MASSACHUSETTS INSTITUTE OF TECHNOLOGY DEPARTMENT OF NUCLEAR ENGINEERING Cambridge, Massachusetts 02139

> THE REACTIVITY AND TRANSIENT ANALYSIS OF MITR-II

> > by

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THE REACTIVITY AND TRANSIENT

ANALYSIS OF MITR-II

by

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B.S., M.S., Institut National des Sciences Appliquées (INSA) de Lyon (1967)

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SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

at the

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July 1972

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THE REACTIVITY AND TRANSIENT ANALYSIS OF MITR-II

by

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Tolga Yarman

Submitted to the Department of Nuclear Engineering on 24 July, 1972, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

ABSTRACT

The two-dimensional, time dependent, three-group diffusion equations for the proposed designed core of the MIT reactor are written with an extra source term accounting for the photoneutrons generated in the D_00 reflector. An analytical expression is developed for this term. Then an approximate flux composed of two spatial shapes chosen beforehand, each having an unknown time coefficient, is inserted into the time dependent multigroup equations and the weighted residual criteria is applied. This yields multimode kinetics equations with generalized definitions for the conventional matrix parameters: generation time, reactivity, delayed neutron (and photoneutron) fractions matrices. Computational methods for these parameters are presented. An accident concerning the withdrawal of the shim rods is examined with the code OZAN written for the purpose of the computations required by the present work. This study suggests that a space-dependent analysis is required to analyse the accident postulated.

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- D. D. Lanning, Professor of Nuclear Engineering
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BIOGRAPHICAL NOTE

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CHAPTER I

INTRODUCTION

The reactivity and transient analysis of a reactor consists of predicting the behavior of the neutron flux at a point in the reactor during a transient. This leads ultimately to information about the behavior of the power level of the reactor, during the transient.

1-1 Point Kinetics Method

There are a number of ways of performing the analysis. The point kinetics method is the conventional one. This method assumes that the time and space dependent neutron flux, throughout a transient can be expressed in terms of the product of two functions: the first one a function of time alone, and the second one a function of space alone. Supposing that the space function is known, one can then derive (from the multigroup diffusion equations) the conventional point kinetics equations for the time function - of the time and space dependent flux expression - .

Parameters appearing in the point kinetics equations;

The point kinetics equations involve a number of parameters (reactivity, generation time and delayed neutron fractions) the value of which depend on the manipulations (weighting, integration, etc.) undertaken to get rid of the space dependency in deriving the point kinetics equations.

Thus the point kinetics method consists of fixing a space function that is supposed to express the space dependency of the time and space dependent flux, and then determining, through appropriate manipulations the conventional parameters of the point kinetics equations.

Case where the space function is the flux shape of the critical reactor;

It is customary to choose as the space function the shape of the critical reactor. In this case (and assuming that the weighting function is the same for all cases) generation time and delayed neutron fractions, are always the same for all changes in the reactor that cause the transient.

Thus the reactivity and transient analysis of a given reactor will consist of determining the reactivity that characterizes the transient in question, and solving the point kinetics equations for the time function of the flux expression. The time and space dependent flux at any point of the reactor is then predicted to be the steady state, critical shape changing in magnitude during the transient in accord with the solution of the point kinetics equations.

Hence, if possible small changes in fission cross section are neglected, the solution of the points kinetics equations characterizes the beha ior of the power level of the reactor during a transient.

1-2 Solution Techniques accounting for the space dependency of the time and space dependent flux during a transient

A number of methods that account for changes in the shape of the flux during a transient have been developed and may be used for the transient analysis of a reactor.

These methods can be placed into two broad categories [26,27].

Indirect solution techniques;

The first category involves indirect solution techniques that make some assumptions about the mathematical form of the time and space dependent flux over subregions or over the entire reactor, and perhaps also over various periods of time during the transient. These assumptions are then forced into the final solution.

Direct solution techniques;

The second category involves direct techniques that generally consist of finding the solution of the finite difference approximation to the time dependent multigroup diffusion equations.

Differences between the Indirect and Direct solution techniques;

It is worthwhile to point out that there are two major differences between the indirect techniques and direct techniques, of attacking the space-dependent kinetics equations. The indirect techniques are reasonably fast in computing the final solution, but lack definitive error bounds. Thus whether or not a set of trial functions (assumptions made about the shape of the time and space dependent flux) will give good results for a particular perturbation, is rather intuitive. The direct finite difference techniques, in contrast, require much more time for computations, but are characterized by definitive error estimates. For this reason they are very useful as numerical standards against which the more approximate methods can be compared.

The very first step that must be taken for the "Reactivity and Transient Analysis of MITR-II" is to chose an appropriate method (among these summarized in the first two sections of the present chapter), or if necessary to construct one ourselves.

1-3 The reactivity and transient analysis of MITR-II; set up of the problem.

MITR-II stands for the redesign of the Massachusetts Institute of Technology research reactor. This reactor [28] (cf. also Appendix G) will be cooled and moderated by light water. The reflector is composed of heavy water. Photoneutron sources are present in the D_2^0 reflector because of the interaction of the radiation coming out of the core with

the deuterium nuclei .

Can the point kinetics method be adequate?

There are complications in applying the point kinetics model to MITR-II. First of all it is not clear how we are going to account for the photoneutrons in the computation of the reactivity characterizing the transient in question. More serious than that, it is not guaranteed in the case of MITR-II, that the time and space dependent flux can be represented using only one shape throughout a transient.

Thus the primary purpose of this thesis is to investigate a more sophisticated method of analysis and to compare the predictions with the ones obtained through a point kinetics type of approach (accounting also for the photoneutrons).

The Basic Model;

As a basic model we assume that the time dependent multigroup diffusion equations can describe the time and space dependent flux in the MITR-II. However the presence of photoneutron sources in D_2^0 reflector, will require more elaboration. Thus we write

$$v^{-1} \frac{\partial \mathscr{Q}(\underline{r},t)}{\partial t} = \left[\nabla \cdot D(\underline{r},t) \nabla - A(\underline{r},t) + (1-\beta) v \chi_{p} \Sigma_{F}^{T}(\underline{r},t)\right] \mathscr{Q}(\underline{r},t)$$

 $+ \sum_{j=1}^{J} \lambda_{j} \chi_{j} \eta_{j} (\underline{r}, t) + S(\underline{r}, t) , \qquad (1-1)$

$$\frac{\partial n_j(\underline{r},t)}{\partial t} = \beta_j v \Sigma_F^T(\underline{r},t) \phi(\underline{r},t) - \lambda_j n_j(\underline{r},t) ,$$

$$(j = 1, ..., J),$$
 (1-2)

where; $S(\underline{r},t)$ refers to the photoneutrons generated in the reflector and the familiar diffusion theory, matrix notation (spelled out in the body of the dissertation - cf. Chapter III-) is used.

An analytical solution of Equations (1-1) and (1-2), even when the photoneutron source term $S(\underline{r},t)$ is not present, is not known, and the method we are to investigate will consist of obtaining an approximate solution to these simultaneous equations. This requires first constructing an analytical expression for the photoneutron source term, $S(\underline{r},t)$.

1-4 Photoneutron source term

In the analysis of a reactor [25], similar to MITR-II it is pointed out that the photoneutrons may be significant during a transient. The argument we develop below, supports this assumption.

A simple scheme;

Consider an atom of U^{235} fissioning in an infinite medium of heavy water. Let N₀ be the total number of delayed photons coming out of the fission products that have sufficient energy to generate photoneutrons. Let $\overline{\Sigma}$ and $\overline{\Sigma}_{D}$ be respectively the average macroscopic attenuation and photoneutron reaction cross sections in D₂0, for the photons of interest. Thus

$$N_{0} \int_{R_{1}}^{R_{2}} \frac{1}{4\pi r^{2}} \overline{\Sigma}_{D} e^{-\overline{\Sigma}r} 4\pi r^{2} dr = N_{0} \frac{\overline{\Sigma}_{D}}{\overline{\Sigma}} (e^{-\overline{\Sigma}R_{1}} - e^{-\overline{\Sigma}R_{2}}), \quad (1-3)$$

represents the total number of photoneutrons produced by the photons of interest in the volume between the two spheres of radius R_2 and R_1 centered at the point where the atom of U^{235} is located in the infinite medium of heavy water (cf. Appendix B).

Next assume that, MITR-II can be represented by a spherical model with R_1 and R_2 being the inner and outer radius of the $D_2 Q_*$ reflector and that the radiation is coming from a point source located at the center of the reactor and embedded in pure $D_2 Q$ (cf. Chapter II). We then expect

$$pct = \frac{N_0 \frac{\overline{\Sigma}_D}{\overline{\Sigma}} (e^{-\overline{\Sigma}R_1} - e^{-\overline{\Sigma}R_2}) \times 100}{N_0 \frac{\overline{\Sigma}_D}{\overline{\Sigma}}} , \qquad (1-4)$$

percent of the total amount of the delayed photoneutrons pro-

duced by delayed photons from fission products of U^{235} on D_2^{0} , to be produced in the D_2^{0} reflector of MITR-II. Taking $R_1 = 30$ cm, $R_2 = 60$ cm and $\overline{\Sigma} = 0.04$ cm⁻¹, we obtain

pct
$$21\%$$
 (1-5)

Thus the ratio of delayed photoneutrons to the total number of neutrons produced due to the fission of U^{235} in an infinite medium of heavy water being $% 1.x10^{-3}$, the MITR-II delayed photoneutrons can reach a fraction of $%2.x10^{-4}$. This may indeed be significant compared to the total delayed neutron fraction ($%7x10^{-3}$).

Prompt photoneutrons;

Besides the delayed photoneutrons there are also prompt photoneutrons due to prompt gamma rays (fission, capture, inelastic scattering, etc.) generated within the reactor. A quick comparison of prompt photoneutrons produced by prompt photons from the fission of U^{235} on D_20 , with delayed photoneutrons produced by delayed photons from the fission products of U^{235} , on D_20 (cf. Chapter II) will suggest that the former ones are as important as the latter ones.

These considerations require that we devote attention to the photoneutrons throughout this thesis. Thus the photoneutron source term will be studied, and Chapter II, Appendices A and B are concerned with an appropriate analytical expression for the photoneutron source term in Eq. (1-1).

1-5 Proposed method

Among the approximate ways of attacking Equations (1-1) and (1-2) summarized in the first two sections of the present chapter we intend to examine the simplest one that will account for the space dependency of the time and space dependent flux.

Time synthesis;

This method, called time synthesis, assumes that $\emptyset(\underline{r},t)$ can be expressed approximately as the sum of two fixed shapes, each having an undetermined, time dependent coefficient. We thus intend to examine a trial function of the form

$$\vec{\varphi}$$
 (r,t) = ψ_1 (r) N_1 (t) + ψ_2 (r) N_2 (t), (1-7)

in which the flux shapes $\psi_1(\underline{r})$ and $\psi_2(\underline{r})$ do not depend on time and can be selected in a number of ways.

Application of the weighted residual method [27];

By substituting the RHS of Eq. (1-7) into Equations (1-1) and (1-2) we obtain residuals.

Chapter III describes the application of the weighted residual method to find equations for $N_1(t)$ and $N_2(t)$ from these residuals. In this chapter, in spite of the complicated expression accounting for the photoneutron source term in Eq. (1-1) we shall still be able to obtain the conventional form for the multi mode kinetics equations, with however different definitions for the various parameters.

Thus the problem will be reduced to solving for N(t)

$$\Lambda \frac{dN(t)}{dt} = \left[\rho_{new}(t) - \overline{\beta}_{new}(t)\right] N(t) + \sum_{j=1}^{H} \lambda_j C_j(t) \quad (1-8)$$

$$\frac{dC_{j}(t)}{dt} = \overline{\beta}_{j_{new}} \quad (t) N(t) - \lambda_{j}C_{j}(t) , \quad (j=1,\ldots, H), \quad (1-9)$$

and where the summation over the delayed neutron groups also includes delayed photoneutron groups, and Λ , ρ_{new} (t) and $\overline{\beta}_{j_{new}}$'s are [2x2] matrices.

1-6 Computation of the parameters Λ , $\rho_{new}(t)$ and $\overline{\beta}_{j_{new}}$ (t)'s; Chapter IV and V

The computation of the matrix parameters that appears in Equations (1-8) and (1-9) turned out to be a difficult problem.

In Chapter V, which is closely related to Chapter IV, methods for computing various parameters appearing in Equations (1-8) and (1-9) in a consistent way are presented.

A computer code OZAN* (described briefly in Appendix N, and presented in Appendix 0) was created to perform computations required by the present work.

-* OZAN means poet in Turkish.

1-7 Chapter VI, A problem treated by the proposed method

We attempted to use OZAN in the case of the withdrawal of the blade of shim rods and to predict the behavior of the power level. The accident of interest is presented in Chapter VI. The complications that arose - because of the particular character of the problem - are then discussed. Finally a comparison of these predictions with the ones obtained through a point kinetics type of approach is made.

1-8 Chapters VII and VIII, checks and conclusions Tests that validate OZAN are described in Chapter VII, and conclusions about the present work are drawn in Chapter VIII.

CHAPTER II

STUDY OF THE PHOTONEUTRON SOURCE TERM $S_{\alpha}(\underline{r},t)$

In this chapter our goal is to develop an analytical expression for $S_g(\underline{r},t)$ which will account for the number of photoneutrons generated per cm³ per sec. within the gth neutron group at a point \underline{r} and time t in the D₂0 reflector.

If we had a D_2^0 cooled AND reflected reactor, we could think of using the data (shown in Table 2-1) relevant to the generation of photoneutrons - in an infinite medium of heavy water by photons coming out of the fission of U^{235} -. With some effectiveness correction due to the leakage out of the reactor of photons giving rise to photoneutrons, this would have covered the production of delayed photoneutrons.

Table 2-1 [1]

	•	and the second secon	
Group index, j	Half-life	λj	β _j (10 ⁻⁵)
1	12.8 d	6.26×10^{-7}	0.05
2.	53 h	3.63×10^{-6}	0.103
3	··· 4.4 h	4.37×10^{-5}	0.323
4	1.65 h	1.17×10^{-4}	2.34
5	27 m	4.28×10^{-4}	2.07
. 6	7.7 m	1.50×10^{-3}	3.36
7	2.4 m	4.81×10^{-3}	7.00
8	41 s	1.69×10^{-2}	20.4
.9	2.5 s	2.77×10^{-1}	65.1
			Total 100.75

Group Constants for Delayed Photoneutrons from U²³⁵ Fission Gammas on D₂O

Average D₂O photoneutron half-life $\equiv (\ln_e 2) \sum (\beta_j / \lambda_j) / \sum \beta_j$ = 16.7 min (following saturation irradiation) Instead, in the MITR-II D_2^0 is present in the reflector only. In addition we have other gamma rays than the ones coming from U^{235} and causing the photoneutron reaction. We would also like to have a space dependent photoneutron source term. All this forces us to drop the previous data of Table 2-1 and to try a different approach to the solution of the problem.

To this end we will start with the production of photons within the reactor. We next compute through a shielding type of calculation the photon flux in a given energy range at a point \underline{r} in the reflector, and finally make use of the photoneutron reaction cross sections.

Let then $I(\underline{r}, \Lambda, t)$ be the non-directional flux of photons of energy Λ per cm² per Mev per second in the reflector at \underline{r} and time t.

Let $\Sigma_{\mathbf{D}}(\underline{r},\Lambda,t)$ be the macroscopic photoneutron reaction cross section of deuterium in the reflector at \underline{r} and time t, for the incident photons of energy Λ .

Let $P_{\Lambda}(E) dE$ be the probability for the photoneutron generated by an incident photon of energy Λ to be emitted within the energy dE around E. ($P_{\Lambda}(E)$ - with some pertinent forms- is described in Appendix C).

Thus the product

 $I(\underline{r},\Lambda,t) \Sigma_{D}(\underline{r},\Lambda,t)P_{\Lambda}(E)dE d\Lambda, \qquad (2-1)$

gives the number of photoneutrons per cm³ per sec. generated in the reflector, at \underline{r} and time t in the range dE about E, by incident photons of energy lying within dA around A.

This is the first step in obtaining $S_g(\underline{r},t)$, the photoneutron source term. However there are a number of problems hidden in Eq. (2-1). How are we going to determine $I(\underline{r},\Lambda,t)$? Trying to solve the transport equation for the directional photon flux over the reactor volume [9] is impractical and also ill advised unless we have reason to believe photoneutrons are very important.

It would in fact be a great simplification if we could work only with the uncollided photons. But would this approximation be valid? In other words, can the photoneutrons generated by photons having had collisions, especially by photons having had one and only one collision, be neglected as compared to photoneutrons generated by the uncollided photons?

The answer to the latter question is developed in Appendix A and is yes (within an approximation of a few per cent).

A second problem concerns the accuracy of the data specifying the production and attenuation of photons, and the accuracy of photoneutron reaction cross sections. Are these data consistent? If so, one should be able to generate theoretically the results of Table 2-1 starting with the data for the production of photons coming out of the fission of U^{235} .

The latter question has been studied in Appendix B, and the data we shall work with, has been found satisfactorily consistent.

Furthermore this checking procedure led us to establish an analytical expression for the decay curves of fission photons having an energy above 2.23 Mev (the threshold energy for the

photoneutron reaction in heavy water) - Fig. B-1 - in terms of the time wise - group decay constants of photoneutrons shown in Table 2-1. This correlation becomes clear when we recognize that the appearance of a photoneutron of a given half life, implies there must be a photon having that same half life to generate the photoneutron in question.

Our next problem concerns the geometry of the system. Even though we use the uncollided photon flux approximation the expression for $I(\underline{r}, \Lambda, t)$ is extremely complicated. Again, since we do not expect photoneutrons to be very important, we make a gross approximation.

Thus if $S_f(\underline{r}, \Lambda, t)$ is the number of photons of "fth type" (this terminology will become more clear shortly) emitted per cm^3 per Mev per second at location \underline{r} in the reactor, with energy Λ and at time t, we define

 $S_{f}(\Lambda,t) = \int_{\underline{r},reactor} S_{f}(\underline{r},\Lambda,t) d\underline{r}$ (2-2)

We then assume for the purpose of computing $I(\underline{r},\Lambda,t)$ in the reflector that the extended source, $S_f(\underline{r},\Lambda,t)$, throughout the reactor may be replaced by the point source, $S_f(\Lambda,t)$, located at the center of the reactor, and embedded in pure D_2^{0} . $\overline{\dagger}$ This simplification has two consequences that tend to cancel each other: the intensity of photons from a source that is

moved back, will be decreased at a point (r,z) in the reflector; but also the attenuation through D_2^0 instead of the heavier core material, is now easier.

For the purpose of comparing these two consequences we suppose we have reason to adopt the scheme shown on the next page.



In addition assume we deal with photons of energy, approximately, 3 Mev, for which the total macroscopic attenuation cross section in the heavy core material and in the D_2^0 is taken to be, respectively, 0.2 and 0.04 cm⁻¹.

Then the attenuation coefficient for both of the cases (point source placed at the center of the reactor and embedded in pure D_2^0 , and point source placed at a more appropriate location within the core - where the self absorption distance can be figured out through a shielding type of information -), - assuming that the photons are emitted isotropically - , is

$$-(30 \times 0.04)$$

 $\frac{1}{4\pi(900)}$ e

and

$$-(3 \times 0.8 + 10 \times 0.04)$$

$$\frac{1}{4\pi(169)} e$$
Hence supposing that the second description for the attenuation is closer to the reality than the first one, we can see that

- Moving back the point source to the center of the reactor decreases the intensity of photons at a point in the reflector as much as: $\frac{900}{169} \approx 5$;

- But also, the attenuation is now easier as much as $\begin{array}{r} -(30 \times 0.04) \\ e \\ \hline -(3 \times 0.8 + 10 \times 0.04) \end{array} ~5. \end{array}$

†

We are now ready to work out an expression for $I(\underline{r}, \Lambda, t)$. This photon flux has two components, one due to the prompt gamma rays, the other due to delayed gamma rays, that, we believe, deserve equal attention.

To see that consider one atom of U^{235} fissionning in the middle of an infinite medium of D_20 . Both prompt and delayed gamma rays will be emitted due to that fission. Thus we intend to compare the number of photoneutrons generated by the uncollided prompt photons, with the number of photoneutrons generated by the uncollided delayed photons, from respectively, the fission, and fission products of U^{235} on D_20 .

For the purpose of calculation we recall the results given in Appendix B for the two-group scheme of photons, and the output of the Code POPOP IV (cf. Appendix D) for the prompt fission gamma rays from U^{235} (that is, 0.163 photons for the higher energy group - $\Lambda_0 = 7$ Mev - and 0.483 photons for the second group - $\Lambda_1 = 3.5$ Mev -, per fission). Then it is found:

- $% 2. \times 10^{-3}$ prompt photoneutrons due to uncollided prompt photons, per fission of U^{235} , and;

- \sim 1.4 x 10⁻³ delayed photoneutrons due to uncollided delayed photons (emitted between t=1 sec. and t= ∞ sec.), per fission of U^{235} .

As will be seen below, there are also other prompt gamma rays than the fission prompt gamma rays. Hence an equal attenuation will be paid to the study of the prompt photoneutron source term as well as the study of the delayed photoneutron source term.

2-1 Component of $I(r, z, \Lambda, t)^*$ due to Prompt gamma rays and the corresponding photoneutron source term

t

The prompt gamma rays are emitted within 10^{-7} sec. and can be coming from the fission event, inelastic scattering of neutrons, or capture of neutrons.

Let $\emptyset(r,z,E,t)$ be the scalar neutron flux at (r,z) of neutrons having an energy within an interval of energy of 1 Mev around E, and at time t.

Let $\Sigma_{f}(r,z,E,t)$ be the macroscopic neutron cross section for fth type of reaction (either fission or inelastic scattering or capture), at (r,z), of neutrons of energy E, at time t, and let $\Gamma_{f_n}^{n}(\Lambda) d\Lambda$ be the yield of photons of energy within $d\Lambda$ and Λ

To be more specific, instead of $I(r,\Lambda,t)$ the notation has been changed to $I(r,Z,\Lambda,t)$ for the (r,Z) geometry.

resulting from the fth type of reaction induced by neutrons of energy E, in nuclei n [that takes place at (r,z)].

Next we define

$$\Sigma_{f_{g}}(r,z,t) = \frac{1}{\emptyset_{g}(r,z,t)} \int_{E_{g}}^{E_{g}-1} \Sigma_{f}(r,z,E,t) \emptyset(r,z,E,t) dE,$$
(2-4)

$$\Gamma_{f_{g}}^{n}(\Lambda) = \frac{1}{\Sigma_{f_{g}}(r,z,t) \mathscr{O}_{g}(r,z,t)} \int_{E_{g}}^{E_{g-1}} \Sigma_{f}(r,z,E,t) \Gamma_{f_{E}}^{n}(\Lambda) \mathscr{O}(r,z,E,t) dE,$$
(2-5)

where E_g and E_{g-1} are the lower and upper limits in this order of g^{th} neutron group (cf. Fig. 2-1).



Fig. 2.1 Neutron Energy group limits for G energy groups

Then with the definitions

$$\Gamma_{f}^{n}(\Lambda) = \text{diag} \left(\Gamma_{f_{1}}^{n}(\Lambda) \dots \Gamma_{f_{G}}^{n}(\Lambda)\right), \qquad (2-6)$$

$$\Sigma_{f}(r,z,t) = \text{column} (\Sigma_{f_{1}}(r,z,t)...\Sigma_{f_{G}}(r,z,t)),$$
 (2-7)

$$\emptyset(\mathbf{r},\mathbf{z},\mathbf{t}) = \operatorname{column} (\emptyset_1(\mathbf{r},\mathbf{z},\mathbf{t})\dots \emptyset_G(\mathbf{r},\mathbf{z},\mathbf{t})), \quad (2-8)$$

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(2-9)

We may write

$$S_{P_{f}}(r,z,E,t) = \frac{1}{4\pi (r^{2}+z^{2})} \int_{\Lambda=2.23 \text{ Mev}}^{\infty} d\Lambda \sum_{D} (r,z,\Lambda,t) P_{\Lambda}(E) e^{-\Sigma (\Lambda,t) \sqrt{r^{2}+z^{2}}}$$

$$2\pi \int r' dr' dz' \Sigma_{f}^{T}(r,z,t) \Gamma_{f}(r,z,\Lambda)^{*} \mathscr{O}(r,z,t)$$

r',reactor z',reactor

for the number of photoneutrons due to photons induced by f^{th} type of neutron reaction, generated per unit energy, per cm³ per sec. at (r,z) and time t.

In Eq. (2-9);
$$\Sigma_{f}^{T}(r,z,t)$$
 is the transpose of $\Sigma_{f}(r,z,t)$.
 $2\pi \int_{r',reactor} dz' \qquad \Sigma_{f}^{T}(r',z',t) \Gamma_{f}(r',z',\Lambda) \emptyset(r',z',t)$

is the previously defined point source $S_{f}(\Lambda,t)$ placed in the

center of the neutron [cf. Eq. (2-2)]. The quantity $e^{-\Sigma(\Lambda,t)\sqrt{r^2+z^2}}$ is the attenuation coefficient, with $\Sigma(\Lambda,t)$ the macroscopic attenuation cross section, for photons of energy Λ , at time t for the heavy water medium.

The term $\frac{1}{4\pi (r^2+z^2)}$ appears because of the assumption that photons are emitted isotropically from a point source at r=z=0.

 $\frac{1}{\Gamma_{f}(r,z,\Lambda)} \equiv \prod_{f}^{n}(\Lambda); \text{ In case there are } N(>1) \text{ nucleis present}$ at (r,z), $\sum_{n=1}^{N} \sum_{f}^{n^{T}}(r,z,t) \prod_{f}^{n}(\Lambda) \text{ shall replace } \sum_{f}^{T}(r,z,t) \prod_{f}^{n}(\Lambda).$ We define now

$$\Sigma_{D_{\ell}}(r,z,t) = \frac{1}{\Delta \Lambda_{\ell}} \int_{\Lambda_{\ell}}^{\Lambda_{\ell}-1} \Sigma_{D}(r,z,\Lambda,t) d\Lambda, \qquad (2-10)$$

where Λ_{ℓ} and $\Lambda_{\ell-1}$ are the lower and upper limits of ℓ^{th} photon group (cf. Fig. 2-2).

$$\Lambda_{0} + - \Lambda_{1}$$

$$\Lambda_{1} + - \Lambda_{2}$$

$$\Delta \Lambda_{2} = \Lambda_{2-1} - \Lambda_{2}$$

Fig. 2-2 Photon Energy Group limits for L energy groups

$$\Sigma_{D}(\mathbf{r},z,t) = \operatorname{column} \left(\Sigma_{D_{1}}(\mathbf{r},z,t) \dots \Sigma_{D_{L}}(\mathbf{r},z,t) \right), \quad (2-11)$$

$$P_{\ell}(E) = \frac{1}{\Delta \Lambda_{\ell}} \int_{\Lambda_{\ell}}^{\Lambda_{\ell}-1} P_{\Lambda}(E) d\Lambda , \qquad (2-12)$$

$$P(E) = diag. (P_1(E) ... P_L(E)),$$
 (2-13)

$$\Sigma_{\ell}(t) = \frac{1}{\Delta \Lambda_{\ell}} \int_{\Lambda_{\ell}}^{\Lambda_{\ell} - \Lambda} \Sigma(\Lambda, t) d\Lambda , \qquad (2-14)$$

$$E(r,z,t) = \text{diag.} \left(e^{-\Sigma_{1}(t)(r^{2}+z^{2})^{\frac{1}{2}}} \cdots e^{-\Sigma_{L}(t)(r^{2}+z^{2})^{\frac{1}{2}}} \right), \quad (2-15)$$

$$\prod_{f_{\ell}}^{n} = \int_{\Lambda\ell}^{\Lambda\ell-1} \Gamma_{f}^{n}(\Lambda) d\Lambda , \qquad (2-16)$$

$$\prod_{f=1}^{n} = \operatorname{column} \left(\prod_{f_{1}}^{n} \cdots \prod_{f_{L}}^{n} \right) , \qquad (2-17)$$

$$P_{g} = \int_{E_{g}}^{E_{g}-1} P(E) dE , \qquad (2-18)$$

 $q_{f}(r',z',t) = \text{column} (\Sigma_{f}^{T}(r',z',t)) [f_{1}(r,z)...\Sigma_{f}^{T}(r',z',t)] [f_{1}(r,z))$

With integrations over Λ from Λ_{ℓ} to $\Lambda_{\ell-1}$ (ℓ varying from L to 1) and over E from E_g to E_{g-1} , summation over the three types of prompt photon production and the above definitions Eq. (2-9) finally becomes

$$S_{P_{g}}(r,z,t) = \frac{1}{4\pi (r^{2}+z^{2})} \sum_{D}^{T} (r,z,t) P_{g}E(r,z,t) x$$

$$2\pi \int_{r',reactor} \int_{z',reactor} \int_{z',reactor} \int_{f=1}^{3} p_{f}(r',z',t) \phi(r',z',t),$$
(2-20)

which is the component of $S_g(r,z,t)$ due to prompt photons. To get more insight into Eq. (2-20) choose two energy groups of photons and define

$$Q(r,z,t) = \frac{1}{2(r^2+z^2)} \int_{r',reactor}^{r' dr'} \int_{z',reactor}^{3} \frac{dz'}{z}$$

$$q_{f}(r',z',t) \phi(r',z',t)$$
 (2-21)

Then Eq. (2-20) yields

$$S_{P_{g}}(r,z,t) = \Sigma_{D_{1}}(r,z,t) P_{l_{g}} E_{\Lambda}(r,z,t) Q_{1}(r,z,t)$$

+
$$\Sigma_{D_2}(r,z,t) P_{2_{\sigma}}E_{2_{\sigma}}(r,z,t) Q_{2_{\sigma}}(r,z,t)$$
 (2-22)

In Eq. (2-22) the first term gives the number of prompt photoneutrons born at (r,z) and time t per cm³ per sec. within the gth group of neutrons, induced by photons belonging to the first energy group of photons. Similarly the second term in Eq. (2-22) gives the number of prompt photoneutrons born at (r,z) and time t per cm³ per sec. within the gth group of neutrons, induced by photons belonging to the second energy group of photons.

The quantities

$$\Sigma_{f_g}(r',z',t) \prod_{f_{lg}}(r,z), (l=1,...,L)$$

appearing in Eq. (2-22) through Eq. (2-21) and Eq. (2-19) are to be determined for all the locations (or materials present in MITRII) and any of the three types of neutron reaction inducing prompt photons. Fortunately there is a code with its own library for doing this.

Thus the code POPOP IV [2] computes

$$SGCS_{lg}(r,z,t) = \sum_{f=1}^{3} \sum_{f_g} (r,z,t) \prod_{f_{lg}} (r,z) ,$$
 (2-23)

the secondary gamma ray cross sections for photons of lth group, induced by neutrons of gth group. In Appendix D POPOP IV

is briefly discussed and the relevant numbers are presented.

2-2 Component of $I(r,z,\Lambda,t)$ due to Delayed gamma rays and the corresponding photoneutron source term

Delayed gamma rays can be due to fission products decay and activation of the material leading to delayed gamma ray emission.

Activation gamma rays of sufficient energy happen not to be significant in MITR II. Hence we need to consider only the decay of fission products.

To this end we turn our attention to the fission product having the decay constant λ_j . The photons that will follow will appear with the same decay constant. Any photoneutrons caused by these photoneutrons will show up with that decay constant too.

We let then, $L_j(r,z,t)$, be the concentration per cm³, per sec. of the jth delayed photon precursor (the fission product having the decay constant λ_j) at (r,z) and t.

Let N_0 be the total number of delayed photon precursors created per fission that may decay with one of the λ_j 's, and let y_j be the fraction of these N_0 delayed photon precursors that decay with the decay constant λ_i .

Let $\Sigma_{\rm F}(r,z,E,t)$ be the macroscopic fission cross section for neutrons of energy E, at (r,z) and t, and define

$$\Sigma_{F_{g}}(r,z,t) = \frac{1}{\emptyset_{g}(r,z,t)} \int_{E_{g}}^{E_{g}-1} \Sigma_{F}(r,z,E,t) \phi(r,z,E,t) dE, (2-24)$$

$$\Sigma_{\rm F}^{\rm T}({\rm r},{\rm z},{\rm t}) = {\rm row} \ (\Sigma_{\rm F_1} \dots \Sigma_{\rm F_G}) \qquad (2-25)$$

L_i(r,z,t) can now be obtained from

$$\frac{\partial L_{j}(r,z,t)}{\partial t} = \Sigma_{F}^{T}(r,z,t) \mathscr{O}(r,z,t) Y_{j}^{N} \mathcal{O}^{-\lambda} J_{j}^{L}(r,z,t) . \qquad (2-26)$$

The total rate at which delayed photons of the jth kind are emitted from the core is then

$$S_{e}^{j}(t) = 2\pi \int r' dr' \int dz' \lambda_{j}L_{j}(r',z',t) . \quad (2-27)$$

r',core z',core

We let Y_{j_l} be the probability that the photons of sufficient energy to produce photoneutron reaction in D_2^0 , emitted from the jth precursor appear in the lth photon group and define

$$Y_j = \text{column } (Y_{j_\ell} \cdots Y_{j_L})$$
, (2-28)

Then as we did with the prompt photons, we assume that all the delayed photons are born at the center of the reactor and are attenuated in reaching to the reflector as if they were travelling through pure D_2^0 . As a result, in complete analogy with Eq. (2-2) we obtain the delayed photonentron source;

$$S_{D_{g}}^{j}(r,z,t) = \frac{1}{4\pi (r^{2}+z^{2})} \sum_{D}^{T}(r,z,t) P_{g}E(r,z,t)Y_{j}\lambda_{j} x$$

$$2\pi \int r' dr' \int dz' L_{j}(r',z',t), (2-29)$$
r', core z', core

at which the-energy wise-group-g photoneutrons appear per unit volume and per unit time at point (r,z) in the reflector and time t due to the -time wise-group j delayed photons.

The total rate of delayed photoneutrons emitted in neutron group g is then

$$S_{D_{g}}(r,z,t) = \sum_{j=7}^{15} S_{D_{g}}^{j}(r,z,t) ,$$
 (2-30)

where having reserved j from 1 to 6 for delayed neutron groups, we use j from 7 to 15 for 9 groups of delayed photoneutrons.

The form of Eq. (2-29) suggests that we picture the de-Hayed photoneutrons appearing at (r,z) as coming from fictitious precursors actually present at (r,z). Accordingly we define a concentration $\theta_g^j(r,z,t)$ of "delayed photoneutron precursors" in relation with the delayed photoneutron group j, and emitting neutrons into neutron group g at time t;

$$\theta_{g}^{j}(r,z,t) = \frac{S_{D}^{j}(r,z,t)}{\lambda_{j}}, \qquad (2-31)$$

so that from Eq. (2-30),

$$S_{D_{g}}(r,z,t) = \sum_{j=7}^{15} \lambda_{j} \theta_{j}(r,z,t) \qquad (2-32)$$

To find equations for the $\theta_g^j(r,z,t)$ we integrate Eq. (2-26) over the core volume and multiply it at the left by

 $\frac{1}{4\pi (r^2 + z^2)} \Sigma_D^T(r, z, t) P_g E(r, z, t) Y, \text{ where we omit the subscript}$ j on the column vector [cf. Eq. (2-28)] since the experimental data (cf. Appendix B) indicates this approximation is justified.

The first term of Eq. (2-26) then becomes

$$\frac{1}{4\pi (r^2+z^2)} \Sigma_D^T (r,z,t) P_g E(r,z,t) Y x$$

$$2\pi \int \mathbf{r'} \, d\mathbf{r'} \int \frac{\partial \mathbf{L}_{j}}{\partial \mathbf{t}} (\mathbf{r'}, \mathbf{z'}, \mathbf{t}) = \frac{\partial \theta_{\mathrm{D}}^{j}(\mathbf{r}, \mathbf{z}, \mathbf{t})}{\partial \mathbf{t}}$$

r', core z', core

$$-\frac{\frac{\partial}{\partial t} (\Sigma_{D}^{T}(r,z,t) P_{g} E(r,z,t)) Y}{\Sigma_{D}^{T}(r,z,t) P_{g} E(r,z,t) Y} \theta_{g}^{j}(r,z,t)$$
(2-33)

and the last term becomes

$$\frac{1}{4\pi (r^2 + z^2)} \Sigma_D^T(r, z, t) P_g E(r, z, t) Y \lambda_j x$$

$$2\pi \int_{\substack{r'dr'\\r',core}} dz' L_j(r',z',t) = \lambda_j \theta_j^j(r,z,t) . \quad (2-34)$$

It appears legitimate to ignore the time dependence of

 $\Sigma_{\rm D}$ (r,z,t) and E(r,z,t). In Eq. (2-33), accordingly we drop the last term and obtain

$$\frac{\partial \theta_{g}^{j}(\mathbf{r},z,t)}{\partial t} = \frac{1}{4\pi (r^{2}+z^{2})} Y_{j} N_{0} \Sigma_{D}^{T}(\mathbf{r},z,t) P_{g} E(\mathbf{r},z,t) Y x$$

$$2\pi \int_{\mathbf{r}, \text{core}}^{\mathbf{r}, \text{dr'}} \int_{\mathbf{z}, \text{core}}^{\mathbf{dz'}} \Sigma_{\mathbf{F}}^{\mathbf{T}}(\mathbf{r}, \mathbf{z}, t) \phi(\mathbf{r}, \mathbf{z}, t) - \lambda_{j} \theta_{g}^{j}(\mathbf{r}, \mathbf{z}, t), (2-35)$$

We discuss in Appendix B how values of λ_j , y_j , N_0 and Y may be obtained from experimental data.

