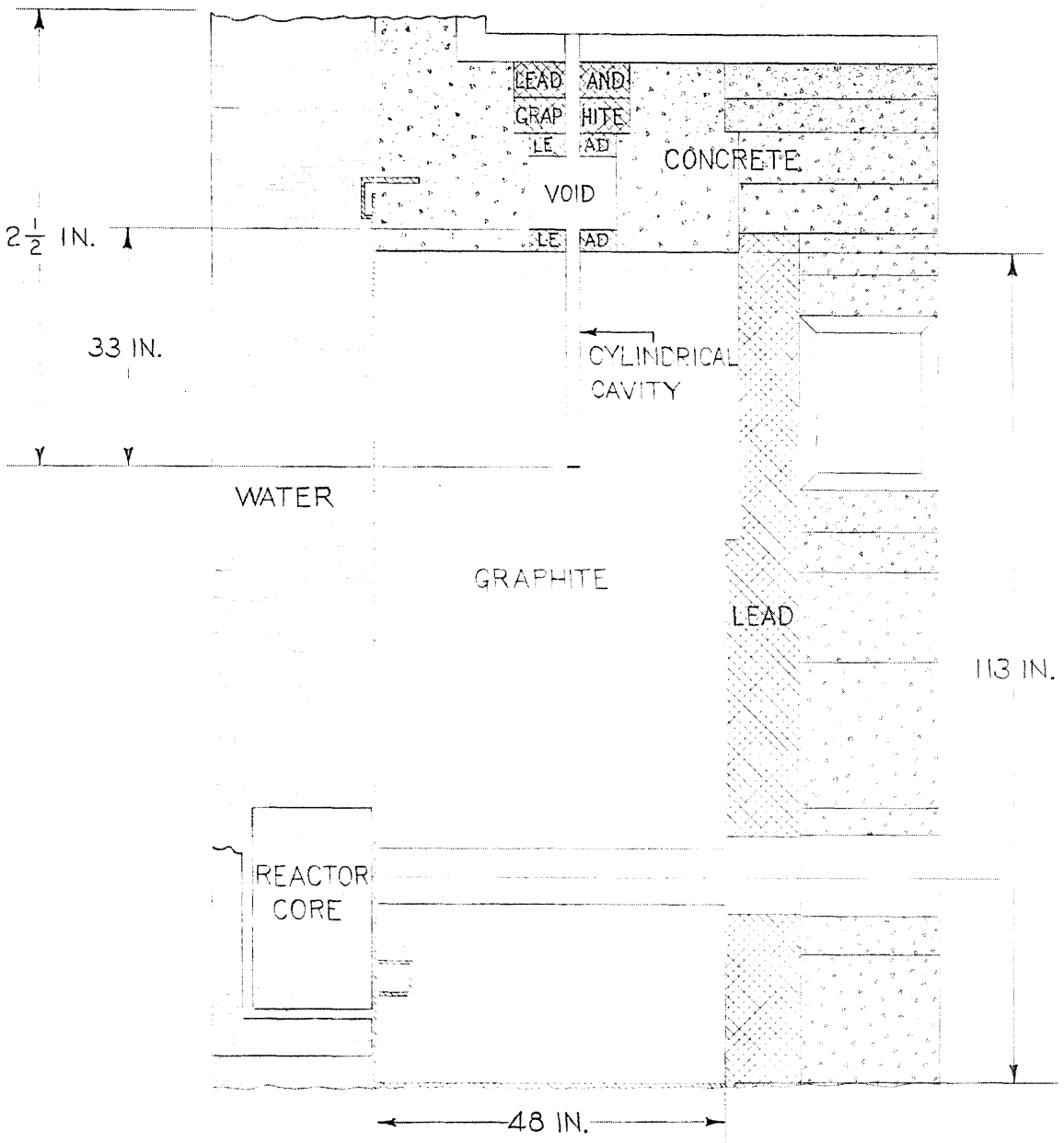

Fig. 1 - Vertical section through the reactor and the shield, showing the graphite thermal column

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used foils. A run made with the normals to the foil surfaces pointing in the vertical direction produced the same relative flux as when the normals pointed horizontally. The foils were held in a vertical line by a Lucite strip with the lowest foil centered 2 in. above the bottom of the exposure cavity in the graphite. Bare foils were exposed for 1 hr, and cadmium-covered foils were exposed for 4 hr.

RESULTS AND DISCUSSION

The thermal neutron flux, as a function of the vertical distance from the bottom of the exposure cavity with the reactor at 1 MW power, is shown in Fig. 2. The points are averaged from two or three runs in most cases. The point at 44 in. was obtained from measurements made with gold foils (0.44 in. by 0.001 in.) at two points, 26 in. and 44 in., which were normalized to fit the remaining points. The observed points fell in a range of ±6% about the average. The averaged cadmium ratio for gold at various points in the cavity is also shown. The individual measurements fell in a range of ±10% about the average. The activities of the foils exposed at the point nearest the bottom of the cylindrical cavity were determined with the ionization chamber and gave a flux value to which the other points were normalized. The error in the measured activity of this point (shown at 2 in. in Fig. 2) is estimated to be ±10%.

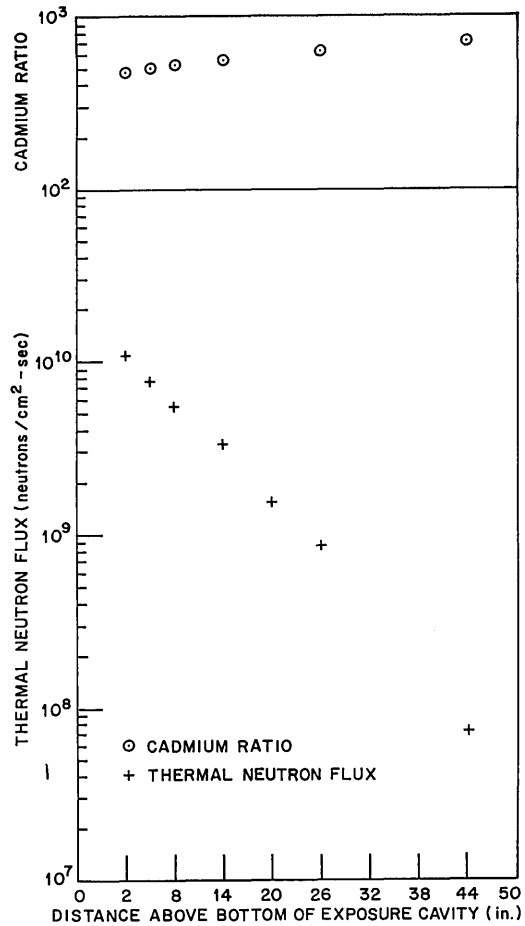

Fig. 2 - Thermal neutron flux and the cadmium ratio in the cavity

The slowness with which the cadmium ratio increases in the cavity could be attributed to the presence of the cavity itself and to the scattering of fast neutrons from nearby parts of the reactor shield.

REFERENCE

1. Smith, C.C., and Seliger, H.H., Rev. Sci. Instr. 24:474 (1953).

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