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PHYSICS EXPERIMENTS FOR CANDU LATTICES

INTRODUCTION

Experiments have been performed in the PDP to measure $1/\eta\ d\eta/dT$ and the effects of asymmetric control rod placement in simple lattices of natural uranium fuel rods in D_2O.

SUMMARY

The $1/\eta\ d\eta/dT$ experiments in the PDP were completed on June 27, 1967. The preliminary measured value for the temperature coefficient of η is:

$$\frac{1}{\eta}\frac{d\eta}{dT} = -0.5 \times 10^{-4}/°C$$

A corresponding theoretical value calculated by the HAMMER code is:

$$\frac{1}{\eta}\frac{d\eta}{dT} = -0.69 \times 10^{-4}/°C$$

Measurements of the neutron flux distributions around a cadmium and an H_2O-filled control rod were also completed.

Analysis is still in progress on both experiments.

DISCUSSION

$\frac{1}{\eta}\frac{d\eta}{dT}$

The experiments were performed on full PDP lattices of one-inch-diameter natural uranium rods contained in copper cladding tubes with ~0.034-inch walls. Two lattices, one with the fuel on a 5.05-inch-square pitch and the other with the fuel on a 7.00-inch triangular pitch were used for the $1/\eta\ d\eta/dT$ measurements. The experiments derived from a differentation of the one group critical equation with respect to temperature

$$\frac{1}{\eta}\frac{d\eta}{dT} = \frac{M^2\frac{dB^2}{dT}}{1 + M^2B^2} + \frac{B^2\frac{dM^2}{dT}}{1 + M^2B^2} - \frac{1}{p}\frac{dp}{dT} - \frac{1}{f}\frac{df}{dT}$$

Measurements at 20°C and 60°C served to determine the buckling, B^2, and the migration area, M^2, and their derivatives with respect to temperature, dB^2/dT and dM^2/dT. The temperature derivatives of the resonance escape probability and the thermal utilization, $1/p\ dp/dT$ and $1/f\ df/dT$, were calculated by the HAMMER code. Preliminary

buckling numbers as determined from flux mapping experiments are listed below.

TABLE I

Lattice Bucklings

Pitch, in.	Temp., °C	Measured B_m^2	"HAMMER" B^2_m	Measured $\frac{dB^2}{dT}$	"HAMMER" $\frac{dB^2}{dT}$
5.05	20	242 μB	241.0 μB	-.60 μB/°C	-.525 μB/°C
	60	219	220.0		
7.0	20	225	227.1	-.53	-.423
	60	204	210.2		

The Inhour equation can be used to provide a relationship between the stable reactor period and reactivity (Δk). Then by equating reactivity to M^2 one obtains an approximate expression for M^2:

$$M^2 = \frac{\Delta k}{\Delta B^2 - \Delta k B^2}$$

The following procedure was used in the M^2 measurements:

1) Measure B^2 of lattice,

2) Add ΔB^2 and measure the resulting period,

3) Calculate Δk from the period, and

4) Solve for M^2.

To improve the accuracy of the measurement, M^2 was measured twice at each temperature. The corresponding preliminary migration area numbers as determined from measurements of pile periods versus moderator height changes are listed in the second table.

TABLE II

M^2 Determination

Pitch, in.	Temp., °C	Doubling Time, sec	M^2, cm^2	$\frac{dM^2}{dT}$
5.05	20	80.0	270.5	0.53
		40.7	267.5	
	60	74.1	281.5	
		35.3	280.0	

Analysis of the experiments is continuing.

The preliminary value of $1/\eta\ d\eta/dT$ derived from these numbers is $-0.5 \times 10^{-4}/°C$.

Asymmetric Control Rods

The asymmetric control rod experiments were performed with the copper-clad fuel rods at the 7-inch triangular lattice pitch. Two different control rods, a cadmium covered, D_2O-filled rod and an aluminum tube filled with H_2O were used in separate experiments. The rods are described in Table III and their asymmetric positioning in the PDP is illustrated in Figure 1.

TABLE III

Asymmetric Control Rod Dimensions

Description	Cd Covered, D_2O Filled	Unclad, H_2O Filled
OD	2.625 in.	3.5 in.
Length	8.5 ft	8.5 ft
Cadmium Thickness	0.030 in.	---

The measurements consisted of buckling worth determinations for each rod (1) located vertically in the center of the reactor and (2) located horizontally in its asymmetrical position and of gold pin irradiations to determine the neutron flux distributions for the unperturbed reactor and for the asymmetric control rods. The experimental data is still under analysis.