2.3 Summary

In order to find an analytical expression for the photoneutron source term in the D_2^0 reflector of MITR-II we have first computed the production of prompt and delayed photons and then, by making a very gross approximation have estimated their attenuation through the core.

Eq. (2-20) (prompt photoneutrons) and Eq. (2-32) coupled with Eq. (2-35) (delayed photoneutrons) are the end products of this procedure. We thus have;

$$S_{g}(r,z,t) = S_{P_{g}}(r,z,t) + \sum_{j=7}^{15} \lambda_{j} \Theta_{g}^{j}(r,z,t)$$
 (2-36)

CHAPTER III

APPLICATION OF THE WEIGHTED RESIDUAL METHOD

We shall use the weighted residual method to describe the space and time dependent flux in terms of spatial shapes chosen beforehand and unknown time coefficients.

To carry out this procedure, we begin with the time dependent multigroup diffusion equation with our extra photoneutron source term

$$\mathbf{v}^{-1} \frac{\partial \mathscr{Q}(\mathbf{r}, \mathbf{z}, \mathbf{t})}{\partial \mathbf{t}} = [\nabla \cdot \mathbf{D}(\mathbf{r}, \mathbf{z}, \mathbf{t}) \nabla - \mathbf{A}(\mathbf{r}, \mathbf{z}, \mathbf{t}) + (1 - \beta) \nabla \chi_p \Sigma_F^{\mathrm{T}}(\mathbf{r}, \mathbf{z}, \mathbf{t})] \mathscr{Q}(\mathbf{r}, \mathbf{z}, \mathbf{t})$$

$$\int_{j=1}^{J} \lambda_{j} \chi_{j} \eta_{j}(r,z,t) + \frac{\alpha}{4\pi(r^{2}+z^{2})} \operatorname{column} \left(\sum_{D}^{T} (r,z,t) \right) P_{g} E(r,z,t)$$

$$2\pi \int r' dr' \int dz'$$

r', reactor $\int z'$, reactor

$$\sum_{f=1}^{3} \operatorname{column} \left[\sum_{f=1}^{T} (r', z', t) \right] \prod_{f \in \mathcal{X}} (r', z') \left[\emptyset(r', z', t) \right] + \sum_{j=J+1}^{H} \lambda_{j} \Theta_{j}(r, z, t),$$

(3-1)

$$\frac{\partial \eta_{j}(\mathbf{r},z,t)}{\partial t} = \beta_{j} v \Sigma_{F}^{T}(\mathbf{r},z,t) \mathscr{O}(\mathbf{r},z,t) - \lambda_{j} \eta_{j}(\mathbf{r},z,t) , \quad (3-2)$$

$$\frac{\partial \Theta_{j}(\mathbf{r}, z, t)}{\partial t} = \frac{\alpha}{4\pi (r^{2} + z^{2})} y_{j} N_{0} \text{ column} \left(\sum_{D}^{T} (r, z, t) P_{g} E(r, z, t) \right)^{48}$$

$$2\pi \int_{\mathbf{r}', \text{core}} \int_{\mathbf{z}', \text{core}} \Sigma_{\mathbf{r}', \text{core}}^{\mathbf{T}}(\mathbf{r}', \mathbf{z}', t) \phi(\mathbf{r}', \mathbf{z}', t) -\lambda_{j} \theta_{j}(\mathbf{r}, \mathbf{z}, t) , (3-3)$$

where

$$V^{-1} = \text{diag} \left(\frac{1}{V_1} \dots \frac{1}{V_G}\right) , \qquad (3-4)$$

 $D(r,z,t) = diag (D_1(r,z,t) \dots D_G(r,z,t)) , (3-5)$

$$\sum_{a_{1}}^{G} (r,z,t) + \sum_{h=1}^{G} \sum_{s} (r,z,t)$$

 $\begin{bmatrix} \Sigma_{11}^{(r,z,t)} \dots \Sigma_{1G}^{(r,z,t)} \\ \vdots \\ \vdots \\ \Sigma_{G1}^{(r,z,t)} \dots \Sigma_{GG}^{(r,z,t)} \end{bmatrix};$

$$A(r,z,t) =$$

$$\begin{array}{c}
G \\
\Sigma_{a_{G}}(r,z,t) + \Sigma \Sigma_{S+}(r,z,t) \\
h=1 \quad hG
\end{array}$$

(3-6)

$$\Sigma_{a_{g}}(r,z,t)$$
: macroscopic absorption cross section of neutrons
belonging to gth group at(r,z) and t ;

α: correction factor (generated or empirical) for overcoming the error introduced by the approximations made for the computation of the photoneutron source term in the reflector; $\Sigma_{s,t}$ (r,z,t): macroscopic scattering cross section of hg

neutrons from group g into group h at(r,z) and t.

$$\beta_{j} : \text{ delayed neutron fraction for group } j, (j=1,..., J)$$

$$\beta = \sum_{\substack{j=1 \\ j=1}}^{J} \beta_{j} \qquad (3-7)$$

There are J delayed neutron group(s).

v : number of neutrons created per fission ,

$$\chi_{\mathbf{p}} = \operatorname{column} (\chi_{\mathbf{p}_1} \cdots \chi_{\mathbf{p}_G}) . \qquad (3-8)$$

There are (H-J) delayed photoneutron group(s).

 $\eta_j(r,z,t)$: delayed neutron precursor concentration for jth group at(r,z) and t.

 $\chi_{j} = \operatorname{column} (\chi_{j_{1}} \cdots \chi_{j_{C}}) \quad . \tag{3-9}$

 $\chi_{p_{g}}$ and $\chi_{j_{g}}$ are the probabilities, respectively for prompt and delayed neutrons of jth group, to appear within the gth neutron group.

By column () in Eq. (3-1) and Eq. (3-3) is meant the column matrix obtained by varying g in P_g of the expression in between the brackets from 1 to G. In the same way column [] in Eq. (3-1) describes the column matrix obtained by varying 2 in \prod_{f_g} from 1 to L.

Finally

$$\Theta_{j}(r,z,t) = \text{column} (\Theta_{1}^{j}(r,z,t) \dots \Theta_{G}^{j}(r,z,t)) .$$
(3-10)

Other symbols appearing in eqs. (3-1), (3-2) and (3-3) have been defined previously.

Since it is impractical to obtain an analytical solution to the system of equations (3-1), (3-2) and (3-3), we shall employ an approximation method based on expressing $\emptyset(\underline{r},t)$ by a trial function of the form

$$\mathscr{D}(\underline{\mathbf{r}},t) = \sum_{i=1}^{I} \psi_{i}(\underline{\mathbf{r}}) N_{i}(t) , \qquad (3-11)$$

where $\psi_i(\underline{r})$ is the ith mode, a column matrix having G elements $(\psi_{ig}(\underline{r}), g=1,...,G)$ that are spatial functions selected beforehand, and N_i(t) is an unknown time coefficient. We then have I unknown time coefficients to be determined.

The idea behind the expression (3-11) consists in choosing $\psi_i(\underline{r})$'s that are linearly independent functions (cf. Appendix E) so that various combinations of them will provide a good approximation to the flux shape expected during the transient. [3]. The accuracy of the solution will naturally depend on the good choice of these spatial shapes.

3-1 Formulation of the residuals

We now rewrite Eq. (3-11) using the matrix notation

$$\overline{\emptyset}(\mathbf{r},\mathbf{z},\mathbf{t}) = \psi(\mathbf{r},\mathbf{z}) \, \mathrm{N}(\mathbf{t}) \, , \qquad$$

(3-12)

with

$$\psi(\mathbf{r}, \mathbf{z}) = \begin{bmatrix} \psi_{11}(\mathbf{r}, \mathbf{z}) & \cdots & \psi_{11}(\mathbf{r}, \mathbf{z}) \\ \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots \\ \psi_{G1}(\mathbf{r}, \mathbf{z}) & \cdots & \psi_{GI}(\mathbf{r}, \mathbf{z}) \end{bmatrix}, \quad (3-13)$$

 $N(t) = column (N_1(t) ... N_1(t))$. (3-14)

The bar on top of $\emptyset(r,z,t)$ is to indicate that this is an approximate solution. Thus when we insert it into Eq. (3-1), Eq. (3-2) and Eq. (3-3) the left hand sides of these equations are no longer exactly equal to their right hand sides. The differences are called residuals;

$$R(r,z,t) = v^{-1} \frac{dN(t)}{dt} \psi(r,z)$$

 $- [\nabla . D(\mathbf{r}, \mathbf{z}, t) \nabla - A(\mathbf{r}, \mathbf{z}, t) + (1 - \beta) v \chi_p \Sigma_F^T(\mathbf{r}, \mathbf{z}, t)] \psi(\mathbf{r}, \mathbf{z}) N(t) -$

$$\int_{j=1}^{J} \lambda_{j} \chi_{j} \eta_{j}(r,z,t) - \frac{\alpha}{4\pi (r^{2}+z^{2})} \operatorname{column} \left(\Sigma_{D}^{T}(r,z,t) P_{g} E(r,z,t) \right)$$

 $2\pi \int_{\mathbf{r}, \mathrm{reactor}}^{\mathbf{r}, \mathrm{dr}} \int_{\mathbf{z}, \mathrm{reactor}}^{\mathbf{d}, \mathrm{z}} \int_{\mathbf{z}, \mathrm{reactor}}^{\mathbf{d}, \mathrm{zolumn}} \sum_{\mathbf{f}, \mathrm{r}, \mathrm{z}, \mathrm{r}, \mathrm{f}}^{\mathbf{T}} [\mathbf{r}, \mathbf{z}, \mathrm{r}, \mathrm{f}]_{\mathbf{f}} [\mathbf{f}_{\ell}(\mathbf{r}, \mathbf{z})]_{\ell}$

$$\psi(\mathbf{r}',\mathbf{z}')N(t) - \sum_{j=J+1}^{H} \lambda_{j}\Theta_{j}(\mathbf{r},\mathbf{z},t) , \qquad (3-15)$$

$$R_{p_{j}}(r,z,t) = \frac{\partial \eta_{j}(r,z,t)}{\partial t} - \beta_{j} v \Sigma_{F}^{T}(r,z,t) \psi(r,z) N(t) + \lambda_{j} \eta_{j}(r,z,t),$$

$$(j=1,\ldots,J), \qquad (3-16)$$

$$R_{H_{j}}(r,z,t) = \frac{\partial \Theta_{j}(r,z,t)}{\partial t} - \frac{\alpha}{4\pi(r^{2}+z^{2})} y_{j}N_{0} \operatorname{column}\left(\Sigma_{D}^{T}(r,z,t)P_{g}E(r,z,t)\right)$$

Y
$$2\pi \int r' dr' \int dz' \Sigma_F^T(r',z',t)\psi(r',z')N(t) + \lambda_j \Theta_j(r,z,t),$$

r', core $J_{z'}$, core

$$(j=(J+1),\ldots, H)$$
 • $(3-17)$

In addition to these three residuals we should in general have interface, boundary and initial condition residuals. However we intend to use good trial functions that will not leave interface residuals and that will satisfy boundary and initial conditions; namely

$$\overline{\emptyset} (R_0, z, t) = \overline{\emptyset}(r, Z_1, t) = \overline{\emptyset}(r, Z_1, t) = 0, \qquad (3-18)$$

$$\vec{\phi}(\mathbf{r}, \mathbf{z}, \mathbf{0}) = \phi(\mathbf{r}, \mathbf{z}, \mathbf{0})$$
 (3-19)

where R_0 is the extrapolated radius of the reactor (the one which is taken for criticality calculations). Similarly Z_+ and Z_- are the upper and lower levels where the flux is taken to be zero.

3-2 Weighting of the residuals and preparation of the equations for the unknown time coefficients

Because of the inherent inaccuracy of Eq. (3-12) we cannot make the residuals (3-15), (3-16) and (3-17) vanish at all points <u>r</u>. However we can choose the N(t) so that the residuals vanish in an integral sense. Accordingly we define the GxI matrix of weighting shapes;

$$W(r,z) = \begin{bmatrix} W_{11}(r,z) & \cdots & W_{11}(r,z) \\ \vdots & & \vdots \\ \vdots & & \vdots \\ W_{G1}(r,z) & \cdots & W_{G1}(r,z) \end{bmatrix}, \quad (3-20)$$

where the ith column is the ith weighting mode and no two weighting modes can be proportional to one another. W_{gi} is chosen to be continuous and defined^{*} throughout the entire reactor.

We then require;

$$D = 2\pi \int_{r,reactor}^{r dr'} \int_{z,reactor}^{dz} W^{T}(r,z) R(r,z,t), \quad (3-21)$$

These conditions will be automatically satisfied since we intend to use the adjoint fluxes as weighting functions.

$$0 = 2\pi \int_{\mathbf{r}, \text{reactor}} r \, d\mathbf{r} \int_{\mathbf{z}, \text{reactor}} W^{\mathbf{T}}(\mathbf{r}, \mathbf{z}) \chi_{j} R_{p_{j}}(\mathbf{r}, \mathbf{z}, t), \qquad 54$$

$$(j=1,...,J),$$
 (3-22)

$$O = 2\pi \int_{\mathbf{r}, \text{reactor}} r \, dr \int_{\mathbf{z}, \text{reactor}} dz \qquad W^{\mathrm{T}}(\mathbf{r}, \mathbf{z}) \ \mathcal{R}_{\mathrm{H}_{j}}(\mathbf{r}, \mathbf{z}, t),$$

$$[j = (J+1), \dots, H), \qquad (3-23)$$

3-3 Formulation of the system of equations for the time dependent coefficients

In order to abstract the equations for N(t) implied by equations (3-21), (3-22) and (3-23) we introduce the definitions;

column
$$[\Sigma_{f}^{T}(r',z',t) ||_{f_{\ell}}(r',z')]\psi(r',z')$$
, (3-24)

$$\xi_{\rm p}({\bf r},z,t) = {\rm column} \ (\xi_{\rm P_1}({\bf r},z,t) \ \dots \ \xi_{\rm P_G}({\bf r},z,t)),$$
 (3-25)

$$\beta_{g}^{j}(r,z,t) = \frac{1}{4\pi(r^{2}+z^{2})} y_{j} N_{0} \Sigma_{D}^{T}(r,z,t) P_{g} E(r,z,t) Y 2\pi \int_{r',core} r' dr' \int_{z',core} dz'$$

$$\Sigma_{\rm F}^{\rm T}({\rm r}',{\rm z}',{\rm t}) \psi({\rm r}',{\rm z}')$$
 (3-26)

55
$$\beta_{j}(r,z,t) = \text{column } [\beta_{1}^{j}(r,z,t)...\beta_{G}^{j}(r,z,t)] , \qquad (3-27)$$

$$\Lambda = 2\pi \int_{r,reactor} r \, dr \int_{z,reactor} dz \quad W^{T}(r,z) \quad V^{-1}\psi(r,z) , \quad (3-28)$$

$$\rho(t) = 2\pi \int_{\mathbf{r}, \mathbf{r} \in actor} r \, dr \int_{\mathbf{z}, \mathbf{r} \in actor} dz \quad W^{\mathrm{T}}(\mathbf{r}, \mathbf{z}) \quad [\nabla \cdot D(\mathbf{r}, \mathbf{z}, t) - A(\mathbf{r}, \mathbf{z}, t) + (1 - \beta) \chi_{\mathrm{D}} \sqrt{\Sigma_{\mathrm{T}}^{\mathrm{T}}}(\mathbf{r}, \mathbf{z}, t)] \psi(\mathbf{r}, \mathbf{z}) + \alpha \xi_{\mathrm{T}}(\mathbf{r}, \mathbf{z}, t) \qquad (3 - 29)$$

+
$$(1-\beta)\chi_{p}\nu\Sigma_{F}^{T}(r,z,t)]\psi(r,z)+\alpha\xi_{p}(r,z,t)$$
, (3-29)

$$\overline{\beta}_{j}(t) = \beta_{j} 2\pi \int_{r, \text{core}} r \, dr \int_{z, \text{core}} dz \quad W^{T}(r, z) v \Sigma_{F}^{T}(r, z, t) \psi(r, z),$$

$$(j = 1, \dots, J), \qquad (3-30)$$

$$D_{j_{i}}(t) = 2\pi \int_{r, core} r \, dr \int_{z, core} dz \quad W_{i}^{T}(r, z) \chi_{j} \eta_{j}(r, z, t) ,$$

$$(i = 1, ..., I), \quad (j = 1, ..., J), \quad (3-31)$$

$$D_{j}(t) = column (D_{j_{1}}(t) \dots D_{j_{I}}(t)), (j = 1, \dots, J), (3-32)$$

$$\overline{\beta}_{j}(t) = 2\pi \int_{r,reflector} r \, dr \int_{z,reflector} dz \quad W^{T}(r,z) \beta_{j}(r,z,t),$$

$$[j = (J+1) \qquad H] \qquad (2-22)$$

$$[j = (J+1), \dots, H]$$
, (3-33)

$$\Theta_{j}(t) = 2\pi \int r dr \int dz \quad W^{T}(r,z)\Theta_{j}(r,z,t), \quad (3-34)$$

r, reflector $\int_{z, reflector} J_{z, reflector}$

With these definitions Eq. (3-21) becomes:

$$\Lambda \frac{dN(t)}{dt} = \rho(t)N(t) + \sum_{j=1}^{J} \lambda_{j}D_{j}(t) + \sum_{j=J+1}^{H} \lambda_{j} \Theta_{j}(t) . \qquad (3-35)$$

Eq. (3-22) becomes

$$\frac{D_{j}(t)}{dt} = \overline{\beta}_{j}(t) N(t) - \lambda_{j} D_{j}(t), (j=1,...,J). \quad (3-36)$$

Finally Eq. (3-23) becomes

$$\frac{d\Theta_{j}(t)}{dt} = \alpha \overline{\beta}_{j}(t) N(t) - \lambda_{j}\Theta_{j}(t), (j = (J+1), \dots, H). (3-37)$$

In order to simplify further we define

$$\overline{\beta}_{j_{new}}$$
 (t) $\equiv \overline{\beta}_{j}(t)$, (j = 1,..., J) , (3-38)

$$\overline{\beta}_{j_{new}}$$
 (t) = $\alpha \overline{\beta}_{j}$ (t), (j = (J+1),..., H), (3-39)

$$\overline{\beta}_{new}(t) = \sum_{j=1}^{H} \overline{\beta}_{j}(t) , \qquad (3-40)$$

$$\rho_{\text{new}}(t) = \rho(t) + \overline{\beta}_{\text{new}}(t) , \qquad (3-41)$$

so that $\rho_{new}(t)$ has four components;

1. The prompt neutron reactivity:

$$2\pi \int_{\mathbf{r},\text{core}}^{\mathbf{r}} d\mathbf{r} \int_{\mathbf{z},\text{core}}^{\mathbf{d}\mathbf{z}} W^{\mathbf{T}}(\mathbf{r},\mathbf{z}) \left[\nabla.D(\mathbf{r},\mathbf{z},t)\nabla-A(\mathbf{r},\mathbf{z},t)\right]_{\mathbf{z},\text{core}}$$

+(1-
$$\beta$$
) $v\chi_p \Sigma_F^T(r,z,t)$] ψ (r,z);

2. The prompt photoneutron reactivity:

$$2\pi \int r dr \int dx \quad W^{T}(r,z) \xi_{p}(r,z,t);$$

r,reflector $\int_{z,reflector} dx \quad W^{T}(r,z) \xi_{p}(r,z,t);$

3. The delayed neutron reactivity:

$$\begin{array}{ccc} J & J \\ \Sigma & \overline{\beta}_{j}(t) = \Sigma & \beta_{j} 2\pi \\ j=1 & j \end{array} \int_{r,core} r dr \int_{z,core} dz & W^{T}(r,z)v\chi_{j}\Sigma_{F}^{T}(r,z,t)\psi(r,z); \end{array}$$

4. The delayed photoneutron reactivity:

 $\begin{array}{ccc} H & H \\ \Sigma & \alpha \overline{\beta}_{j}(t) = & \Sigma & 2\pi \\ j = J + 1 & j = J + 1 \end{array} \int_{r, reflector} dr & \int_{z, reflector} W^{T}(r, z) \beta_{j}(r, z, t).$

Both prompt and delayed photoneutron reactivities are produced in the reflector.

We finally define

$$C_{j}(t) \equiv D_{j}(t)$$
, $(j = 1, ..., J)$, $(3-42)$
 $C_{j}(t) \equiv O_{j}(t)$, $(j = (J+1), ..., H)$, $(3-43)$

With the new definitions we obtain from Eq. (3-35), Eq. (3-36) and Eq.(3-37) a system of equations for the unknown time coefficients that has the familiar point kinetics form;

$$\Lambda \frac{dN(t)}{dt} = \left[\rho_{new}(t) - \overline{\beta}_{new}(t)\right] N(t) + \sum_{j=1}^{H} \lambda_j C_j(t) , \quad (3-44)$$

$$\frac{dC_{j}(t)}{dt} = \overline{\beta}_{j_{new}}(t) N (t) - \lambda_{j}C_{j}(t) , (j=1,..., H) . (3-45)$$

By analogy with the point kinetics equations $\Lambda(IxI)$ will be called the generation time matrix; $\rho_{new}(t)$ (IxI), the reactivity matrix; $\overline{\beta}_{j}$ (t) (IxI), the delayed neutron fraction matrix for j_{new}

the jth group and $C_j(t)$ (Ixl), the precursor amplitude function matrix for the jth group.

It is worthwhile to point out that the form obtained for the above equations does not depend on the formulation of the energy and time dependent photon flux or the choice of the geometry in the course of the calculation of the photoneutron source term in the reflector. In a different case the same form would be found with however different expressions for the parameters Λ , $\rho(t)$ and $\beta_{i}(t)$'s.

Equations (3-44) and (3-45) represent a set of I (H+1) equations for I time coefficients and IxH precursor amplitude functions. There are several ways of solving these equations [4]. That topic is outside of the scope of the present work. One of these ways based on the weighted residual method with subdomain weighting has been adopted since it was the only method implemented by an available computer program, when we first needed a solution. This method is briefly described in Appendix F.

3-4 Summary

In order to find a solution for the space and time dependent flux we have used an expression in prechosen spatial shapes and unknown time dependent coefficients. The insertion of this approximate flux into the equations gave us residuals. Then we have chosen as many weighting modes as the number of unknown time coefficients, weighted the residuals and integrated over the reactor volume. That procedure furnished us equations of the point kinetics type for the unknown time coefficients.

We must describe now a method of computing the very complicated integral expressions for Λ , $\rho_{new}(t)$ and $\overline{\beta}_{jnew}(t)$'s (subject to Chapter V). This however shall require that we know the way the spatial shapes have been selected, that is done next.

CHAPTER IV

SELECTION OF OUR SPATIAL FUNCTIONS

To describe in the simplest way the time and space dependent flux during a transient in MITR-II, we shall choose two trial modes and two weighting modes. Each of the modes is a G-element column vector of spatial functions (G being the number of neutron groups).

Thus

$$\phi(\mathbf{r},t) = \psi_1(\mathbf{r}) N_1(t) + \psi_2(\mathbf{r}) N_2(t), \qquad (4-1)$$

where $N_1(t)$ and $N_2(t)$ will be determined through the manipulations involving $W_1(\underline{r})$ and $W_2(\underline{r})$, described in the previous chapter.

Following former criticality calculations done for MITR-II, a three-group model in (r,z) geometry (cf. Appendix G) with no upscattering and down scattering to the closest lower group only, is adopted. That model has 40 mesh points in the r direction and 48 mesh points in the z direction. The boundaries for neutron energy groups are given in Table 4-1. Group boundaries for three-group scheme

Group	Group boundaries in Mev
Fast	$3 \times 10^{-3} - \infty$
Epithermal	4×10^{-7} - 3 x 10 ⁻³
Thermal	$2.5 \times 10^{-10} - 4 \times 10^{-7}$

The code Exterminator II[5] was used to obtain the spatial functions.

4-1. The Selection of the First Trial and Weighting Modes

The first trial mode is taken to be the solution of

$$\{\nabla \cdot D_{1}(\underline{r}) \nabla - A_{1}(\underline{r}) + [(1-\beta)\chi_{p} + \sum_{j=1}^{J} \beta_{j}\chi_{j}] v \Sigma_{F_{1}}^{T}(\underline{r})\} \psi_{1}(\underline{r}) = 0, \qquad (4-2)$$

where $D_1(\underline{r}) = D(\underline{r},0)$, $A_1(\underline{r}) = A(\underline{r},0)$, $\Sigma_{F_1}(\underline{r}) = \Sigma_F(\underline{r},0)$ and $D(\underline{r},t)$, $A(\underline{r},t)$, $\Sigma_F(\underline{r},t)$ have been defined previously.

That is physically, (ignoring the photoneutrons) $\psi_1(\underline{r})$ is the flux shape of MITR-II in a steady state critical condition.

Both prompt and delayed neutrons appear in the fast group of the three-group scheme shown in Table 4-1. Therefore

$$X = X_{p} = X_{j} = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$$
(4-3)

Thus Eq. (4-2) will be written as

$$[\nabla \cdot D_{1}(\underline{r}) \nabla - A_{1}(\underline{r}) + \nu \chi \Sigma_{F_{1}}^{T}(\underline{r})] \psi_{1}(\underline{r}) = 0. \qquad (4-4)$$

 $W_1(\underline{r})$ is chosen to be $\psi_1^*(\underline{r})$; the solution of the equation adjoint to Eq.(4-4), namely

$$H_{1}^{+}(\underline{r}) \psi_{1}^{*}(\underline{r}) = 0 , \qquad (4-5)$$

with

$$\langle \psi_{1}(\underline{\mathbf{r}}) | \mathbf{H}_{1}^{+}(\underline{\mathbf{r}}) | \psi_{1}^{*}(\underline{\mathbf{r}}) \rangle = \langle \psi_{1}^{*}(\underline{\mathbf{r}}) | \mathbf{H}_{1}(\underline{\mathbf{r}}) | \psi_{1}(\underline{\mathbf{r}}) \rangle, \quad (4-6)$$

and

$$H_{1}(\underline{r}) = \nabla \cdot D_{1}(\underline{r}) \quad \nabla - A_{1}(\underline{r}) + \nu \chi \quad \Sigma_{F_{1}}^{T}(\underline{r})$$
(4-7)

4-2 The Selection of the second trial and weighting modes

The selection of the second trial and weighting modes will be undertaken in the case of a particular transient where a control rod has been withdrawn. We intend to study the transient up to time t=T; by then the reactor is presumed to be on a prompt critical period.

Thus the rod being in its withdrawn position at time t=T, we select as the second expansion mode a vector such that in the vicinity of time t=T;

$$\phi(\underline{r},t) = \psi_2(\underline{r})e , \qquad (4-8)$$

$$\nabla^{-1} \frac{\partial \mathscr{Q}(\mathbf{r},t)}{\partial t} = [\nabla \cdot D(\underline{\mathbf{r}},t) \nabla - A(\underline{\mathbf{r}},t) + (1-\beta)\chi_{p} \nabla \Sigma_{F}^{T}(\underline{\mathbf{r}},t)] \mathscr{Q}(\underline{\mathbf{r}},t)$$

+
$$\sum_{j=1}^{J} \lambda_j \chi_j \eta_j (\underline{r}, t)$$
, (4-9)

$$\frac{\partial \eta_{j}(\underline{r},t)}{\partial t} = \beta_{j} \vee \Sigma_{F}^{T} \phi(\underline{r},t) - \lambda_{j} \eta_{j}(\underline{r},t), \quad (j=1,\ldots,J), \quad (4-10)$$

and

$$\mathcal{N}_{j}(\underline{r},t) = M_{j}(\underline{r})e \qquad (4-11)$$

Eq. (4-10) with Equations (4-9) and (4-11) then gives;

$$M_{j}(\underline{r}) = \frac{\beta_{j} \nu \Sigma_{F}^{T}(\underline{r},t)\psi_{2}(\underline{r})}{\omega + \lambda_{j}} \qquad (4-12)$$

and Eq. (4-9) with Equations (4-8), (4-12) and (4-3) becomes

$$\{\nabla \cdot D(\underline{\mathbf{r}}, t) \nabla - A(\underline{\mathbf{r}}, t) - y^{-1} \omega + \chi v \left(1 - \sum_{j=1}^{J} \frac{\omega \beta_j}{\omega + \lambda_j}\right) \Sigma_F^T(\underline{\mathbf{r}}, t) \} \psi_2(\underline{\mathbf{r}}) = 0$$

$$(4-13)$$

In the case of a prompt run away we expect to find $\omega >> \lambda_j$ so that, at t=T,

$$\{\nabla \cdot D_{2}(\underline{r}) \nabla - [A_{2}(\underline{r}) + \omega \nabla^{-1}] + (1 - \beta) \chi_{\nu} \Sigma_{F_{2}}^{T}(\underline{r}) \} \psi_{2}(\underline{r}) = 0, \quad (4 - 14)$$

where $D_2(\underline{r}) = D(\underline{r},t)$, $A_2(\underline{r}) = A(\underline{r},T)$ and $\Sigma_{F_2}(\underline{r}) = \Sigma_F(\underline{r},T)$.

An eigenvalue ω can be found such that Eq.(4-14) is satisfied at every point.

The numerical procedure for finding a value of ω that satisfies Eq.(4-14) is called a poison search, one introducing a $(\frac{1}{V})$ - poison (i.e. an effective neutron absorber whose cross section varies inversely with the incident neutron velocity) which is spread uniformly throughout the supercritical reactor until criticality calculation for the reactor yields an eigenvalue of $\frac{1}{1-6}$.

Thus our second trial mode is determined through a poison search procedure.

 $W_2(\underline{r})$ is chosen to be $\psi_2^*(\underline{r})$; the solution of the equation adjoint to Eq.(4-14). Thus as with Equations(4-5),(4-6) and(4-7) we have;

$$H_2^+$$
 (r) ψ_2^* (r) = 0 , (4-15)

$$\langle \psi_2(\underline{\mathbf{r}}) | H_2^{\dagger}(\underline{\mathbf{r}}) | \psi_2^{\dagger}(\underline{\mathbf{r}}) \rangle = \langle \psi_2^{\dagger}(\underline{\mathbf{r}}) | H_2(\underline{\mathbf{r}}) | \psi_2(\underline{\mathbf{r}}) \rangle , \qquad (4-16)$$

$$H_{2}(\underline{\mathbf{r}}) = \nabla \cdot D_{2}(\underline{\mathbf{r}}) \nabla - A_{2}(\underline{\mathbf{r}}) - \omega \nabla^{-1} + (1-\beta) \nabla \chi \Sigma_{F_{2}}^{T}(\underline{\mathbf{r}}) \cdot (4-17)$$

4-3 Recomputation, in an integral sense, of the eigenvalue relative to the trial mode

In Section 4-1 we have tacitly assumed that the reactor is critical; also both in sections 4-1 and 4-2 a well converged solution was supposed to be available so that Equations (4-4) and (4-14) are valid at every point of the reactor.

The fact that the reactor may not be critical could be dismissed by merely assuming that the eigenvalue of the reactor is already within $v\chi \Sigma_{\mathbf{F}_1}^{\mathbf{T}}(\underline{\mathbf{r}})$, the same way $\frac{1}{1-\beta}$ divides

 $\nu \chi \Sigma_{F_2}^{T}(\underline{r})$ in the case of Eq.(4-14). More serious than that is the fact that we may not have a converged solution. Then the eigenvalue [assumed to be unity in case of Eq.(4-4) and $\frac{1}{1-\beta}$ in case of Eq.(4-14)] coming from a criticality calculation does not anymore insure the balance - in Equations(4-4) and (4-14) - at every point of the reactor.

In addition, the fact that we drop some of the figures of the fluxes coming out of Exterminator-II run or we might use a slightly different scheme of calculation as compared to the one used in Exterminator-II, may also disturb the balance in Equations (4-4) and (4-14). That is if $\psi_1(\underline{r})$, for example, as it is punched out on cards from an Exterminator-II run, is inserted in Eq. (4-4) and the latter being weighted by $\psi_1^*(\underline{r})$, is integrated over the reactor volume, a finite value results rather than exactly zero. This is an undesirable situation for we intend to make use further (cf. Chapter V section 5-2), of the balance equations (4-4) and (4-14).

Thus it was necessary to recompute

$$k_{\mathbf{k}} = \frac{\int_{\underline{\mathbf{r}}, \text{reactor}} \mathbf{W}_{1}^{T}(\underline{\mathbf{r}}) \mathbf{F}_{\mathbf{k}}(\underline{\mathbf{r}}) d\underline{\mathbf{r}}}{\int_{\underline{\mathbf{r}}, \text{reactor}} \mathbf{W}_{1}^{T}(\underline{\mathbf{r}}) [\mathbf{A}_{\mathbf{k}}'(\underline{\mathbf{r}}) - \nabla . \mathbf{D}_{\mathbf{k}}(\underline{\mathbf{r}}) \nabla] \psi_{\mathbf{k}}(\underline{\mathbf{r}}) d\underline{\mathbf{r}}} , \quad (4-18)$$

where for k=1; $F_k(\underline{r}) = v\chi \Sigma_{F_1}^T(\underline{r})$, $A_k^{\dagger}(\underline{r}) = A_1(\underline{r})$; for k=2; $F_k(\underline{r}) = v \Sigma_{F_2}^T(\underline{r})$ and $A_k^{\dagger}(\underline{r}) = A_2(\underline{r}) + \omega V^{-1}$, so that we assume

we could write;

$$[\nabla \cdot D_{k}(\underline{r}) - A_{k}'(r) + \frac{1}{k_{k}} \vee \chi \Sigma_{F_{k}}^{T}(\underline{r})] \psi_{k}(\underline{r}) = 0, k = 1, 2.$$
(4-19)

4-4 Summary

We intend to use two trial modes for the expression of the time and space dependent flux. The first one is composed of the flux shape at the beginning of the transient and the second one, the flux shape at the end of the transient (the end of the time during which we wanted to study the transient). Thus along the bracketing idea, the flux shape will run from the steady state shape onto the shape at the end of the transient.

Both of the modes and the corresponding weighting modes for MITR-II will be computed for a 40x48 mesh point-cylindrical model and three-group scheme, from a steady state type of equations.

The computation of the second mode and its adjoint in the particular case of withdrawal of a control rod, required a poison search.

The computations will be performed with the code Exterminator-II. Thereafter it was necessary to recompute in an integral sense, the eigenvalue relative to the trial mode, to overcome the disturbance of the balance in equations giving $\psi_1(\mathbf{r})$ and $\psi_2(\mathbf{r})$, due to numerical disagreements.

CHAPTER V

METHODS FOR COMPUTING THE PARAMETERS APPEARING IN THE FINAL EQUATIONS FOR THE UNDETERMINED TIME COEFFICIENTS

The aim in this chapter is to formulate a way for computing Λ , $\rho(t)$ and $\overline{\beta}_{j}(t)$'s in new β_{jnew}

$$\Lambda \frac{dN(t)}{dt} = \left(\rho(t) - \overline{\beta}(t) \right) N(t) + \sum_{j=1}^{H} \lambda_j C_j(t), \quad (5-1)$$

$$\frac{dC_j(t)}{dt} = \overline{\beta}_j(t)N(t) - \lambda_j C_j(t), \quad (j=1,\ldots,H), \quad (5-2)$$

where

$$\overline{\beta}(t) = \sum_{j=1}^{H} \overline{\beta}_{j}(t) .$$
(5-3)

The expressions giving the coefficients Λ , $\rho(t)$, $\overline{\beta}_{j}(t)$'s involve two main forms:

1.
$$2\pi \int rdr \int dz \quad W^{T}(r,z)F(r,z,t) = \underline{C}_{1}(t), \quad (5-4)$$

r, reactor

where $\underline{F}(r,z,t)$ is a known function of r, z, and t; and



Fig. 5-1 Mesh Scheme in (r,z) Geometry

2. $2\pi \int r dr \int dz \quad W^{T}(r,z) (\nabla . D(r,z,t) \nabla \psi(r,z)) = \underline{C}_{2}(t).$ r,reactor

For the purpose of calculating $\underline{C}_{1}(t)$ and $\underline{C}_{2}(t)$ consider the Fig. 5-1 [6], where in two dimensions an equivalent mesh volume, V_{eq} composed of four submesh volumes: V_{1} , V_{2} , V_{3} , and V_{4} , is shown around the mesh point (v,u).

As is customary, we define for each mesh volume a constant neutron cross section for any event (fission, absorption, etc.), hence a constant diffusion coefficient, for each neutron group. Also, a constant value for $\psi_{gi}(r,z)^*$ and $W_{gi}(r,z)$ is fixed within the equivalent mesh volume around the mesh point (v,u) (cf. Fig. 5-2).

As shown in Fig. 5-2, there are $U \times V$ mesh points and $(U-1) \times (V-1)$ mesh volumes.

5-1 Calculation of $\underline{C}_1(t)$

In terms of the coordinate system described above $\underline{C}_{l}(t)$ can be written as

$$\underline{C}_{1}(t) = 2\pi \sum_{v=2}^{V-1} \sum_{u=1}^{U-1} W_{v,u}^{T} \int_{V_{eq}} rdr \int_{V_{eq}} dz F(r,z,t), \quad (5-6)$$

where the integration is performed over the equivalent mesh volume V_{eq} around the mesh point (v,u) and the summation * The gth element of the ith mode, as it is computed by the Code Exterminator II.


Fig. 5-2 Set Up of the Mesh Scheme

is carried up to U-1 and V-1 only, since $W_{v,u}^{T}$ vanishes at u = U for all values of v, and at v = 1 and v = V for all values of u.

