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CONTINUOUS MONITORING OF FRONT-TO-REAR
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FINAL REPORT, PRODUCTION TEST IP-165-C
CONTINUOUS MONITORING OF FRONT-TO-REAR FLUX BALANCE

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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FINAL REPORT, PRODUCTION TEST IP-165-C CONTINUOUS MONITORING OF FRONT-TO-REAR FLUX BALANCE

INTRODUCTION

Nuclear reactors which contain a significantly large volume operating at or near the same flux level are subject to oscillations of the maximum flux from one region of the reactor to another. To control these flux movements it is necessary to know the location of the flux "peaks" and "valleys" and the rate of change of the flux at these points. Existing monitoring instruments readily present only a two-dimensional picture of the flux distribution within the reactor; the front-to-rear distribution must be inferred from graphite temperatures or octant monitoring chambers which are not ideally suited for the job. The objective of this test was to evaluate a paired-column arrangement for continuously monitoring the front-to-rear flux balance in one region of the reactor and to control any significant unbalance with the prototypic slug column displacement equipment.

SUMMARY AND CONCLUSIONS

One of the paired-columns was not charged in proper sequence and the full capabilities of the system were not realized. However, front-to-rear flux movements could be detected in the region of the paired test channels and generally could be controlled by the remotely operated displacement facility. The sensitivity of the paired columns was less than that of the local graphite temperature, and it is concluded that even properly charged paired columns as designed for the test would not be suitable for operational use in monitoring and controlling front-to-rear flux movements. It might be possible to devise a suitable in-pile loading which would satisfactorily detect flux movements; however, such a loading would probably be supplanted by the chamber - wire activation combination which is being investigated for possible use in monitoring the in-pile flux distribution.⁽¹⁾

DISCUSSION

The test loadings were placed in the near side of the KW reactor in a region in which numerous flux oscillations had been experienced during preceeding operating periods. Tube 3652-KW contained 85 inches of perfs next to the downstream dummy pattern with fifteen eight-inch natural uranium pieces and eighteen six-inch E metal pieces upstream. The adjacent tube, 3653-KW, was to have contained eighteen six-inch E metal pieces next to the downstream dummy pattern with fifteen eight-inch natural uranium pieces upstream. Because of a charging error the tube actually contained thirteen six-inch E metal pieces, eight natural uranium pieces, five E metal pieces and finally seven natural uranium pieces. Heat generation in tube 3652-KW was due to central and upstream flux whereas heat generation in tube 3653-KW was planned to be due to central and downstream flux; the actual split column makeup would not be as sensitive to downstream flux. The makeup of the paired columns was calculated to cause no reactivity losses relative to full-length natural uranium columns.⁽²⁾ The displacement facility,⁽³⁾ located in tube 3851-KW, contained fifteen natural uranium pieces centered with mint material. The entire charge in the displacement facility could be moved either upstream or downstream during operation to control the front-to-rear flux distribution in that region.

(1) HW-57097-Specifications for Prototype In-Core Flux Monitor, AG Dunbar, 8-7-58.

(2) HW-56065-Production Test IP-165-C-Continuous Monitoring of Front-to-Rear Flux Balance, WL Bunch, 5-14-58

(3) HW-51412-Supplement A, PT-64-CE-Poison Column Displacement During Reactor Operation, WE Cawley and WS Nechodom, 1-31-58.

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A flux oscillation was detected in the region of these tubes on 8-23-58 and data were obtained for about three days. Graphite temperatures in the region (T/C's numbered 3-R and 4-R, located near the second slug from the rear and front respectively of tube 4257) indicated maximum flux changes of up to about 10 per cent in time spans of 8 to 14 hours. The heat generation rate of the pair of segmented columns was analyzed as follows: The tube powers were averaged and the difference between the heat generation of the individual tubes and the average value was obtained. This difference should reflect the front-to-rear flux movements independent of changes in the other two dimensions. All of these values indicated that the flux was skewed to the front; that is, the tube with E metal toward the front (3652-KW) was generating from 1.5 per cent to 6.0 per cent more heat than the one with the E metal primarily toward the rear. A plot of the variation of tube temperature differences and graphite temperatures is shown in Figure 1. The data show that the tube powers and the graphite temperature were relatively consistent in indicating oscillations.