ASYMMETRICAL CONTROL ROD IN PDP

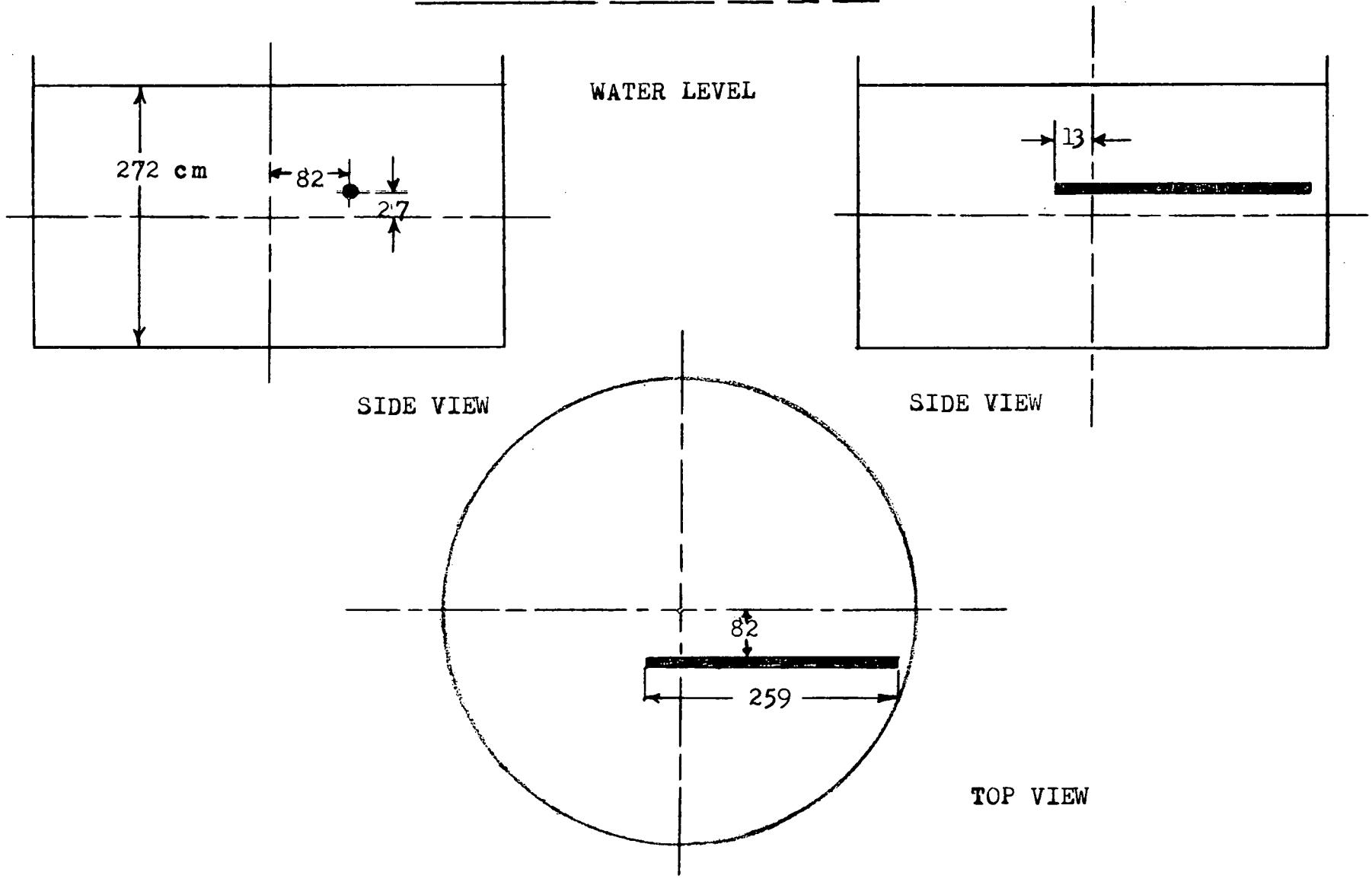

Figure 1

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