In accord with Eq. (5-6) we then have

$$= \sum_{v=2}^{v-1} \sum_{u=1}^{u-1} W_{v,u}^{T} \left(\frac{F_{v-1,u-1}(t)V_{1} + F_{v-1,u}(t)V_{2} + F_{v,u-1}(t)V_{3} + F_{v,u}(t)V_{4} \right)$$

where $\underline{F}_{v,u}(t)$ is the constant quantity involving cross sections within the $(v,u)^{th}$ mesh volume at time t; and

$$V_{1} = \Delta \theta \, \frac{h_{v-1}}{2} \cdot \frac{h_{u-1}}{2} \left(r - \frac{h_{u-1}}{4} \right), \qquad (5-8)$$

with $r = \sum_{u=1}^{U-1} h_u$,

$$V_2 = \Delta \theta \, \frac{h_{v-1}}{2} \cdot \frac{h_u}{2} \left(r + \frac{h_u}{4} \right), \qquad (5-9)$$

$$V_3 = \Delta \theta \frac{h_v}{2} \cdot \frac{h_{u-1}}{2} \left(r - \frac{h_{u-1}}{4} \right), \qquad (5-10)$$

$$V_{4} = \Delta \theta \frac{h_{v}}{2} \cdot \frac{h_{u}}{2} \left(r + \frac{h_{u}}{4} \right).$$
 (5-11)

In addition, the cross sections at the left-hand side of the center line are taken to be zero. Integrating Eq. (5-7) over the angle (θ from 0 to 2π) and using the expressions (5-9), (5-10), and (5-11), we arrive at

$$\underline{C}_{1}(t) = \frac{\pi}{2} \sum_{v=2}^{V-1} \sum_{u=1}^{U-1} W_{v,u}^{T} \left\{ \left(\underline{F}_{v-1,u-1}(t)h_{v-1}h_{u-1} + \underline{F}_{v,u-1}(t)h_{v}h_{u-1} \right) \left(r - \frac{h_{u-1}}{4} \right) + \left(\underline{F}_{v-1,u}(t)h_{v-1}h_{u} + \underline{F}_{v,u}(t)h_{v}h_{u} \right) \left(r + \frac{h_{u}}{4} \right) \right\}.$$
(5-12)

5-2 Calculation of $\underline{C}_2(t)$

 $\underline{C}_2(t)$ is an I×I matrix (I being the number of expansion modes) composed of elements:

$$\underline{C}_{2ik}(t) = 2\pi \int rdr \int dz \quad W_{i}^{T}(r,z) \Big(\nabla . D(r,z,t) \nabla \psi_{k}(r,z) \Big),$$
(5-13)
$$dz \quad W_{i}^{T}(r,z) \Big(\nabla . D(r,z,t) \nabla \psi_{k}(r,z) \Big),$$

$$l = 1, 2, k = 1, 2$$

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We know from the previous chapter (Eq. (4-19)) that the two $\Psi_k(\mathbf{r},\mathbf{z})$'s are the solutions of

$$\left(\nabla \cdot D_{k}(r,z)\nabla - A_{k}'(r,z) + \frac{F_{k}(r,z)}{k_{k}}\right)\psi_{k}(r,z) = 0, \ k = 1,2 \quad (5-14)$$

Because of the assumed spatial independence of D(r,z,t)in the bth submesh volume around the mesh point (v,u), we can write

$$\nabla . D(\mathbf{r}, z, t) \nabla \psi_{k}(\mathbf{r}, z) = D_{b_{v, u}}(t) \nabla . \nabla \psi_{k}(\mathbf{r}, z), \qquad (5-15)$$

but also from Eq. (5-14),

$$D_{k_{b_{v,u}}} \nabla \cdot \nabla \psi_{k}(\mathbf{r}, z) = \begin{pmatrix} F_{k_{b_{v,u}}} \\ A_{k_{b_{v,u}}} - \frac{F_{k_{b_{v,u}}}}{k_{k_{b_{v,u}}}} \psi_{k}(\mathbf{r}, z). \quad (5-16)$$

Thus, combining Equations (5-15) and (5-16), we have in the bth submesh volume around the mesh point (v,u)

$$\nabla . D(\mathbf{r}, z, t) \nabla \psi_{k}(\mathbf{r}, z) = D_{b_{v,u}}(t) D_{k_{b_{v,u}}}^{-1} \left[A_{k_{b_{v,u}}}^{\prime} - \frac{1}{k_{k}} F_{k_{b_{v,u}}} \right] \psi_{k}(\mathbf{r}, z),$$

such that, through Eq. (5-12), $\underline{C}_{2}(t) = \frac{\pi}{2} \sum_{v=2}^{V-1} \sum_{u=1}^{U-1} W_{v,u}^{T} row \begin{cases} (5-18) \\ v \\ v \\ v \\ u \end{cases}$

$$\left\{ \begin{bmatrix} D_{v-1,u-1}(t)M_{k_{v-1,u-1}}h_{v-1} + D_{v,u-1}(t)M_{k_{v,u-1}}h_{v} \end{bmatrix} h_{u-1} \left\{ r - \frac{h_{u-1}}{4} \right\} + \\ \begin{bmatrix} D_{v-1,u}(t)M_{k_{v-1,u}}h_{v-1} + D_{v,u}(t)M_{k_{v,u}}h_{v} \end{bmatrix} h_{u} \left\{ r + \frac{h_{u}}{4} \right\} \end{bmatrix} \psi_{k_{v,u}} \right\},$$

where row { } denotes the row matrix whose k^{th} (k=1,...,K) element stands in between { }. (Note that this element is

G×l matrix), and а

$$M_{k_{b_{v,u}}} = D_{k_{b_{v,u}}}^{-1} \left(A_{k_{b_{v,u}}}^{'} - \frac{F_{k_{b_{v,u}}}}{k_{k}} \right).$$
(5-19)

The column vector $D_{b_{v,u}}(t)M_{k_{v,u}}\psi_{k_{v,u}}$ encountered

in Eq. (5-18) when written explicitly is

(5-20)



The $\underline{C}_{2ik}(t)$ can be presented as

$$\underline{C}_{2ik}(t) = LAP_{ik}(t) = \frac{\pi}{2} \sum_{v=2}^{V-1} \sum_{u=1}^{U-1} \left(W_{il_{v,u}} X_{1k_{v,u}}(t) + W_{i2_{v,u}} X_{2k_{v,u}}(t) + W_{i3_{v,u}} X_{3k_{v,u}}(t) \right),$$

$$(5-21)$$

where the notation $LAP_{ik}(t)$ (cf. laplacian) is introduced with (5-22) X_{1} (t)

$$\begin{split} &= \left\{ \left[\left[\sum_{a_{1_{k_{v-1},u-1}}}^{1_{k_{v-1},u-1}} + \sum_{b_{1_{k_{v-1},u-1}}}^{1_{k_{v-1},u-1}} - \frac{\sum_{k_{v-1},u-1}^{1_{k_{v-1},u-1}}^{1_{k_{v-1},u-1}} \right]^{COEF} \sum_{k_{v-1},u-1}^{1_{v-1}} (t)h_{v-1} \right. \\ &+ \left[\sum_{a_{1_{k_{v-1},u}}}^{1_{k_{v-1},u-1}} + \sum_{b_{2_{1_{k_{v-1},u}}}}^{1_{k_{v-1},u-1}} - \frac{\sum_{k_{v-1},u}^{1_{k_{v-1},u}}}{1_{k_{v}}} \right]^{COEF} \sum_{k_{v-1},u}^{1_{k_{v-1},u-1}} (t)h_{v-1} \\ &+ \left[\sum_{a_{1_{k_{v-1},u}}}^{1_{k_{v-1},u}} + \sum_{b_{2_{1_{k_{v-1},u}}}}^{1_{k_{v-1},u}} - \frac{\sum_{k_{v-1},u}^{1_{k_{v-1},u}}}{1_{k_{v}}} \right]^{COEF} \sum_{k_{v-1},u}^{1_{k_{v-1},u}} (t)h_{v-1} \\ &+ \left[\sum_{a_{1_{k_{v,u}}}}^{1_{k_{v-1},u}} + \sum_{b_{2_{1_{k_{v,u}}}}}^{1_{k_{v-1},u}} - \frac{\sum_{k_{v,u}}^{1_{k_{v-1},u}}}{1_{k_{v},u}} \right]^{COEF} \sum_{k_{v-1},u}^{1_{k_{v-1},u}} (t)h_{v} \\ &+ \left[\sum_{a_{1_{k_{v,u}}}}^{1_{k_{v-1},u}} + \sum_{b_{2_{1_{k_{v,u}}}}}^{1_{k_{v,u}}} - \frac{\sum_{k_{v,u}}^{1_{k_{v,u}}}}{1_{k_{v},u}} \right]^{COEF} \sum_{k_{v,u}}^{1_{k_{v-1},u}} (t)h_{v} \\ &+ \left[\sum_{a_{1_{k_{v,u}}}}^{1_{k_{v-1},u}} + \sum_{b_{2_{1_{k_{v,u}}}}}^{1_{k_{v-1},u}}} + \sum_{b_{2_{1_{k_{v,u}}}}}^{1_{k_{v,u}}} \right]^{COEF} \sum_{k_{v,u}}^{1_{k_{v-1},u}} (t)h_{v} \\ &+ \left[\sum_{a_{1_{k_{v,u}}}}^{1_{k_{v,u}}} + \sum_{b_{2_{1_{k_{v,u}}}}}^{1_{k_{v,u}}} - \frac{\sum_{b_{1_{k_{v,u}}}}^{1_{k_{v,u}}}}{1_{k_{v,u}}} \right]^{COEF} \sum_{k_{v,u}}^{1_{k_{v,u}}} (t)h_{v} \\ &+ \left[\sum_{a_{1_{k_{v,u}}}}^{1_{k_{v,u}}} + \sum_{b_{2_{1_{k_{v,u}}}}}^{1_{k_{v,u}}} + \sum_{b_{2_{1_{k_{v,u}}}}}^{1_{k_{v,u}}} + \sum_{b_{2_{1_{k_{v,u}}}}}^{1_{k_{v,u}}} \right]^{COEF} \sum_{k_{v,u}}^{1_{k_{v,u}}} (t)h_{v} \\ &+ \left[\sum_{b_{1_{k_{v,u}}}}^{1_{k_{v,u}}} + \sum_{b_{1_{k_{v,u}}}}^{1_{k_{v,u}}} + \sum_{b_{1_{k_{v,u}}}}^{1_{k_{v,u}}} + \sum_{b_{1_{k_{v,u}}}}^{1_{k_{v,u}}} \right]^{COEF} \sum_{b_{1_{k_{v,u}}}}^{1_{k_{v,u}}} \\ &+ \left[\left[\sum_{b_{1_{k_{v,u}}}}^{1_{k_{v,u}}} + \sum_{b_{1_{k_{v,u}}}^{1_{k_{v,u}}}} + \sum_{b_{1_{k_{v,u}}}}^{1_{k_{v,u}}} + \sum_{b_{1_{k_{v,u}}}^{1_{k_{v,u}}} \right]^{COEF} \sum_{b_{1_{k_{v,u}}}}^{1_{k_{v,u}}} \\ &+ \left[\left[\sum_{b_{1_{k_{v,u}}}}^{1_{k_{v,u}}} + \sum_{b_{1_{k_{v,u}}}^{1_{k_{v,u}}} + \sum_{b_{1_{k_{v,u}}}^{1_{k_{v,u}}}} \right]^{COEF} \sum_{b_{1_{k_{v,u}}}^{1_{k_{$$

(equation continued on next page)

(5-22 cont.)



where



78 (5-24) X_{2k}(t) $= -\left[\left(\sum_{k_{v-1}, u-1}^{\text{COEF}_{2}} (t)h_{v-1} + \sum_{k_{v}, u-1}^{\text{COEF}_{2}} (t)h_{v} \right) \right]$ $h_{u-1}\left(r-\frac{h_{u-1}}{4}\right) + \left(\sum_{i=1}^{L} \frac{\operatorname{COEF}_{2}(t)h_{v-1} + \sum_{i=1}^{L} \operatorname{COEF}_{2}(t)h_{v}}{k_{v,u} + \sum_{i=1}^{L} \operatorname{COEF}_{2}(t)h_{v}}\right)$ $h_{u}\left(r+\frac{h_{u}}{4}\right)\psi_{1_{k_{v,u}}} + \left\{\left|\left(\sum_{a_{2_{k_{v-1,u-1}}}} + \sum_{32_{k_{v-1,u-1}}}\right)COEF_{2_{k_{v-1,u-1}}}(t)h_{v-1}\right.\right|\right\}\right\}$ + $\begin{pmatrix} \Sigma_{a_{2_{k_{v,u-1}}}} + \Sigma_{\overline{3}_{2_{k_{v,u-1}}}} \end{pmatrix}^{\text{COEF}_{2_{k_{v-1,u-1}}}} (t)h_{v} h_{u-1} \left(r - \frac{h_{u-1}}{4}\right)$ + $\left[\begin{bmatrix} \Sigma_{a_{2_{k_{v-1},u}}} + \Sigma_{3_{2_{k_{v-1},u}}} \end{bmatrix}^{\text{COEF}_{2_{k_{v-1},u}}} \right]^{\text{COEF}_{2_{k_{v-1},u}}}$ + $\begin{pmatrix} \Sigma_{a_{2_{k_{v,u}}}} + \Sigma_{3_{k_{v,u}}} \end{pmatrix}^{\text{COEF}_{2_{k_{v,u}}}}(t)h_{v} h_{u} \begin{pmatrix} h_{u} \\ r + \frac{h_{u}}{4} \end{pmatrix} \end{pmatrix}^{\psi_{2_{k_{v,u}}}}$

and,

79 (5–25)

$$\begin{split} & x_{3k_{\mathbf{v},\mathbf{u}}}^{(t)} \\ &= - \left[\left[\sum_{\frac{1}{2} 2_{k_{\mathbf{v}-1},\mathbf{u}-1}^{COEF} 3_{k_{\mathbf{v}-1},\mathbf{u}-1}^{COEF} (t)h_{\mathbf{v}-1}^{(t)} + \sum_{\frac{1}{2} 2_{k_{\mathbf{v},\mathbf{u}-1}}^{COEF} 3_{k_{\mathbf{v},\mathbf{u}-1}}^{(t)}(t)h_{\mathbf{v}}^{(t)} \right] \\ & h_{u-1} \left[r - \frac{h_{u-1}}{4} \right] + \left[\sum_{\frac{1}{2} 2_{k_{\mathbf{v}-1},\mathbf{u}}^{COEF} 3_{k_{\mathbf{v}-1},\mathbf{u}}^{(t)}(t)h_{\mathbf{v}-1}^{(t)} + \sum_{\frac{1}{2} 2_{k_{\mathbf{v},\mathbf{u}}}^{COEF} 3_{k_{\mathbf{v},\mathbf{u}}}^{(t)}(t)h_{\mathbf{v}}^{(t)} \right] \\ & h_{u} \left[r + \frac{h_{u}}{4} \right] \right] \psi_{2_{k_{\mathbf{v},u}}}^{(t)} + \left[\left[\sum_{\frac{1}{3} 2_{k_{\mathbf{v}-1},\mathbf{u}-1}^{COEF} 3_{k_{\mathbf{v}-1},\mathbf{u}-1}^{(t)}(t)h_{\mathbf{v}-1}^{(t)}(t)h_{\mathbf{v}-1}^{(t)} + \sum_{\frac{1}{3} 3_{k_{\mathbf{v},u-1}}^{(t)}(t)h_{\mathbf{v}}^{(t)}(t)h_{\mathbf{v}}^{(t)} + \sum_{\frac{1}{4} 3_{k_{\mathbf{v},u}-1}^{(t)}(t)h_{\mathbf{v}}^{(t)} + \sum_{\frac{1}{4} 3_{k_{\mathbf{v},u}}^{(t)}(t)h_{\mathbf{v}}^{(t)} + \sum_{\frac{1}{4} 3_{k_{\mathbf{v},u}-1}^{(t)}(t)h_{\mathbf{v}}^{(t)} + \sum_{\frac{1}{4} 3_{k_{\mathbf{v},u}}^{(t)}(t)h_{\mathbf{v}}^{(t)} + \sum_{\frac{1}{4} 3_{k_{\mathbf{v},u}}^{(t)}(t)h_{\mathbf{v},u}^$$

5-3 A different approach to the leakage integral for a special case

The indirect method just described avoids the use of the finite difference technique to determine the laplacian part of \underline{C}_{2ik} (t). However, a direct approach to the leakage integral is necessary when we want to compute k_k , the eigenvalue of the balance equation for Ψ_k (cf. Eq. (4-18)). That quantity was assumed to be known in the course of the previous section.

Thus we want to compute

$$\underline{\mathbf{L}}_{\mathbf{k}} = \int_{\mathbf{V}_{1}, \text{reactor}} d\mathbf{r} \quad \mathbf{W}_{1}^{\mathrm{T}}(\underline{\mathbf{r}}) \nabla \cdot \mathbf{D}_{\mathbf{k}}(\underline{\mathbf{r}}) \psi_{\mathbf{k}}(\underline{\mathbf{r}}).$$
(5-26)

With the help of Fig. 5-1, Eq. (5-26) can be written

as

$$\underline{\mathbf{L}}_{\mathbf{k}} = \sum_{\mathbf{v}=2}^{\mathbf{V}-1} \sum_{u=1}^{\mathbf{U}-1} W_{\mathbf{1}}^{\mathrm{T}} \left[\mathbf{D}_{\mathbf{k}} \mathbf{v}_{\mathbf{1}}, u-1 \right]^{2\pi} \int_{\mathbf{V}_{\mathbf{1}}} r dr \int_{\mathbf{V}_{\mathbf{1}}} dz \, \nabla \cdot \nabla \psi_{\mathbf{k}}(\mathbf{r}, z) \right]$$

+
$$D_{k_{v-1},u}^{2\pi} \int_{V_2}^{rdr} \int_{V_2}^{dz \nabla \cdot \nabla \psi_k(r,z)}$$

+
$$D_{k_{v,u-1}}^{2\pi} \int_{V_3}^{rdr} \int_{V_3}^{dz \nabla \cdot \nabla \psi_k(r,z)}$$

+
$$D_{k_{v,u}}^{2\pi} \int_{V_{4}}^{rdr} \int_{V_{4}}^{dz \nabla \cdot \nabla \psi_{k}(r,z)}$$

By the divergence theorem the integrals in Eq. (5-27) can be reduced to surface integrals of $\frac{\partial \Psi_k}{\partial n}(\mathbf{r},z)$ (the derivative of $\Psi_k(\mathbf{r},z)$ in the direction of outward normal to the surface) over the six surfaces which enclose the equivalent mesh volume.

Making this transformation on, for instance, the second integral in Eq. (5-27) yields

$$2\pi \int_{V_2}^{rdr} \int_{V_2}^{dz} \nabla . \nabla \psi(\mathbf{r}, z)$$
(5-28)
=
$$\int_{S_1} \frac{\partial \psi(\mathbf{r}, z)}{\partial n} dS + \int_{S_2} \frac{\partial \psi(\mathbf{r}, z)}{\partial n} dS + \int_{S_9} \frac{\partial \psi(\mathbf{r}, z)}{\partial n} dS$$

+
$$\int_{S_{10}} \frac{\partial \psi(\mathbf{r}, z)}{\partial n} dS.$$

Since the neutron current, $D_{g_k}(r,z) = \frac{\psi \partial_{g_k}(r,z)}{\partial n}$ is

assumed to be continuous across interfaces, the surface integrals over the common surfaces to the submesh volumes cancel when the four expressions similar to Eq. (5-28) are added. Then Eq. (5-27) becomes,

(5-29)

$$\underline{\underline{L}}_{k} = \sum_{v=2}^{V-1} \sum_{u=1}^{U-1} W_{1v,u}^{T} \left(\underbrace{\underline{D}_{kv-1,u}}_{v-1,u} \underbrace{\sum_{b=1}^{2}}_{S_{b}} \int_{S_{b}} \frac{\frac{\partial \psi_{k}(r,z)}{\partial n}}{dS} \right) dS$$

$$+ \underbrace{\underline{D}_{kv-1,u-1}}_{v-1,u-1} \underbrace{\sum_{b=3}^{4}}_{S_{b}} \int_{S_{b}} \frac{\frac{\partial \psi_{k}(r,z)}{\partial n}}{dS} dS + \underbrace{\underline{D}_{kv,u-1}}_{v,u-1} \underbrace{\sum_{b=5}^{6}}_{S_{b}} \int_{S_{b}} \frac{\frac{\partial \psi_{k}(r,z)}{\partial n}}{\partial n} dS$$

(equation continued on next page)

+
$$D_{k_{v,u}} \sum_{b=7}^{8} \int_{S_{b}} \frac{\partial \psi_{k}(r,z)}{\partial n} dS$$
. (5-29)
cont.

Next we let \underline{I}_{p_k} stand for $\int_{S_p} \frac{\partial \psi_k(r,z)}{\partial n} dS$ and note that

$$\underline{I}_{k} = \frac{\Psi_{k} - \Psi_{k}}{h_{u}} \Delta \theta \frac{h_{v-1}}{2} \left(r + \frac{u}{2} \right), \quad (k=1,2), \quad (5-30)$$

$$\underline{I}_{2_{k}} = \frac{\Psi_{k_{v-1,u}} - \Psi_{k_{v,u}}}{h_{v-1}} \Delta \theta \frac{h_{u}}{2} \left(\frac{h_{u}}{4} \right), \quad (k=1,2), \quad (5-31)$$

$$\underline{I}_{3_{k}} = \frac{\Psi_{k_{v-1,u}} - \Psi_{k_{v,u}}}{h_{v-1}} \Delta \theta \frac{h_{u-1}}{2} \left(r - \frac{h_{u-1}}{4} \right), (k=1,2), \quad (5-32)$$

$$\underline{I}_{4_{k}} = \frac{\psi_{k_{v,u-1}} - \psi_{k_{v,u}}}{h_{u-1}} \Delta \theta \frac{h_{v-1}}{2} \left(r - \frac{h_{u-1}}{2} \right), (k=1,2), \quad (5-33)$$

$$\underline{I}_{5_{k}} = \frac{\Psi_{k_{v,u-1}} - \Psi_{k_{v,u}}}{h_{u-1}} \Delta \theta \frac{h_{v}}{2} \left(r - \frac{h_{u-1}}{2} \right), \quad (k=1,2), \quad (5-34)$$

$$\underline{I}_{6_{k}} = \frac{\psi_{k_{v+1,u}} - \psi_{k_{v,u}}}{h_{v}} \Delta \theta \frac{h_{u-1}}{2} \left(r - \frac{h_{u-1}}{4} \right), (k=1,2), \quad (5-35)$$

$$\underline{I}_{7_{k}} = \frac{\psi_{k}}{h_{v}} \Delta \theta \frac{h_{u}}{h_{v}} \left(\frac{h_{u}}{4} \right), \quad (k=1,2), \quad (5-36)$$

$$\underline{I}_{8_{k}} = \frac{\psi_{k_{v,u+1}} - \psi_{k_{v,u}}}{h_{u}} \qquad \frac{h_{v}}{2} \left(r + \frac{h_{u}}{2} \right), \quad (k=1,2). \quad (5-37)$$

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Inserting Equations (5-30) up to (5-37) into Eq. (5-27) and integrating over the angle (θ from 0 to 2π) one gets (5-38)

$$\underline{\mathbf{L}}_{\mathbf{k}} = \sum_{\mathbf{v}=2}^{\mathbf{V}-1} \sum_{u=1}^{\mathbf{U}-1} W_{\mathbf{1}}^{\mathrm{T}} \left\{ \frac{\psi_{\mathbf{k}_{\mathbf{v},u+1}}}{h_{u}} \left(D_{\mathbf{k}_{\mathbf{v}-1,u}} h_{\mathbf{v}-1} + D_{\mathbf{k}_{\mathbf{v},u}} h_{\mathbf{v}} \right) \left(\frac{h_{u}}{2} \right) \right\}$$

$$+ \frac{\Psi_{k_{v-1,u}}}{h_{v-1}} \left[D_{k_{v-1,u}} h_{u} \left(r + \frac{h_{u}}{4} \right) + D_{k_{v-1,u-1}} h_{u-1} \left(r - \frac{h_{u-1}}{4} \right) \right]$$

$$+ \frac{\psi_{k_{v,u-1}}}{h_{u-1}} \left(D_{k_{v-1,u-1}} h_{v-1} + D_{k_{v,u-1}} h_{v} \right) \left(\frac{h_{u-1}}{2} \right)$$

$$+ \frac{\psi_{k_{v+1,u}}}{h_{v}} \left(D_{k_{v,u-1}} h_{u-1} \left(r - \frac{h_{u-1}}{4} \right) + D_{k_{v,u}} h_{v} \left(r + \frac{h_{u}}{4} \right) \right)$$

(

$$-\psi_{k_{v,u}}\left(\left[\begin{array}{c} D_{k_{v-1,u}}h_{v-1} + D_{k_{v,u}}h_{v}\\ + D_{k_{v,u}}u\end{array}\right]\frac{1}{h_{u}}\left[\begin{array}{c} h_{u}\\ + \frac{h_{u}}{2}\\ + \end{array}\right] + \left[\begin{array}{c} D_{k_{v-1,u}}h_{v}\left[\begin{array}{c} h_{u}\\ + \frac{h_{u}}{4}\\ + \end{array}\right]\right]$$

+
$$D_{k_{v-1,u-1}} h_{u-1} \left(r - \frac{h_{u-1}}{4} \right) \frac{1}{h_{v-1}} + \left(D_{k_{v-1,u-1}} h_{v-1} + D_{k_{v,u-1}} h_{v} \right) \times$$

(equation continued on next page)

$$\times \frac{1}{h_{u-1}} \left(r - \frac{h_{u-1}}{2} \right) \left(D_{k_{v,u-1}} h_{u-1} \left(r - \frac{h_{u-1}}{4} \right) + D_{k_{v,u}} h_{u} \left(r + \frac{h_{u}}{4} \right) \right) \frac{1}{h_{v}} \right) \right\} \cdot \frac{1}{h_{v}}$$

This method of evaluating the leakage integral has not been used to calculate $\underline{C}_2(t)$ because we cannot insure that it is valid to write relationships such as

$$D_{g_{k}}^{L}(r,z,t) \frac{\partial \psi_{gk}(r,z)}{\partial n} = D_{g_{k}}^{R}(r,z,t) \frac{\partial \psi_{gk}}{\partial n}$$
(5-39)

with L and R indicating the left and right hand sides of an interface, respectively, and n being either r or z.

Whereas with a diffusion coefficient belonging to the space function in question, an equation like Eq. (5-39) is true, it will not in general hold for any other diffusion coefficient. Hence we had to work out the method described in the previous section.

5-4 Computation of k_k

The calculation of $\underline{C}_2(t)$ cannot be completed unless k_k is known. For this purpose, besides the leakage integral [Eq. (5-38)] we need the fission and absorption integrals. These quantities are given by

$$\begin{split} \underline{\mathbf{F}}_{\mathbf{k}} &= \frac{\pi}{2} \sum_{\mathbf{v}} \sum_{\mathbf{u}} w_{11_{\mathbf{v},\mathbf{u}}} \sqrt{\left\{ \left[\left[\sum_{\mathbf{F}_{1k_{\mathbf{v}-1},\mathbf{u}-1}^{\mathbf{h}_{\mathbf{v}-1} + \sum_{\mathbf{F}_{1k_{\mathbf{v},\mathbf{u}-1}}^{\mathbf{h}_{\mathbf{v}-1} + \sum_{\mathbf{F}_{1k_{\mathbf{v},\mathbf{u}-1}}^{\mathbf{h}_{\mathbf{v}-1} + \sum_{\mathbf{F}_{1k_{\mathbf{v},\mathbf{u}-1}}^{\mathbf{h}_{\mathbf{v}-1} + \sum_{\mathbf{F}_{1k_{\mathbf{v},\mathbf{u}-1}}^{\mathbf{h}_{\mathbf{v}-1} + \sum_{\mathbf{F}_{1k_{\mathbf{v},\mathbf{u}}}^{\mathbf{h}_{\mathbf{v}}} \right] h_{\mathbf{u}} \left[\mathbf{r} + \frac{h_{\mathbf{u}}}{4} \right] \right] \psi_{1k_{\mathbf{v},\mathbf{u}}}} \\ &+ \left[\left[\sum_{\mathbf{F}_{2k_{\mathbf{v}-1},\mathbf{u}-1}^{\mathbf{h}_{\mathbf{v}-1} + \sum_{\mathbf{F}_{2k_{\mathbf{v},\mathbf{u}-1}}}^{\mathbf{h}_{\mathbf{v}}} \right] h_{\mathbf{u}} \left[\mathbf{r} - \frac{h_{\mathbf{u}-1}}{4} \right] \right] \\ &+ \left[\sum_{\mathbf{F}_{2k_{\mathbf{v}-1},\mathbf{u}-1}}^{\mathbf{h}_{\mathbf{v}-1} + \sum_{\mathbf{F}_{2k_{\mathbf{v},\mathbf{u}-1}}}^{\mathbf{h}_{\mathbf{v}}} \right] h_{\mathbf{u}} \left[\mathbf{r} + \frac{h_{\mathbf{u}}}{4} \right] \right] \psi_{2k_{\mathbf{v},\mathbf{u}}}} \\ &+ \left[\left[\sum_{\mathbf{F}_{3k_{\mathbf{v}-1},\mathbf{u}-1}}^{\mathbf{h}_{\mathbf{v}-1} + \sum_{\mathbf{F}_{3k_{\mathbf{v},\mathbf{u}-1}}}^{\mathbf{h}_{\mathbf{v}}} \right] h_{\mathbf{u}} \left[\mathbf{r} - \frac{h_{\mathbf{u}-1}}{4} \right] \\ &+ \left[\sum_{\mathbf{F}_{3k_{\mathbf{v}-1},\mathbf{u}-1}}^{\mathbf{h}_{\mathbf{v}-1} + \sum_{\mathbf{F}_{3k_{\mathbf{v},\mathbf{u}-1}}}^{\mathbf{h}_{\mathbf{v}}} \right] h_{\mathbf{u}} \left[\mathbf{r} - \frac{h_{\mathbf{u}-1}}{4} \right] \\ &+ \left[\sum_{\mathbf{F}_{3k_{\mathbf{v}-1},\mathbf{u}-1}}^{\mathbf{h}_{\mathbf{v}-1} + \sum_{\mathbf{F}_{3k_{\mathbf{v},\mathbf{u}-1}}}^{\mathbf{h}_{\mathbf{v}}} \right] h_{\mathbf{u}} \left[\mathbf{r} - \frac{h_{\mathbf{u}-1}}{4} \right] \right] \\ &+ \left[\sum_{\mathbf{F}_{3k_{\mathbf{v}-1},\mathbf{u}}}^{\mathbf{h}_{\mathbf{v}-1} + \sum_{\mathbf{F}_{3k_{\mathbf{v},\mathbf{u}}}}^{\mathbf{h}_{\mathbf{v}}}} \right] h_{\mathbf{u}} \left[\mathbf{r} + \frac{h_{\mathbf{u}}}{4} \right] \right] \psi_{3k_{\mathbf{v},\mathbf{u}}}} \right], \quad (5-40)$$

 $\underline{\mathbf{A}} = \frac{\pi}{2} \sum_{\mathbf{v}=2}^{\mathbf{V}-1} \sum_{\mathbf{u}=2}^{\mathbf{U}-1} \left(\mathbb{W}_{11_{\mathbf{v},\mathbf{u}}} \mathbb{Z}_{1k_{\mathbf{v},\mathbf{u}}} \mathbb{W}_{12_{\mathbf{v},\mathbf{u}}} \mathbb{Z}_{2k_{\mathbf{v},\mathbf{u}}} \mathbb{W}_{13_{\mathbf{v},\mathbf{u}}} \mathbb{Z}_{3k_{\mathbf{v},\mathbf{u}}} \right)$

(5-41)

where $Z_{1k_{v,u}}$, $Z_{2k_{v,u}}$, and $Z_{3k_{v,u}}$ can be found from

Equations (5-23), (5-24), and (5-25) by taking out the terms involving the fission cross sections, omitting

 $\operatorname{COEF}_{g_{k_{h}}}$'s and changing the signs.

Finally we have

$$k_{k} = \frac{\underline{F}_{k}}{\underline{A}_{k} - \underline{L}_{k}} \qquad (5-42)$$

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5-5 Final expressions for the parameters Λ , $\rho(t)$, $\overline{\beta}_{j(t)}_{new}$

Using the final integral expressions found for Λ , p(t), and $\overline{\beta}_{j(t)}$'s in Chapter III, and Equations (5-12) new and (5-21), one obtains

$$\Lambda_{ik} = \frac{\pi}{2} \sum_{v=2}^{V-1} \sum_{u=1}^{U-1} \left(\sum_{g=1}^{G} W_{ig_{v,u}} V_{g}^{-1} \psi_{kg_{v,u}} \right) \left[\left(h_{v-1} + h_{v} \right) h_{u-1} \left(r - \frac{h_{u-1}}{4} \right) + \left(h_{v-1} + h_{v} \right) h_{u} \left(r + \frac{h_{u}}{4} \right) \right],$$

 $\rho(t) = PPR_{ik}(t) + LAP_{ik}(t) + FMA_{ik}(t) + DPR_{ik}(t), \quad (5-44)$ new_{ik}

where the prompt photoneutron reactivity matrix is defined by its ith row, kth column element;

$$\begin{split} & \text{PPR}_{1k}(t) & (5-45) \\ & = \frac{\pi}{2} \sum_{re=1}^{\text{RE}} \text{ATT}_{re} \sum_{v} \sum_{u} \sum_{u} W_{11v,u} \begin{cases} \sum_{v=1}^{L} \sum_{v=1}^{L} e^{-h_{u-1}} e^{-h_{u$$

RE being the number of regions in the reflector, each coupled with a constant attenuation factor for photons to simplify the computation. That is, ATT_{re} replaces

 $\frac{1}{4\pi(r^2+z^2)} e^{-\Sigma_{\ell}(r^2+z^2)^{\overline{2}}}$ within the reth region (cf. Appendix H); and

$$\operatorname{SGCS}_{gl_{v,u}}(t) = \sum_{f=1}^{3} \Sigma_{f_{gv,u}}(t) \prod_{flg}^{n}; \qquad (5-46)$$

where n stands for the nuclei n present at (v,u). The computation of $LAP_{ik}(t)$ is described in Section 5-2 above; and $FMA_{ik}(t)$ can be found from the expression for $LAP_{ik}(t)$ by omitting $COEF_{g_k}$'s and the dependency

of the cross sections on k, making the cross sections time-dependent and changing all the signs.

The delayed photoneutron reactivity matrix is defined by its ith row, kth column element;

$$DPR_{ik}(t) = \sum_{j=J+1}^{H} \overline{\beta}_{jnew_{ik}}(t) , \qquad (5-47)$$

with

<mark>89</mark> (5-48)

$$\overline{\beta}_{j(t)} = \frac{\pi}{2} y_{j} N_{0} \sum_{re=1}^{RE} ATT_{re} \sum_{v u} \sum_{u}^{W_{il}} y_{iu} \begin{cases} L \\ \sum_{l=1}^{V} y_{l} \\ v u \end{cases}$$
over the reflector

$$\left\{ \left[\sum_{v=1,u=1}^{v} (t)h_{v-1} + \sum_{v,u=1}^{v} (t)h_{v} \right] h_{u-1} \left[r - \frac{h_{u-1}}{4} \right] \right\}$$

$$+ \left[\sum_{v=1,u=1}^{v} (t)h_{v-1} + \sum_{v,u=1}^{v} (t)h_{v} \right] h_{u} \left[r + \frac{h_{u}}{4} \right] \right]$$

$$\times \frac{\pi}{2} \sum_{v=u}^{v} \sum_{u} \left[\sum_{g=1}^{G} \sqrt{\left(\sum_{g=1}^{v} \left(\sum_{v=1,u=1}^{v} (t)h_{v-1} + \sum_{g_{v-1,u=1}}^{v} (t)h_{v-1} + \sum_{g_{v,u=1}}^{v} (t)h_{v} \right] h_{u-1} \left[r - \frac{h_{u-1}}{4} \right] + \left[\sum_{g=1,u=1}^{v} (t)h_{v-1} + \sum_{g_{v,u=1}}^{v} (t)h_{v} \right] h_{u} \left[r + \frac{h_{u}}{4} \right] \right] \psi_{gk_{v,u}} \right\}, (j = (g+1), \dots, H).$$

We finally have,

(5-49)

$$\overline{\beta}_{j}(t) = \overline{\beta}_{j} \frac{\pi}{2} \sum_{v u} \sum_{u u v} \left[\int_{v, u} \sum_{v u v} \int_{v, u} \left[\int_{v-1, u-1} \sum_{v-1, u-1} \int_{v-1} \int_{v-1}$$

(equation continued on next page)

90 (5-49 cont.)

$$+ \Sigma_{F_{1_{v,u-1}}(t)h_{v}}h_{u-1}\left(r-\frac{h_{u-1}}{4}\right) + \left(\Sigma_{F_{1_{v-1,u}}(t)h_{v-1}}\right) + \Sigma_{F_{1_{v,u}}(t)h_{v}}h_{u}\left(r+\frac{h_{u}}{4}\right) \psi_{1k_{v,u}} + \left(\left[\Sigma_{F_{2_{v-1,u-1}}(t)h_{v-1}}\right] + \Sigma_{F_{2_{v,u-1}}(t)h_{v}}h_{u-1}\left(r-\frac{h_{u-1}}{4}\right) + \left(\Sigma_{F_{2_{v-1,u}}(t)h_{v-1}}\right) + \Sigma_{F_{2_{v,u-1}}(t)h_{v}}h_{u}\left(r+\frac{h_{u}}{4}\right) \psi_{2k_{v,u}} + \left(\left[\Sigma_{F_{3_{v-1,u-1}}(t)h_{v-1}}\right] + \Sigma_{F_{3_{v,u-1}}(t)h_{v}}h_{u-1}\left(r-\frac{h_{u-1}}{4}\right) + \left(\Sigma_{F_{3_{v-1,u-1}}(t)h_{v-1}}\right) + \Sigma_{F_{3_{v,u-1}}(t)h_{v}}h_{u-1}\left(r-\frac{h_{u-1}}{4}\right) + \left(\Sigma_{F_{3_{v-1,u-1}}(t)h_{v-1}}\right) + \Sigma_{F_{3_{v,u-1}}(t)h_{v}}h_{u}\left(r+\frac{h_{u}}{4}\right) \psi_{3k}, (j = 1, ..., j).$$

5-6 Computation of k_{OZAN}^* for $\rho_{new_{11}}(0)$

For clarity assume we have only one expansion mode (point kinetics case) that is composed of the steady state shape of the reactor and the reactor is critical. Had then $\rho_{new_{11}}$ [Eq.(5-^h4)] failed to vanish, the time-dependent

* OZAN is the name of the computer code written to perform calculations required by the present work.

equations will predict a change in the power level that must remain constant. To remedy this erroneous behavior we shall compute a quantity k_{OZAN} that divides the fission integral in Eq. (5-44), and insures that $\rho_{new_{11}}(0) = 0$. Thus if the reactor is critical at the beginning of the transient we define

$$\kappa_{\text{OZAN}} = \frac{F_{11}(0)}{A_{11}(0) - [LAP_{11}(0) + PPR_{11}(0) + DPR_{11}(0)]}$$
(5-50)

with

 $\Sigma_{F_1}(\underline{r})$

k_{OZAN}

$$F_{11}(t) - A_{11}(t) = FMA_{11}(t).$$
 (5-51)

Note that in case the photoneutrons are neglected $k_{OZAN} \equiv k_1$ [cf. Eq. (4-18)].

