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SEPTEMBER, 1963
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MONTHLY TECHNICAL REPORT
SEPTEMBER, 1963

Reactor Physics
Research and Engineering
N-REACTOR DEPARTMENT

Paul F. Nichols
and
Reactor Physics Staff

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MONTHLY TECHNICAL REPORT
SEPTEMBER, 1963

REACTOR PHYSICS

I. RESEARCH AND DEVELOPMENT ACTIVITIES

A. Single Tube Fuel Element Study

Enough raw data has now been generated to complete the survey study of the use of single tube fuel elements in N-Reactor. FLEX 2 cases have been run during the month in which the flow spacer-target tube was loaded with Li-Al alloy (for tritium production) or depleted U (for plutonium production.) Additional calculations of some operating parameters, such as temperature coefficients of reactivity, for the latter cases still remain to be done.

B. Production Losses Encountered Upon Simultaneous Irradiation of Np²³⁷ Target Material

Reactivity losses encountered upon loading one ninth of the N-Reactor process tubes with Np²³⁷ target tubes containing ~ 35 gms Np²³⁷ per foot are estimated to be ~ 5%. Using this same supercell arrangement in which eight regular fuel cells surround a target cell, estimates have been made of the enrichment required to change η sufficiently to bring the reactivity of the supercell back to its normal value. The estimated enrichment is (1.08 ± 0.02) percent.

The Pu production from the uranium fuel elements for this case is different from the initial N-Reactor uniform loading of .947% tube-in-tube fuel elements. From calculations of the conversion ratios for the two fuels of different enrichments and from adjusting the production for the loss in number of uranium tubes present, estimates were made of these production losses. The following table indicates the values obtained.

TABLE I

<u>ENRICHMENT</u>	<u>REACTOR POWER</u>	<u>PRODUCTION LOSS</u>
1.08	3550 MW	-16.2%
1.08	4000 MW	- 5.6%

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The reactor power of 3550 MW is that which would result with a tube power of 4000 KW with only 8/9 of the tubes operating as power producing tubes. To achieve a reactor power of 4000 MW, a tube power of about 4500 KW is needed.

C. Hazards Associated with Startup Physics Tests

This work is complete except for unforeseen problems which might arise before startup. The data is being summarized and a report is in preparation.

D. N-Reactor Operator Certification Lectures

The second set of lectures on ex-reactor nuclear safety and in-reactor heat generation was presented to prospective N-Reactor operators. The subjects covered were identical to those in the first set of lectures.

E. Startup Measurements of Lattice Parameters and Spectral Indices

Irradiation during zero power physics tests of special N-Reactor fuel elements, containing experimental radioactivants, under high temperature (530° F) and high pressure (1400 lbs/in²) is a "first" in Hanford experimental reactor technology. The preparation of special fuel elements for this purpose poses some problems in fabrication.

Two methods of fabricating the special elements are under consideration. The first method is essentially the conventional method of machining and drilling fuel wafers, loading them with radioactivants and subsequently assembling them in tubes of cladding. Separate cladding tubes are not available and would have to be specially fabricated.

In the second method production line fuel pieces would be drilled parallel to their axis from each end to a depth of approximately 3-1/2 inches. Maximum diameter drills would be used leaving only about 0.020 inches of fuel next to the cladding. These holes would be plugged with rods containing pins of the radioactivant materials. The holes for these rods will be drilled through the fuel piece end caps. This eliminates nearly all the unbonded surfaces inherent in method one and is expected to

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minimize final closure problems. Electron beam welding would be used for the final closure. This method precludes the use of sector foils ~~that~~ that provide a backup measurement in method one.

The choice between these two methods depends upon whether sufficient accuracy can be achieved in drilling the coaxial holes in the fuel in the second method. Work on drilling test holes is underway and appears promising. Drill runout on the initial hole was 0.006 inches.

Completion of the specifications document for the tests has been delayed pending the completion of fabrication plans.

Special problems have been encountered in a consideration of the testing of these fuel elements for integrity. Because of the use of cadmium (melting point 320.9° C or 609.6° F) in one element the autoclave temperature must be low enough to neither melt nor soften the cadmium. Because of this and the additional closures on the end caps these fuel pieces must be considered substandard. Some method of monitor for a rupture or diversion of the single channel coolant flow appears appropriate.

F. Neutron Lifetime in N-Reactor

The consideration of the uncertainty in, and the best value of, the prompt neutron lifetime in N-Reactor has continued this month.

The appropriate formulation for the neutron lifetime is

$$\lambda = \frac{\int \int \frac{1}{v(E)} \phi(r,E) dV dE}{\int \int \Sigma_a(r,E) \phi(r,E) dV dE} \quad (1)$$

which can be written as

$$\lambda = \frac{\sum_i \phi_i V_i \left(\frac{1}{v}\right)_i}{\sum_i \phi_i V_i \Sigma_{a_i}}$$

Where $\left(\frac{1}{v}\right)$ is the average of $1/v$ over the energy distribution of the neutron flux. This can also be written as

(1) Private communication - P. F. Gast, Consulting Engineer, Hanford Laboratories

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$$k = \frac{\sum_i \phi_i V_i \left(\frac{1}{\bar{v}}\right)}{\sum_i \phi_i V_i \Sigma_{a_i}}$$

where $\bar{v}$ is the average of v over the energy distribution of the neutron density, because

$$\left(\frac{1}{\bar{v}}\right)_{\phi} = \frac{\int \frac{1}{v} \phi dE}{\int \phi dE} = \frac{\int n dE}{\int v n dE} = \frac{1}{(\bar{v})_n}$$

Preliminary application of this formulation for k to the N-Reactor lattice yields a value of 0.498 ms, compared with the value quoted in HW-69000 (N-Reactor Technical Manual) of 0.538 ms.

G. Production Estimates for Tritium Only

Rough estimates have been obtained from the FLEX 2 code for production of tritium for the case in which highly enriched uranium is used to fuel the reactor. No significant amounts of plutonium are produced in this case. The current estimate is for tritium production in the range of 0.9 to 1.0 gm-equivalent/MWD. Further study is underway in an attempt to find more nearly optimized designs which will have a higher production rate.

Some difficulty is being encountered in the use of the FLEX 2 code on this problem for cases in which the fuel and target regions are heavy absorbers. The detailed cause of the difficulty is not yet well understood.

H. Code Development

The document describing the FLEX 2 code has been reviewed and has been distributed.

Work is underway to modify the development deck so that it will handle more directly the cases involving inert carriers. At present fake densities must be used as input, and the output numbers corrected in an inverse process by hand.

I. FLEX Calculations for Other Customers in R&E

The effect of active zone charge length on tube flow rates was found for

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the Process Evaluation and Control Subsection.

The required enrichment to generate a desired heat flux on a thermocouple slug was obtained for Chemistry and Metallurgy Subsection.

J. Preparation of Technical Bases

The selection has been completed of the items of technical information to be included in the technical bases on speed of control and total control. In some cases the technical data has already been generated, and in others it still needs to be generated. After the new information has been obtained, written technical bases will be prepared.

II. REPORTS ISSUED

HW-78944, "Reactor Physics Monthly Technical Report, August, 1963"

HW-78968, "Flex 2 - A Fuel Element Design/Analysis Code," September 18, 1963,
by R. J. Shields

HW-79028, "Estimated Losses in Pu Production Rates from Simultaneous
Irradiation of Np²³⁷ Target Material," September 18, 1963,
by E. E. Mills

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