To determine how much variation in heat generation rate should be expected from flux changes of the order of the 10 per cent measured by the graphite oscillations, the two flux distributions of Figure 2 were hypothesized based on typical traverses obtained recently at the K reactors. By taking the area under the curves represented by each material and applying an appropriate heat generation factor (1.0 for uranium, 1.2 for E metal and 0 for aluminum or water) it was found that the percentage change in heat generation of the two tubes is approximately 4.5 per cent -- just slightly greater than that actually experienced in the test (see Table I). It is concluded that the experimental tubes did measure the flux unbalance as well as could be expected but that a system of this type is not sufficiently sensitive to be of value.

The displacement facility operated fairly satisfactorily throughout the test; the position indicator gave some trouble due to water leaking into the electrical system. The effectiveness of the displacement facility in controlling front-to-rear flux movements was not established with any degree of confidence. At times displacement column movement seemed to check flux movements; at other times it seemed to have little or no effect. It may be necessary to place a distributed system of displacement facilities throughout the reactor to evaluate adequately the merits of such a system. The mechanical and operational properties of the displacement facility are to be reported by others.

CONCLUSIONS

Pairs of segmented columns such as those utilized in this test do not appear to provide an operationally practical method of monitoring the front-to-rear flux balance. This conclusion is based on the lack of sensitivity of the system as instrumented. Development work invested in instrumentation and optimizing the charge pattern would probably yield a workable system, but this does not seem advisable at the present time in light of the more promising monitoring systems currently being evaluated.

W. L. Bunch

W. L. Bunch
Irradiation Testing Operation

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Figure 1

VARIATION OF TUBE TEMPERATURE DIFFERENCES AND GRAPHITE TEMPERATURE AS A FUNCTION OF TIME

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Charge Location

HYPOTHETICAL FLUX OSCILLATION FROM COSINE TO SKEWED OF MAGNITUDE COMPARABLE TO THAT ENCOUNTERED IN TEST
See Table 1 for Calculations

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TABLE 1

TUBE POWER CALCULATIONS BASED ON HYPOTHETICAL FLUX DISTRIBUTIONS
SHOWN IN FIGURE 2

<u>Tube No.</u>	<u>Material</u>	<u>Cosine Area</u>	<u>Distribution Power</u>	<u>10 % Upstream Area</u>	<u>Skewing Power</u>
3652	Empty	235	0	215	0
	Uranium	758	0.750	725	0.725
	E Metal	380	0.450	425	0.510
	Totals	1365	1.206	1365	1.235
3653 (design)	E Metal	380	0.456	350	0.420
	Uranium	750	0.750	760	0.760
	Empty	235	0	255	0
	Totals	1365	1.206	1365	1.180
3653 (as actually loaded)	E Metal	235	0.282	215	0.258
	Uranium	375	0.375	345	0.345
	E Metal	200	.240	195	0.234
	Uranium	320	0.320	355	0.355
	Empty	235	0	255	0
	Totals	1365	1.217	1365	1.192

The changes in tube power to be expected from the hypothetical flux movement from a cosine distribution to the skewed upstream distribution are:

Tube 3652	1.235-1.206	+ 2.4 %
Tube 3653(design)	1.180-1.206	- 2.2 %
Tube 3653(actual)	1.192-1.217	- 2.1 %

In the test an apparent flux change of 5-8 per cent (as measured by graphite temperatures) resulted in the following tube power changes from the average:

Tube 3652	+ 2.1 %
Tube 3653	- 2.1 %

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