We point out that while k (k = 1,2) was introduced k to make use of the balance equation furnishing $\psi_k(\underline{r})$ in order to compute LAP_{ik}(t) [Eq. (5-21)], k_{OZAN} is physically the eigenvalue of the reactor (at t = 0), computed in an integral sense. Hence the fission cross sections of the critical reactor are supposed to be equal to 5-7 Representation of the time dependency of the parameters $\rho_{new}(t)$ and $\overline{\beta}_{j_{new}}(t)$'s

The solution to the system of equations for the time coefficients will require analytical representations for the parameters $\rho_{new}(t)$ and $\overline{\beta}_{jnew}(t)$'s. For this jnew purpose we shall assume that throughout the transient

$$\rho_{new}(t) = \rho_{new}(0) + \rho_{l}t,$$
(5-52)

$$\overline{\beta}_{j_{new}}(t) = \overline{\beta}_{j_{new}}(0) + \overline{\beta}_{j_1}t, (j = 1, ..., H), (5-53)$$

where $\rho_{new}(0)$ and $\overline{\beta}_{j_{new}}(0)$ are the initial values of

 $\rho_{new}(t)$ and $\overline{\beta}_{j_{new}}(t)$, and

$$\rho_{1} = \frac{\rho_{\text{new}}(T) - \rho_{\text{new}}(0)}{T}, \qquad (5-54)$$

$$\overline{\beta}_{j_{1}} = \frac{\overline{\beta}_{j_{\text{new}}}(T) - \overline{\beta}_{j_{\text{new}}}(0)}{T}, \qquad (5-55)$$

where T in seconds is the duration of the transient beginning at t = 0.

5-8 Summary

In this chapter we have developed a method for computing various parameters appearing in the equations for the unknown time coefficients. For this purpose a finite difference technique is used in keeping with the way the spatial functions are computed.

The leakage part of the reactivity matrix requires a special treatment since the time-dependent diffusion coefficient in the desired integral is not the one associated with the expansion modes and the continuity condition across interfaces fails. This procedure, however, requires knowing the eigenvalue that balances the equation from which the trial mode is generated. In calculating this eigenvalue we were able to use a direct way of attacking the leakage integral.

If the reactor was critical at the beginning of the transient and the photoneutrons were felt to be significant, it was then necessary to introduce an eigenvalue k_{OZAN} so that the initial value of the first element of the reactivity matrix vanishes. Thus k_{OZAN} is the eigenvalue of the reactor (at t = 0).

CHAPTER VI

A PROBLEM HANDLED BY THE PROPOSED METHOD

To compare the proposed synthesis method (use of two spatial modes in the expansion of the space and time dependent flux) with the point kinetics type of approach (use of only one spatial mode for the same expansion), we have considered the following problem:

The MITR-II operator looses control on the shim rods during the start up of the reactor. It is assumed that all six shim blades begin moving out at once rather than the usual operation of a single blade at a time. - It is worthwhile to mention that this is a very improbable accident, involving a simultaneous short circuit of six contacts. - That is the bank of shim rods starts from its shutdown position - corresponding to a -0.12 of reactivity (we will further clarify what we mean by the word "reactivity") - going up with a constant insertion rate, 0.003 in reactivity per sec. (that notion of ramp insertion of reactivity will also be further clarified).

The bank continues going up until the reactor reaches the power level of 6 MW (assuming even further that the high rate-of-rise shut down system does not operate). Once the powermeter reads 6 MW, the shim rods receive automatically the order to scram. However there is a delay of 0.1 sec. due to the instrumentation. That is from 6 MW on the power level will continue to increase for 0.1 second more. The question is: What will be the maximum power level of the reactor during this incident?

6-1 Further Theoretical Preparations

There are a number of hidden difficulties, that we must overcome to be able to attack the problem by our proposed method. All of these difficulties, except one, are due to the fact that the reactor is subcritical at the beginning of the transient.

The first difficulty involves the fact that we need an external source to start up the reactor. Yet nowhere in the course of the development of the proposed method have we taken into account an external source.

> 6-1-1 Overcoming the Difficulty Due to the Presence of an External Source

Adding an external source term to the diffusion equation (3-1) and carrying out the calculations from there is impractical. Instead we found it easier to describe the source by the activity of a fictitious delayed neutron precursor that has a relatively long half life. The strength of this activity can be computed in the following way: Consider the point kinetics equations with the familiar notation:

$$\frac{dN_{PK}(t)}{dt} = \frac{\rho_{PK}(t) - \beta_{PK}}{\Lambda_{PK}} N_{PK}(t) + \sum_{j=1}^{H} \lambda_j C_{PK_j}(t) + S_{PK},$$
(6-1)

$$\frac{dC_{PK_{j}}(t)}{dt} = \frac{\beta_{PK_{j}}}{\Lambda_{PK}} N_{PK}(t) - \lambda_{j} C_{PK_{j}}(t), (j = 1, ..., H), (6-2)$$

where the subscript PK stands for point kinetics, and everything is a scalar. At this stage the initial reactivity and the constant reactivity insertion we have pointed out above, should be understood merely as two quantities used to determine $\rho_{\rm PK}(t)$ - in case of a ramp change. (We will later consider the way they are obtained.)

We take the time origin at the time the reactor becomes critical with the given motion of the rods (i.e., $-t_g = 40$ sec. after the transient has started; the initial reactivity being -0.12 and the insertion rate 0.003 per sec.). In addition we assume the reactor is at 1 milliwatt power level at the beginning of the transient. That is, 5 MW being the power level of the critical reactor working under normal circumstances, at the start up the power level is,

$$N_{PK}$$
 (t_s) = $\frac{1 \times 10^{-3}}{5 \times 10^{-6}} = 2 \times 10^{-10}$, (6-3)

times smaller than the normal power level (5 MW) of the reactor.

Thus assuming that the reactor is at a steady state with the external source in, prior to the change, we obtain from Eq. (6-2)

$$\frac{\beta_{PK_{j}}}{\Lambda_{PK}} N_{PK}(t_{s}) = \lambda_{j} C_{PK_{j}}(t_{s}), (j = 1, ..., H) .$$
(6-4)

Next with $\frac{dN_{PK}(t)}{dt} \Big|_{t_s} = 0$, Equations (6-4) and

(6-1) yield (for the source, S_{PK} , represented as a fictitious precursor concentration, C_{PK} (t_s), decaying with a time constant, λ_{H+1})

$$S_{PK} \equiv \lambda_{H+1} C_{PK}(H+1) (t_s) = \frac{-\rho_{PK}(t_s)}{\Lambda_{PK}} N_{PK} (t_s)$$
(6-5)

with

$$\beta_{\rm PK} = 0$$
 (6-6)

We can pick λ_{H+1} as small as we want so that

$$C_{PK}(H+1)$$
 (t) = $C_{PK}(H+1)$ (t_s) e ^{$\lambda_{H+1}(t-t_s), (6-7)$}

stays constant throughout the transient. Thus we choose arbitrarily $\lambda_{H+1} = 1 \times 10^{-13} \text{ sec.}^{-1}$.

 $\Lambda_{\rm PK}$ is taken (1.x 10⁻⁴), - as it will be justified later - to be the first row, first column element of the generation time matrix [cf. Eq. (3-44)].

Hence we can compute C_{PK} (t_s) (to be (H+1)

 $\frac{0.12 \times 2 \times 10^{-10}}{1 \times 10^{-4} \times 1 \times 10^{-13}} = 2.4 \times 10^{6}$ and express S_{pK} in terms of the (H+1)th fictitious precursor concentration.

6-1-2 Selection of the First Spatial Mode

A second difficulty arises when we come to choose a spatial shape to describe the flux at the beginning of the transient. The period of time while the reactor is still subcritical - during the transient - is not of interest. Also the computations may be unnecessarily time consuming if we took a look at the transient with the two-shape method starting subcritical. Thus we choose as the first trial mode the flux shape of the critical reactor, and start studying the transient with the two-shape method at the time when the reactor becomes - momentarily - critical under the given accident. That, however, brings up a major difficulty:

Since the reactor is not at a steady state when it becomes critical, how do we compute the precursor concentrations at time t = 0 (-t_s seconds after the transient took off)? This is answered in the next two sections.

6-1-3 Calculation of the Initial Value of the First Precursor Amplitude Function

We need to compute $C_j(0)$'s, j = 1, ..., (H+1), of Eq. (3-45). $C_j(t)$ is a column matrix having two elements in the case of two trial modes. The calculation of the first element will be done in this section whereas we save the calculation of the second element for the next section.

Over the period of time $t_s \leq t \leq 0$, only one trial mode (the flux shape of the critical reactor) is used to describe the flux. Then at t = 0 we can write

$$C_{j_1}(0) = \Lambda_{PK} C_{PK_j}(0), [j = 1,..., (H+1)], (6-8)$$

where $C_{j}(t)$ is the solution of Eq. (3-45), $C_{PK_{j}}$ the solution of Eq. (6-2), and the subscript 1 stands for the first element of the column matrix $C_{j}(0)$.

Thus with Equations (6-3), (6-5), (6-6), (6-8) and $\rho_{PK}(t) = -0.12 + 3 \times 10^{-3} (t-t_s)$, $\Lambda_{PK}(\equiv \Lambda_1) \approx 1. \times 10^{-4}$, the Equations (6-1) and (6-2) will furnish $C_{j_1}(0)$'s. For the purpose of the calculation we have run a points kinetics computer code [18] to find $N_{PK}(0) \equiv N_1(0)$, the factor that multiplies the power level when the reactor becomes - momentarily - critical under the given accident.

We emphasize that while writing the Equation (6-8), we have tacitly assumed that the reactivity $\rho_{PK}(t)$ is the same as $\rho_{new_{11}}(t)$ of Eq. (3-44) for $t_s \leq t \leq 0$. That is, for instance, if we computed the reactivity corresponding to "bank of shim rods completely inserted", through Equations (3-41) and (3-29) we assume we would find -0.12 (the number taken above as the negative reactivity of the shutdown reactor). However this is not necessarily true for that reactivity may be determined through other procedures (weighting by unity instead of a weighting function, taking the relative difference of the eigenvalues of the reactor at the shutdown and critical positions - thus abandoning the perturbation type of calculation where the flux shape of the critical reactor is used alone -, etc.).

Now we turn our attention to the second element of the column matrix $C_{i}(0)$.

6-1-4 Calculation of the Initial Value of the

Second Precursor Amplitude Function

To compute C_j(0), j = 1, ..., (H+1), we recall through Equations (3-42), (3-43), (3-31) and (3-34)

$$C_{j_i}(t) \equiv D_{j_i} = 2\pi \int r dr \int dz \qquad \stackrel{T}{W_i}(r,z) \chi_{j_i} \eta_{j_i}(r,z,t),$$

r, core $\int z$, core

$$(i = 1, 2), (j = 1, ..., J),$$
 (6-9)

$$C_{j_i}(t) \equiv \Theta_{j_i}(t) = 2\pi \int r dr \int dz \quad W_i^T(r,z)$$

r,reflector z,reflector

$$\theta_{j}(r,z,t), (i = 1,2), [j = (J+1),..., H],$$

(6-10)

$$C_{(H+1)_{i}}(t) = s \ 2\pi \int r \ dr \int dz \qquad W_{i}^{T}(r,z) \ \chi, \ (i = 1,2),$$

r, reactor $\int z$, reactor (6-11)

where s is the constant source spread out uniformly throughout the reactor such that

$$\lambda_{H+1} C_{(H+1)} (t_s) = S_{PK} , \qquad (6-12)$$

first mentioned in Eq. (6-1), and χ is defined through Eq. (4-3).

The initial conditions for the undetermined time

coefficients being N(t) = $\begin{pmatrix} 2 \times 10^{-10} \\ 0 \end{pmatrix}$, we find it legitimate to assume;

- At times very close to t = 0 (t > 0), the second shape contributes practically nothing, and, with one shape and one undetermined time coefficient, it is appropriate to write

$$n_{j}$$
 (r,z,t) = M_{j} (r,z) $e^{\omega t}$, (j = 1,..., J), (6-13)

and

$$\theta_{j}$$
 (r,z,t) = T_j(r,z) $e^{\omega t}$, [j = (J+1),..., H],
(6-14)

- ω at times close to t = 0 can be considered independent of t.

Then one can through Equations (3-45), (6-9), (6-10), (6-13) and (6-14), arrive at

$$C_{j_{i}}(t) = C_{j_{i}}(0) e^{\omega t}, (i = 1,2), (j = 1,..., H),$$

(6-15)

where

$$C_{j_{i}}(0) = 2\pi \int_{r, \text{core}} r \, dr \int_{z, \text{core}} dz \quad W_{i}^{T}(r, z) \chi_{j} M_{j}(r, z),$$

(i = 1,2), (j = 1,..., J), (6-16)

$$C_{j_i}(0) = 2\pi \int r dr \int dz \quad W_i^T(r,z) x$$

r, reflector $\int_{z, reflector} W_i^T(r,z) x$

$$T_{j}(r,z), (i = 1,2), [j = (J+1),..., H],$$

(6-17)

and

$$(\omega + \lambda_{j}) C_{j_{i}}(t) = \left(\overline{\beta}_{j_{new}}(t) N(t)\right)_{i} (i = 1, 2),$$

 $(j = 1, ..., H),$ (6-18)

where $C_{j_i}(t)$, (i = 1,2) and $\overline{\beta}_{j_{new}}$ (t)'s, (i = 1,2), were

defined in Chapter III.

Thus taking the ratio of the equation obtained with i = 1, in Eq. (6-18), to the equation obtained with i = 2, in Eq. (6-18), we finally have, near time t = 0

$$\frac{C_{j_{1}}(t)}{C_{j_{2}}(t)} = \frac{\overline{\beta}_{j_{new_{11}}}(t)}{\overline{\beta}_{j_{new_{21}}}(t)}, (j = 1, ..., H).$$
(6-19)

Knowing $C_{j_1}(0)$, $(j = 1, \dots, H)$, we then can com-

pute from Eq. (6-19)

$$C_{j_{2}}(0) = C_{j_{1}}(0) \frac{\overline{\beta}_{j_{new_{21}}}^{(0)}}{\overline{\beta}_{j_{new_{11}}}^{(0)}} \cdot (6-20)$$

The calculation of $C_{(H+1)_2}(0)$ is straightforward

from Eq. (6-11). Taking
$$\chi = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$$
, we have

$$C_{(H+1)_{2}}(0) = C_{(H+1)_{1}}(0) \frac{2\pi \int_{r,reactor} r \, dr}{2\pi \int_{r,reactor} \int_{z,reactor} dz \, W_{11}(r,z)} \frac{2\pi \int_{r,reactor} r \, dr}{\int_{r,reactor} \int_{z,reactor} dz \, W_{11}(r,z)} \frac{2\pi \int_{r,reactor} r \, dr}{\int_{r,reactor} \int_{z,reactor} (6-21)}$$

6-1-5 Determination of the Position of the Bank of Shim Rods at the Time the Signal for Scram is Received

The last difficulty to overcome is how to determine the position of the bank of shim rods at the time the signal for scram is received. We must estimate this position in order to choose the second trial mode for the expansion of the flux (poison search, cf. Chapter IV, section 4-2).

This last question is resolved by using the point kinetics approach. A point kinetics code [18] is applied

in order to determine the time at which $N_{PK}(t)$ [cf. Eqs. (6-1) and (6-2)] is 1.2, that is the time at which the power level reaches a 6 MW (5 x 1.2) level. We then add 0.1 second to find the time, T, at which the bank of shim rod will scram. To determine the bank position at that time T, we write

$$\rho_{PK}(T) = \rho_{PK}(0) + \rho_{1PK} T,$$
(6-22)

with $\rho_{PK}(0) = 0$. and $\rho_{1_{PK}} = 3 \times 10^{-3}$ [The terms in Eq. (6-22) are equal to the corresponding first row, first column elements of the matrix equation (5-52).], Now we consider Fig. 6-1 [19] where for MITR-II the reactivity versus the position of the shim rods bank is shown. Knowing $\rho_{PK}(T)$ permits us to use this figure to determine the approximate position of the shim bank at time T. (One should however keep in mind that, the reactivity appearing in Fig. 6-1 does not exactly correspond to that defined previously. The reactivity of Fig. 6-1 was calculated by computing the eigenvalue of the reactor with the bank of shim rods at different positions; then taking the relative difference $\Delta k/k$ for that position.)

The ramp change slope of the reactivity matrix, ρ_1 [cf. Eq. (5-52)], can be calculated by computing first



Fig. 6-1 The Bank of Shim Rods Worth Curve for MITR-II [19]
$\rho_{new}(0)$, the reactivity matrix at time t = 0 (the time the reactor becomes momentarily critical and we begin studying the transient with the two-trial mode method); next by determining the reactivity matrix at time T, through the integral expression for reactivity formulated in Chapter III, and finally by writing

$$\rho_1 = \frac{\rho_{\text{new}}(T) - \rho_{\text{new}}(0)}{T} . \qquad (6-23)$$

We note that within our scheme of attacking the transient if only one trial mode is chosen to describe the spatial shape of the flux we will use for the ramp change slope of the reactivity, the first row, first column element of the matrix ρ_1 [cf. Eq. (6-23)]. That will not necessarily equal ρ_1 (3 x 10⁻³) of Eq. (6-22) because of the difference in the definitions of our reactivity and the reactivity of Fig. 6-1.

Now that we have overcome the difficulties encountered because of the special nature of the problem, we can proceed with it by our proposed method. The code OZAN (cf. Appendices N and O) has been created to perform the computations required by the present work. It has been used along with the code Exterminator-II [5] and the point kinetics code [18]. The relevant results are presented in the next section.

6-2 Results

The point kinetics code [18] is run first to furnish the precursor concentrations [hence through Eq. (6-8), the first element of the column matrix $C_j(0)$, j = 1, ...,(H+1)] and the time T at which the bank of shim rods receive the signal to scram. (The transient will be studied by the two-trial mode method throughout the period of time $0 \le t$ $\le T$.) The relevant input and output are presented below.

6-2-1 Input to the Point Kinetics Code [18]

Table 6-1-1 Input (1) to the Point Kinetics Code [18]

Generation time: Λ_{PK}	1.2980×10^{-4} sec.
Initial Reactivity: p _{PK} (t _s)	-0.12
Ramp change slope of Reactivity: $\frac{d\rho_{PK}(t)}{dt}$	$3 \times 10^{-3} \text{sec.}^{-1}$

Delayed Photoneutron Group: j	β _{PK} j	$\lambda_{j} (sec^{-1})$
1	3.010 E-4	1.27 E-2
2	1.709 E-3	3.17 E-2
3	1.529 E-3	0.115
4	3.082 E-3	0.311
5	8.980 E-4	1.40
6	3.280 E-4	3.87
7	3.255 E-5	0.277
8	1.020 E-5	1.69 E-2
9	3.500 E-6	4.81 E-3
10	1.680 E-6	1.50 E-3
11	1.035 E-6	4.28 E-4
12	1.170 E-6	1.17 E-4
13	1.615 E-7	4.37 E-5
14	5.15 E-8	3.63 E-6
15	0.	1. E-13
	1 1	1 All All All All All All All All All Al

Table 6-1-2 Input (2) to the Point Kinetics Code [18]

y E-n stands for: $y \times 10^{-n}$

6-2-2 Comments on the Input to the Point Kinetics Code, Correction Factor for the Delayed Neutron Fractions

In Table 6-1-1 $\Lambda_{\rm PK}$ appears to be 1.298 x 10⁻⁴ (rather than 1.0107 x 10⁻⁴ as computed by OZAN for the first row, first column element of the matrix Λ). The reason is that $\Lambda_{\rm PK}$ was obtained by a previous run where, as the weighting function, the flux, instead of the adjoint flux, was used. For the same reason the delayed photoneutron fractions shown in Table 6-1-2 (j = 7,..., 14) differ from those given subsequently in this chapter. These differences are not very important since the run with the point kinetics code was made only to estimate the quantities - $C_{\rm PK_{4}}(0)$'s, N(0), and T - and not to determine them

precisely. In addition, because of the nature of the transient, the delayed neutrons (chiefly the delayed photoneutrons) are not very significant. Thus, the fact that the numbers for the delayed photoneutron fractions, shown in Table 6-1-2, differ from the ones presented subsequently (obtained by using the adjoint flux as the weighting function), is even more tolerable.

α (the correction factor introduced in Chapter III for overcoming the error due to approximations made in calculating the photoneutron source term - see Chapter II) was taken equal to 10 (approximately).

Correction Factor for the Delayed Neutron Fractions

The delayed neutron fractions shown in Table 6-1-2 (j = 1,..., 6) are not exactly the ones given by the nuclear data [20]. The reason for that is as follows: At emission, the energy of a delayed neutron is generally less than the energy of a prompt neutron. Therefore during the thermalization, a delayed neutron has less chance to leak out of the reactor, than a prompt neutron. That is, in causing fission, a delayed neutron is more effective than a prompt neutron. However, in the three-group scheme that we have adopted, both delayed and prompt neutrons are born in the same - fast - group. The fact that the delayed neutrons are worth more is, then, not taken into account automatically.

An adequate way to correct for this condition would be to multiply the β_i by the factor

 $\frac{\int_{\underline{\mathbf{r}}, \text{core}} d\underline{\mathbf{r}} \ \psi_{1}^{\star}(\underline{\mathbf{r}}) \ \sum_{\mathbf{F}}^{\mathbf{T}}(\underline{\mathbf{r}}, \circ) \ \chi_{j} \ \psi_{1}(\underline{\mathbf{r}})}{\int_{\underline{\mathbf{r}}, \text{core}} d\underline{\mathbf{r}} \ \psi_{1}^{\star}(\underline{\mathbf{r}}) \ \sum_{\mathbf{F}}^{\mathbf{T}}(\underline{\mathbf{r}}, \circ) \ \chi_{p} \ \psi_{1}(\underline{\mathbf{r}})} , \ (j = 1, \dots, 6),$ $\frac{d\underline{\mathbf{r}} \ \psi_{1}^{\star}(\underline{\mathbf{r}}) \ \sum_{\mathbf{F}}^{\mathbf{T}}(\underline{\mathbf{r}}, \circ) \ \chi_{p} \ \psi_{1}(\underline{\mathbf{r}})}{(\underline{\mathbf{r}}, \circ)} ,$ $\frac{d\underline{\mathbf{r}} \ \psi_{1}^{\star}(\underline{\mathbf{r}}) \ \sum_{\mathbf{F}}^{\mathbf{T}}(\underline{\mathbf{r}}, \circ) \ \chi_{p} \ \psi_{1}(\underline{\mathbf{r}})}{(\underline{\mathbf{r}}, \circ)} ,$ $\frac{d\underline{\mathbf{r}} \ \psi_{1}^{\star}(\underline{\mathbf{r}}) \ \sum_{\mathbf{F}}^{\mathbf{T}}(\underline{\mathbf{r}}, \circ) \ \chi_{p} \ \psi_{1}(\underline{\mathbf{r}})}{(\underline{\mathbf{r}}, \circ)} ,$

where a multigroup scheme is considered so that $\chi_j \neq \chi_p$. (In expression (6-24) the familiar notation is being used; i.e., the subscript 1 refers to the steady state of the reactor).

This method of computing the correction factor for the delayed neutrons was not undertaken because applying it for a fifteen-group scheme would be very expensive. Also on a theoretical ground we had reason to believe that one could estimate the correction factor by applying a neutron balance argument to the already available fifteengroup Exterminator-II output for MITR-II.

Therefore, rather than choosing the expensive, straightforward way of solving the problem, we developed a method (described briefly in Appendix K) based on the multigroup output of Exterminator-II obtained for MITR-II. The computer code embodying this method is shown in Appendix L. (It is worthwhile to mention that this code worked for less than a fiftieth of the cost estimated for the more exact calculation.)

Unfortuantely a serious difficulty was encountered: When the eigenvalue of the reactor was recomputed through the numbers obtained by the proposed method, a discrepancy (of about 8%) was found as compared to the eigenvalue given by the original output of Exterminator-II. This is thought to be due to the fact that the convergence of the flux in the output was rather poor (relative convergence of the flux = 4.48×10^{-1}). As a result, the neutron current across interfaces was not continuous. Indeed when we computed the total leakage out of the core by means of the numbers (given in the fifteen-group output of Exterminator-II) relevant to the core and by means of the numbers relevant to the regions outside of the core we found a difference of about 10%. This fact increases confidence in our method and code, but does not change our doubts about the result;

$$CF_{j} = 1.2467, j = 1, \dots, 5$$
,

$$CF_6 = 1.4312$$
 , (6-25)

where CF stands for correction factor (CF₆ is greater than CF_j , j = 1, ..., 5, since the 6th group delayed neutrons, at the emission, are less energetic than the delayed neutrons of other groups).

With some account taken of Eq. (6-25) and in view of estimates appearing in reference [21], CF_j , (j = 1,..., 5), was chosen to be 1.20 and accordingly CF_6 , 1.38. 6-2-3 Output from the Point Kinetics Code

 $N_{PK}(0)$ was found to be 4.242331 x 10^{-9} , and corresponding $C_{PK_{i}}(0)$'s are shown in Table 6-2. The behavior

of the power level beyond 6 MW is sketched in Fig. 6-2. The time T, when the shim rods receive the signal to scram, is seen to be 3.77 sec. At the end of this time the point kinetics code predicts a power level of 81.80 MW.

6-2-4 The Accident Analyzed

Further Preparations for the Code OZAN;

Knowing T we compute $\rho_{PK}(T) = 1.131 \times 10^{-2}$ through Eq. (6-22). Applying the procedure discussed in section 6-1-5 above, we found from Fig. 6-1 that at time t=T the rods would be about an inch higher from their initial postion. Accordingly a poison search was made through Exterminator-II. The value ω [cf. Eq. (4-18)] was found to be 17.262131 (the eigenvalue of the reactor was required to converge to $\frac{1}{1-\beta} = 1.007896$ and turned out to be - after

90 iterations - 1.0078964). Thus the absorption cross sections throughout the reactor were increased by ωv^{-1} (the average values shown in Table 6-3 were used for v^{-1}) and a second shape and its adjoint were computed.





Table 6-2 The Precursor Concentrations at Time t = 0Under the Accident in Question, as Computed by the Point Kinetics Code

j	с _{ркј} (0)
1	0.78880 E-7
2	0.29879 E-6
3	0.15651 E-6
4	0.18583 E-6
5	0.18175 E-7
6	0.26554 E-8
7	0.21027 E-8
8	0.23295 E-8
9	0.16389 E-8
10	0.19797 E-8
11	0.38836 E-8
12	0.15587 E-7
13	0.57189 E-8
14	0.21868 E-7
15	0.18490 E+7

 $y \in n$ stands for $y 10^n$

The output from the point kinetics code will be a portion of the input to OZAN.

The value for V_g (g = 1 to 3);

An average for V_g was computed through

$$v_{g}^{-1} = \frac{\int_{e_{g}}^{d\underline{r}} \int_{e_{g}}^{E_{g}-1} dE \phi (\underline{r}, E, o) V^{-1} (E)}{\int_{e_{g}}^{d\underline{r}} \int_{e_{g}}^{E_{g}-1} dE \phi (\underline{r}, E, o)} \cdot (6-26)$$

For the purpose of the calculation the fifteengroup output of Exterminator-II for MITR-II was used with V(E)'s (for fifteen-group scheme) taken from reference [22]. We thus computed

$$\mathbf{v}_{g}^{-1} = \frac{\sum_{m}^{M} \sum_{h=h_{g-1}}^{h_{g}} \phi_{mh}(0) \ \mathbf{v}_{h}^{-1}}{\sum_{m}^{M} \sum_{h=h_{g-1}}^{h_{g}} \phi_{mh}(0)}, \qquad (6-27)$$

where M is the number of compositions, $\phi_{mh}(0)$ is the flux given in the output in question, for the hth group and in the mth material, V_h is the hth group velocity as given in reference [22] and h_{q-1} and h_q are respectively the initial

and final groups in the fifteen-group scheme that are framing the gth group of the three-group scheme.

The computer code that was written in order to perform the computation for Eq. (6-27) is presented in Appendix M. The results are shown in Table 6-3.

a	V ⁻¹ (sec/cm)	V(cm/sec)
1	1.9903×10^{-9}	5.0244 x 10^8
2	2.3170 x 10^{-7}	4.3159 x 10^6
3	4.5454 x 10^{-6}	2.200 x 10^5

Table 6-3 Average Group Velocities for MITR-II

Further input data to OZAN;

In addition to data already discussed, it is necessary to input to OZAN, the mesh volume dimensions, various cross sections at the beginning and the end of the transient, the delayed neutron fractions, etc. A complete set up of the input is discussed in Appendix N and shown in Appendix O.

6-2-5 Output from OZAN (NMODES* = 2)

The output relevant to the final step before the solution of the time dependent equations is as follows;

The generation time matrix:

$$\Lambda = \begin{pmatrix} 0.10107 \ E-3 & 0.97859 \ E-4 \\ 0.98072 \ E-4 & 0.95077 \ E-4 \end{pmatrix}; \quad (6-28)$$

The reactivity matrix at t = 0:

$$p_{\text{new}}(0) = \begin{pmatrix} -0.40165523 \text{ E}-5 & 0.14627143 \text{ E}-2 \\ 0.19336105 \text{ E}-4 & -0.52609537 \text{ E}-1 \end{pmatrix};$$
 (6-29)

The ramp change slope of the reactivity matrix:

$$\rho_{1} = \begin{pmatrix} 0.20038732 & E-2 & 0.22407090 & E-2 \\ 0.15396409 & E-1 & 0.16423021 & E-1 \end{pmatrix}; \quad (6-30)$$

The delayed neutron (and photoneutron) fraction matrices;

 $\begin{pmatrix} 0.30100 & E-3 & 0.29948 & E-3 \\ 0.28180 & E-3 & 0.28045 & E-3 \end{pmatrix} , \begin{pmatrix} 0.17090 & E-2 & 0.17003 & E-2 \\ 0.16000 & E-2 & 0.15923 & E-2 \end{pmatrix}$

* NMODES: the number of trial modes used in expanding the flux.

 $\begin{pmatrix} 0.15290 & E-2 & 0.15213 & E-2 \\ 0.14315 & E-2 & 0.14246 & E-2 \end{pmatrix} , \begin{pmatrix} 0.30820 & E-2 & 0.30664 & E-2 \\ 0.28855 & E-2 & 0.28716 & E-2 \end{pmatrix}$

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 $\begin{pmatrix} \mathbf{0.89800} & \mathbf{E-3} & \mathbf{0.89345} & \mathbf{E-3} \\ \mathbf{0.84073} & \mathbf{E-3} & \mathbf{0.83669} & \mathbf{E-3} \end{pmatrix}, \begin{pmatrix} \mathbf{0.32800} & \mathbf{E-3} & \mathbf{0.32634} & \mathbf{E-3} \\ \mathbf{0.30708} & \mathbf{E-3} & \mathbf{0.30561} & \mathbf{E-3} \end{pmatrix}$

 $\begin{pmatrix} \mathbf{0.11281} \ E-3 & \mathbf{0.11271} \ E-3 \\ \mathbf{0.11012} \ E-3 & \mathbf{0.11003} \ E-3 \end{pmatrix}, \begin{pmatrix} \mathbf{0.35308} \ E-4 & \mathbf{0.35278} \ E-4 \\ \mathbf{0.34467} \ E-4 & \mathbf{0.34438} \ E-4 \end{pmatrix}$

		9	1. 	.0
0.12153	E-4	0.12142 E-4	0.58236 E-5	0.58186 E-5
0.11863	E-4	0.11853 E-4)	, 0.56849 E-5	0.56801 E+5

٦	3
1	. 1

0.35744 E-5 **0.35713** E-5 $\begin{pmatrix} 0.35744 & E-5 & 0.35713 & E-5 \\ 0.34893 & E-5 & 0.34863 & E-5 \end{pmatrix} , \begin{pmatrix} 0.40277 & E-5 & 0.40243 & E-5 \\ 0.39318 & E-5 & 0.39284 & E-5 \end{pmatrix}$

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1	.3		. 1	4
0.55621 E-6	0.55573 E-6		0.17575 E-6	0.17560 E-6
0.54296 E-6	0.54250 E-6	,	0.17157 E-6	0.17142 E-6

$$\begin{pmatrix}
0.0 & 0.0 \\
0.0 & 0.0
\end{pmatrix}, (6-31)$$

where for the delayed photoneutron fractions, a correction factor $\alpha = 10$ is used and the 15th matrix elements are set to zero since the fictitious 15th group delayed precursor amplitude functions are used merely to represent the external source.

Note that the first row, first column element of the matrix ρ_1 is different than 3 x 10^{-3} - initially input to the point kinetics code as the ramp change slope of the reactivity - because of the difference between the definition of reactivity of Fig. 6-1 and the one adopted throughout the present dissertation (cf. Chapter III).

To attack the time dependent equations, we finally have to add to Equations (6-28) up to (6-31) the $N_{PK}(0)$ and $C_j(0)$'s computed through the point kinetics code and the manipulations described in the previous sections. It was mentioned (cf. section 6-2-2) that we did not use the best values for, Λ_{PK} and β_{j} 's in determining $N_{PK}(0)$ and the Car (0)'s earlier. For the present run

 $N_{PK}(0)$ and the $C_{PKj}(0)$'s earlier. For the present run (OZAN, NMODES = 2) we had a chance to recompute the initial

Table (6-4) Initial Precursor Amplitude Functions

	· · · · · · · · · · · · · · · · · · ·	
j	c _{j1} (0)	с _{ј2} (0)
1	0.1010 E-10	0.94559 E-11
2	0.38500 E-10	0.36045 E-10
3	0.20100 E-10	0.18818 E-10
4	0.23900 E-10	0.22376 E-10
5	0.27000 E-11	0.25278 E-11
6	0.42100 E-12	0.39415 E-12
7	0.98000 E-12	0.95666 E-12
8	0.10900 E-11	0.10640 E-11
9	0.77400 E-12	0.75557 E-12
10	0.93600 E-12	0.91371 E-12
11	0.18300 E-11	0.17864 E-11
12	0.73200 E-11	0.71457 E-11
13	0.26900 E-11	0.26259 E-11
14	0.10200 E-10	0.99571 E-11
15	0.23600 E+03	0.22763 E+03

y E n stands for $y \times 10^n$

values $N_{PK}(0)$ and C_{PK_j} 's through the point kinetics code, using this time, Λ_{11} (for Λ_{PK}), and β_{j} (0)'s (for β_{PK_j} 's) obtained from a previous OZAN run. Λ_{PK} as a result became 1.0149 x 10⁻⁴ and β_{PK} (= $\sum_{j=1}^{15} \beta_{PK_j}$), 8.03316 x 10⁻³ (instead of 7.89737 x 10⁻³ used for the previous point kinetics run).

The corresponding $N_{PK}(0)$ is 4.149860 x 10^{-3} and the final $C_{j_1}(0)$ [cf. Eq. (6-8), with H = 14] is presented along with $C_{j_2}(0)$ [cf. Equations (6-20) and (6-21)] in Table (6-4).

 $C_{l_1}(0)$ computed from $C_{PK_1}(0)$ of Table 6-2 becomes for instance, 0.78880 E-7 x 1.298 E-4 \simeq 0.1020 E-10. The difference between that number and the one given for $C_{l_1}(0)$ in Table 6-4 (0.1010 E-10) is 1%. The difference between $N_{PK}(0)$ just computed and $N_{PK}(0)$ computed through the previous run is also about the same. Thus these differences are not very significant, as it was anticipated in section 6-2-2.

The solution of the time dependent equations is presented in Table (6-5).

Table 6-5 The Two Time Coefficients

t(sec.)	N ₁ (t)	N ₂ (t)
0	0.41499 E-08	0.
1	0.61103 E-08	0.20874 E-08
2	0.99747 E-08	0.10478 E-08
3	0.61673 E-07	0.22693 E-06
4	-0.54800 E-01	0.92655 E 00
5	-0.12375 E+19	0.47876 E+19

With Respect to the Time

We note that while at the beginning of the transient N₁(t) is dominant and N₂(t) is small (one can show that for the initial conditions imposed $\frac{dN_2(t)}{dt} = 0$, as the rods get closer to the position 2.54 cm higher than

their initial level, the second shape gradually takes over.

