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FEBRUARY, 1964
Reactor Physics

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February 28, 1964

MONTHLY TECHNICAL REPORT
FEBRUARY, 1964

Reactor Physics
Research and Engineering
N-REACTOR DEPARTMENT

Paul F. Nichols
and
Reactor Physics Staff

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MONTHLY TECHNICAL REPORT
FEBRUARY, 1964

I. RESEARCH AND DEVELOPMENT

A. Code Development - FLEX 3

While debugging FLEX 3 an error in the calculation of the effective surface for resonance integral estimations showed up. This error was traced back through FLEX 2 and FLEX 1, and has therefore been with FLEX programs for several years. The error occurred only for those fuels that had a non-uranium bearing rod as the innermost fuel region. This programming error has been eliminated from both FLEX 2 and FLEX 3. It is not anticipated that this will prove to have a significant effect on the results of co-producer survey studies done previously.

The ability of FLEX 3 to search for "target" concentrations instead of U^{235} concentrations for a desired reactivity has disclosed that many of the previous co-producer runs had targets that had excess concentrations and were essentially black with as little as half as much material. As a result the target absorber concentration estimated in previous co-producer survey studies can be reduced and still retain the same product split.

B. Charcoal Filter Temperature

Upon trying to determine good estimations of radiant heat transfer and convection heat transfer to air brought to the filters by the stack draft, it became apparent that the estimation of the fraction of Iodine getting to the filter was really the limiting or controlling factor, and that approximate cooling rates were sufficiently adequate for the study.

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I. (continued)

B. (continued)

The conclusions concerning the need for additional cooling for the filters are not yet firm.

C. Technical Bases - Speed-of-Control and the Hot Star up Accident

Thus far kinetics studies have been made for the hot startup accident terminated by the Ball Safety System. A reactivity ramp of 1.0 mk/sec due to rod withdrawal was assumed with coolant conditions of 100% flow and 161.7°C inlet water temperature. The trip signal was generated by an excessive power level indication of 100 MW as set on the intermediate instrumentation. The results show that under these conditions coolant boiling would occur but fuel melting would not be expected.

The two most important variables in these studies are the instrument delay times and the reactivity ramps. The maximum reactivity ramp of 1.0 mk/sec is much more accurately known than the instrument delay time. Therefore satisfaction of the speed-of-control criteria by the rod system depends heavily on the instrument delay time. The manufacturer indicates that the log level response time is 0.1 to 0.5 seconds. This does not include the delays in the safety circuit. A value of 0.5 seconds was chosen for these studies.

D. Pu Fuel Study

Using basic burn-out and reactivity behavior data calculated by Hanford Laboratories personnel, preliminary fuel cycle data were prepared for use in making an economics evaluation of the different designs studied. Reliability of the fuel cycle data is limited due to the small amount of burn out information available and the uncertainties involved in the calculations.

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I. (continued)

D. (continued)

The by-product formation rates obtained with a plutonium fuel load in N-Reactor are still under study by our personnel. There is quite a variation between the cross sections which Meleager calculates and those given by the Westcott formulation. This is due to the self-shielding effects included in the Meleager formulation. Consequently, there is considerable variation in the product formation as predicted by Meleager and the PUBO code with Westcott cross sections used as input. This variation is especially noticeable during the initial part of the irradiation but the results come into better agreement at an irradiation time of approximately two years.

At the present time, cross section input is being prepared for the PUBO code from initial cross sections given by Meleager. In this way it can be determined if the cross section changes which occur in Meleager have much effect on the by-product formation rates.

E. Study of Iron Fuel Supports for Tube-in-Tube Fuel

A series of FLEX 2 computer code calculations is being run to determine the effects on reactivity of the tube-in-tube fuel when the Zr-2 outer supports are replaced with iron supports. The cases have been prepared but no results are yet available. The additional iron was added as a very thin cylindrical region outside the outer clad of the fuel.

F. Criticality Predictions for Other Reactors

A survey of some of the literature concerning past start-ups revealed the following comparison of predicted and actual values of k given in Table I.

