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Argonne National Laboratory

THERMAL-NEUTRON FLUXES FOR CP-5 VERTICAL IRRADIATION FACILITIES

by

D. S. Frazier

RELEASED FOR ANNOUNCEMENT
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THERMAL-NEUTRON FLUXES FOR
CP-5 VERTICAL IRRADIATION FACILITIES

by

D. S. Frazier

Reactor Operations Division

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THERMAL-NEUTRON FLUXES FOR CP-5 VERTICAL IRRADIATION FACILITIES

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ABSTRACT

Thermal neutron fluxes measured in the CP-5 reactor at Argonne National Laboratory over a two-year period are presented graphically. The method used in measuring the fluxes is described briefly.

INTRODUCTION

This report presents graphically the thermal neutron fluxes determined for various vertical-irradiation facilities in the CP-5 reactor at Argonne National Laboratory. These graphs are a composite of several flux measurements made over the period from June 1962 to September 1964. Measurements were not made in all irradiation facilities each time a flux measurement of the reactor was made.

METHOD

The foil activation method was used to determine the thermal neutron flux. By this method, 1-cm-square by 0.001-in.-thick gold foils are irradiated at the positions within the reactor at which the flux was to be determined.

If an aluminum-covered foil is irradiated first, and then a cadmium-covered foil (20-mil-thick cadmium cover) is irradiated at the same spot in the reactor, the thermal neutron flux can be determined by subtracting the epicadmium neutron flux as determined by the cadmium-covered foil, from the total neutron flux as determined from the aluminum-covered foil.

The actual fluxes are determined from the irradiated foils by counting their activity with calibrated Geiger-Mueller counters and absorbers and using these data, along with other pertinent data such as decay time and time length of irradiation to calculate the fluxes. The formula used to determine the flux for the power level at which the foils are irradiated is

$$\phi = \frac{1}{E} \times \frac{C A}{60 \text{ Na } g \sigma (1 - e^{-\lambda t_1}) e^{-\lambda t_2}},$$

where

- ϕ = Neutron flux, neutrons/cm²-sec;
- C = Counting rate, counts per min;
- A = Atomic weight of gold in gm, 197;
- 1/E = Calibration factor, disintegrations per min/counts per min;
- 60 = Conversion factor (converts decays/sec to decays/min);
- Na = Avogadro's number, 6.0248×10^{23} atoms/gm atomic weight;
- g = Foil weight, gm;
- σ = Activation cross section for gold, 9.6×10^{-23} cm²;
- λ = Decay constant for gold, 1.782×10^{-4} min⁻¹;
- t₁ = Effective irradiation time, min;

and

- t₂ = Decay time before foils are counted, min.

The counters were calibrated with foils irradiated in the Standard Pile at Argonne National Laboratory.

The activities of the foils are corrected for dead time and background of the counters.

The irradiation time during the rise to power and irradiation is determined by integrating the area under a curve traced by a recorder displaying the current from an ionization chamber located within the reactor.

The neutron flux is determined for the power level at which the foils are irradiated. These values are then multiplied by an appropriate factor to bring the flux to the value that exists when the reactor is operating at its normal power level. Since the power level at which the reactor operated over the past approximate two-year period varied, all values were normalized for a power level of 4.6 MW.

The accuracy of the flux determinations is dependent on the certainty of the flux from the standard pile, which is $\pm 7\%$. It is estimated that, in general, the overall accuracy is $\pm 15\%$. The curves on the graphs included in this report were drawn between values determined at 6-in. intervals, unless a point was obviously erroneous. Certain curves obviously in error were excluded from the report.

Figure 1 shows the physical location of the various vertical irradiation facilities within the reactor.

Figure 2 shows the symbols used with the graphs.

Figures 3-44 present graphically the sub-cadmium or thermal neutron fluxes for the various vertical irradiation facilities in the CP-5 reactor.

ACKNOWLEDGMENT

Data for the curves included in this report were taken from various internal memoranda originated at Argonne National Laboratory by Dr. J. H. Talboy, Jr., H. Norman, D. A. Herbst, and the author of this report.

Fig. 1. Schematic Diagram of CP-5 Vertical Irradiation Facilities

LEGEND

JUNE 1962

AUGUST 1962

NOVEMBER 1962

MARCH 1963

MAY 1963

SEPTEMBER 1963

DECEMBER 1963

MARCH 1964

SEPTEMBER 1964

Fig. 2. Legend for Figs. 3-44

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Vertical Irradiation Facility VT-1

Fig. 4. Sub-cadmium Neutron Flux for
Vertical Irradiation Facility VT-2

Fig. 5. Sub-cadmium Neutron Flux for Vertical Irradiation Facility VT-3

Fig. 6. Sub-cadmium Neutron Flux for Vertical Irradiation Facility VT-4

Fig. 7. Sub-cadmium Neutron Flux for Vertical Irradiation Facility VT-5

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Fig. 40. Sub-cadmium Neutron Flux for Vertical Irradiation Facility VT-48

Fig. 41. Sub-cadmium Neutron Flux for
Vertical Irradiation Facility VT-49

Fig. 42. Sub-cadmium Neutron Flux for
Vertical Irradiation Facility VT-50

Fig. 43. Sub-cadmium Neutron Flux for Vertical Irradiation Facility VT-51

Fig. 44. Sub-cadmium Neutron Flux for Vertical Irradiation Facility VT-52