As will be explained in the next chapter, one can obtain an equivalent time function $N_{eq}(t)$ out of $N_{l}(t)$ and $N_{2}(t)$ with appropriate manipulations. Thus the power

level follows $N_{eq}(t) = N_1(t) + \frac{\Lambda_{12}}{\Lambda_{11}} N_2(t)$.

 $N_{eq}(t)$ for the present run is shown in Fig. 6-3.



Fig. 6-3 Behavior of N_{eq}(t) under the Accident in Question, Studied by the Proposed Method

In this figure we see that 6 MW level is reached at around 4 sec., and 0.1 second later the power level reaches about 90 MW.

We note that around t = T, the inverse period, ω , of the reactor is about the one predicted by the poison search made for the second trial mode ($\omega = \frac{1}{N_{eq}} \frac{dN_{eq}}{dt} \simeq 17.2$

around 3.7 sec.).

The derivation of an equivalent scalar reactivity and generation time and their variation with respect to the time, is presented in the next chapter.

6-2-6 Output from OZAN (NMODES = 1)

The same study is repeated with however only one trial function. Thus the problem is reduced to a point kinetics case. Then the solution $N_1(t)$ is searched with $\Lambda_{PK} = \Lambda_{11}$, $\rho_{PK}(0) = \rho_{new_{11}}(0)$, $\rho_{1}_{PK} = \rho_{1}_{11}$, and $\beta_{PK}_{j} = \beta_{1}_{11}$, $\beta_{PK} = \beta_{1}_{11}$, β_{PK

equations (6-28), (6-29), (6-30) and (6-31).

The behavior of $N_1(t)$ is shown in Fig. (6-4), where we see that 6 MW level is reached at around 5.06 sec. 0.1 sec. more from there on brings the reactor onto about 60 MW power level.



We note that (although $\omega \simeq 23$ around 5.1 sec. in the last case) N₁(t) of Fig. (6-4) is much slower than N_{eq}(t) of Fig. (6-3). A comparison of these two quantities with respect to the time is shown in Table 6-6.

Table 6-6 Behavior of the Power Level Predicted by

t(sec.)	N _{eq} (t) (NMODES=2)	N _l (t) (NMODES=1)
1	0.813 E-08	0.742 E-08
2	0.201 E-07	0.140 E-07
3	0.282 E-06	0.438 E-07
4	0.850	0.991 E-06
5	0.340 E+19	0.332

OZAN-NMODES = 2-and -NMODES = 1-

We emphasize that in both studies (cf. Table 6-6) everything was the same except for the number of trial modes used in the expansion of the flux.

In the next chapter we shall discuss in detail the validity of the numbers shown in Table 6-6. If these results are correct, there is certainly a large difference between the two predictions shown in Table 6-6.

6-3 Summary

In this chapter we aimed to study a fictitious accident with the proposed method and compare the results (NMODES = 2) with those obtained through a point kinetics approach (NMODES = 1). We also wanted to answer the question: For the given accident, how far beyond 6 MW does the power level continue to climb in 0.1 more sec.?

The problem was of a special nature [startup subcritical and requiring that we have an estimate of the answer(position of the rods when they receive the signal to scram) before beginning space-dependent analysis].

We decided to use a single critical shape until the rods were at a critical position and then use the twoshape method for the rest of the transient.

We then required more theoretical preparations. An external source was expressed in terms of an extra delayed neutron precursor concentration. The initial values (at t = 0) for the first precursor amplitude functions and the first time coefficient, as well as the duration of the transient (T) - input to OZAN - were estimated through a point kinetics code. The initial values for the second precursor amplitude functions were found in a consistent way [Equations (6-20) and (6-21)].

The position of the rods at t = T was then deter-

mined. Then a poison search was made and the second shape and its adjoint were computed.

Finally a study of the problem with OZAN (NMODES = 2 and NMODES = 1) was undertaken. The end results are summarized in Table 6-7.

Table 6-7

Summary of the Results

	the first point kinetics run	OZAN NMODES=2	OZAN NMODES=1
time t (sec.) at which the 6 MW level is reached	3.67	≃ 4.	5.06
the power level (MW) reached 0.1 sec.after time t	81.8	≃ 90	60

In conclusion it is important to recall that this is a fictitious case, not only has the assumption been made that the safety controls and instrumentation failed but also the inherent safety features of negative void and temperature coefficients have been neglected. If the negative reactivity feed back from the void formation is included, the shape of the transient would be significantly altered.

Rather than an explicit representation of the power history for the proposed problem, the results of these calculations should be viewed as study of the importance of special effects in fast transient calculations. The fact that the OZAN result with NMODES = 2 is significantly higher than the result with NMODES = 1, indicates that care must be taken if one is trying to make conservative conclusions based only on a point kinetics calculations.

CHAPTER VII.

CROSS CHECKING OF THE RESULTS

The main question that arises from the previous chapter is: Do we believe in the numbers we have obtained? In fact this question has two parts:

1. Do we believe in the computer code (OZAN) written to perform the computations required by the proposed method?

2. Assuming that the answer to the first question is yes, do we believe in the prediction made by the proposed method?

Unfortunately the second question will be answered only superficially (and that will be done in the next chapter). Much more would have to be done to answer this question definitively.

In this chapter, we shall consider the validity of the computer code (OZAN) written to perform computations required by the proposed method. For this purpose five distinct tests were applied.

7-1 Some of the results computed through OZAN checked against the same quantities computed by Exterminator-II

The eigenvalues relative to the spatial shapes and the first row first column element of the generation time matrix

are computed in both OZAN and Exterminator-II. In addition an Exterminator-II poison search predicted a value for ω (the inverse period that the reactor supposedly assumes near the time the rods receive the signal for scram). ω can also be estimated through the time behavior of the expansion coefficients predicted by OZAN (NMODES = 2) - cf. Fig. 6-3.

The results are summarized in Table 7-1, where $k_k(k=1,2)$ is given by Eq. (4-18) [Note that in the case of Exterminator-II the weighting function is unity. Thus, in computing $k_k(k=1,2)$ - assuming that the current across interfaces is continuous - , the leakage integral involved in the denominator of Eq. (4-18) was reduced to a surface integral over the outer surface of the reactor]. Λ_{11} is the one obtained from Eq. (3-28) through the normalization

$$\Lambda_{11} = \frac{2\pi \int_{r,reactor}^{r} dr}{\frac{1}{k^{(*)}} 2\pi \int_{r,core}^{r} dr} \int_{z,reactor}^{dz} \psi_{1}^{*^{T}}(r,z) v^{-1} \psi_{1}(r,z)} , \quad (7-1)$$

where the integrals are evaluated by the methods shown in Chapter V.

We point out that the relative convergence for the first shape, given by Exterminator-II was 3.452×10^{-4} and for the second shape, 6.199×10^{-5} ; for the first weighting mode,

(*) In OZAN, instead of k_1 , k_{OZAN} (1.01795673) is used. However this is a minor difference

Table 7-1

Comparison of some of the results computed through OZAN with the same quantities computed through Exterminator-II

	OZAN (NMODES=2)	Exterminator-II
k ₁ (Eigenvalue of the first trial mode)	1.01737499	0.99973398
k ₂ (Eigenvalue of the second trial mode)	1.02579212	1.007946
<pre></pre>	1.0107050x10 ⁻⁴	1.043922x10 ⁻⁴
ω (inverse period at around time t=T =3.77 sec.)	vl7.2(t=3.7 sec.)	17.262131

8.180x10⁻¹ and for the second weighting mode, 8.528x10⁻¹ (Note the poor degree of convergence for the weighting mode as compared to the degree of convergence for the spatial shape ; the same number of iterations were used in computing both.).

Thus the agreement of the eigenvalues (shown in Table 7-1) computed by OZAN with the ones computed by Exterminator-II is within less than 1.75%. The discrepancy between the generation time computed by one code and the generation time computed by the other code is less than 3.2%.

We conjecture that the difference between the eigenvalue computed by one code and the eigenvalue computed by the other may be due to the differences between the methods of computations used in both codes; namely differences in the evaluation of the leakage integral, use of - a rather poor - weighting function in OZAN, in comparison to use of unity as weighting function in Exterminator-II, etc. It is nevertheless possible that programming or input errors in OZAN may be responsible for the discrepancies observed between the two codes. We note however that k_1 and k_2 computed by OZAN are consistent with respect to k_1 and k_2 computed by Exterminator-II in that $(k_2-k_1)_{OZAN} = 8.41713 \times 10^{-3}$ while $(k_2-k_1)_{Ext.II} = 8.212 \times 10^{-3}$.

7-2 Cross checking of the elements of the matrix ρ_1 [The ramp change slope of the reactivity matrix - Eq. (6-30)], against the same quantities computed by a perturbation type of approach handled by an independent code written for this purpose We recall that ρ_1 is computed through Eq. (5.54) in OZAN. That is specifically, we have (in terms of the notation adopted throughout the dissertation);

$$\mathbf{T}\rho_{1} = (2\pi) \left| \begin{array}{c} r \ dr \\ r, reactor \end{array} \right| dz \qquad \mathbb{W}^{T}(r, z) \left\{ \left[\nabla . D(r, z, T) - A(r, z, T) \right] \right\}$$

+
$$\chi_{P} \nu \Sigma_{F}^{T}(\mathbf{r}, \mathbf{z}, \mathbf{T})] \psi(\mathbf{r}, \mathbf{z}) + \alpha \xi_{P}(\mathbf{r}, \mathbf{z}, \mathbf{T}) + \sum_{j=J+1}^{H} \overline{\beta}_{jnew}$$
 (T))

$$-(2\pi) r dr dz W^{T}(r,z) \{ [\nabla.D(r,z,0)-A(r,z,0) - A(r,z,0) - A(r$$

$$+ \chi_{p} \nu \Sigma_{F}^{T}(\mathbf{r}, \mathbf{z}, \mathbf{0})] \} \psi(\mathbf{r}, \mathbf{z}) + \alpha \xi_{p}(\mathbf{r}, \mathbf{z}, \mathbf{0}) + \Sigma_{j=J+1}^{H} \overline{\beta}_{j \text{ new}} (\mathbf{0})) , \qquad (7-2)$$

Actually OZAN will test each component (D,A, $\Sigma_{\rm F}$, $\xi_{\rm P}$ and $\overline{\beta}_{\rm new}$) and will then form the differences.

$$\{2\pi \mid r, dr \mid dz \quad W^{T}(r, z) [COMP(r, z, T)] \quad \psi (r, z) \}$$

r, reactor z, reactor

$$-\{2\pi \int \mathbf{r} \, d\mathbf{r} \int d\mathbf{z} \quad \mathbf{W}^{\mathrm{T}}(\mathbf{r},\mathbf{z}) \ [\text{COMP}(\mathbf{r},\mathbf{z},0)] \ \psi \ (\mathbf{r},\mathbf{z})\},$$

r,reactor z,reactor

(where COMP stands for D, A, $\boldsymbol{\Sigma}_{_{\rm F}}$ etc.) only if the component in

(7-3)

question is subject to a change during the transient.

Thus, since only D and A vary during the accident (withdrawal of the control rods) we have studied, OZAN has computed as $T\rho_1$ the quantity

$$T\rho_{1} = \{2\pi \int r dr \int dz \quad W^{T}(r,z) [\nabla.D(r,z,T)-A(r,z,T)] \\ r,reactor \int z,reactor$$

$$\psi(\mathbf{r},\mathbf{z}) = \{2\pi \mid \mathbf{r} \text{ dr} \mid dz \quad W^{\mathrm{T}}(\mathbf{r},\mathbf{z}) [\nabla . D(\mathbf{r},\mathbf{z},0) - A(\mathbf{r},\mathbf{z},0)]$$

r, reactor z, reactor

$$\psi(r,z)$$
 (7-4)

That is, OZAN does not consider the particular-perturbation-nature of the problem, according to which Eq. (7-4) can be written

$$T \rho_1 = 2\pi \int r dr \int dz W^T(r,z) [\nabla.\delta D(r,z)]$$

r, perturbed area

 $-\delta A(r,z)]\psi(r,z)$, (7-5)

where $\delta D(r,z) = D(r,z,T) - D(r,z,0), \delta A(r,z) = A(r,z,T) - A(r,z,0),$ and the "perturbed area" refers to the location of the reactor being perturbed by the withdrawal of the rods. Thus instead of computing the integrals shown in Eq. (7-5) over only one mesh volume (for the problem studied the perturbation takes place in one mesh volume), OZAN deals with the problem as though it were general and computes $T\rho_1$ from Eq. (7-4) with the integrals performed over the entire reactor volume.

Thus we can check the results obtained by OZAN through Eq. (7-4), against results obtained by applying Eq. (7-5). For the purpose of this calculation a separate code was written (shown in Appendix 0, next to the code OZAN). Results are compared in Table 7-2.

Table 7-2

The matrix ρ_1 computed by OZAN and by a perturbation type of approach

	OZAN	Perturbation type of approach
	0.20929807E29 0.12860273E30	0.20932522E29 0.12861792E30
^ρ 1 _Α	0.12197004E30 0.90442634E30	\0.12199029E30 0.90486858E30/
ρ ₁ Α	(0.88040249E29 -0.67456125E28) (0.71528204E30 -0.11339531E29)	(0.88058761E29 -0.67489701E28) (0.71562643E30 -0.11343823E29)

 $yEx \equiv yx10^{x}$

In Table 7-2 ρ_1 and ρ_1 refer to the components of ρ_1 due to absorption and leakage so that

 $\rho_1 = \rho_1 + \rho_1_D$

(7-6)

In order to normalize, these quantities must be divided by the denominator of Eq. (7-1).

We note that the two sets of numbers shown in Table 7-2 agree with each other very closely. This is, we believe, strong evidence that, the matrix elements (-at least-of ρ_1) are correctly computed in OZAN.

7-3 The matrix ρ_1 calculated algebraically in terms of quantities output from OZAN; comments on $\rho_{new}(0)$: the initial value of the reactivity matrix

Our third way of cross-checking consists of calculating ρ_1 through an algebraic relationship that involves quantities output from OZAN. We first develop that relationship.

7-3-1 Algebraic relationship

For this purpose define

$$H_{1}(\underline{r}) = \nabla \cdot D_{1}(\underline{r}) \nabla - A_{1}(\underline{r}) + \frac{F_{1}(\underline{r})}{K_{1}} , \qquad (7-7)$$

and

$$H_{2}(\underline{r}) = \nabla \cdot D_{2}(\underline{r}) \nabla - A_{2}(\underline{r}) + \frac{F_{2}(\underline{r})}{k_{2}} - \omega v^{-1} , \qquad (7-7)$$

with the notation used in Chapter IV.

 $H_1(\underline{r})$ and $H_2(\underline{r})$ are the operators used in computing $\psi_1(\underline{r})$ and $\psi_2(\underline{r})$.

We next substract Eq. (7-7) from Eq. (7-8) to obtain

$$H_{2}(\underline{r}) - H_{1}(\underline{r}) = \nabla \delta D(\underline{r}) \nabla - \delta A(\underline{r}) + F_{1}(\underline{r}) (\frac{1}{k_{2}} - \frac{1}{k_{1}}) - \omega v^{-1}, \quad (7-9)$$

where $\delta D(\underline{r}) = D_2(\underline{r}) - D_1(\underline{r}); \ \delta A(\underline{r}) = A_2(\underline{r}) - A_1(\underline{r}), \ \text{and we}$ have used the fact that $F_1(\underline{r}) = F_2(\underline{r}).$

Further define

$$\delta(\mathbf{r}) = \nabla \delta D(\mathbf{r}) \nabla - \delta A(\mathbf{r}) , \qquad (7-10)$$

and

$$H_{B}(\underline{r}) = \frac{F_{1}(\underline{r})}{k_{OZAN}} BET$$
(7-11)

(where BET = $\sum_{j=1}^{6} \overline{\beta}_{j}$ (0))

Then with convenient manipulations we arrive at

$$\delta(\underline{\mathbf{r}}) = H_2(\underline{\mathbf{r}}) - H_1(\underline{\mathbf{r}}) + H_B(\underline{\mathbf{r}}) \frac{k_2 - k_1}{k_2 k_1 BET} k_{OZAN} + \omega v^{-1} . \qquad (7-12)$$

The matrix ρ_1 can now be written as

$$\rho_{1} = \frac{\langle \psi^{*^{T}}(\underline{r}) | \delta(\underline{r}) | \psi(\underline{r}) \rangle}{T} \qquad (7-13)$$

Thus we are able to express ρ_1 in terms of

$$\langle \psi^{*^{T}}(\underline{r}) | H_{2}(\underline{r}) | \psi(\underline{r}) \rangle , \qquad (7-14)$$

$$\langle \psi^{*^{T}}(\underline{r}) | H_{1}(\underline{r}) | \psi(\underline{r}) \rangle , \qquad (7-15)$$

$$\langle \psi^{\star^{\mathrm{T}}}(\underline{r}) | \mathrm{H}_{\mathrm{B}}(\underline{r}) | \psi(\underline{r}) \rangle$$
 , (7-16)

$$\langle \psi^{\star^{T}}(\underline{r}) | \omega v^{-1} | \psi(\underline{r}) \rangle (\equiv \Lambda)$$
, (7-17)

and k_1 , k_2 , k_{OZAN} and $\overline{\beta}_{new}_{11}$ (0). These quantities are output from OZAN except for some of the matrix elements of expressions (7-14) and (7-15) that are the subject of the next subsection.

7-3-2 Review of elements of the matrices (7-14) and (7-15)

This review will be done in five stages; 1. The first-row, first-column element of the matrix (7-14) cannot be evaluated:

Apparently there is no possibility of evaluating the element, $\langle \psi_1^{\mathbf{T}}(\underline{\mathbf{r}}) | \mathbf{H}_2(\underline{\mathbf{r}}) | \psi_1(\underline{\mathbf{r}}) \rangle$ under the circumstances we are working with.

2. Two elements are zero by definition:

The elements $\langle \psi_1^{\star^T}(\underline{r}) | H_1(\underline{r}) | \psi_1(\underline{r}) \rangle$ and $\langle \psi_1^{\star^T}(\underline{r}) | H_2(\underline{r}) | \psi_2(\underline{r}) \rangle$ vanish because of Eq. (4-19) [cf. the definition of k_k (k = 1, 2)].

3. Two elements should vanish in view of the definition for k_k (k = 1, 2):

If $\psi_1(\underline{r})$ and $\psi_2(\underline{r})$ were well converged, we could write (at all points in the reactor)

$$H_{1}(\underline{r}) | \psi_{1}(\underline{r}) \rangle = 0 , \qquad (7-18)$$

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and

$$H_{2}(\underline{r}) | \psi_{2}(\underline{r}) \rangle = 0$$
 , (7-19)

through the definitions

$$\psi_{1}^{*T}(\underline{r}) | H_{1}(\underline{r}) | \psi_{1}(\underline{r}) \rangle = 0 , \qquad (7-20)$$

and

$$\langle \psi_1^{\star^{\mathrm{T}}}(\underline{r}) | H_2(\underline{r}) | \psi_2(\underline{r}) \rangle = 0$$
 , (7-21)

Equations (7-18) and (7-19) would then imply respectively

$$\langle \psi_2^{\star^{\mathrm{T}}}(\underline{\mathbf{r}}) | H_1(\underline{\mathbf{r}}) | \psi_1(\underline{\mathbf{r}}) \rangle = 0$$
 , (7-22)

and

$$\langle \psi_2^{*^{\mathrm{T}}}(\underline{\mathbf{r}}) | H_2(\underline{\mathbf{r}}) | \psi_2(\underline{\mathbf{r}}) \rangle = 0$$
 . (7-23)

4. Two elements should vanish in view of the definition of the adjoint mode:

Provided proper continuity properties exist, the elements $\langle \psi_2^{\star^T}(\underline{r}) | H_2(\underline{r}) | \psi_1(\underline{r}) \rangle$ and $\langle \psi_1^{\star^T}(\underline{r}) | H_1(\underline{r}) | \psi_2(\underline{r}) \rangle$ can be written respectively

$$\langle \psi_1^{\mathrm{T}}(\underline{r}) | \mathrm{H}_2^{+}(\underline{r}) | \psi_2^{*}(\underline{r}) \rangle$$
, (7-24)

and

$$\langle \psi_2^{\mathrm{T}}(\underline{r}) | H_1^{\dagger}(\underline{r}) | \psi_1^{\dagger}(\underline{r}) \rangle$$
, (7-25)

with $H_1^+(\underline{r})$ and $H_2^+(\underline{r})$ defined in Chapter IV.
If $\psi_2^{\star}(\underline{r})$ and $\psi_1^{\star}(\underline{r})$ were well converged we would have

$$H_{2}^{+}(\underline{r}) | \psi_{2}^{*}(\underline{r}) \rangle = 0 , \qquad (7-26)$$

and

$$H_{1}^{+}(\underline{r}) | \psi_{1}^{*}(\underline{r}) \rangle = 0 \qquad , \qquad (7-27)$$

at all the points of the reactor. Thus expressions (7-24) and (7-25) would vanish.

5.
$$\langle \psi_2^{\star^{\mathrm{T}}}(\underline{r}) | H_1(\underline{r}) | \psi_2(\underline{r}) \rangle$$
 :

To calculate this element we consider

$$H_{OZAN}(\underline{r}) = \nabla \cdot D_{1}(\underline{r}) \nabla - A_{1}(\underline{r}) + \frac{F_{1}(\underline{r})}{K_{OZAN}} + H_{PPN}(\underline{r}) + H_{DPN}(\underline{r}), (7-28)$$

where $H_{PPN}(\underline{r})$ and $H_{DPN}(\underline{r})$ are respectively the prompt and the delayed photoneutron operators defined through

$$\langle \psi^{*T}(\underline{\mathbf{r}}) | H_{PPN}(\underline{\mathbf{r}}) | \psi(\underline{\mathbf{r}}) \rangle , \qquad (7-29)$$

and

$$\psi^{*^{T}}(\underline{r}) | H_{DPN}(\underline{r}) | \psi(\underline{r}) \rangle , \qquad (7-30)$$

that is, the prompt and the delayed photoneutron reactivity matrices introduced in Chapter III. Both matrices (7-29) and (7-30) are output from OZAN.

With appropriate manipulations we obtain

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$$H_{1}(\underline{r}) = H_{OZAN}(\underline{r}) + H_{B}(\underline{r}) (\frac{1}{k_{1}} - \frac{1}{k_{OZAN}}) \frac{k_{OZAN}}{BET} - H_{PPN}(\underline{r})$$

$$- H_{\rm DPN}(\underline{r})$$
 , (7-31)

such that

$$\langle \psi^{*} | H_{OZAN}(\underline{r}) | \psi(\underline{r}) \rangle = \rho_{new}(0) \qquad ; \qquad (7-32)$$

the initial value of the reactivity matrix (comments about $\rho(0)$ are saved for the subsection 7-3-4).

Thus using Eq. (7-31), Eq. (7-12) can be written as

$$\delta(\underline{\mathbf{r}}) = H_2(\underline{\mathbf{r}}) - H_{OZAN}(\underline{\mathbf{r}}) + \frac{H_B(\underline{\mathbf{r}})}{BET} (1 - \frac{k_{OZ}}{k_2}) + H_{PPN}(\underline{\mathbf{r}}) + H_{DPN}(\underline{\mathbf{r}}) + \omega v^{-1} .$$
(7-33)

Hence ρ_1 will be calculated through Eq. (7-13) by making use of Eq. (7-12) (for the first row, second column, and second row, first column; elements) and Eq. (7-33) (for the second row, second column element) in conjunction with the comments made for the matrices (7-14) and (7-15). Further information is given in Table 7-3.

In numbers (appearing in Table 7-3) relevant to the photoneutrons a correction factor $\alpha = 10$ is present.

Table 7-3 Further information for the purpose

of the algebraic calculation

^k ozan	1.01795673
$\overline{\beta}_{new_{11}}(0)$	0.78469925E-2
The delayed neutron fraction matrix [that corresponds to $H_{B}(\underline{r})$]	(0.78469925E-2 0.78072660E-2) (0.73465705E-2 0.73112361E-2)
The prompt photoneutron pro- duction matrix [that cor- responds to $H_{PPN}(\underline{r})$]	(0.21412867E29 0.24675711E29) (0.20902955E29 0.24088097E29)
The delayed photoneutron fraction matrix [that cor- responds to $H_{DPN}(\underline{r})$]	(0.17435974E-3 0.17421108E-3) (0.17020771E-3 0.1700626E-4)

 $y \in x \equiv y \times 10^{x}$

For purposes of normalization the numbers for the prompt photoneutron should be divided by $0.54379688 \times 10^{32}$.

7-3-3 Results

Results are regrouped in Table 7-4.

Table 7-4 Elements of the matrix ρ_1 calculated algebraically (by hand) compared with the same elements computed through OZAN

	Algebra	OZAN
Second row first column (21) element	0.254 E-2	0.15396 E-1
First row second column (12) element	0.2241 E-2	0.22409 E-2
Second row second column (22) element	0.1643 E-1	0.16423 E-1

 $y \equiv x \equiv y \times 10^{X}$

We note that the agreement between the last two elements of Table 7-4 is very good. However the first element computed through OZAN is badly off as compared to the result given by the algebra for the same element. This, we believe, is due to the incorrectness of the assumption that expression (7-24) vanishes -this expression is computed nowhere in OZAN . Similarly, if indeed we assume, throughout the calculation of the (12) element that $\langle \psi_1^{*T}(\underline{r}) | H_1(\underline{r}) | \psi_2(\underline{r}) \rangle$ (which can be calculated based on the output from OZAN, to be 1.404×10^{-3}) vanishes [cf. Eq. (7-20)], then we find - through the algebra for the (12) element- 0.2610 x 10^{-2} instead of 0.2241 x 10^{-2} .

The error in assumptions such as Eq. (7-20) implies that the fluxes determined by Exterminator-II are not well converged. The degree of convergence for the two adjoint modes are shown in Table 7-5. $\psi_1^*(\underline{\mathbf{r}})$ was computed in 60 iterations and $\psi_2^*(\underline{\mathbf{r}})$, 50 iterations. For a comparison the degree of convergence for $\psi_1^*(\underline{\mathbf{r}})$ after 50 iterations, is also shown.

Table 7-5 Degree of convergence of the adjoint modes

Fluxes	Iteration number	Relative convergence	Absolute convergence
$\psi_1^*(\underline{r})$	60	8.1799 E-1	-9.5230 E-1
$\psi_2^*(\underline{r})$	50	8.5283 E-1	-9.9201 E-1
Ψ <mark>1</mark> (<u>r</u>)	50	8.5275 E-1	-9.9206 E-1

We note the worse convergence for $\psi_2^*(\underline{r})$. We also note that if $\psi_1^*(\underline{r})$ were computed out of 50 iterations (instead of 60), then its convergence would be as bad as the one for $\psi_2^*(\underline{r})$. These facts may be responsible for the greater divergence from zero of $\langle \psi_2^*^T(\underline{r}) | H_2(\underline{r}) | \psi_1(\underline{r}) \rangle$ [this can be computed - see Eq. (7-34) - making use of Eq. (7-12) to be 0.048 than the divergence from zero of $\langle \psi_{1}^{T}(\underline{r}) | H_{1}(\underline{r}) | \psi_{2}(\underline{r}) \rangle$ (0.0014).

We have calculated $\langle \psi_2^{\star^{T}}(\underline{r}) | H_2(\underline{r}) | \psi_2(\underline{r}) \rangle$ from

$$<\psi_{2}^{*^{T}}(\underline{r}) |H_{2}(\underline{r})|\psi_{1}(\underline{r})> = <\psi_{2}^{*^{T}}(\underline{r}) |\delta(\underline{r})|\psi_{1}(\underline{r})>$$

$$+ <\psi_{2}^{*^{T}}(\underline{r}) |H_{1}(\underline{r})-H_{B}(\underline{r})| \frac{k_{2}-k_{1}}{k_{2}k_{1}\overline{\beta}_{new_{11}}(0)} k_{OZAN}|\psi_{1}(\underline{r})>-\Lambda_{22} ,$$

$$(7-34)$$

[cf. Eq. (7-12)], where $\langle \psi_2^{\star^{T}}(\underline{r}) | \delta(\underline{r}) | \psi_1(\underline{r}) \rangle$ is taken to be the (21) element of the matrix ρ_1 as computed by OZAN.

We shall defer discussion of some suggestions based on the results just derived until the next chapter.

However, because it is closely related to the algebra developed within the present section, we take the opportunity in the following section to comment on $\rho_{new}(0)$, the initial value of the reactivity matrix.

7-3-4 Comments on $\rho_{new}(0)$, the initial value of the reactivity matrix

The matrix $\rho_{new}(0)$ [cf. Eq. (7-32)] deserves special attention. Starting to apply the time dependent

Equations (3-44) and (3-45) with some residual reactivity although this may be small - , while the reactor is critical, is undesirable numerically. Thus to avoid an erroneous prediction, k_{OZAN} was introduced in Chapter V, so that, if the reactor is critical at the beginning of the transient, we have $\rho_{new_{11}}$ (0) = 0. The purpose of k_{OZAN} is then to compensate for the extra reactivity due to the presence of photoneutrons (the balance for the equilibrium trial mode, $\psi_1(\underline{r})$, being maintained by dividing the fission cross sections by k_1 - eigenvalue of the first trial mode computed through OZAN).

If k_{OZAN} were the eigenvalue of a well converged first trial mode coming out of Exterminator II, we would have $\rho_{new}_{11}(0) = \rho_{new}_{21}(0) = \rho_{new}_{12}(0) = 0$ [cf. respectively Equations (7-20), (7-22) and (7-25)], since $H_{OZAN}(\underline{r})$ [cf. Eq. (7-27)] would then be identical to $H_1(\underline{r})$ [cf. Eq. (7-31)]. Failing that, we have numbers presented in Eq. (6-29).

Comments about the (11), (21) and (12) elements of $\rho_{\rm new}(0)$.

On the RHS of Eq. (6-29) note that by definition the (11) element is zero (within the accuracy that the machine can insure on single precision).

We would like the (21) element to be as close to zero as the (11) element in view of Eq. (7-18) - written for $H_{OZAN}(\underline{r})$ instead of $H_1(\underline{r})$ - . However not only the fact that the eigenvalue computed for $\psi_1(\underline{r})$ through OZAN diverges from the one given by Exterminator-II (for $\gtrsim 1.75$ %) but also the presence of the photoneutrons makes k_{OZAN} a rather artificial eigenvalue computed just to insure $[\rho_{new_{11}}(0) = 0]$. Thus un-

fortunately a relationship such as Eq. (7-18) does not hold for $H_{OZAN}(\underline{r})$. Hence the value of the LHS of Eq. (7-22) is closely bound to the character of the weighting function. We also note that the second adjoint, having the worse degree of convergence (cf. Table 7-5), makes the divergence from zero, of the (21) element about five times worse than the divergence from zero of the (11) element.

Fortunately the (21) element is still satisfactorily close to zero.

Finally note that we would not expect the (12) element to vanish even if $H_{OZAN}(\underline{r})$ and $H_1(\underline{r})$ were identical since it was pointed out - in subsection 7-3-3 - that presumably, because of the bad convergence of $\psi_1^*(\underline{r})$, $\langle \psi_1^*(\underline{r}) | H_1(\underline{r}) | \psi_1(\underline{r}) \rangle$ is equal to 1.404x10⁻³ [rather than zero, cf. Eq. (7-25)].

Steady State Predictions;

It is important to determine whether or not the expansion coefficients $N_1(t)$ and $N_2(t)$ will stay steady if the reactor remains in its critical state, that is if we solve Equations (3-44) and (3-45) for expansion coefficients with $\left[\rho_{new}(t) = \rho_{new}(0)\right]^*$.

The answer to this question more properly belongs to the next chapter (since it rather deals with the second question we have introduced at the beginning of the present chapter). However we find it easier to give the answer here. To answer this question the solution of Equations (3-44)and (3-45) with $\rho_{new}(t) = \rho_{new}(0)$, the Λ and $\overline{\beta}_{j_{new}}$'s of Equations (6-28) and (6-31) and the precursor amplitude functions found from $\frac{dC_j(t)}{dt} = 0$, $(j=1,\ldots, H)$, was determined [by applying the subroutine [24] that takes care of the solution of the time dependent Equations (3-44) and (3-45), in OZAN]. The time coefficients $N_1(t)$ and $N_2(t)$ were found to be satisfactorily steady for the period of interest.

Further comments;

It is recognized that in the previous test, $N_2(0) = 0$. Thus the (12) element has no effect on the result. Hence during the normal run - when $N_2(t)$ becomes greater - the divergence from zero of this element may be of importance. We save the discussion of this point for the next chapter (section 8-3).

7-4 Cross checking the subroutine that solves the time dependent equations

The code [24] that solves the time dependent Equations (3-44) and (3-45) was installed in OZAN after necessary modifications were made. This code has been checked against an other code in the work cited in reference [4] that also solves the multimode kinetics equations. Good agreement was found in the special case of one group of delayed neutrons.

In case only one trial mode is used the multimode kinetics equations reduce to the conventional point kinetics equations.

Thus the prediction made through OZAN (NMODES=1) with 15 groups of delayed neutrons should agree with the one obtained through a point kinetics code if the same parameters are supplied. We were able to obtain good agreement between the point kinetics code [18] and OZAN (NMODES=1).

7-5 The point kinetics model equivalent to the multimode synthesis scheme; cross checking the behavior of the power level predicted by OZAN.

In this section we shall first show that one is able to compute a scalar generation time, reactivity, delayed neutron fractions and a time coefficient equivalent to respectively; generation time matrix, Λ , reactivity matrix $\rho_{new}(t)$, delayed neutron fraction matrices, $\overline{\beta}_{j_{new}}(t)$, $[j=1,\ldots,(H+1)]$ and time

coefficient matrix N(t). Thus the point kinetics model described by Λ_{eq} , $\rho_{eq}(t)$ and $\beta_{eq}(t)$'s should predict a change in power level from N_{eq}(t) equivalent to that defined by N₁(t) and N₂(t).

 $N_{eq}(t)$ will thus be checked against the behavior of the power level computed through the point kinetics code run with Λ_{eq} , $\rho_{eq}(t)$ and $\beta_{eq}(t)$'s.

7-5-1 The equivalent point kinetics model

For the purpose of developing the equivalent point kinetics model we express the neutron flux as

$$\vec{\varphi}(\mathbf{r},z,t) = \psi_{eq}(\mathbf{r},z,t) N_{eq}(t) [= \psi_1(\mathbf{r},z)N_1(t) + \psi_2(\mathbf{r},z)N_2(t)],$$
(7-35)

where now the shape, $\psi_{eq}(r,z,t)$ is a function of time, since we use only one time coefficient $N_{eq}(t)$ to represent

 $[\psi_1(r,z)N_1(t) + \psi_2(r,z)N_2(t)].$

Derivation;

Replacing $\emptyset(r,z,t)$ in Equations (3-1), (3-2) and (3-3) by $\psi_{eq}(r,z,t) N_{eq}(t)$ - this expression being identical to $\psi_1(r,z)N_1(t) + \psi_2(r,z)N_2(t)$ - leads us to the residuals defined through Equations (3-15), (3-16) and (3-17), where $\psi(r,z)N(t)$ should now be read: $\psi_{eq}(r,z,t)N_{eq}(t)$. Thus the first term of of the right hand side of Eq. (3-15) becomes

 $v^{-1} \frac{\partial [\psi_{eq}(r,z,t)N_{eq}(t)]}{\partial t}$. We weight the residuals [Eq. (3-15), (3-16) and (3-19)] with the first weighting mode. Thus the first term of the RHS of Eq. (3-15) becomes

$$N_{eq}(t) \int_{\underline{r}, reactor} W_{1}^{T}(\underline{r}) V^{-1} \frac{\partial \psi_{eq}(\underline{r}, t)}{\partial t} + \underbrace{r_{r}, reactor}$$

$$\frac{dN_{eq}(t)}{dt} \int_{\underline{r}, reactor}^{d\underline{r}} W_{1}^{T}(\underline{r}) V^{-1} \psi_{eq}(\underline{r}, t) . \qquad (7-36)$$

For the amplitude function, $N_{eq}(t)$, to contain most of the time dependence, $\psi_{eq}(\underline{r},t)$ should embody only slowly varying time functions for all \underline{r} and t. One way of insuring this is to impose the constraint condition [23]. That is

$$d\underline{r} \qquad W_1^{\mathrm{T}}(\underline{r}) \quad V^{-1} \quad \frac{\partial \psi_{\mathrm{eq}}(\underline{r},t)}{\partial t} = 0 \qquad . \quad (7-37)$$

r, reactor

That means

$$\int_{\underline{\mathbf{r}}, \operatorname{reactor}} d\underline{\mathbf{r}} \, \mathbb{W}_{1}^{\mathrm{T}}(\underline{\mathbf{r}}) \, \mathbb{V}^{-1} \, \psi_{\mathrm{eq}}(\underline{\mathbf{r}}, t) = \operatorname{cste} \, , \, (7-38)$$

where cste stands for a constante number that is determined by merely setting t to zero - in Eq. (7-38) - . Thus

cste =
$$\int_{\underline{r}, \text{reactor}} d\underline{r} W_{1}^{T}(\underline{r}) V^{-1} \psi_{eq}(\underline{r}, 0)$$

$$\equiv \int_{\underline{\mathbf{r}}, \text{reactor}} d\underline{\mathbf{r}} \ W_{1}^{T} (\underline{\mathbf{r}}) \ V^{-1} \ \psi_{1}(\underline{\mathbf{r}}) \equiv \Lambda_{11} \qquad . (7-39)$$

Then multiply both sides of Eq. (7-38) by $N_{eq}(t)$ to obtain

$$\begin{bmatrix} d\underline{r} & W_{1}^{T}(\underline{r}) & V^{-1} \ \overline{\emptyset}(\underline{r},t) \equiv N_{1}(t) \end{bmatrix} \begin{bmatrix} d\underline{r} & W_{1}^{T}(\underline{r}) & V^{-1}\psi_{1}(\underline{r}) \\ \underline{r}, reactor \end{bmatrix} \begin{bmatrix} d\underline{r} & W_{1}^{T}(\underline{r}) & V^{-1}\psi_{1}(\underline{r}) \end{bmatrix}$$

+N₂(t)
$$\int_{\underline{\mathbf{r}}, \text{reactor}}^{d\underline{\mathbf{r}}} W_1^{\mathrm{T}}(\underline{\mathbf{r}}) \nabla^{-1} \psi_2(\underline{\mathbf{r}}) \equiv N_1(t) \Lambda_{11} + N_2(t) \Lambda_{12}(t) = \Lambda_{11} N_{eq}(t).$$

(7-40)

Thus N_{eq}(t) is defined as

$$N_{eq}(t) = N_1(t) + \frac{\Lambda_{12}}{\Lambda_{11}} N_2(t)$$
, (7-41)

and can be calculated at various times based on the output from OZAN.

