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PART III, TASK 9

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Physics Verification Program, Part III, Task 9
Quarterly Technical Report, July-September 1973

H. W. Webb, M. N. Baldwin

Key Words: Critical Assembly, Fission Rate, Lumped
Burnable Poison, Neutron Absorption

ABSTRACT

In experimental Task 9, the fission rate in low-enriched UO_2 fuel pins and the neutron absorption rate in the boron of a simulated lumped burnable poison (LBP) material in a critical assembly are being measured. These rates are being compared for a few select core positions and for two types of LBP pins.

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1. INTRODUCTION

In April of 1973, Babcock & Wilcox (B&W) began Part III, Task 9, of the Physics Verification Program, entitled Capture Measurements. The program is jointly sponsored by B&W and the U. S. Atomic Energy Commission. The objective of the task is to measure the fission rate in UO_2 fuel at selected positions within a critical assembly, and to compare it with the neutron absorption rate in the boron of a simulated lumped burnable poison (LBP).

Earlier phases of Task 9 activities may be found in reference 9. This report summarizes the work completed during the third quarter of 1973, which has consisted principally of accumulating the bulk of the experimental data. Completed tasks of the program are summarized in references 1 through 8.

2. DESCRIPTION OF CRITICAL ASSEMBLY

The facility used in Task 9 is a critical assembly situated within a 5-foot-diameter by 6.5-foot-high core tank with 1/2-inch-thick aluminum walls. The water-handling equipment, instrumentation, control system, and other auxiliaries are all of conventional design. This facility is located at B&W's Lynchburg Research Center. The core, fuel rods, and LBP pins are fully described in reference 9.

3. THEORY

The objective of this task is to measure the fission rate in UO_2 fuel at selected positions within the critical assembly and to compare it with the neutron absorption rate in a simulated LBP material placed in other selected locations. The method being applied to this work relates the ^{99}Mo fission product activity in an irradiated fuel sample to the fission rate, and the ^{24}Na activity in an irradiated simulated LBP material to the total neutron absorption rate in that material. Absolute counting is avoided by measuring under identical counting conditions the ^{99}Mo and ^{24}Na activity from samples of identical composition irradiated in a highly thermal neutron flux for which the ratio of fission rate to absorption rate is known. The theory behind this task is fully described in reference 9.

4. EXPERIMENTAL METHOD

4.1. Lattice Irradiations

One special fuel rod and two special poison pins were used to perform the lattice irradiations in the central "element" of core XIII. Figure 4-1 shows the location of the 16 lumped burnable poison pins and the special test fuel pins. The first series of measurements used thin-walled LBP pins and the second series used thick-walled LBP pins. Within each series of measurements, sample fuel pellets and test LBP sections were irradiated in two different configurations as indicated by Case I and Case II of Figure 4-1.

During these irradiations, the sample fuel pellet and the sample LBP section were centered 78.7 cm above the reference plane. Axial power variations were eliminated by adjusting the moderator boron concentration and the auxiliary control rod position so that the critical moderator height was always 145.0 cm above the reference plane. The total core power was normalized with two 0.25-inch-diameter gold foils which were located 75 cm above the reference plane and mounted on the cladding of the fuel pins in positions N8-E15 and N8-W15. All irradiations were for 20 minutes at ~1 kW.

4.2. Sample Processing

Soon after shutdown, the two LBP removable sections were removed, weighed, and dissolved in 250 ml of demineralized water in separate polyethylene bottles. The pre-weighed sample fuel pellet was also removed and dissolved in 250 ml of warm concentrated nitric acid in a polyethylene bottle.

4.3. Sample Counting

Soon after being dissolved, the LBP samples were gamma counted on a Ge-Li detector-4096 multichannel analyzer system. The time from reactor

Figure 4-1. Central "Element" Cross Section

Case I

Case II

- ⊗ — Inconel Tube
- — LBP Pin
- Ⓢ — Sample LBP Pin
- ⓕ — Sample Fuel Pin

shutdown to start of count varied from 26 to 390 minutes. The live counting time was 10^4 seconds for the LBP samples from the thin-walled pins and 2×10^4 seconds for samples from the thick-walled pins. Both the 2.75- and 1.37-MeV ^{24}Na gamma peaks were counted.

The fuel sample was also gamma counted in the same geometry and on the same counting system. The time from reactor shutdown to start of count varied from 1230 to 1555 minutes, and the live counting time was 10^3 seconds. The 140.5-keV gamma peak from the ^{99}Mo decay was the peak of interest.

4.4. Data Reduction

The ^{99}Mo and ^{24}Na data were converted to relative saturated activities (Tables 4-1 and 4.2).

Table 4-1. Core XIII ^{99}Mo and ^{24}Na Activity
Data From Thin-Walled Poison Pins

Run No.	Relative ^{99}Mo saturated activity, 10^2 counts/min-gUO ₂		Relative ^{24}Na saturated activity, 10^4 cts/min-gNaBF ₄		
	Core position		Core position		
	<u>S3E3</u>	<u>S2</u>	<u>S4E4</u>	<u>S2E2</u>	<u>S5E2</u>
1726	3.11		2.36	2.40	
1727		3.59	2.16		2.44
1728	3.36		2.38	2.39	
1729		3.61	2.13		2.61
1731	3.33		2.19	2.25	
1732		3.39	2.63		2.61

Table 4-2. Core XIII ^{99}Mo and ^{24}Na Activity
Data From Thick-Walled Poison Pins

Run No.	Relative ^{99}Mo saturated activity, 10^2 counts/min-gUO ₂		Relative ^{24}Na saturated activity, 10^4 cts/min-gNaBF ₄		
	Core position		Core position		
	<u>S3E3</u>	<u>S2</u>	<u>S4E4</u>	<u>S2E2</u>	<u>S5E2</u>
1737		4.56			4.78
1738	4.53		4.80	4.35	
1739		4.66	4.37		4.86
1742	4.45		4.40	3.99	
1743		4.67	5.20		4.93
1744	4.50		4.76	4.24	

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