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MONTHLY TECHNICAL REPORT
MAY, 1963

REACTOR PHYSICS

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MONTHLY TECHNICAL REPORT
MAY, 1963

REACTOR PHYSICS

Paul F. Nichols

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MONTHLY TECHNICAL REPORT
MAY, 1963

REACTOR PHYSICS

I. RESEARCH AND DEVELOPMENT ACTIVITIES

A. Enriched Fuel (1.25 Per Cent U^{235})

The use of 1.25 enrichment as either a spike material or as a target support in the NPR has been studied. A document is being issued (HW-77740) which concludes that the enriched material can be used either way if extruded as the outer fuel tube with the inner fuel containing either .947 enrichment or 1 per cent lithium in aluminum. Its use as a reactivity booster will create conditions bordering on nucleate boiling on the outer jacket.

B. Code Development

Flex 2 has been completely converted from Fortran to FAP, but only a few of the possible paths through the program have been debugged. The conversion has resulted in a savings of about 7000 core locations and a reduction in execution time of about 20 per cent. Debugging of options other than the fixed geometry-fixed enrichment option has been postponed while changes in isotope buildup-burnout formulations are being made. Previously Np^{239} hold up was ignored and a correction applied to Pu^{239} afterward. However, for short irradiations an error resulted in Pu^{240} and Pu^{241} concentrations. The best method of overcoming this defect is being sought. Other changes to the program have

[redacted]

been the inclusion of Sm^{151} and recognition that the fission yields of xenon are different for U^{235} and Pu.

The current operating deck of Flex 2 has developed two sources of trouble. Neutron temperature calculations failed to work for D_2O moderation, and cases seeking the required enrichment occasionally blew up. These two troubles have been tracked down and are in the process of being fixed.

C. Pu Burning and Recycle

The study of the use of Pu as a fuel in the NPR required some appropriate fuel dimensions to start the study by the Applied Physics Operation in Hanford Laboratories. Two sets of dimensions have been found corresponding to a target element (in this case LiAl) being either inside or outside the Pu fuel element. The dimensions given below are suitable for Pu concentrations in aluminum of about 4 per cent by weight for the Pu driver element and natural Li concentrations of 1 per cent by weight in LiAl in the target elements.

OUTSIDE DRIVER

Material	Outside Diameter (inches)
Zr	2.406
Pu-Al	2.354
Zr	1.819
H_2O	1.764
Zr	1.380
Li-Al	1.294
Void	.409

INTERIOR DRIVER

Material	Outside Diameter (inches)
Zr	2.640
Li-Al	2.590
Zr	2.316
H_2O	2.251
Zr	1.819
Pu-Al	1.736
Zr	.890
H_2O	.835

[redacted]

The fuel element dimensions have been given to the Applied Physics Operation so that they can begin work on the project. They will attempt to generate information yielding estimates of long-term reactivity changes, temperature coefficients and isotopic compositions of the fuel as a function of exposure.

Similar work is planned for mixed oxide (PuO_2UO_2) fuel elements, but the input data for the study have not been generated to date.

D. <u>Single Tube Fuel Element</u>

The comparatively high cost of fabricating tube-in-tube fuel elements motivates an interest in the possible use of single tube fuel elements. A study has been started on the nuclear physical characteristics of the single tube fuel element. The Flex 2 computer program is being used for this work. The program will generate information on lattice physics parameters, fuel isotopic changes, and certain thermal characteristics. A broad survey on a wide range of dimensions and weights is planned. Some difficulty is being encountered in getting the input data in the proper form.

E. <u>Heavy Isotope Production</u>

The production of heavy isotopes such as Cm^{242} and Cm^{244} may noticeably increase the long-term economic efficiency of N-Reactor. Better information on the production rates of these isotopes is needed in order to define areas needing closer study. Preliminary work has been initiated on the calculation of production rates for various fuel element designs and compositions. The use of the Jason-Meleager fuel cycle analysis chain is being evaluated, and the chain will probably be used for this work.

Some of the work of E. A. Eschbach and his people in Programming Operation, Hanford Laboratories, is quite applicable to our study. They use the Jason-Meleager chain. We will make use of their results wherever it is appropriate to do so.

F. U^{233}-Th^{232} Fuel Cycle

A physics study of the use of a thorium-uranium fuel cycle in NPR is also needed for economics analyses. Work on this topic, to date, has been of a very preliminary nature. The work so far has consisted of a study of reaction-decay chains, and a search for a reasonably consistent set of cross sections and other basic data for the isotopes involved. Some problems are apparent in finding appropriate values for the resonance integrals of the thorium. Production of useful heavy by-product isotopes does not appear as promising in the U^{233}-Th chain as in the Pu-U^{238} chain.

G. Physics Input for Economic Studies

A rough draft of a document has been prepared giving standard values of conversion ratios, burnup as a function of exposure, etc., applicable to economic studies on tube-in-tube fuel elements.

H. Pu^{240} Effective Resonance Integral

A paper written by Nichols on work done in Hanford Laboratories on the effective resonance integral of Pu^{240} was revised and resubmitted to "Nuclear Science and Engineering" during the month. We have received notification that the paper has been accepted for publication.

I. N-Reactor Operator Certification Lectures

Considerable effort was devoted to preparing and presenting lectures to the N-Reactor operators as part of the certification training program.

[redacted]

The lectures covered the subjects of nuclear safety external to the reactor and in-reactor heat generation sources.

The nuclear safety topics covered were:

1) Introduction to outside-of-reactor nuclear safety
2) Significant parameters and conditions which influence critical mass values
3) The methods and bases for using these parameters as control factors
4) Methods of obtaining criticality data
5) Specific bases on which N-fuel handling might be based.

The in-reactor heat generation topics covered were:

1) Equilibrium nuclear heat sources
2) Location of equilibrium heat release and the release fractions
3) Shutdown nuclear heat sources
4) Locations and fractions of shutdown nuclear heat release.

An outline and brief summary of the topics covered were prepared. Interested persons may obtain copies from R. V. Poe of this Subsection.

J. Bases for Control and Nuclear Instrumentation

The progress on this work was limited because available manpower was diverted to the preparation and presentation of lectures for operator training program. Preparation of required input for various transient conditions has received limited attention. The input desired are tables of control rod and ball system strengths vs. time after scram, and reactivity input functions vs. time for various events causing positive increases in reactivity. Definition of input functions for incidents such as cold water injection and stack flooding which spread throughout the system are proving to be the most difficult to handle. The code CLUMSY I may be quite useful for this problem. Actual investigations with the code must be made before it is known how accurate these inputs must be defined.

K. Shield Evaluation

Meetings were held with Harold S. Davis and G. T. Haugland of NRD to obtain information about the design bases for the biological and thermal shields. The shield designs are based upon a mixture of calculated information and experimental data.

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