Next multiply both sides of Eq. (7-41) by Λ_{11} and take the derivative of both sides with respect the time. The result is

$$\Lambda_{eq} \frac{dN_{eq}(t)}{dt} = \Lambda_{11} \frac{dN_{1}(t)}{dt} + \Lambda_{12} \frac{dN_{2}(t)}{dt} , \quad (7-42)$$

with

$$\Lambda_{eq} \equiv \Lambda_{11}$$
 (7-43)

Furthermore we note that the procedure of weighting the residuals analogous to those given by Equations (3-15), (3-16) and (3-19) [the only difference being that $\psi_{eq}(\underline{r},t)N_{eq}(t)$ replaces $\psi(\underline{r}) N(t)$] by $W_1^T(\underline{r})$, leads us to equations for $N_{eq}(t)$

that are identical to the first scalar equations of the matrix equations (3-44) and (3-45); namely the equations

$$\Lambda_{11} \frac{dN_{1}(t)}{dt} + \Lambda_{12} \frac{dN_{2}(t)}{dt} = [\rho_{new_{11}}(t) - \overline{\beta}_{new_{11}}(t)]N_{1}(t) +$$

$$[\rho_{\text{new}_{12}}(t) - \overline{\beta}_{\text{new}_{12}}(t)] N_2(t) + \sum_{j=1}^{H+1} \lambda_j C_{j1}(t) , \qquad (7-44)$$

$$\frac{dC_{j}(t)}{dt} = \overline{\beta}_{j_{new_{11}}}(t)N_{1}(t) + \overline{\beta}_{j_{new_{12}}}N_{2}(t) - \lambda_{j}C_{j_{1}}(t)$$

$$(j = 1, ..., (H+1)]$$
, $(7-45)$

where in accord with the comment made (in the previous chapter) about the external source expressed in terms of an extra delayed neutron precursor amplitude function, j's are extended to (H+1).

Next we define

$${}^{\beta}eq_{j} \stackrel{(t)}{=} \frac{{}^{\beta}j_{new_{11}} \stackrel{(t)N_{1}(t)+\overline{\beta}}{j_{new_{12}}}}{N_{eq}(t)}, [j=1,...,H],$$

(Note that
$$\overline{\beta}_{(H+1)_{new_{11}}} = \overline{\beta}_{(H+1)_{new_{12}}} = 0$$
),

$$\beta_{eq}(t) = \sum_{j=1}^{H} \beta_{eq}(t) , \qquad (7-47)$$

and

$$\rho_{eq}(t) = \frac{\rho_{new_{11}}(t) N_1(t) + \rho_{new_{12}}(t) N_2(t)}{N_{eq}(t)}$$
(7-48)

Thus the equations (7-44) and (7-45) [identical to those we would obtain by finding $N_{eq}(t)$, through weighting by $W_1^{T}(\underline{r})$ the residuals given by Equations (3-15), (3-16) and (3-17) with $\psi(\underline{r})N(t)$ replaced by $\psi_{eq}(\underline{r},t)N_{eq}(t)$], can now be written through Equations (7-43), (7-46), (7-47) and (7-48) as

$$\Lambda_{eq} \frac{dN_{eq}(t)}{dt} = \left[\rho_{eq}(t) - \beta_{eq}(t)\right] N_{eq}(t) + \sum_{j=1}^{H+1} \lambda_j C_{eq_j}(t) , \quad (7-49)$$

$$\frac{dC_{eq_j}(t)}{dt} = \beta_{eq_j}(t)N_{eq}(t) - \lambda_j C_{eq_j}(t), [j=1,...,(H+1)] , (7-50)$$

where $C_{eq_j}(t)$ stands for $C_{j_1}(t)$.

Thus we have been able to derive a point kinetics model equivalent to the multimode synthesis scheme.

Normalization;

Note that Λ_{eq} , $\rho_{eq}(t)$ and $\beta_{eq_j}(t)$'s as they appear in equations (7-49) and (7-50) have not been normalized. [cf. Equations (7-43), (7-46) and (7-48)]. However that does not affect the preceding derivation since we know the normalization consists merely in dividing all the matrix elements of Λ , $\rho_{new}(t)$, and $\beta_{j_{new}}(t)$'s by the same number: denominator of the RHS of Eq. (7-1) - where k_1 should be read as $k_{OZAN} -$. Thus dividing both sides of Equations (7-43), (7-46) and (7-48) we obtain Λ_{eq} , $\rho_{eq}(t)$, and $\beta_{eq_j}(t) - (j=1,\ldots,H) - now normal$ $ized in terms of the normalized <math>\Lambda_{11}$, $[\rho_{new_{11}}(t)$, and $\rho_{new_{12}}(t)$],

and $[\beta_{j_{new_{11}}}(t), and \beta_{j_{new_{12}}}(t) - (j = 1, ..., H) -].$

Naturally $N_{eq}(t)$ predicted through Equations (7-49) and (7-50) where Λ_{eq} , $\rho_{eq}(t)$, and $\beta_{eqj}(t)$'s are normalized is the same as $N_{eq}(t)$ predicted through the same equations with Λ_{eq} , $\rho_{eq}(t)$ and $\beta_{eqj}(t)$'s not normalized. This can be seen from Eq. (7-41). Dividing the numerator and the denominator of $(\Lambda_{12}/\Lambda_{11})$ by the same quantity, will not affect the left hand side of Eq. (7-41), that is, $N_{eq}(t)$. Note that to arrive at Equations (7-49) and (7-50) the second adjoint mode $\psi_2^*(\underline{r})$ (or any other function) could have been chosen as the weighting function. Equations (7-49) and (7-50), now with

$$\Lambda_{eq} \equiv \Lambda_{21} , \qquad (7-51)$$

$$\beta_{eq_j}(t) = \frac{\overline{\beta}_{j \text{ new}_{21}}(t)N_1(t) + \overline{\beta}_{j \text{ new}_{22}}(t)N_2(t)}{N_{eq}(t)},$$

$$(j=1,..., H)$$
, $(7-52)$

$$\beta_{eq}(t) = \sum_{j=1}^{H} \beta_{eq_j}(t) , \quad (7-53)$$

and

$$\rho_{eq}(t) = \frac{\rho_{new_{21}}(t)N_1(t) + \rho_{new_{22}}(t)N_2(t)}{N_{eq}(t)} , \quad (7-54)$$

would predict

$$N_{eq}(t) = N_1(t) + \frac{\Lambda_{22}}{\Lambda_{21}} N_2(t)$$
 (7-55)

Note that $N_{eq}(t)$ defined through Eq. (7-41) is different from the one defined through Eq. (7-55). However the definition of $\psi_{eq}(\underline{r},t)$ [through Eq. (7-38) where now $W_1^T(\underline{r})$ is replaced by $\psi_2^{\star^T}(\underline{r})$] is also not the same as the one given through Eq. (7-38). Thus denoting $\psi_{eq_1}(\underline{r},t)$; $\psi_{eq}(\underline{r},t)$ defined through Eq. (7-38) by using $\psi_1^{T}(\underline{r})$ as the weighting function, and $\psi_{eq_2}(\underline{r},t)$; $\psi_{eq}(\underline{r},t)$ defined through Eq. (7-38) by using $\psi_2^{*T}(\underline{r})$ as the weighting function and with

$$N_{eq_1}(t) \equiv N_{eq}(t) Eq. (7-41)$$
, (7-56)

and

$$N_{eq_2}(t) \equiv N_{eq}(t)_{Eq.(7-55)}$$
 (7-57)

We expect to have, through Eq. (7-35),

$$\overline{\emptyset}(\underline{\mathbf{r}},t) \equiv \psi_{eq_1}(\underline{\mathbf{r}},t) \, \mathbb{N}_{eq_1}(t) = \psi_{eq_2}(\underline{\mathbf{r}},t) \, \mathbb{N}_{eq_2}(t) \quad (7-58)$$

Hence using a different weighting function in obtaining the equivalent point kinetics equations parameters, leads to a different shape function $[\psi_{eq}(\underline{r},t)]$, and a different time coefficient $[N_{eq}(t)]$. However since $|\Lambda| = 1.282 \times 10^{-3}$, we have

$$\frac{\Lambda_{22}}{\Lambda_{21}} \sim \frac{\Lambda_{12}}{\Lambda_{11}} \qquad , \qquad (7-59)$$

and

$$N_{eq_1}(t) \sim N_{eq_2}(t)$$
, (7-60)

Thus

Utility of the equivalent point kinetics Model;

Since the evaluation of Λ_{eq} , $\rho_{eq}(t)$ and $\beta_{eq}(t)$'s require the solution of Equations (3-44) and (3-45), the utility of the equivalence between Equations (3-44), (3-45) and Equations (7-49), (7-50) lies in reducing the complicated matrix scheme to more familiar scalar equations.

The comparison of Equations (7-49) and (7-50) (description of the transient equivalent to OZAN, NMODES = 2) with Equations (3-44) and (3-45) when just one trial mode is used [-the matrix N(t) being reduced to a scalar N₁(t), thus - OZAN, NMODES=1], will be presented in the next chapter.

7-5-2 Cross checking N_{eq} (t) calculated through Eq. (7-41) against N_{eq} (t) computed through a point kinetics code

The last cross checking undertaken for OZAN consisted of determing Λ_{eq} , $\rho_{eq}(t)$, and $\beta_{eq}(t)$'s from respectively the identity (7-43), and Equations (7-48) and (7-46), computing $N_{eq}(t)$ with these quantities through a point kinetics code, and comparing $N_{eq}(t)$ to the result calculated from Eq. (7-41).

Actually $\beta_{eq_j}(t)$'s can be considered to be constant throughout the transient and, since Λ_{11} is close to Λ_{12} , $N_{eq}(t) \approx N_1(t) + N_2(t)$; moreover $\overline{\beta}_{j_{new_{11}}}[j=1,...,(H+1)]$ is

(7-61)

almost equal to $\overline{\beta}_{j \text{ new}_{12}}$; thus $\beta_{eq_j}(t) \stackrel{\sim}{\sim} \overline{\beta}_{j \text{ new}_{11}}$. In addition Λ_{eq} need not be calculated. Thus we are concerned with only the calculation of $\rho_{eq}(t)$ in order to be prepared for the point kinetics code. $\rho_{eq}(t)$ is shown in Table 7-6.

Table 7-6 The equivalent scalar reactivity

time (sec.)	$\rho_{eq}(t) \times 10^3$		
1	2.445		
2	5.10		
3	7.80		
4	10.85		
5	14.04		

Approximating the reactivity $\rho_{eq}(t)$ by a series of ramp changes and with Λ_{11} , $\rho_{eq}(t)$, $\overline{\beta}_{j}$ new₁₁ and also C (0)'s PKj PKj from Table 6-2 used as input, $N_{eq}(t)$ was computed through the point kinetics code. For a comparison few numbers are shown in Table 7-7. Table 7-7 Comparison of $N_{eq}(t)$ calculated through Eq. (7-39) with $N_{eq}(t)$ computed through the point kinetics code

t(sec.)	N _{eq} (t) (from the point	N _{eq} (t) (OZAN)
0.8	0.71210 E-8	0.713 E-8
0.9	0.75586 E-8	0.748 E-8
1.0	0.80455 E-8	0.813 E-8

 $y \in x \equiv yx10^{x}$

We note that numbers for $N_{eq}(t)$ calculated from Eq. (7-41) based on the output from OZAN, agree satisfactorily with numbers for $N_{eq}(t)$ computed through OZAN (within an error of less than 1.15%).

7-6 Summary

In this chapter we have taken a look at five different ways of checking the results given by OZAN to answer the question: Do we believe in the computer code (OZAN) written to perform computations required by the proposed method? At some stages we have presented results that made a positive answer difficult (discrepancy in the eigenvalues and generation time,) the (21) element of the matrix ρ_1 , etc.). We pointed out however, that discrepancies encountered in section (7-1) are, we believe, due to both the bad convergence of the fluxes determined by Exterminator-II and to the difference in the methods used for computations in both OZAN and Exterminator-II. The worse convergence of the second adjoint mode was found to be responsible for the anomolous divergence of $\rho_{1_{21}}$ (algebra) from $\rho_{1_{21}}$ (OZAN).

On the other hand sections 7-2, 7-4 and 7-5 as well as $\rho_{1_{12}}$ (OZAN) and $\rho_{1_{22}}$ (OZAN) that checked well against $\rho_{1_{12}}$ (algebra) and $\rho_{1_{22}}$ (algebra) very much favor a positive answer to the question of validity of the code OZAN.

Thus we are inclined to say, we believe in OZAN.

CHAPTER VIII

THE VALIDITY OF THE PROPOSED METHOD AND CONCLUSIONS

This chapter includes a discussion of the photoneutrons, a word about the reactivity concept, a tentative to answer questions concerning the validity of the two-shape method, a summary of the conclusions and recommendations for further work.

8-1 Photoneutrons

Much effort has been devoted throughout this thesis research to analyse quantitatively the generation of both prompt and delayed photoneutrons in MITR-II.

8-1-1 Prompt photoneutrons

For α (the correction factor introduced to account for the error due to various approximations made in calculating the photon intensity at a point in the reflector region) = 1 we found

$$PPR_{11}(0) \gtrsim 3.94 \times 10^{-5}$$
 , (8-1)

where $PPR_{11}(0)$ denotes the (11) element of the prompt photoneutron production matrix at t = 0. This result implies that, if (assuming that α can be taken equal to 1) the prompt photoneutrons are neglected, an error of less than $4.\times10^{-5}$ is made in computing the (initial) reactivity^{*} of the reactor.

8-1-2 Delayed Photoneutrons

In order to see the importance of the delayed photoneutrons in determining the reactor inverse period, for various reactivity insertions we computed [28]

RHO =
$$\omega (\Lambda + \sum_{j=1}^{H} \frac{BETAT_j}{\omega + \lambda_j})$$
, (8-2)

where RHO is a reactivity that corresponds to ω , and Λ , the neutron generation time of the reactor. Λ has been taken (1.043922x10⁻⁴) as given by the Exterminator-II output for the inverse velocities presented in Chapter VI. For easy reference BETAT_j's and λ_j 's are presented in Table 8-1.

The computation of RHO for various values of ω was repeated changing the correction factor α for the delayed photoneutron fractions (j = 7, ..., 14). The results are presented in Table 8-2.

* i.e. $\rho_{\text{new}_{11}}$ (0) defined in Chapter III.

Delayed neutron fractions and the corresponding

decay constants

j	BETAT.	$\lambda_{1}(\text{sec}^{-1})$
	J	
1	0.3010 E-3	0.1240 E-1
2	0.1709 E-2	0.3050 E-1
3	0.1529 E-2	0.111
4	0.3082 E-2	0.301
5	0.8980 E-3	1.14
6	0.3280 E-3	3.01
7	0.1128 E-4	0.277
8	0.3531 E-5	0.169 E-1
9	0.1215 E-5	0.481 E-2
10	0.5824 E-6	0.150 E-2
11	0.3574 E-6	0.428 E-3
12	0.4028 E-6	0.117 E-3
13	0.5562 E-7	0.437 E-4
14	0.1757 E-7	0.363 E-5

 $y E x \equiv y \times 10^{X}$



Table 8-2 Effect of delayed photoneutrons in determining the inverse period, for various connection factors. Numbers presented are reactivities multiplied by a hundred.

$\alpha \qquad \omega(sec^{-1})$	0.02	0.04	0.06	0.08	0.1
0	0.13078	0.20049	0.24888	0.28612	0.31640
1	0.13128	0.20113	0.24961	0.28692	0.31726
3	0.13229	0.20240	0.25106	0.28851	0.31897
5	0.13329	0.20368	0.25252	0.29011	0.32069

As expected we see from Table 8-2 that the delayed photoneutrons become more important for small insertions of reactivity.

 $\omega(\sec^{-1})$ is plotted versus RHO for $\alpha = 1$ (as shown in Chapter II) in Fig. 8-1.

8-2 The Equivalent Reactivity

In Chapter VII (section 7-5) we have shown that an equivalent generation time, set of delayed neutron fractions and reactivity can be defined so that with these parameters the P equation predicts the same solution as the one given through the multimode kinetics equations (synthesis method).

The equivalent reactivity makes it easy to visualize the difference between various predictions;

Comparing the parameters $(\Lambda_{eq}, \beta_{eq}(t) \text{ and } \rho_{eq}(t))$ of the point kinetics model equivalent to OZAN (NMODES=2), to those $(\Lambda_{11}, \overline{\beta}_{new_{11}}(t), \rho_{new_{11}}(t))$ determined for the point kinetics type of approach; (OZAN, NMODES=1) we see that the only one that is significantly different is

$$\rho_{eq}(t) \text{ [for } \beta_{eq}(t) = \frac{\overline{\beta}_{new_{11}}(t)N_1(t) + \overline{\beta}_{new_{12}}(t)N_2(t)}{N_{eq}(t)};$$

$$N_{eq}(t) = N_{1}(t) + \frac{\Lambda_{12}}{\Lambda_{11}} N_{2}(t); \frac{\Lambda_{12}}{\Lambda_{11}} \gtrsim 1, \text{ thus } N_{eq}(t) \gtrsim N_{1}(t) + N_{2}(t);$$

$$\overline{\beta}_{new_{11}}$$
 (t) $\overline{\lambda}\overline{\beta}_{new_{12}}$ (t) $\overline{\lambda}\overline{\beta}_{new_{11}}$ (0); thus β_{eq} (t) $\overline{\lambda}\overline{\beta}_{new_{11}}$ (0); and

 $\Lambda_{eq} = \Lambda_{11}$].

Thus the three different approaches (the point kinetics Code [18], OZAN; NMODES=1, and OZAN; NMODES=2) undertaken in Chapter VI for analysing the effects of withdrawal of the bank of shim rods, are equivalent to solving equations of type

$$\frac{dN_{eq}(t)}{dt} = \frac{\left(\rho_{eq}(t) - \beta_{eq}(t)\right)}{\Lambda_{eq}} N_{eq}(t) + \sum_{j=1}^{H+1} \lambda_j C_j(t), \quad (8-3)$$

$$\frac{dC_{j}(t)}{dt} = \frac{\beta_{eqj}}{\Lambda_{eq}} N_{eq}(t) - \lambda_{j}C_{j}(t) , (j=1,\ldots, H) , (8-4)$$

where $\Lambda_{eq} \equiv \Lambda_{PK}$ (cf. Chapter VI) $\equiv \Lambda_{11}$ (cf. OZAN, NMODES = 1), and $\beta_{eq_j}(t) \sim \beta_{PK_j}$ (cf. Chapter VI) $\equiv \overline{\beta}_{j}$ (0) (cf. OZAN, $j_{new_{11}}$ (0) (cf. OZAN, NMODES=1), for respectively $\rho_{eq}(t) = \rho_{PK}(t)$ (cf. Chapter VI), $\rho_{eq}(t) = \rho_{new_{11}}(t)$ (cf. OZAN, NMODES=1), and

$$\rho_{eq}(t) = \frac{\rho_{new_{11}}(t)N_1(t) + \rho_{new_{12}}(t)N_2(t)}{N_{eq}(t)} \text{ [cf. Eq. (7-41), OZAN,}$$

NMODES = 2].

Comparison of various reactivities;

The comparison of these various reactivities, that have been defined for the same transient (withdrawal of the control rods, cf. Chapter VI) is shown in Table 8-3. This table also includes values of two other definitions of reactivity obtained by making the first weighting function unity throughout the entire reactor, first in OZAN (NMODES=1) and then in OZAN (NMODES=2). (We will later come back to the latter study to point out the importance of the weighting function in the weighted residual technique.) Table 8-3 Comparison of various reactivities defined for the same transient (cf. Chapter VI) through different approaches

t(sec.) рк	OZAN (NMODES =1)	OZAN (NMODES =2)	OZAN (NMODES =1) W_1 (<u>r</u>)=1.	OZAN (NMODES =2) W (\underline{r})=1.
0.	0.	0.	0.	0.	0.
1	0.3×10^{-2}	0.2×10^{-2}	0.2445×10^{-2}	0.627x10 ⁻²	0.585x10 ⁻²
2	0.6x10 ⁻²	0.4×10^{-2}	0.510×10^{-2}	1.253x10 ⁻²	0.855x10 ⁻²
3.4.4.4	0.9×10^{-2}	0.6×10^{-2}	0.788×10^{-2}	1.88×10 ⁻²	
4	1.2×10^{-2}	0.8x10 ⁻²	1.085×10^{-2}	2.51×10^{-2}	-
5	1.5x10 ⁻²	1.0×10^{-2}	1.404×10^{-2}	3.14×10^{-2}	-

 P_{K} stands for the reactivity determined by the first approach undertaken in Chapter VI in the course of the study of the withdrawal of the rods by the point kinetics code [18].

Numbers presented in the last two columns of Table 8-3; The numbers presented in the last two columns of Table 8-3 were obtained in the following way;

A calculation has been made with the first weighting function unity throughout the reactor (and everything else being the same) for the problem (withdrawal of control rods) subject to Chapter VI. The relevant initial value and the ramp change shape of the reactivity matrices, $\rho_{new}(0)$ and ρ_1 were taken from the output OZAN (NMODES=2). A normalization factor (cf. Chapter VIII, section 7-5)

 $\int_{\underline{r}, \text{core}}^{\underline{dr}} (1)^{T} \nu \chi \Sigma_{F}^{T}(\underline{r}, 0) \psi_{1}(\underline{r}) [(1)^{T} \text{ denoting the transpose}$

of the column matrix composed of G (number of neutron groups) elements that are unity] is already present in these matrix elements. On the other hand a normalization factor

 $\int_{\underline{r},core} d\underline{r} \ \psi_1^{\star^T}(\underline{r}) \nu \ \chi \ \Sigma_F^T(\underline{r},0) \psi_1(\underline{r}) \text{ is present in the numbers}$ shown in second, third and fourth columns of the Table 8-3. Thus for the purpose of the comparison an adjustment of the $\rho_{new}(0)$ and ρ_1 relevant to the study; $W_1(\underline{r}) = 1$, OZAN (NMODES=2) is made such that the (11) element of the generation time matrix relevant to this study becomes equal to the (11) element of the generation time matrix obtained through the study where $\psi_1^{\star}(\underline{r})$ is used (as the weighting function).

Then the fifth column numbers of Table 8-3 were obtained by writing, with the adjusted (11) elements of $\rho_{new}(0)$ and ρ_1 relevant to the study; $W_1(\underline{r}) = 1$, OZAN (NMODES=2);

$$\rho_{eq}(t) = \rho_{new_{11}}(0) + t \rho_{11}$$

and the last column numbers of Table 8.3 were obtained by using the Eq. (7-48) along $\rho_{new_{11}}(0)$, $\rho_{new_{12}}(0)$, ρ_{1} , and ρ_{1}_{12}

relevant to the same study.

We recognize that different sets of numbers for reactivity versus time, shown in Table 8-3 are responsible for different predictions about the transient studied. Thus the interpretation of a prediction in terms of the equivalent parameters (and mainly equivalent reactivity) makes us better understand, how this prediction is different from others.

8-3 The Validity of the two-shape calculations

In the previous chapter we examined the correctness of the code OZAN and defined the question of the validity of the proposed method. Specifically one has to examine what conditions must be fulfilled in order to make an accurate prediction for a transient through the weighted residual method and whether or not we fulfilled those conditions for the present study. Are two shapes sufficient for the purpose of analyzing the accident mentioned in Chapter VI? Even further, in Chapter VII it is pointed out that we used the two-shape method to observe the transient only after the reactor had become critical. If the two shape method had been used for the entire transient would the result be significantly different from those given in Chapter VI ?

Unfortunately we will not be able to give a definitive answer to these questions without further study.

We intend, however to discuss two points that relate to the character of the weighted residual method and are for consideration to resolve some of the obscurities.

a) It was pointed out earlier (cf. Chapters IV and V) that in order to compute the leakage integral $\int dr W^{T}(r)$ r,reactor

 $\nabla .D(\underline{r},t) \nabla \psi(\underline{r})$ (in matrix notation) we needed the balance equations through which $\psi_1(\underline{r})$ and $\psi_2(\underline{r})$ [column vectors, components of $\psi(\underline{r})$] are generated. Thus the eigenvalues k_1 and k_2 for the balance equations in question were computed through OZAN, in an integral sense. For the eigenvalues relative to $\psi_1(\underline{r})$ and $\psi_2(\underline{r})$ computed through the code (Exterminator-II) would not insure these balance equations (due to the poor convergence of the fluxes and differences in computations used in both codes, etc.) when applied to OZAN.

In addition k_{OZAN} was introduced to compensate the photoneutrons and insure that at time the reactor becomes critical the (11) element of the reactivity matrix, $\rho_{new_{11}}$ (0) vanishes

so that we do not go to the time dependent equations with a residual reactivity at that time. Otherwise an erroneous prediction would result.

The examination of possible errors arising from these (somewhat artificial) manipulations is made below throughout the subsection 8-3-1.

 b) A second point of this validity consideration is a study of the effect of the weighting on the prediction through the weighted residual method. This is done in the subsection 8-3-2.

8-3-1 Eigenvalues computed in an integral sense

For the purpose of studying the possible errors arising from the introduction of the eigenvalues k_1 , k_2 and k_{OZAN} , computed in an integral sense (to satisfy the required balances) we develop arguments about k_{OZAN} and k_2 . We then try to show that we do not have to fear the artificialities introduced by the definition of these quantities.

1. k_{OZAN};

The purpose of defining a quantity k_{OZAN} was to compensate for the presence of the photoneutrons (Neither of the operators that generated the trial shapes through Exterminator-II included the photoneutrons) by forcing $\rho_{new_{11}}$ (0) to vanish. However

since $k_{OZAN}(\underline{r})$ then differs from $H_1(\underline{r})$ (a correction factor α = 10 has been used for photoneutrons throughout the OZAN studies), a relationship such as $H_1(\underline{r}) | \psi_1(\underline{r}) \rangle = 0$ does not hold for $H_{OZAN}(\underline{r})$. Thus we expect $\langle \psi_2(\underline{r}) | H_{OZAN}(\underline{r}) | \psi_1(\underline{r}) \rangle$ [the (21) element of the initial value of the reactivity matrix] to differ from zero. This quantity turned out to be 1.93×10^{-5} , which is still satisfactorily close to zero. Thus we feel the (21) element introduced by this approximation is negligible.

The (12) element of the initial value of the reactivity matrix; $\psi_1^{\star^T}(\underline{\mathbf{r}}) |_{H_{OZAN}}(\underline{\mathbf{r}}) |_{\psi_2}(\underline{\mathbf{r}}) > \text{ is } \gtrsim 1.463 \times 10^{-3}$. If there were no photoneutrons it would be $\langle \psi_1^{\star^T}(\underline{\mathbf{r}}) |_{H_1}(\underline{\mathbf{r}}) |_{\psi_2}(\underline{\mathbf{r}}) >$ which should vanish if $\psi_1^{\star}(\underline{\mathbf{r}})$ were well converged. Numerically for the unconverged values used, the (12) element without photoneutrons is 1.404×10^{-3} . The difference between $\langle \psi_1^{\star^T}(\underline{\mathbf{r}}) |_{H_{OZAN}}(\underline{\mathbf{r}}) |_{\psi_2}(\underline{\mathbf{r}}) >$ and $\langle \psi_1^{\star^T}(\underline{\mathbf{r}}) |_{H_1}(\underline{\mathbf{r}}) |_{\psi_2}(\underline{\mathbf{r}}) >$ is then of a minor importance in view of the (12) element of the ramp change slope of the reactivity matrix: 2.241×10^{-3} .

Thus the introduction of k_{OZAN} is a small correction and apparently gives its expected result.

*

 It does not matter if the reactor has not been poisoned to compute k₂ through OZAN.

The second trial mode was generated through Exterminator-II) by increasing the absorption cross sections by the quantity ωv^{-1} throughout the reactor (cf. Chapter IV). To be rigorous we should do the same thing when we come to compute k_2 through OZAN. Failure to do so the eigenvalue k_2 (computed in an integral sense through OZAN) will be different (greater) than the one obtained if the reactor was poisoned. $k_{2_{NP}}$ (NP standing

for "nonpoisoned") will then be rather artificial (for it is

computed so that the balance - cf. Chapter IV - is insured for a flux through some cross sections that does not belong to this flux).

A sensitivity study was made to see the effect on the matrix elements of not poisoning the reactor in computing the eigenvalue k_2 through OZAN. A comparison is presented in Table 8-4-1.

Table 8-4-1 Comparison of reactivity matrix elements in cases the reactor has been poisoned for the computation of k₂ through OZAN, and the reactor has not been poisoned for the same computation

	P	NP
k ₂	1.02579212	1.02754307
ρ _{new} (0)	(x 0.14621585 E-2) (x -0.52545846 E-1)	$\begin{pmatrix} x & 0.14627143 E-2 \\ x & -0.52609537 E-1 \end{pmatrix}$
°۱	(x 0.22408564 E-2 (x 0.16423166 E-1)	$\begin{pmatrix} x & 0.22407090 & E-2 \\ x & 0.16423021 & E-1 \end{pmatrix}$

$y \equiv x \equiv y \times 10^{x}$

P stands for the case the reactor was poisoned for OZAN to compute k_2 , NP for the case the reactor was not poisoned for the same computation.
The crosses in Table 8-4-1 refer to the (11) and (21) elements of the matrices in question that are not affected at all (since these elements do not involve the second trial mode).

The numbers shown in Table 8-4-1 affirm that the differences due to computing k_2 by poisoning the reactor and not poisoning it, are minor. This can also be seen from Table 8-4-2 where we give numbers for $N_1(t)$ and $N_2(t)$ for both cases.

Table 8-4-2 The time coefficients $N_1(t)$ and $N_2(t)$ for both cases: the reactor has been poisoned to compute k_2 through OZAN, and it has not been poisoned for the same computation

t(sec.)	P	NP	
1	0.61083 E-8	0.611027 E-8	N ₁ (t)
	0.20901 E-8	0.20874 E-8	N ₂ (t)
2	0.99663 E-8	0.99747 E-8	$N_1(t)$
	0.10495 E-7	0.10478 E-7	$N_2(t)$
3	0.61598 E-7	0.61673 E-7	N ₁ (t)
	0.22798 E-6	0.22693 E-6	N ₂ (t)

P, NP and y E x that stand in Table 8-4-2 were defined for Table 8-4-1.

The results presented throughout both parts of this subsection suggest that we do not have to fear artificialities introduced during the course of the proposed method, due to the definitions in an integral sense of k_1 , k_2 and k_{OZAN} . An undesirable perturbation (photoneutrons, small variations in the cross sections, etc.) is then successfully absorbed in the definition of the eigenvalue of interest, to reassure the required balance equation. For the study undertaken in part 2 of this subsection this can be clearly seen from the algebraic relationship obtained in Chapter VII (section 7-3) for the elements of the ramp change slope of the reactivity matrix [cf. Eq.(7-33)],

$$\delta(\underline{\mathbf{r}}) = H_2(\underline{\mathbf{r}}) + \frac{H_B(\underline{\mathbf{r}})}{BET} \times \frac{k_2 - k_{OZAN}}{k_2} - H_{OZAN}(\underline{\mathbf{r}}) + H_{PPN}(\underline{\mathbf{r}})$$

$$+ H_{DPN}(\underline{r}) + \omega v^{-1} . \qquad (8-5)$$
(We recall that $\rho_1 = \frac{\langle \psi^{\star T}(\underline{r}) | \delta(\underline{r}) | \psi(\underline{r}) \rangle}{T}$)

In case the reactor has not been poisoned to compute ρ_1 the last term in the RHS of Eq. (3-5) will be omitted, but

since $k_{2_{NP}}$ is now greater than $k_{2_{P}}$ (P standing for the case the reactor is poisoned to compute k_{2} through OZAN), $(\rho_{1_{12}})_{NP}$ and $(\rho_{1_{22}})_{NP}$ are still approximately equal to respectively $(\rho_{1_{12}})_{D}$ and $(\rho_{1_{22}})_{P}$ (cf. Table 8-4-1). This implies that a

relationship such as

$$\omega v^{-1} = \frac{1}{k_{2p}^{2}} - \frac{1}{k_{2NP}^{2}} H_{B}(\underline{r}) \frac{k_{OZAN}}{\overline{\beta}_{new_{11}}}(0) , \quad (8-6)$$

is approximately true; that gives (through the values for k_{2_p} , $k_{2_{NP}}$, k_{OZAN} , BET, and ω given ealier);

Λ % 1.305 <
$$\psi^{*^{T}}(\underline{r})$$
 |H_B(r) |ψ(r) > . (8-7)

which happens to be indeed right (cf. Table 8-5).

Table 8-5 Comparison of the elements of the generation time matrix with the ones obtained through the approximate Relationship (8-7)

Λ	Λ _{Eq.(8-7)}
(0.1011 E-3 0.9786 E-4)	(0.1023 E-3 0.1020 E-3)
0.9807 = 4 0.9508 = 4	\0.960 E-4 0.955 E-4

8-3-2 Weighting

Throughout this subsection we will try to emphasize the importance of the weighting functions in the weighted residual method. This is done in three parts.

1. The (12) element of the initial value of the reactivity matrix is not small enough;

It was pointed out earlier that (cf. Chapter VII section 7-3-4) the (12) element of the initial value of the reactivity matrix is not close enough to zero due to the bad convergence of $\psi_1^*(\mathbf{r})$ ($\langle \psi_1^{\mathbf{r}^T}(\underline{\mathbf{r}}) | H_1(\underline{\mathbf{r}}) | \psi_2(\underline{\mathbf{r}}) \rangle \approx 1.4 \times 10^{-3}$, and the photoneutrons are shown - cf. part 1. of the previous subsection not to play a major role in this divergence from zero), and may be a source of trouble. Through Eq. (7-48) one can indeed see that, because the (12) element of the initial value of the reactivity matrix is not negligible as compared to tx ρ_{1}_{12} (for

the period of time of interest), there is a certain contribution of $\rho_{new_{12}}(0)$ in the computation of the equivalent reactivity, $\rho_{eq}(t)$. Equivalent reactivity $\rho_{eq}(t)$ is calculated assuming that $\rho_{new_{12}}(0)$ vanishes, and compared in Table 8-6, to the numbers obtained by taking the finite value - for $\rho_{new_{12}}(0)$ computed through OZAN.

Thus apparently the prediction about the transient would not be as severe if the first adjoint mode were well converged so that $\langle \psi_1^T(\underline{r}) | H_1(\underline{r}) | \psi_1(\underline{r}) \rangle$ vanishes and $\rho_{new_{12}}(0)$ is close

Table 8-6 Comparison of $\rho_{eq}(t)$ of Table 7-6 with $\rho_{eq}(t)$

calculated by making $\rho_{new_{12}}(0)$, zero.

t(sec.)	$ \rho_{eq}(t) \text{ [with } \rho_{new_{12}}(0)^{\gamma}] $ 0.1463E-2	$\rho_{eq}(t) [with \rho_{new_{12}}(0)=0]$
1	2.445 E-3	2.075 E-3
2	5.100 E-3	4.33 E-3
3	7.880 E-3	6.70 E-3
4	10.850 E-3	9.25 E-3
5	14.04 E-3	12.15 E-3

 $y Ex \equiv j \times 10^{x}$

enough to zero.

We note that in any case;

- A space-dependent analysis (for the transient we have studied) results in a different (and hopefully more accurate) prediction than a point kinetic analysis (cf. numbers presented in Table 8-6 compared to the numbers presented in the third column of Table 8-3);

- The reactivity $\rho_{eq}(t)$ versus time is initially lower than $\rho_{PK}(t)$ (cf. the second column of Table 8-3) for sometime and finally intercepts it [at around 5 sec. in case we have numbers presented in the second column of Table 8-6 and later in case we have numbers presented in the third column of the same table].

2. A comment about the (21) element of the ramp change slope of the reactivity matrix that was found badly off as compared to the prediction made by the algebra (cf. Chapter VII, section 7-3);

It may be thought that we can overcome the divergence of ρ_1 computed through OZAN (NMODES=2), from the value given by the algebraic relationship (developed in Chapter VII, section 7-3), by simply setting ρ_1 to this algebraic result. This is not as simple for the reasons we give below;

The divergence in question was found due to the bad convergence of the second adjoint made [specifically $<\psi_2^{*^{T}}(\underline{r}) | H_2(\underline{r}) | \psi_1(\underline{r}) >$ was found to be $\sqrt[\infty]{5. \times 10^{-2}}$, whereas

it is expected to vanish].