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TABLE I

REACTOR STARTUP	PARAMETER	REACTOR CONDITIONS	PRED. VALUES	MEAS. VALUES	ERROR IN $\Delta k/k$
1. Shippingport Atomic Power Station (a)	k excess	Hot, clean, green	17.0% $\Delta k/k$	13.97 $\Delta k/k$	3.1% $\Delta k/k$
2. Hallam Nuclear Power Facil- ity (b)	Fuel element for critical mass	cold, clean, wet	37 $\pm$ 3	50	
3. Yankee Atom- ic Power Plant (c)	k excess	hot, clean, green	10.2% $\Delta k/k$	11.4% $\Delta k/k$	1.2% $\Delta k/k$
4. Elk River Reactor Plant (d)	k excess	cold, clean, green	11.2% $\Delta k/k$	9.3% $\Delta k/k$	1.9% $\Delta k/k$

REFERENCES

- (a) Shippingport Atomic Power Station
WAPD-BT-12 - "One Year of Operating Experience at
Shippingport".
- (b) Hallam Nuclear Power Facility
NAA-SR-MEMO-7526 - "HNPF Dry and Wet Criticality
Calculational Methods".
- (c) Yankee Atomic Power Plant
Transactions of the American Nuclear Society,
Vol. 4, P. 97, 1961.
- (d) Elk River Reactor
Transactions of the American Nuclear Society,
Vol. 6-#1, P. 65, June, 1963.

G. Startup Review

A review of the results obtained during the physics startup tests has been in progress during the month. The knowledge of several of the parameters at the present time (February, 1964) is discussed below.

1. Buckling

The buckling is a quantity which was measured at startup and has a value of approximately 100 ub.

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I. (continued)

G. (continued)

1. (continued)

This is 12 ub smaller than the predicted value of 112 ub which was based upon a migration area of 647 cm^2 and a k_{∞} of 1.072. Because the buckling is a function of both quantities, the difference in the buckling indicates that either the assumed value of k_{∞} , or of migration area, or both, are different than the actual values.

2. Migration Area

The migration area is also a quantity which was measured at startup. The measurements are much less sensitive than the measurements of buckling and may be susceptible to systematic error. The tentative value obtained from the startup measurements is approximately 560 cm^2 . A reasonable, but rather arbitrary, assignment of the uncertainty in this value is $\pm 60 \text{ cm}^2$. Although the value of 560 cm^2 appears to be rather low a symmetric uncertainty is assigned because the magnitude of any systematic errors is unknown.

3. k_{∞}

The value of k_{∞} can be inferred from the startup results, but is not a quantity measured at startup. The value of k_{∞} consistent with a buckling of 100 ub and a migration area of 560 cm^2 is $k_{\infty} = 1.056$. Recent measurements in the PCTR⁽¹⁾ in which a zirconium process tube and zirconium cladding were substituted for mockup aluminum components indicate

(1) HW-80731, "Measured Differences in k_{∞} Between the N-Lattice and the PCTR Mockup", L.C. Davenport, February 10, 1964.

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I. (continued)

G. (continued)

3. (continued)

that the predicted value of $k_{\infty} = 1.072$ should be corrected downward by approximately 0.008 to account for what is probably resonance absorption in the zirconium lattice components. Thus, on the basis of knowledge presently available, the predicted value of k_{∞} would be reduced to $k_{\infty} = 1.064$. This is within 8 mk of the value of $k_{\infty} = 1.056$, based upon a buckling of 100 ub and a migration area of 560 cm².

4. Best Values

The best values at the present time of k_{∞} and M^2 would appear to be:

$$k_{\infty} = 1.056$$

$$M^2 = 560 \text{ cm}^2$$

These values are consistent with the measured buckling of 100 ub obtained from the startup tests.

II. REPORTS

HW-80937, "Fission Product Formation in Fuel Elements",
R.J. Shields, February 2, 1964. SECRET

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