DEVELOPMENT OF A LUMPED PARAMETRIC
MODEL FOR SCOPING INVESTIGATIONS OF
UNCERTAINTIES IN FAST REACTOR
PROBABALISTIC SAFETY ANALYSIS

Progress Report

Karl O. Ott and Larry B. Luck

Purdue University
West Lafayette, Indiana

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

October 1, 1974 - March 31, 1975

PREPARED FOR THE U. S. ENERGY RESEARCH AND DEVELOPMENT
ADMINISTRATION UNDER CONTRACT AT(11-1)-2515

MASTER

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Introduction:

This report describes the progress made under contract No. AT(11-1)-2515 during the period October 1, 1974 to March 31, 1975. The report is divided into three sections - Applicable Milestones, Functional Division of Work, and a Report of Work Performed. The first two sections are in outline form to provide organizational clarity.

A. Applicable Milestones

1. Mathematical formulation of the general method; identification and definition of the various volumetric distributions.
2. Analytic representation of the stationary and time dependent volumetric distributions.
3. Evaluation of the stationary distributions for several initial conditions.

B. Functional Division of Work Performed October 1, 1975 to March 31, 1975

1. Identification, development of computational formulas, and programming of the necessary volumetric distributions.
2. Development of a data base for the subject reactor eg. the CRBR.
3. Development and procurement of computer programs necessary to obtain the analysis parameters for the subject reactor.
 - a. One dimensional diffusion code for calculation of:
 1. Consistently defined kinetics parameters,
 2. reactivity change between stationary states,
 3. spatially dependent Doppler coefficients,
 4. collapsed group constant sets for 2-D calculations.
 - b. Two dimensional diffusion code, 2-DB, to calculate detailed power distributions for various points in the fuel cycle.

4. Subsidiary Calculations

- a. Detailed 2-D power distributions using 2-DB with few group cross sections
- b. Multichannel time dependent power and temperature distributions using PARSEC.

5. Computation of volumetric distributions

- a. Single pin
- b. Single Subassembly
- c. Stationary reactor distributions from triangular mesh 2-DB power distributions
- d. Transient reactor distributions from multichannel power distributions from PARSEC

C. Report of Work Performed

The objective of this work is to develop a safety analysis methodology to provide a quasi-mechanistic description of fast reactor accident progression. It is necessary to describe the relationships between the state of the reactor core and reactivity without resorting to the time consuming calculation of detailed neutronic-thermohydraulic parameters. The novel approach to be developed here is to describe the reactor state by means of various volumetric distributions. These volumetric distributions provide the link between the reactor state and reactivity.

The required volumetric distributions have been identified and the mathematical formulas derived and programmed for computation for both stationary and transient cases. These distributions include: (1) fuel volume as a function of temperature, (2) cladding volume as a function of temperature, (3) coolant volume as a function of temperature, (4) fuel volume as a function

of fuel power density. The distributions in the transient cases are also implicit functions of time. Further distributions, such as sodium ^{void} volume will have to be considered during a later phase of the transient.

The stationary distributions are based on a triangular mesh two dimensional power distribution calculation by the 2-DB Code. The resultant distributions include the effects of incoherencies such as control rod perturbations in the power distribution and flow rate variation across the subassembly. The model used to compute the distributions is based on an idealized thermohydraulic concept in which reactor and subassembly distributions are sums of distributions of representative uncoupled fuel pins. The fuel temperature profile is given in both the transient and stationary cases by the parabolic relationships characteristic of solid homogeneous pins. In the stationary cases, the fine detail of the triangular mesh power distribution allows 18 representative pins per subassembly. The 18 pins are a result of considering an interior, edge, and corner representative pin in each of 6 triangles in the hexagonal subassembly. Preliminary stationary volumetric distributions have been obtained for the subject reactor. Several sets of stationary volumetric distributions are necessary - corresponding the subject reactor at various points in its fuel cycle. It is expected that the character of the volumetric distributions will vary considerably, for example, from the clean initial core to the final equilibrium composition.

The transient volumetric distributions are based on power distributions obtained from the multi-channel thermohydraulic code PARSEC. In this model, a somewhat lesser amount of detail is obtained for a reasonably small amount of computer time. The transient cases use one representative pin per two subassemblies due to the channel modeling of the PARSEC code and due to the need to limit computational expense. The preliminary transient volumetric

distributions will be available when various problems relating to the use of the PARSEC code are resolved.

A one dimensional diffusion code is being developed to calculate the various kinetic parameters such as effective delayed neutron fractions, generations time and steady state reactivities after a transient, to collapse group constants for 2-DB, and to provide spatially dependent Doppler Coefficients for PARSEC. The development of this code, based on extensive modifications to an existing code, has been substantially completed. The one dimensional code is used since it can provide adequate accuracy for much less computational expense than the more commonly used two dimensional codes. Results from a two dimensional code could easily be substituted at a later time if necessary or desirable.

The development of simple analytic formulas to represent stationary and time dependent volumetric distributions is currently in the conceptual stage. The development of these simple representations is necessary to avoid the time consuming and unwieldy manipulation of empirical data in the final dynamics program system. It is further expected that these formulas will improve the understanding of the basic relationship between the reactor state and reactivity.

Compliance with the contract provisions is as follows. Milestone (1) has been accomplished. Milestone (2) is currently in the conceptual stage and has not been completed. Milestone (3) is partially complete. It should be noted, however, that the actual calculation of the volumetric distributions is requiring a substantial effort which does not appear as a milestone. Milestone (3) which addresses the evaluation of volumetric distribution assumes that these calculations have been done. After these computations are completed, Milestones (2) and (3) can then be considered jointly.

Finally, there was no mention in the milestone schedule of the need for a 1-D code to accomplish the tasks mentioned in B.3.a. A program of this sort was not available at Purdue and had to be developed, at the cost of considerable time and effort.