On the other hand in section 7-2 (Chapter VII) it was shown that the elements of the matrix ρ_1 can be merely computed by taking into account the perturbed area only (that is four points and the relevant fluxes and cross sections). That means, since setting ρ_1 to the value found by the algebra implies $\langle \psi_2^{\mathbf{T}}(\underline{\mathbf{r}}) | \mathbf{H}_2(\underline{\mathbf{r}}) | \psi_1(\underline{\mathbf{r}}) \rangle = 0$, convenient values for $\psi_2^{\mathbf{t}}(\underline{\mathbf{r}})$ over the four points (of the perturbed area) in question, are then tacitly assumed (so that the relationship of interest is now satisfied). This in return implies all the matrix elements that involve $\psi_2^{\star}(\underline{r})$ must be accordingly adjusted, or an erroneous prediction will result.

We may think from a different point of view that the nature of the weighted residual method does not require relationships such as $\langle \psi_2^{\mathbf{T}}(\underline{\mathbf{r}}) | H_2(\underline{\mathbf{r}}) | \psi_1(\underline{\mathbf{r}}) \rangle = 0$, so that a bad converged adjoint function can be allowed as a weighting function. This is shown to be incorrect throughout the final part of this subsection.

3. Effect of Changing the weighting function

Changing the weighting function makes a large difference. We have examined a case where $W_1(\underline{r})$ is chosen to be unity for all the points of the reactor, for the same accident presented in Chapter VI. The equivalent reactivity, $\rho_{eq}(t)$ for this case is already presented in the last column of Table 8-3.

We will be content here by giving the final predictions as compared to the ones obtained through the run where $W_1(\underline{r})$ was $\psi_1^*(\underline{r})$ (cf. Table 8-7). Table 8-7 Comparison of the results obtained by making

 $W_1(\underline{r}) = 1$ with those obtained by making $W_1(\underline{r}) = \psi_1^*(\underline{r})$

t(sec.)	OZAN (NMODES=2) $W_1(\underline{r}) = 1$	OZAN (NMODES=2) $W_1(\underline{r}) = \psi_1^*(\underline{r})$	
1	0.554 E9	0.611 E-8	N ₁ (t)
	0.128 E8	0.209 E-8	N ₂ (t)
2	0.257 E27	0.997 E-8	N ₁ (t)
	0.116 E27	0.105 E-7	N ₂ (t)

The prediction with $W_1(\underline{r}) = 1$ is erroneous. The reason is that the reactivity insertion $\rho_{eq}(t)$, estimated for the accident is much higher with $W_1(\underline{r}) = 1$. (cf. Table 8-3). Apparently it is inappropriate to use just any weighting function in the weighted residual method. As suggested by the perturbation theory or variational method, the adjoint modes that correspond to the spatial shapes are more properly used as weighting functions. Moreover it is important to have reasonably well converged adjoint functions (as well converged as the spatial shapes) in order to make an accurate prediction.

We find it interesting to note that $\rho_{eq}(t)$, $W_1(\underline{r}) = 1$, NMODES=2 behaves better than $\rho_{eq}(t)$, $W_1(\underline{r}) = 1$, NMODES=1 (cf. the last two columns of Table 8-3). It seems then that the two-shape method (NMODES=2) improves the results as compared to a point kinetics type of approach (NMODES=1). However the prediction is still far beyond being realistic.

**

We conclude in this section thus, that the answer of the question: Do we believe in the proposed method?, lies in answering the question: Did we use well converged weighting functions?, everything else, we believe, working correctly. A positive answer to the latter question is not available due to lack of funds, and it seems, better results would be obtained if we had more converged weighting functions, that remains however to be shown.

* * *

In any case one unfortunately cannot tell whether or not he made a good prediction through the weighted residual method until he compares his results with the exact solution, although the method was proven to give successful results (for a much simpler case however) [27], if care is taken to insure "good" working conditions.

It is believed that for some cases, obtaining the exact solution may be even easier. For the generation of well converged trial shapes and weighting functions along the application of the weighted residual criteria, may be as time consuming as 90 minutes of computation (case of the present study) on an IBM 360/65 computer. Even if the exact solution is thought to be "little" more costly than that, we believe it may be worth spending the computation time to obtain a reassuring prediction.

8-4 SUMMARY

It was shown that equivalent point kinetics parameters can be defined so that the same prediction made through the multimode kinetics equations about a transient, can be made through a point kinetics equations. It was emphasized that the equivalent reactivity is the predominant parameter in the kind of accident undertaken. Thus it was pointed out that the equivalent reactivity concept makes it easier to visualize the differences in the procedures used by various methods.

We were concerned that erroneous prediction may be caused by the definitions of the eigenvalues k_1 , k_2 and k_{OZAN} in an integral sense. The artificialities introduced through the definitions (in an integral sense) of k_1 , k_2 and k_{OZAN} are proven to be of a minor importance.

Finally a study about the importance of the weighting functions used in the weighted residual method is presented. It is shown that not just any function can be used as a weighting function, and the adjoint functions are the most appropriate ones for this purpose. Furthermore the weighting functions are required to be as converged as the trial shapes. Otherwise an erroneous prediction may result.

8-5 Recommendations for further work

The concern about the proposed technique has always been the fact that it lacks definitive error bounds.

We recognize that for a good set of fluxes (trial shapes and their adjoint modes) the algebraic relationships presented in Chapter VII (section 7-3) would be satisfied and we would feel much more comfortable about the predictions under these circumstances.

• We suggest a study should be done to see the effect of the convergence of the fluxes on the predictions (however in a much simpler case than the one we have undertaken for the

present work). Then we thought a line may be drawn between the divergence of the predictions from the exact solution and the degree at which the algebraic relationships are satisfied.

It may, then, also be possible without having to generate more converged fluxes, to adjust in a consistent way the "bad" matrix elements so that a better prediction can be made quickly. The proposed method would be more fruitful and more satisfactory under these circumstances.

The effect, on the prediction, of more trial shapes and more neutron groups remains to be seen. However the limitations of the available facilities (computer care storage, use of input output devices, etc.) may impede the combination of such studies.

A comparison between the multimode method with OZAN and an exact solution for a simplified transient problem would give valuable information about the validity and usefulness of the proposed method.

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APPENDIX A

PHOTONEUTRONS GENERATED BY PHOTONS HAVING HAD ONE AND ONLY ONE COLLISION, FROM U²³⁵ ON D₂0

The purpose in this Appendix is to investigate whether the photoneutrons generated in D_2O by photons from U^{235} , having had one and only one collision, could be neglected as compared to photoneutrons produced by uncollided photons under the same circumstances.

To this end we seek an estimate of photoneutrons generated by photons having had one and only one collision, from U^{235} on D_20 .

Assume then that we know the directional flux of uncollided photons of energy Λ' , per cm², per Mev, per steradian, per sec., from an atom of U^{235} at a central location, in an infinite medium of D_2O , at r', in the direction $\underline{\Omega}'$ and at time $t':\xi'(r',\Lambda',\Omega',t')$ photons per cm² × Mev × steradian × sec.

Thus

$$\psi'(\mathbf{r}',\Lambda',\Omega',t) = \int_0^t \xi'(\mathbf{r}',\Lambda',\Omega',t')dt', \qquad (A-1)$$

gives the total number of uncollided photons of energy

within a unit interval of energy around Λ' , crossing a unit area at r' perpendicular to the direction $\underline{\Omega}'$, within a unit solid angle around $\underline{\Omega}'$, between t' = 0 and t' = t, from an atom of U^{235} placed in a central location in an infinite medium of D_20 .

Define now the microscopic Compton scattering cross section

$$d^{2}_{e}\sigma(\Lambda' \rightarrow \Lambda) = \frac{r_{0}^{2}}{2} \left(\frac{\Lambda}{\Lambda'}\right)^{2} \left(\frac{\Lambda'}{\Lambda} + \frac{\Lambda}{\Lambda'} - \sin^{2}\theta\right) d\mu \sin \theta d\theta,$$

where r_0 is the classical radius of the electron, Λ' and Λ are the energies of the photon respectively before and after the scattering; in addition, various angles $(\theta, \mu, \Omega, \Omega')$ are shown in Fig. A-1.

Let \underline{N}_{D_2O} be the number of D_2O molecules per cm³ and Z be the number of electrons present in one molecule of D_2O , (Z = 10); such that,

(A-3)

$$\phi'(\mathbf{r}',\Lambda' \rightarrow \Lambda,\Omega',t)d\underline{\mathbf{r}}' = \psi'(\mathbf{r}',\Lambda',\Omega',t)d\underline{\mathbf{r}}' \quad d^2_{e}\sigma(\Lambda' \rightarrow \Lambda)\underline{N}_{D_2O}Z$$

is the number of photons among those described by the Eq. (A-1), scattered in the elementary volume $d\underline{r}'$, into the solid angle $d\Omega = d\mu \sin \theta \ d\theta$.

(A-2)

Furthermore through the study of Compton collision,

$$\frac{1}{\Lambda'} - \frac{1}{\Lambda} = \frac{1 - \cos \theta}{E_0}, \qquad (A-4)$$

where $E_0 = 0.51$ Mev, and considering Λ' to be constant,

$$E_0 \frac{d\Lambda}{\Lambda^2} = \sin \theta \, d\theta, \qquad (A-5)$$

so that the energy of the scattered photon stays within $d\Lambda$ around Λ ; once the solid angle $d\Omega$ is chosen, Λ being determined through Eq. (A-4) and $d\Lambda$ through Eq. (A-5).



from $d\Omega'$ into $d\Omega = d\mu \sin\theta d\theta$

The photon flux due to photons described in Eq. (A-3) is $\phi'(r',\Lambda' \rightarrow \Lambda,\Omega',t)dr'$ divided by ds, the surface area seen by $d\Omega$, at r and,

$$ds = d\Omega |\underline{r} - \underline{r'}|^2 \qquad (A-6)$$

Define now, $\Sigma_{D}(\Lambda)$ and $\Sigma(\Lambda)$ to be respectively the photoneutron reaction and the attenuation cross section for photons of energy Λ in D_2O .

We can, then, write the total number of photoneutrons generated by photons having had one and only one collision, from an atom of U^{235} on an infinite medium of D_2^0 to be

$$S_{1} = \int_{\mathbf{r}',\mathbf{r},\Lambda',\Omega',\Omega} \frac{d\mathbf{r}'d\mathbf{r}d\Lambda'd\Omega'\psi'(\mathbf{r}',\Lambda',\Omega',\infty)d^{2}}{\mathbf{r}',\mathbf{r},\Lambda',\Omega',\Omega} \sigma(\Lambda' \to \Lambda) \underline{N}_{D_{2}O} Z \times$$

$$\frac{1}{ds} e^{-\Sigma(\Lambda) |\underline{r}-\underline{r}'|} \Sigma_{D}(\Lambda),$$

where denotes the integrations over the $r', r, \Lambda', \Omega', \Omega$

variables r', r, Λ', Ω' and Ω , and ∞ in $\psi'(r', \Lambda, \Omega', \infty)$ stands for $t = \infty$; that is, the atom of U^{235} being fissioned, we wait for all the gamma rays to come out of the fission products.

To perform the calculation of S_1 we consider the Fig. B-2 (of Appendix B) where we have $a(\Lambda',t)$, the number of photons of energy Λ' emitted per sec., per Mev, t second(s) after the fission of an atom of U^{235} took place.

Then,

$$\psi'(\mathbf{r}',\Lambda',\Omega',\mathbf{t}) = \left\{ \int_0^t a(\Lambda',t')dt' \right\} \frac{1}{4\pi} \times \frac{1}{ds'} e^{-\Sigma(\Lambda')\mathbf{r}'},$$
(A-8)

where

$$ds' = d\Omega'r'^2, \qquad (A-9)$$

and

$$d\underline{r}' = r'^2 \sin \theta' d\theta' d\mu' dr' \qquad (A-10)$$

in the spherical coordinate system relative to $O(U^{235})$.

Next notice,

$$dr = dsd|r-r'|.$$
 (A-11)

Eq. (A-7), through Equations (A-8) up to (A-11), thus becomes,

(A-12)

$$S_{1} = \int_{\mathbf{r}'=0}^{\infty} \int_{|\underline{\mathbf{r}}-\underline{\mathbf{r}'}|=0}^{\infty} \int_{\theta'=0}^{\pi} \int_{\theta=0}^{\pi} \int_{\mathcal{U}'=0}^{\pi} \int_{\mathcal{U}=0}^{\infty} \int_{\Lambda'=E_{th}}^{\infty} \int_{\mathbf{r}'=0}^{\infty} a(\Lambda',t')dt' \frac{1}{4\pi} \sin \theta' d\theta' d\mu' dr' e^{-\Sigma(\Lambda')r'} d\Lambda'$$

$$d^{2}_{e}\sigma(\Lambda' \rightarrow \Lambda)\underline{N}_{D_{2}O}\Sigma\Sigma_{D}(\Lambda)d|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}'|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}|\underline{r}|\underline{r}-\underline{r}|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}|e^{-\Sigma(\Lambda)}|\underline{r}-\underline{r}|e^{-\Sigma$$

where E_{th} is for the threshold energy for photoneutron reaction in D_2O (2.23 Mev).

Note that r', θ' , μ' and $|\underline{r}-\underline{r}'|$ are independent variables and that μ comes into play within $d_e^2(\Lambda' \rightarrow \Lambda)$ only; thus define

$$d_e \sigma = \int_{\mu=0}^{2\pi} d_e^2 \sigma. \qquad (A-13)$$

Further define

$$A(\Lambda') = \int_0^\infty a(\Lambda', t) dt \qquad (A-14)$$

Next consider L photon groups (Fig. A-2) such that $\Lambda_{\ell} = \Lambda_{\ell-1} - \Lambda_{\ell}$ ($\ell = 1, ..., L$) is small enough to replace $d\Lambda$.



Fig. A-2 Photon energy groups

Then the scattering can be assumed to remove the photon into a lower energy group. Also the scattering cross section for photons of energy within such group, into a lower energy group, can be taken as constant and equal to $d_e^2 \sigma(\overline{\Lambda}_l' \rightarrow \overline{\Lambda}_l), \overline{\Lambda}_l'$ and $\overline{\Lambda}_l$ being the representative energies of the photon energy groups to which

the photon belongs respectively before and after the scattering.

We define

$$A_{\ell} = \frac{1}{\Lambda \Lambda_{\ell}} \int_{\Lambda_{\ell}}^{\Lambda_{\ell}-1} A(\Lambda) d\Lambda, \qquad (A-15)$$

$$\Sigma_{D_{\ell}} = \frac{1}{\Lambda \Lambda_{\ell}} \int_{\Lambda_{\ell}}^{\Lambda_{\ell}-1} \Sigma_{D}(\Lambda) d\Lambda \qquad (A-16)$$

$$\Sigma_{\ell} = \frac{1}{\Lambda \Lambda_{\ell}} \int_{\Lambda_{\ell}}^{\Lambda_{\ell}-1} \Sigma(\Lambda) d\Lambda \qquad (A-17)$$

With the above remarks and definitions Eq. (A-12) can then be written as

$$S_{1} = \underline{N}_{D_{2}O}Z \underset{\ell'=1}{\overset{L}{\sum}} A_{\ell'} \Delta \Lambda_{\ell'}, \frac{1}{\Sigma_{\ell'}} \underset{\ell=\ell'+1}{\overset{L}{\sum}} d_{e}\sigma(\ell' \rightarrow \ell)\Sigma_{D_{\ell}} \times \frac{1}{\Sigma_{\ell'}}$$

where

$$d_{e}\sigma(\ell' \rightarrow \ell) \equiv \int_{\mu=0}^{2\pi} d_{e}^{2}\sigma(\overline{\Lambda}_{\ell}' \rightarrow \overline{\Lambda}_{\ell}) \text{ or precisely}$$
(A-19)

$$d_{e}\sigma(\ell' \rightarrow \ell) = \pi r_{0}^{2} \left(\frac{\overline{\Lambda}_{\ell}}{\overline{\Lambda}_{\ell'}} \right)^{2} \left(\frac{\overline{\Lambda}_{\ell'}}{\overline{\Lambda}_{\ell}} + \frac{\overline{\Lambda}_{\ell}}{\overline{\Lambda}_{\ell'}} - \sin^{2}\theta \right) \sin \theta \, d\theta,$$

$$\frac{1}{\overline{\Lambda_{g}}'} - \frac{1}{\overline{\Lambda_{g}}} = \frac{1 - \cos \theta}{E_{0}} , \qquad (A-20)$$

$$\sin\theta \,d\theta = E_0 \,\frac{\Delta \Lambda_{\ell}}{\Lambda_{\ell}^2} \quad . \tag{A-21}$$

Combining Equations (A-18) through (A-21) we finally have

$$S_{1} = \pi \underline{N}_{D_{2}O} Zr_{0}^{2} \underbrace{\sum_{\boldsymbol{\ell}'=1}^{L-1} \underline{A}_{\boldsymbol{\ell}'}}_{\boldsymbol{\ell}'=1} \underbrace{\frac{1}{\Sigma_{\boldsymbol{\ell}'}}}_{\boldsymbol{\ell}'} \underbrace{\sum_{\boldsymbol{\ell}=\boldsymbol{\ell}'+1}^{L} \left(\frac{\overline{\Lambda}_{\boldsymbol{\ell}}}{\overline{\Lambda}_{\boldsymbol{\ell}'}}\right)^{2} \left(\frac{\overline{\Lambda}_{\boldsymbol{\ell}'}}{\overline{\Lambda}_{\boldsymbol{\ell}}} + \frac{\overline{\Lambda}_{\boldsymbol{\ell}}}{\overline{\Lambda}_{\boldsymbol{\ell}'}}\right)$$
(A-22)
$$-1 + E_{0}^{2} \left(\frac{1}{E_{0}} + \frac{1}{\overline{\Lambda}_{\boldsymbol{\ell}}} - \frac{1}{\overline{\Lambda}_{\boldsymbol{\ell}'}}\right)^{2} \left|E_{0} \frac{\Delta \Lambda_{\boldsymbol{\ell}}}{\overline{\Lambda}_{\boldsymbol{\ell}}^{2}} \underbrace{\Sigma_{D_{\boldsymbol{\ell}}}}_{\boldsymbol{\ell}} \times \frac{1}{\Sigma_{\boldsymbol{\ell}}},$$

where

$$\underline{A}_{g}' = A_{g}' \Delta A_{g}'. \qquad (A-23)$$

A-2 Scheme for numerical application

The scheme presented in Table A-1 was the one

adopted for numerical calculations and the

Table A-1

Photon Energy Groups to Compute S1

e	$\Lambda_{l-1}(Mev)$	$\overline{\Lambda}_{\ell}(Mev)$
1	6.00	5.000
2	4.00	3.500
3	3.00	2.875
4	2.75	2.625
5	2.50	2.365

determination of the relevant data $(\underline{A}_{\ell}, \Sigma_{D_{\ell}}, \Sigma_{\ell}, \ell=1,...,5)$ is discussed in the Appendix B.

Results are grouped in Table A-2.

Table A-2

Data to Compute S1

٤	<u>A</u> £	$\sigma_{D_{\ell}} \times 10^{27}$ (cm ²)	Σ _g (cm ²)
1	0.0692		
2	0.141	2.25	0.0366
3	0.0518	1.70	0.0405
4	0.0804	1.20	0.0424
5		0.60	0.0448

Note that the number for \underline{A}_{ℓ} 's * given in Table A-2 has been calculated for the time interval $2 \sec . \le t \le 10^3 \sec .$ To speak rigorously a correction ought to be made for those photoneutrons generated (by photons having had collisions) within 2 sec. and after 10^3 sec. the fission event took place. Nevertheless we show in this Appendix that photoneutrons generated by photons having had collisions can be neglected. Thus the time correction in question is omitted.

* The value, \underline{A}_1 , of Table A-2 is 0.0692 whereas it would be 0.0650 as calculated from the last column of Table B-4. The difference is due to the fact that the latter number accounts for photons of the first energy group with an upper limit of only 6 Mev. Yet there are photons of energy beyond 6 Mev. An effort is made to include those photons in the first group. Thus an estimate of the number of photons, emitted from the fission products of an atom of U²³⁵, of energy beyond 6 Mev is made through the enery dependence formula for photons of interest (cf. Appendix B, Fig. B-6):

6.22 $e^{-1.1\Lambda}$ ($\Lambda > 4$ Mev). The number

 $\int_{0}^{\infty} 6.22 e^{-1.1\Lambda} d\Lambda = 0.421 \times 10^{2}, \text{ is then added to } 0.0650$ to obtain 0.0692. Note that $\frac{\sigma_{D}(\Lambda)}{\Sigma(\Lambda)}$ beyond 6 Mev is approximately constant.

In addition r_0 is taken to be 2.818 × 10⁻¹³ and \underline{N}_{D_20} , 3.32 × 10²².

A-3 Result and conclusion

The calculation for Equation (A-20) was carried out with a computer program shown in Appendix J. The result is

$$S_1 = 0.93 \times 10^{-4}$$
 photoneutrons/fission of U^{235} (A-24)

On the other hand we learn from the Table B-1 of Appendix B that the total number of photoneutrons produced by photons from U^{235} fission products interacting with D_20 is 2.44 × 10⁻³. We assume that the difference $(2.44 \times 10^{-3} - 0.093 \times 10^{-3})$ is due to those photoneutrons produced by the uncollided photons (that is an approximation of about 12% according to section B-2 of Appendix B). Thus, with an error of a few percent, we note that this will be even less for a finite system as in the case of MITR-II, because of the leakage of a considerable number of photons out of the reactor (about 20% only of the fission photons are absorbed in the D20 reflector of the Franco-German reactor ALIZE III)_, the photoneutrons due to photons having had collisions can be neglected.

APPENDIX B

CORRELATION BETWEEN THE DATA RELEVANT TO THE DELAYED PHOTONS FROM U²³⁵ FISSION PRODUCTS AND THE DATA RELEVANT TO THE DELAYED PHOTONEUTRONS GENERATED BY THOSE PHOTONS, IN D₂0

The purpose of this Appendix is to determine whether the data relevant to the generation of delayed photons from U^{235} fission products (Fig. B-1 and Fig. B-2) is consistent with the attenuation and photoneutron reaction cross sections of photons in D_2^0 (Fig. B-3 and Fig. B-4). If this is the case, then through those data one should be able to obtain the data relevant to the production of delayed photoneutrons by photons from U^{235} fission products in D_2^0 (cf. Table B-1).

To this end we consider the fission of one atom of U^{235} in an infinite medium of D_20 .

Let then \underline{A}_{ℓ} be the total number of photons within ℓ^{th} group of photons coming from the fission products of one atom of U^{235} , between 2 and 10^3 sec. after the fission event took place. For these photons let Σ_{ℓ} and $\Sigma_{D_{\ell}}$ be the attenuation and photoneutron reaction cross sections in D_20 .

Thus, taking into account only uncollided photons,

$$S_{0} = \sum_{\ell=1}^{L} \underline{A}_{\ell} \Sigma_{D_{\ell}} \int_{0}^{\infty} \frac{1}{4\pi r^{2}} e^{-\Sigma_{\ell} r} 4\pi r^{2} dr = \sum_{\ell=1}^{L} \underline{A}_{\ell} \frac{\Sigma_{D_{\ell}}}{\Sigma_{\ell}} , (B-1)$$

is the number of photoneutrons generated by photons coming from





Table B-1 [16]

Half-Lives and Yields of Photoneutrons from U²³⁵ Fission Products in D₂O

	. Photoneutron yield	Photoneutrons (10^{-5})	
Half-life	22-sec delayed-neutron yield	Fission	
53 h	0.00074	0.25	
4. 4 h	0.00232	0.78	
1.65 h	0.0168	5.65	
27 m	0.0149	5.01	
7.7 m	0.0242	8.14	
2.4 m	0.0504	17.0	
41 s	0.147	49.5	
2.5 s	0.469	158.0	
	• • • • • • • • • • • • • • • • • • •		

 $Sum = 244.33 \times 10^{-5}$











Fig. B-4 Photoneutron production cross section for deuterium [15]

the fission products of one atom of U^{235} , placed in an infinite medium of D_2^0 , in the interval 2 sec. to 10^3 sec. after the fission event took place. (L is the number of photon groups.).

B-1 Calculation of \underline{A}_{0}

For the calculation of \underline{A}_{ℓ} we aim to obtain, starting with Fig. B-2, curves similar to the ones of Fig. B-1, but for more than two groups of photons. \underline{A}_{ℓ} will be then, the area under the ℓ^{th} curve (2 sec. $\leq t \leq 10^3$ sec.) multiplied by the width of the ℓ^{th} group of photons.

Actually we shall end by adopting the two-group scheme (cf, Fig. B-1). However at this stage of the development we do not know whether or not the photoneutrons produced in D_2^0 by photons of energy beyond 5 Mev (upper energy limit of photons sketched in Fig. B-1) can be neglected as compared to the photoneutrons produced by the less energetic photons. In addition we must prepare the material to be used in Appendix A (study of the photoneutrons produced by photons having had collisions), and that will require a scheme with more than two-group of photons. Also for a consistency check of the data we try to avoid possible errors due to the calculation of average cross sections for a few-group scheme.

 \underline{A}_{l} is accordingly first calculated in the following way for fifteen-groups of photons;

- Make up Table B-2 out of Fig. B-2, with $P_{g}(t)$ being the number of photons/Mev x fission x sec., belonging to the l^{th} group of photons, versus time after fission;

- Then similarly to Fig. B-1, draw Fig. B-5, where we have for each of fifteen groups of photons, the decay of the fission products photons.

- Finally integrate graphically each of the curves of Fig. B-5 between t=2 sec. and t=10³ sec. (cf. Table B-3) to make up Table B-4, where the product of this procedure, A_{l} 's (l=1,..., 15 - the most energetic group bearing the number 15 -) are given, so that

$$\underline{A}_{\ell} = \Delta \Lambda_{\ell} A_{\ell} = \Delta \Lambda_{\ell} \int_{2}^{1000} P_{\ell}(t) dt, \ell = 1, \dots, 15, (B-2)$$

where $\Delta \Lambda_{\ell}$ is the width of the ℓ^{th} group of photons.

Table B-2 Photon activity from Fission products of U^{235} versus time after the fission, for 15-group scheme

The second se				
Energy group &	Representative Energy (Mev) A _l	Group Width (Mev)	Time after Fission (sec)	Photons/ Mev x fission x sec.
1	2.365	0.27	1.7	2.3×10^{-2}
			10.7	7.0×10^{-3}
			40	2.5×10^{-3}
			250	1.5×10^{-4}
			1000	4.0×10^{-5}
2	2.625	0.25	1.7	1.5×10^{-2}
			10.7	4.4×10^{-3}
			40	2.0×10^{-3}
			250	1.4×10^{-4}
			1000	4.0×10^{-5}
3	2.875	0.25	1.7	1.2×10^{-2}
			10.7	2.5×10^{-3}
			40	1.2×10^{-3}
			250	1.5×10^{-4}
			1000	1.0×10^{-5}
4	3.125	0.25	1.7	1.2×10^{-2}
			10.7	2.5×10^{-3}
			40	8.0×10^{-4}
			250	8.0×10^{-5}
			1000	9.0 \times 10 ⁻⁶
	•	1	1	

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Energy	Representative	Group	Time after	Photons/
group	Energy_	Width	Fission	Mev x
2	(Mev) $\overline{\Lambda}_{0}$	(Mev)	(sec)	fission
	~			x sec.
E	2 275	0.25	17	1.0×10^{-2}
D	3.3/3	0.25	1.1	1.0 X 10
			10.7	2.0×10^{-3}
			1007	
	n an		40	9.0×10^{-4}
				-1
			250	1.0×10^{-1}
				5
			1000	3.0×10
6	3.625	0.25	1.7	1.0×10^{-2}
				210 11 20
			10.7	2.0×10^{-3}
				_3
			40	1.0×10^{-3}
				5
			250	8.0×10
			1000	1.0×10^{-5}
			1000	1.0 X 10
				3
7	3.825	0.25	1.7	9.0 \times 10 ⁻⁵
				3
			10.7	1.5×10^{-5}
			40	7.0×10^{-4}
				7.0 X 10
		la de la companya de La companya de la comp	250	4.0×10^{-5}
				-6
			1000	4.0×10^{-0}
0	4 125	0 25	1 7	c 0 10 ⁻³
Ο	±.140	0.25	1.1	0.0 X TU
			10.7	1.0×10^{-3}
			40	6.0×10^{-4}
				_5
			250	7.0×10^{-3}
			1000	2 06
			TOOO	3.0 X 10
(I			· · · ·	

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Energy group £	Representative Energy (Mev) A _l	Group Width (Mev)	Time after Fission (sec)	Photons/ Mev x fission x sec.
9	4.375	0.25	1.7 10.7 40 250 1000	4.0×10^{-3} 8.0 × 10 ⁻⁴ 2.0 × 10 ⁻⁴ 4.0 × 10 ⁻⁵ 2.0 × 10 ⁻⁶
10	4.625	0.25	1.7 10.7 40 250 1000	3.0×10^{-3} 6.0 × 10 ⁻⁴ 1.8 × 10 ⁻⁴ 2.0 × 10 ⁻⁵ 1.0 × 10 ⁻⁶
11	4.875	0.25	1.7 10.7 40 250 1000	2.2×10^{-3} 4.2×10^{-4} 1.4×10^{-4} 1.3×10^{-5} 4.0×10^{-7}
12	5.125	0.25	1.7 10.7 40 250 1000	1.8×10^{-3} 5.0 x 10 ⁻⁴ 1.1 x 10 ⁻⁴ 1.0 x 10 ⁻⁵ 1.8 x 10 ⁻⁷

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Energy group l	Representative Energy (Mev) ^T l	Group Width (Mev)	Time after Fission (sec)	Photons/ Mev x fission x sec.
13	5.375	0.25	1.7	2.0×10^{-3}
			40	1.8×10^{-4}
			250	9.0 x 10^{-6}
			1000	1.0×10^{-7}
14	5.625	0.25	1.7	8.0×10^{-4}
			10.7	2.0×10^{-4}
	$\left \left \left$		40	1.0×10^{-4}
			250	7.0×10^{-6}
			1000	3.0×10^{-8}
15	5.875	0.25	1.7	5.0 \times 10 ⁻⁴
			10.7	1.5×10^{-4}
			40	6.0×10^{-5}
			250	6.0×10^{-6}
			1000	1.0×10^{-8}







Table

e B-3

¹2

Graphical Integration of curves of Fig. B-5

 $P_2(t) \Delta t$ P₁(t) $P_1(t) \Delta t$ t(sec) Δt P,(t) t(sec) Δt $\dot{x10}^2$ $\tilde{x10}^2$ after (sec) after (sec) fisfission sion 1.8x10⁻² 1.3×10^{-2} 2.5 1 1.80 2.5 1.30 1 1.5×10^{-2} 1.1×10^{-2} 3.5 1 1.50 3.5 1 1.10 1.2×10^{-2} 9. $x10^{-3}$ 2.40 5 2 5 2 1.80 1.0×10^{-2} 7.6×10^{-3} 7 2.00 7 2 2 1.52 8. $x10^{-3}$ 6.5×10^{-3} 1.60 9 2 9 2 1.30 5.6×10^{-3} 4.5×10^{-3} 15 5.60 10 15 10 4.50 3.8×10^{-3} 3.0×10^{-3} 25 3.80 25 10 10 3.00 2.8×10^{-3} 2.3×10^{-3} 35 10 2.80 35 10 2.30 1.9×10^{-3} 1.5×10^{-3} 50 50 20 3.80 20 3.00 1.3×10^{-3} 1.0×10^{-3} 70 2.60 70 20 20 2.00 7.5x10⁻⁴ 7.0×10^{-3} 90 20 1.50 90 20 1.40 5.2×10^{-4} 4.5×10^{-4} 2.60 125 50 125 50 2.25 2.8×10^{-4} 2.5×10^{-4} 175 50 1.40 175 50 1.25 1.5×10^{-4} 1.4×10^{-4} 250 100 1.50 250 100 1.40 9.5x10⁻⁵ 9.0x10⁻⁴ 100 350 0.95 350 100 0.90 7.5x10⁻⁵ 7.0×10^{-5} 450 100 0.75 100 450 0.70 5.6x10⁻⁵ 5.5x10⁻⁵ 200 600 200 1.12 600 1.10 4.5×10^{-5} 4.4×10^{-5} 850 300 850 300 1.35 1.32 1000 1000 $P_1(t) dt %39.07 \times 10^{-2}$ $P_2(t)dt % 32.14 \times 10^{-2}$

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t(sec) after fis- sion	∆t (sec)	P ₃ (t)	P ₃ (t)Δt x10 ²	t(sec) after fis- sion	∆t (sec)	P ₄ (t)	$P_4(t)\Delta t$ x10 ²
2.5	1	7.0×10^{-3}	7.0	2.5	1	8.5x10 ⁻³	8.5
3.5	1	6.0×10^{-3}	6.0	3.5	1	6.5×10^{-3}	6.5
5	2	4.5×10^{-3}	9.0	5	2	5.0×10^{-3}	10.0
7	2	3.5×10^{-3}	7.0	7	2	3.5×10^{-3}	7.0
9	2	3.0×10^{-3}	6.0	9	2	3.0×10^{-3}	6.0
15	10	2.0×10^{-3}	20.0	15	10	1.9×10^{-3}	19.0
25	10	1.5×10^{-3}	15.0	25	10	1.2×10^{-3}	12.0
35	10	1.3×10^{-3}	13.0	35	10	9.0×10^{-4}	9.0
50	20	1.0×10^{-3}	20.0	50	20	6.4×10^{-4}	12.8
70	20	8.0×10^{-4}	16.0	70	20	4.5×10^{-4}	9.0
90	20	6.0×10^{-4}	12.0	90	20	3.4×10^{-4}	6.8
125	50	4.5×10^{-4}	22.5	125	50	2.3×10^{-4}	11.5
175	50	2.7×10^{-4}	13.5	175	50	1.5×10^{-4}	7.5
250	100	1.5×10^{-4}	15.0	250	100	8.0×10^{-5}	8.0
350	100	9.0×10^{-5}	9.0	350	100	5.0×10^{-5}	5.0
450	100	5.5×10^{-5}	5.5	450	100	3.3×10^{-5}	3.3
600	200	3.2×10^{-5}	6.4	600	200	2.0×10^{-5}	4.0
850	300	1.5×10^{-5}	4.5	850	300	1.2×10^{-5}	3.6
L	$\int_{2}^{1000} P_{3}(t) dt \sqrt{207.4 \times 10^{-3}} \int_{2}^{1000} P_{4}(t) dt \sqrt{149.5 \times 10^{-3}}$						

.

t(sec) after fis- sion	∆t (sec)	P ₅ (t)	P ₅ (t) Δt x10 ²	t(sec) after fis- sion	∆t (sec)	P ₆ (t)	P ₆ (t)∆t x10 ²
2.5	1	7.0×10^{-3}	7.0	2.5	1	7.0×10^{-3}	7.0
3.5	1	5.0×10^{-3}	5.0	3.5	1	5.0×10^{-3}	5.0
5	2	3.7×10^{-3}	7.4	5	2	3.7×10^{-3}	7.4
7	2	2.8×10^{-3}	5.6	7	2	2.8×10^{-3}	5.6
9	2	2.3×10^{-3}	4.6	9	2	2.3×10^{-3}	4.6
15	10	1.6×10^{-3}	16.0	15	10	1.6×10^{-3}	16.0
25	10	1.2×10^{-3}	12.0	25	10	1.25×10^{-3}	12.5
35	10	9.6×10^{-4}	9.6	35	10	1.1×10^{-3}	11.0
50	20	7.5×10^{-4}	15.0	50	20	8.0×10^{-4}	16.0
70	20	6.0×10^{-4}	12.0	70	20	6.0×10^{-4}	12.0
90	20	4.5×10^{-4}	9.0	90	20	4.5×10^{-4}	9.0
125	50	3.0×10^{-4}	15.0	125	50	2.6×10^{-4}	13.0
175	50	1.9×10^{-4}	9.5	175	50	1.5×10^{-4}	7.5
250	100	1.0×10^{-4}	10.0	250	100	7.0×10^{-4}	7.0
350	100	7.0×10^{-5}	7.0	350	100	5.0×10^{-5}	5.0
450	100	5.5x10 ⁻⁵	5.5	450	100	3.5×10^{-5}	3.5
600	200	4.4×10^{-5}	8.8	600	200	2.2×10^{-5}	4.4
850	300	3.4×10^{-5}	13.2	800	300	1.3x10 ⁻⁵	3.9
		P ₅ (t)dt%172	2.2×10^{-3}		\int_{2}^{1000}	P ₆ (t)dt%150	.4x10 ⁻³

						· .	
t(sec) after fis- sion	∆t (sec)	P ₇ (t)	P ₇ (t)Δt x10 ³	t(sec) after fis- sion	∆t (sec)	P ₈ (t)	P ₈ (t)∆t x10 ³
2.5	1	5.0x10 ⁻³	5.0	2.5	1	3.2×10^{-3}	3.2
3.5	1	3.5×10^{-3}	3.5	3.5	1	2.3×10^{-3}	2.3
5	2	2.6×10^{-3}	5.2	5	2	1.7×10^{-3}	3.4
7	2	2.0×10^{-3}	4.0	7	2	1.3×10^{-3}	2.6
9	2	1.8×10^{-3}	3.6	9 9	· · · · · · · · · · · · · · · · · · ·	1.2×10^{-3}	2.4
15	10	1.3×10^{-3}	13.0	15	10	8.6×10^{-3}	8.6
25	10	1.0×10^{-3}	10.0	25	10	7.0×10^{-4}	7.0
35	10	8.5×10^{-4}	8.5	35	10	6.4×10^{-4}	6.4
50	20	6.0×10^{-4}	12.0	50	20	5.0×10^{-4}	10.0
70	20	3.5×10^{-4}	7.0	70	20	3.5×10^{-4}	7.0
90	20	2.0×10^{-4}	4.0	90	20	2.5×10^{-4}	5.0
125	50	1.0×10^{-4}	5.0	125	50	1.5×10^{-4}	7.5
175	50	5.0×10^{-5}	2.5	175	50	9.0×10^{-5}	4.5
250	100	2.6×10^{-5}	2.6	250	100	5.0×10^{-5}	5.0
350	100	1.5×10^{-5}	1.5	350	100	2.8×10^{-5}	2.8
450	100	1.0x10 ⁻⁵	1.0	450	100	1.8×10^{-5}	1.8
600	200	7.0×10^{-6}	1.4	600	200	1.0×10^{-5}	2.0
850	300	4.6×10^{-6}	1.38	850	300	3.0×10^{-6}	0.9
Teo and teo and	$\int_{2}^{1000} \int_{2}^{1000} P_{7}(t) dt \sqrt[3]{90.18 \times 10^{-3}} \int_{2}^{1000} P_{8}(t) dt \sqrt[3]{82.4 \times 10^{-3}}$						

t(sec) after fis- sion	∆t (sec)	P _g (t)	P ₉ (t)∆t ×10 ³	t(sec) after fis- sion	∆t (sec)	P ₁₀ (t)	P ₁₀ (t)∆t x10 ³
2.5	1	3.0×10^{-3}	3.00	2.5	1	2.2×10^{-3}	2.20
3.5	1	2.1×10^{-3}	2.10	3.5	1	1.6×10^{-3}	1.60
5	2	1.5×10^{-3}	3.00	5	2	1.2×10^{-3}	2.40
7	2	1.1×10^{-3}	2.20	7	.2.	9.0×10^{-4}	1.80
9	2	9.5×10^{-4}	1.90	9	2	7.5×10^{-4}	1.50
15	10	5.8×10^{-4}	5.80	15	10	4.6×10^{-4}	4.60
25	10	3.6×10^{-4}	3.60	25	10	2.9×10^{-4}	2.90
35	10	2.7×10^{-4}	2.70	35	10	2.1×10^{-4}	2.10
50	20	2.0×10^{-4}	4.00	50	20	1.5×10^{-4}	3.00
.70	20	1.4×10^{-4}	2.80	70	20	1.0×10^{-4}	2.00
90	20	1.1x10 ⁻⁴	2.20	90	20	8.0x10 ⁻⁵	1.60
125	50	8.5×10^{-5}	4.25	125	50	5.2×10^{-5}	2.60
175	50	6.0x10 ⁻⁵	3.00	175	50	3.5×10^{-5}	1.75
250	100	4.0×10^{-5}	4.00	250	100	2.1x10 ⁻⁵	2.10
350	100	2.5×10^{-5}	2.50	350	100	1.2×10^{-5}	1.20
450	100	1.4×10^{-5}	2.80	450	100	7.0×10^{-6}	1.40
600	200	7.0×10^{-6}	1.40	600	200	3.5×10^{-6}	0.70
850	300	3.3×10^{-6}	0.66	850	300	1.7x10 ⁻⁶	0.34
L	$\int_{2}^{1000} P_{g}(t) dt_{2}^{51.91 \times 10^{-3}} \int_{2}^{1000} P_{10}(t) dt_{2}^{35.79 \times 10^{-3}}$						

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t(sec) after fis- sion	∆t (sec)	P ₁₁ (t)	P ₁₁ (t)Δt x10 ³	t(sec) after fis- sion	Δt (sec)	P ₁₂ (t)	P ₁₂ (t) At x10 ³
2.5	1	1.6x10 ⁻³	1.60	2.5	1	1.4×10^{-3}	1.40
3.5	1	1.2×10^{-3}	1.20	3.5	1	1.15×10^{-3}	1.15
5	2	8.5×10^{-4}	1.70	5	2	9.0×10^{-4}	1.80
7	2	6.5×10^{-4}	1.30	7	2	7.0×10^{-4}	1.40
9	2	5.3×10^{-4}	1.06	9	2	6.0×10^{-4}	1.20
15	10	3.3×10^{-4}	3.30	15	10	3.7×10^{-4}	3.70
25	10	2.1×10^{-4}	2.10	25	10	2.0×10^{-4}	2.00
35	10	1.5×10^{-4}	1.50	35	10	1.3×10^{-4}	1.30
50	20	1.1x10 ⁻⁴	2.20	50	20	8.5x10 ⁻⁵	1.70
70	20	7.5×10^{-5}	1.50	70	20	5.5x10 ⁻⁵	1.10
90	20	5.8x10 ⁻⁵	1.16	90	20	4.0×10^{-5}	0.80
125	50	3.8×10^{-5}	1.90	125	50	2.5×10^{-5}	1.25
175	50	2.5×10^{-5}	1.25	175	50	1.7×10^{-5}	0.85
250	100	1.3×10^{-5}	1.30	250	100	1.0x10 ⁻⁵	1.00
350	100	7.0×10^{-6}	0.70	350	100	5.0x10 ⁻⁶	0.50
450	100	3.5×10^{-6}	0.70	450	100	2.0x10 ⁻⁶	0.40
600	200	1.6x10 ⁻⁶	0.32	600	200	8.0x10 ⁻⁷	0.16
850	300	6.8x10 ⁻⁷	0.14	850	300	3.0x10 ⁻⁷	0.06
	.1000				.1000		
	P	$(t) dt_{1}^{2}24$	93×10^{-3}		P	(t)dt?21.	77×10^{-3}

1							
t(sec) after fis- sion	∆t (sec)	P ₁₃ (t)	P ₁₃ (t) Δt x10 ³	t(sec) after fis- sion	∆t (sec)	P ₁₄ (t)	$P_{14}(t) \Delta t$ x10 ⁴
2.5	1	1.4×10^{-3}	1.40	2.5	1	5.5x10 ⁻⁴	5.5
3.5	1	9.5×10^{-4}	0.95	3.5	1 .	4.0×10^{-4}	4.0
5	2	6.5×10^{-4}	1.30	5	2	3.2×10^{-4}	6.4
7	2	4.5×10^{-4}	0.90	7	2	2.5×10^{-4}	5.0
9	2	3.7×10^{-4}	0.74	9	2	2.3×10^{-4}	4.6
15	10	2.6×10^{-4}	2.60	15	10	1.7×10^{-4}	17.0
25	10	2.1×10^{-4}	2.10	25	10	1.3x10 ⁻⁴	13.0
_35	10	1.9×10^{-4}	1.90	35	10	1.1×10^{-4}	11.0
50	20	1.3×10^{-4}	2.60	50	20	7.0×10^{-5}	14.0
70	20	6.5x10 ⁻⁵	1.30	70	20	4.5×10^{-5}	9.0
90	20	5.0x10 ⁻⁵	1.00	90	20	3.3×10^{-5}	6.6
125	50	3.0x10 ⁻⁵	1.50	125	50	2.0×10^{-5}	10.0
175	50	1.7x10 ⁻⁵	0.85	175	50	1.2×10^{-5}	6.0
250	100	9.0x10 ⁻⁶	0.90	250	100	6.0x10 ⁻⁶	6.0
350	100	4.5x10 ⁻⁶	0.45	350	100	2.7x10 ⁻⁶	2.7
450	100	1.7×10^{-6}	0.34	450	100	8.0x10 ⁻⁶	1.6
600	200	5.5x10 ⁷	0.11	600	200	2.3x10 ⁻⁶	0.5
850	300	1.7x10 ⁻⁷	0.04	850	300	7.0x10 ⁻⁶	0.1
· .	$\int_{2}^{1000} P_{13}(t) dt_{2}^{20.98 \times 10^{-3}} \int_{2}^{1000} P_{14}(t) dt_{2}^{12.30 \times 10^{-3}}$						

Table B-3 (continued)

..

t (sec) after	∆t(sec)	P ₁₅ (t)	$P_{15}(t) \Delta t \times 10^4$
fission			
2.5	1	3.5×10^{-4}	3.5
3.5	1	1.8×10^{-4}	1.8
5	2	2.2×10^{-4}	4.4
7	2	1.8×10^{-4}	3.6
9	2	1.7×10^{-4}	3.4
15	10	1.2×10^{-4}	12.0
25	10	8.5×10^{-5}	8.5
35	10	6.5×10^{-5}	6.5
50	20	5.0 x 10^{-5}	10.0
70	20	3.5×10^{-5}	7.0
90	20	2.6×10^{-5}	5.2
125	50	1.7×10^{-5}	8.5
175	50	1.0×10^{-5}	5.0
250	100	5.5 x 10^{-6}	5.5
350	100	2.5×10^{-6}	2.5
450	100	9.0 x 10^{-7}	1.8
600	200	2.1×10^{-7}	0.44
850	300	4.0×10^{-8}	0.08
		1.000	

 $\int_{2}^{1000} P_{15}(t) dt \ 89.72 \times 10^{-4}$

Table (B-4) A_{ℓ} 's for fifteen groups of photons

Energy group l	Representative energy T _l (Mev)	Δ $\overline{\Lambda}_{l}$ (Mev)	A _l : Photons/Mev x fission
1	2.365	0.27	0.3907
2	2.625	0.25	0.3214
3	2.875	0.25	0.2074
4	3.125	0.25	0.1495
5	3.375	0.25	0.1722
6	3.625	0.25	0.1504
7	3.825	0.25	0.0902
8	4.125	0.25	0.0824
9	4.375	0.25	0.0519
10	4.625	0.25	0.0358
11	4.875	0.25	0.0249
12	5.125	0.25	0.0218
13	5.375	0.25	0.0210
14	5.625	0.25	0.0123
15	5.825	0.25	0.0090

 $\Delta \overline{\Lambda}_{\ell}$; width of ℓ^{th} group

We point out that later in the library of the code POPOP IV (cf. Appendix D) we found numbers for \underline{A}_{ℓ} 's (photons from the fission of U²³⁵, t > 1 sec.) presented below;

e.	Λ _ℓ (Mev)	<u>A</u> _l
1	2.2	3.40500 E-1
2	2.6	2.27500 E-1
3	3.0	1.27860 E-1
4	3.5	9.41499 E-2
5	4.0	6.93300 E-2
6	4.5	3.36500 E-2
7	5.0	1.61900 E-2
8	5.5	7.77000 E-3
9	6.0	0.

where Λ_{ℓ} refers to the upper energy limit of the ℓ^{th} group, and yE-n stands for y x 10^{-n} .

We note that (although slightly higher) these numbers check against our results (11.917 E-2 and 39.264 E-2 against 9.9 E-2 and 34.8 E-2 of Table B-7 - presented further -. In addition according to those numbers of the library of the code POPOP IV we have: 12.694 E-2 for the energy interval 3.5 Mev - 10 Mev, and 43.246 E-2 for the energy interval 2.23 Mev - 3.5 Mev.).

B-2 Calculation of
$$S_0 = \sum_{\ell=1}^{L} \frac{A_{\ell}}{\Sigma_{\ell}} \frac{\Sigma_{D\ell}}{\Sigma_{\ell}}$$

One can then with the help of Fig. B-3, Fig. B-6 and Table B-4, make up the Table B-5, where the last column multiplied by $\Delta \Lambda_{\underline{\ell}}$ and summed over ℓ furnishes the result of Eq. (B-1).

Energy group l	$\sum_{\substack{\ell \\ (cm^{-1})}}^{\Sigma_{\ell} \times 10^{2}}$	σ _{Dℓ} (mb)	$\frac{A_{\ell} \sigma_{D_{\ell}} (mb)}{\Sigma_{\ell} (cm^{-1})}$
1	4.48	0.60	5.24
2	-, 4.24	1.20	9.10
3	4.05	1.70	8.72
4	3.88	2.10	8.11
5	3.73	2.20	10.15
6	3.58	2.30	9.66
7	3.45	2.37	6.21
8	3.33	2.40	5.93
9	3.23	2.44	3.92
10	3.13	2.42	2.87
11	3.05	2.41	1.965
12	2.96	2.40	1.770
13	2.90	2.37	1.720
14	2.83	2.30	1.00
15	2.77	2.26	0.735
	1		1

Table B-5 Calculation of $A_{\ell} \sigma_{D_{\ell}} / \Sigma_{\ell}$

That is, $S_0 = \begin{pmatrix} 15 \\ \Sigma \\ \ell = 1 \end{pmatrix} \begin{pmatrix} \sigma_D_\ell \\ \Delta \\ \Lambda_\ell \end{pmatrix} \times 2 \times \frac{N}{D_2 O} = 19.42 \times 2 \times 3.32 \times 10^{-5}$

= 1.29×10^{-3} photoneutrons/fission of U^{235} , 2 sec. $\leq t \leq 10^{3}$ sec.

This answer is to be compared to the summation of the number presented in the last column of Table B-1, that is 2.44×10^{-3} photoneutrons/fission of U^{235} . However one should notice that in the course of the calculation of the number S_0 above, we have dealt with photons of energy up to 6 Mev only, whereas some of the photoneutrons will be produced by photons of energy beyond 6 Mev. In addition we have taken into account photons generated between t = 2 sec. and t = 10^3 sec. only, whereas delayed photons appearing within 2 sec. or 10^3 sec. after the fission, will also give rise to photoneutrons. Thus the number for S_0 , found above should be corrected accordingly before being compared to 2.44 $\times 10^{-3}$, result of Table B-1.

B-2-1 Estimation of photoneutrons produced by photons of energy beyond 6 Mev.

In order to estimate the number of photoneutrons produced by photons of energy beyond 6 Mev, coming from the fission products of U^{235} , in an infinite medium of D_2^0 between t=2 sec. and t=10³ sec. after fission, we draw the last column of Table B-5 versus the second column of Table B-4 for $\overline{\Lambda}_{\underline{k}} \geq 4$ Mev, that is Fig. B-6 (where, the last column of Table B-4 versus the second column of Table B-4 is also plotted-bottom curves- for $\overline{\Lambda}_{\underline{k}} \geq$ Mev., for use in Appendix A, section A-2). We then approximate the photoneutrons produced by photons of energy beyond



Fig. B-6 For extrapolation beyond 6 MW, the total number of photons from fission products of U^{235} versus energy (≥ 4 MeV) - bottom curve and the total number of photoneutrons produced by those photons - upper curve are approximated by straight lines

6 Mev by $\int_{-\infty}^{\infty} 4.9 \times 10^2 e^{-1.1\Lambda} d\Lambda \gtrsim 0.62$, that is to be added to 19.42. With this S_0 becomes 1.34 x 10^{-3} photoneutrons/fis-

sion of U^{235} , 2 sec. $\leq t \leq 10^3$ sec.

by

B-2-2 Time correction brought to the total number of photoneutrons produced per fission of U^{235} .

In order to compare the result of Table B-1, that is the number 2.44 x 10^{-3} , to the number S₀ we obtained, we have to remove from the former, the number of photoneutrons produced within 2 sec. and after 10^3 sec. the fission of U^{235} took place; since N has been calculated for the interval of time 2 sec. $< t < 10^3$ sec.

We assume that, a photoneutron decaying with one of the half lifes shown in Table B-1, implies there must be a photon appearing with that same half life, that creates the photoneutron in question. Thus we let N_{0} (l-e ^j) be the total number of jth -time wise- group of photons emitted until t. Then, assuming that there is only one energy-group of photons with $\overline{\Sigma}$ and $\overline{\Sigma}_{D}$ being the average attenuation and photoneutron reaction cross sections of photons in D20, to achieve the "time correction" the number 2.44 x 10^{-3} should be multiplied

$$C = \frac{\sum_{D} \sum_{j} \left[N_{0j} (1 - e^{-\lambda_{j} \times 10^{3}}) - N_{0j} (1 - e^{-\lambda_{j} \times 2}) \right]}{\sum_{\overline{\Sigma}} \sum_{j} N_{0j}}$$
(B-3)

Defining y_j to be the yield of a photon of jth time group,

and noting

$$N_{0,i} = N_{0} Y_{j}$$
, (B-4)

where

$$N_0 = \sum_{j} N_{0j}, \qquad (B-5)$$

and $\sum_{j} y_{j} = 1$, we find that C becomes

$$C = \sum_{j} y_{j} \left(e^{-\lambda_{j}} \times 2 - e^{-\lambda_{j}} \times 10^{3} \right) \qquad (B-6)$$

 y_j 's are presented in Table B-6, being calculated from the information of Table B-1.

Table B-6 Yield of a photoneutron of -time wise-group j

j	λj	Уj
1	2.77×10^{-1}	0.647
2	1.69×10^{-2}	0.2025
3	4.81×10^{-3}	6.97×10^{-2}
4	1.50×10^{-3}	3.34×10^{-2}
5	4.28×10^{-4}	2.05×10^{-2}
6	1.17×10^{-4}	2.31×10^{-2}
7	4.37×10^{-5}	3.19×10^{-3}
8	3.63×10^{-6}	1.008×10^{-3}
9	6.26×10^{-7}	0.496×10^{-3}

The calculation of 1 from Eq. (B-6) then gives $C_{n}^{2}0.67$.

We should also include with the number S_0 the number of photoneutrons produced by photons having had one and only one collision (calculated in Appendix A), that is $S \gtrsim 1.345 \times 10^{-3} +$ $0.93 \times 10^{-4} = 1.44 \times 10^{-3}$ photoneutrons/fission of U^{235} . This is now to be compared to the number 2.44 $\times 10^{-3} \times 0.673 \gtrsim 1.64 \times 10^{-3}$ photoneutrons/fission of U^{235} . The agreement is satisfactory (for a difference of about 12%, which is we think, partially due to the procedure of calculation, graphical integrations etc.).

Hence we conclude the data relevant to the generation of photons from U^{235} fission products and the attenuation and photoneutron reaction cross sections of those photons in D_2^{0} , are consistent.

B-3 The two group scheme of Fig. B-1

The upper curve of Fig. B-6 suggests that the photoneutrons produced by photons of energy beyond 5 Mev (that is $\int_{5}^{\infty} 4.9 \times 10^{2} e^{-1.1\Lambda} d\Lambda$) can be neglected (within an error of

about 8%). We also have shown we do not have to carry photoneutron generated by photons having had collisions (cf. Appendix A) that required a multigroup scheme. Henceforth we can adopt instead of the complicated fifteen-group scheme derived from Fig. B-2, the two-group scheme already presented in Fig. B-1 (2.3 Mev $\leq \Lambda \leq 5$ Mev, 1 sec. $\leq t \leq 10^3$ sec).

The relevant numbers are shown in Table B-7.

Table B-7 The two-group photon scheme

L	[∧] £-1 (Mev)	ΔΛ _ℓ (Mev)	$\underline{A}_{\ell} \times 10^2$	$\Sigma_{\ell} (cm^{-1}) \times 10^2$	σ _D (mb)
1	7	1.5	9.9	3.28	2.39
2 2 1	3.5	1.2	34.8	4.00	1.56

 $\Lambda_2 = 2.3 \text{ Mev}$

In Table B-7

$$\underline{\mathbf{A}}_{\boldsymbol{\ell}} = \mathbf{A}_{\boldsymbol{\ell}} \Delta \boldsymbol{\Lambda}_{\boldsymbol{\ell}} , \qquad \boldsymbol{\ell} = 1, 2, \qquad (B-7)$$

and A_{ℓ} is obtained by integration of the curves of Fig. B-1 between t = 1 sec. and t = 10^3 sec. For this purpose we approximated the two curves of Fig. B-1, by two equations each; specifically we found for the upper curve of Fig. B-1;

$$a_1(t) = 6 \times 10^{-3} t^{-0.816}$$
, sec $\leq t \leq 10^2$ sec, (B-8)

$$a_1(t) = 3.83$$
 $t^{-2.084}$, $10^2 \sec \cdot 4 \le 10^3 \sec$, (B-9)

and for the lower curve of Fig. B-1 ;

$$a_2(t) = 3.0 \times 10^{-2} t^{-0.85}$$
, 1 sec. $\leq t \leq 10^2$ sec., (B-10)

$$a_2(t) = 3.75 \times 10^{-1} t^{-1.398}$$
, $10^2 \text{ sec.} \le 10^3 \text{ sec.}$ (B-11)

In addition Σ_{ℓ} and $\sigma_{D_{\ell}}$ ($\ell = 1,2$) were collapsed from the fifteen-group data. We neglect the photoneutrons generated by photons of energy beyond 5 Mev. and also the photoneutrons

generated by photons having had collisions. We then estimate through the two-group scheme of Table B-7 the number of the photoneutrons produced by the delayed photons from the fission products of an atom of U^{235} placed in the middle of an infinite medium of D_2^{0} . The result agrees with the data: 2.44 x 10^{-3} of Table B-1, within 30% of error.

[It is worthwhile to mention that using \underline{A}_{ℓ} 's computed through the numbers (presented above) of the library of the code POPOP IV ($\underline{A}_{1} = 12.694 \times 10^{-2}$, $\underline{A}_{2} = 43.246 \times 10^{-2}$), the data shown in Table B-7, and the result of Appendix A, the agreement with the data: 2.44×10⁻³ of Table B-1 falls within 6% of error.]

B-4 Representation of Fig. B-1 in terms of the data of Table B-1

We were able to reproduce the data of Table B-1, having started with the data relevant to Fig. B-2 or Fig. B-1. This suggests that we can describe the emission of the gamma rays from U^{235} fission products, of sufficient energy to produce photoneutron reaction in D₂0, by

$$a_{\ell}(t) = \frac{1}{\Delta \Lambda_{\ell}} Y_{\ell} \sum_{j=1}^{J} \lambda_{j} y_{j} N_{0} e^{-\lambda_{j} t}, \qquad (B-12)$$

with $\Delta \Lambda_{l}$, the width of the lth photon group. Y_{l} is the probability that a fission product photon of sufficient energy to produce photoneutron reaction in $D_{2}0$, appears within the lth group (assuming that this probability is not a function

of time). λ_j is the decay constant of the jth(j=1,...,j) group shown in Table B-1. y_j 's are presented in Table B-6 and N_0 is defined through Eq. (B-5). Y_l is represented by [17];

$$Y_{\ell} = \frac{\int_{\ell}^{\Lambda_{\ell} - 1} \frac{-1.1\Lambda}{\Lambda_{\ell} 1.1 e} d\Lambda}{\int_{2.23}^{\infty} 1.1 e^{-1.1\Lambda} d\Lambda}$$
(B-13)

(cf. also the lower curve of Fig. B-6). That is for the twogroup scheme we make up the Table B-8.

£	۲ ₂
1	0.24
2	0.76

Table B-8 Y_{ℓ} , $\ell = 1,2$

 N_0 remains to be determined so that we can make use of Eq. B-12. Thus from Eq. B-12

$$\underline{A}_{\ell} = \Delta \Lambda_{\ell} \int_{0}^{\infty} a_{\ell}(t) dt = Y_{\ell} N_{0}. \qquad (B-14)$$

Next insert the RHS of Eq.(B-14) in Eq.(B-1). Then with the numbers of Tables B-7 and B-8 we obtain

$$N_0 \sim 0.8$$
 (B-15)

Finally based on Equations (B-12), (B-15) and the Tables B-1, B-6, B-7 and B-8, we can make up the Table B-1 and Fig. B-7 where a comparison of the theoretical and experimental behavior of

$$a(t) = \sum_{\substack{\ell=1}}^{2} a_{\ell}(t) \Delta \Lambda_{\ell} \qquad (B-16)$$

is shown

Table B-9 Comparison of the theoretical and experimental values of a(t)

t(sec)	8 $-\lambda_{jt}$ $\Sigma \lambda_{jN_{0}}e^{jtheoretical}$ j=1 j	a(t) experimental
1	1.1×10^{-1}	4.8×10^{-2}
10	1.2×10^{-2}	7.5×10^{-3}
10 ²	1.2×10^{-3}	9.5 x 10^{-4}
10 ³	1.8×10^{-5}	3.4×10^{-5}



Behavior of a(t)

B-5 Conclusion

In this Appendix we have shown that the data relevant to the production of photons -from the fission products of U^{235} -<u>and</u> the data relevant to the attenuation of photons and photoneutron reaction (cross sections) in heavy water are consistent (within \approx 10% of accuracy). Thus for the purpose of our calculations, we can make use of the attenuation and photoneutron reaction cross sections in D_2^{0} , satisfactorily (at least for the photons of interest:

 $\Lambda > 2.23$ MeV).

Moreover, this checking of one data against the other led us, neglecting the photoneutrons produced by photons having had collisions, to derive an analytical representation for the curves of Fig. B-1 as the summation of nine exponential functions: $e^{-\lambda_j t}$, λ_j (j = 1,..., 9) being the decay constant of the jth -time wise- delayed photoneutron group (cf. Table 2-1).

Thus for the purpose of our calculations, Eq. (B-12) coupled with Eq. (B-15) will be used to express the production of delayed photons from U^{235} fission products*.

* It is worthwhile to mention that this enables us further to drive our equations for the unknown time coefficients (cf. Chapter III) into the familiar point kinetics form, thus making the solution much easier to find.

APPENDIX C

THE PROBABILITY $P_{\Lambda}(E_{\Lambda})$, THAT A PHOTONEUTRON INDUCED IN D_2O BY PHOTONS OF ENERGY Λ , WILL BE BORN WITH AN ENERGY E_{Λ}

A formula relating the energy E_{Λ} of a photoneutron induced by photons of energy Λ can be found in Reference [10] to be

$$\mathbf{E}_{\Lambda} = \frac{1}{2} \left(\Lambda - 2.23 - \frac{\Lambda^2}{1862}\right) + \Lambda \left(\frac{\Lambda - 2.23}{931}\right)^{\frac{1}{2}}, \quad (C-1)$$

where Λ and ${\rm E}_{\Lambda}$ are in MeV.

The Table C-1 and Fig. C-1 illustrate Eq. (C-1).

Table C-1

Energy ${\bf E}_{\Lambda}$ of a Photoneutron Induced by

Photons of Energy Λ , in D_2O

Λ (MeV)	2.5	3	4	5
E _Λ (MeV)	0.195	0.488	1.08	1.67

According to Eq. (C-1) an appropriate analytical representation of $P_{\Lambda}(E_{\Lambda})$ would be,

$$P_{\Lambda}(E) = \delta(E - E_{\Lambda}) \qquad (C-2)$$



Furthermore, from Fig. C-1 we can see that the minimum energy that photoneutrons born in a heavy water medium carry, is 43 keV. The lower limit of the fast energy group of our three group scheme being 3keV, all the photoneutrons, therefore, will be born in the fast group.

On the other hand, through Eqs. (2-18), (2-13), (2-12) and (C-2), we have,

$$P_{g} = \operatorname{diag} \left[\frac{1}{\Delta A_{1}} \int_{A_{1}}^{A_{0}} dA \int_{Eg}^{Eg-1} \delta(E-E_{\Lambda}) dE \cdots \frac{1}{\Delta A_{L}} \int_{A_{L}}^{A_{L}-1} dA \int_{Eg}^{Eg-1} \delta(E-E_{\Lambda}) dE \right].$$
(C-3)

Hence,

$$P_{g} = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}, g = 1, P_{g} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, g \neq 1 \quad (C-4)$$

where only two groups of photons have been considered.

APPENDIX D

THE SECONDARY GAMMA RAY CROSS SECTIONS FROM THE CODE POPOP IV

In the expression for the prompt photoneutron source term we have quantities such as, $\Sigma_{f_g}(r,z,t) \prod_{f_{g}}(r,z)$, which is the cross section for photons, induced by jth type of neutron reaction (either fission or prompt capture or inelastic scattering) due to neutrons of energy group g, to appear in the photon group ℓ , at (r,z) and t.

Thus we need to evaluate

$$SGCS_{lg}(r,z,t) = N(r,z,t) \sum_{f=1}^{3} \sigma_{f_q}(r,z) \prod_{f_{lg}}(r,z) (D-1)$$

where N(r,z,t) is the atom density at (r,z) and t, and $\sigma_{f_g}(r,z)$, the microscopic cross section corresponding to

 $\Sigma_{f_q}(r,z,t)$.

The various quantities, $\int_{f=1}^{3} \sigma_{f_{g}}^{n} \prod_{f_{lg}}^{n}$

[where n replacing (r,z), denotes the nuclide n present at (r,z)], were computed by the code POPOP IV [2].

D-1 Input to the Code POPOP IV

Input to the code POPOP IV consists of the boundaries of the neutron and photon energy groups, the nuclei of interest, and the reaction of interest. It is also necessary to input the neutron cross sections $\sigma_{f_g}^n$'s. The code computes $\prod_{f_{g_g}}^n$ out f_{g_g} of its own library, performs the multiplication $\sigma_{f_g}^n \propto \prod_{f_{g_g}}^n$ and eventually sums it over f if there is more than one reaction that the nuclei n can undergo.

D-1-1 Cross sections input to the Code

The few groups fission and capture cross sections were ready for MITR-II (cf. Appendix I), whereas we had to determine the inelastic scattering cross sections.

There are only two elements present in MITR-II that can cause inelastic scattering gamma rays having an energy above the threshold energy for photoneutron reaction in D_2^0 (2.23 Mev). These are carbon and oxygen. The inelastic scattering cross sections for these two elements were estimated in the following way;

Capture cross section is identical to absorption cross section in case of a non fissile material. It is equal to the difference of absorption and fission cross sections in case of a fissile material.



where f(E) [7] is the fission spectrum for U^{235} and σ_{jin} (E) [8], the inelastic scattering cross section for the jth nuclide at energy E.

Only fast neutrons (belonging to the fast group; E>3Kev) can cause inelastic scattering.

Hence, assuming
$$\int_{3Kev}^{\infty} f(E) dE=1$$
, Eq. (D-2) becomes,

$$\sigma_{j_{in_{1}}} = \int_{j_{threshold}}^{\infty} f(E) \sigma_{j_{in}}(E) dE. \qquad (D-3)$$

Equation (D-3) can then be written as,

$$\sigma_{j_{in_{1}}} = \sum_{n=1}^{N} \sigma_{j_{in_{1}}} F_{n} , \qquad (D-4)$$

where

$$F_n = \int_{E_n}^{E_{n-1}} f(E) dE$$
 (D-5)

The calculations based on this formula are presented in Table D-1.

Table D-1 Calculation of the inelastic scattering cross section of $6^{C^{12}}$ and $8^{0^{16}}$ for the fast

group of our scheme

Element	E threshold (Mev)	n	E _n (Mev)	F _n x10 ²	σ _{in} (barn)	^o in _n Fn×10 ³
6 ^{C¹²}	4.8	1	6	3.489	0.1	3.489
		2	7	1.301	0.3	3.903
		3	8	0.615	0.3	1.845
		4	9	0.286	0.4	1.144
		5	10	0.131	0.3	0.393
						$\sum_{n=1}^{5} \sigma_{in_n} F_n =$
						10.774 mb
_ 16						
8 ⁰	6.55	1	7	0.650	0.04	0.260
		2	8	0.615	0.20	1.230
		3	9	0.286	0.30	0.858
		4	10	0.131	0.35	0.458
						$\sum_{n=1}^{4} \sigma_{in_n} F_n =$
	2011 C			•		

 χ^{+}
Thus for the inelastic microscopic scattering cross sections we input to the Code POPOP IV, the numbers in millibarn, (10.8, 0,0) for carbon and (2.8, 0,0) for oxygen.

D-1-2 Neutron and Photon energy group boundaries input to the Code POPOP IV

The neutron and photon energy group boundaries are given in Tables D-2 and D-3.

Table D-2 Upper energy limits of the neutron

energy groups

g	E (ev) g-l
1	1×10^{7}
2	3×10^3
3	4×10^{-1}

Table D-3 Upper energy limits of the photon energy groups

Ł	El-1 (Mev)
1	7.0
2	3.5

D-2 Output from the Code POPOP IV; the microscopic secondary gamma ray cross sections

In Table D-4 are given, in barn, the final microscopic secondary gamma ray cross sections for the two-photon and threeneutron energy group, for various material present in MITR-II. The second column gives the nuclide numbers that refer to the material in question (cf. Appendix I).

The reason that two D_20 's appear in Table D-4 is that the few group microscopic cross sections have been obtained through a flux weighted collapsing procedure from a multigroup scheme. We may then have two different cross sections for the same material at different locations.

In Table D-4 yE-x stands for $yx10^{-x}$.

We point out that the gamma rays born in H₂0 are due to the inelastic scattering of neutrons with the oxygen nucleis only.

D-3 Macroscopic secondary gamma ray cross sections for materials present in MITR-II.

In order to get $SGCS_{lg}(r,z,t)$ we have to multiply the numbers given in Table D-4 by the atom densities given in Appendix I. Table D-5 shows the macroscopic secondary gamma ray cross sections, in cm⁻¹, for the two photon and three neutron energy group, for various compositions (cf,Appendix G) in MITR-II at the strady state. Table D-4 The microscopic secondary gamma ray cross sections (in barn) for various materials

present in MITR-II

-			Neutron Energy Group								
Material	Nuclide Number(s)	Photon Energy Group	1	2	3						
н ₂ о	3,7,12,14,	1	1.06848E-3	0.	0.						
	19,26,30,		1.40488E-6	0.	0.						
	31	2									
^D 2 ⁰	21	1	3.56848E-3	2.63000E-5	8.63000E-5						
		2	1.40488E-6	0.	0.						
D20	40,51	1	3.06848E-3	2.45000E-5	9.86000E-4						
		2	1.40488E-6	0.	0.						
U ²³⁵	1,5,9,15,17	1	2.87140E-1	5.08125	5.53837E+1						
	23,27	2	8.48170E-1	1.51157E+1	1.63794E+2						
Al	4,8,11,13,20, 22,25,29,32, 34,36,38,41, 44,48,50,52,	1 2	1.13679E-3 8.59558E-4	5.29197E-3 4.00139E-3	7.52636E-2 5.69087E-2						
	54,55										

				· · · · · · · · · · · · · · · · · · ·	the second se
U ²³⁸	2,6,10,16,18	1	5.37749E-01	6.43148	3.54914E-01
	24,28	2	9.64999E-02	1.15414	6.36899E-02
Pb		1	1.57480E-04	4.37896E-04	2.43840E-03
	33	2	0.	0.	0.
Ca	35	1	1.22047	2.95523	4.10662E+02
	and and a second se	2	1.48315	3.59126	4.99046E+02
С	39,53	1	5.4455E-03	7.72509E-05	2.24250E-03
		2	0.	2.57500E-05	7.47500E-04
1		(•	,

Table D-5 The Secondary Gamma Ray cross sections (in cm^{-1})

for various compositions in MITR-II at the steady state

	• • • • • • • • • • • • • • • • • • •	Neutron Energy Group								
Composition Number	Photon Energy Group	1	2	3						
1	1	0.1839E-03	0.2402E-03	0.2463E-01						
	2	0.3707E-03	0.6233E-02	0.6759E-01						
2	1	0.5189E-04	0.1592E-02	0.2263E-02						
	2	0.2588E-04	0.1204E-03	0.1713E-02						
3	1	0.1900E-03	1.2508E-02	0.2565E-02						
	2	0.3868E-03	0.6538E-02	0.7084E-01						
7	1	0.8243E-04	0.1722E-05	0.1502E-04						
	2	0.1392E-06	0.6480E-06	0.9218E-05						
8	1	0.5173E-05	0.1443E-04	0.8040E-04						
	2	0.	0.	0.						

Table D-5 (continued)

the second s				
9	1	0.8549E-02	0.2084E-01	2.8644
	2	0.1034E-01	0.2520E-01	3.4759
10	1	0.6846E-04	0.3186E-03	0.4529E-02
	2	0.5174E-04	0.2409E-03	0.3427E-02
16	1	0.4536E-03	0.6431E-05	0.1866E-03
	2	0.	0.2141E-05	0.6222E-04
17	1	0.7671E-04	0.1655E-03	0.2348E-02
	2	0.2680E-04	0.1248E-03	0.1775E-02
18	1	0.3567E-04	0.	0.
	2	0.4676E-07	0.	0.
19	1	0.3699E-04	0.1593E-04	0.2265E-03
	2	0.2631E-05	0.1205E-04	0.1714E-03
23	1	0.3888E-04	0.3185E-04	0.4527E-03
	2	0.5213E-05	0.2408E-04	0.3425E-03
24	1	0.6846E-04	0.3186E-03	0.4529E-02
	2	0.5174E-04	0.2409E-03	0.3427E-02

The Composition numbers 4,5,6,11,12,13,14,15,20,21 do not appear in Table D-5, the sets of Compositions (1,5,6,14), (2,15), (3,4,13), (10,11,12) and (18,20,21) being identical.

APPENDIX E

LINEAR DEPENDENCE OF THE SPATIAL FUNCTIONS

Obtaining the time dependent coefficients through the system of equations,

$$\Lambda \frac{dN(t)}{dt} = \left[\rho_{new}(t) - \overline{\beta}_{new}(t)\right] N(t) + \sum_{j=1}^{n} \lambda_{j}C_{j}(t), \quad (E-1)$$

$$\frac{dC_{j}(t)}{dt} = \overline{\beta}_{j_{new}}(t) - \lambda_{j}C_{j}(t), \qquad (E-2)$$

will require inverting the generation time matrix Λ . This is possible if the determinant of the matrix Λ is not singular. Moreover, numerically an "almost" singular determinant for the matrix Λ is to be avoided. Thus the normalized determinant (Grahm determinant)

det(G) =
$$1 - \frac{\Lambda_{12} \Lambda_{21}}{\Lambda_{11} \Lambda_{22}}$$
, (E-3)

 $\Lambda_{ik} = \langle W_i^{T}(\underline{r}) | v^{-1} | \psi_k(\underline{r}) \rangle, i = 1, 2, k = 1, 2, (E-4)$

should be greater than an imposed criterium.

If we fear an "almost" linear dependence, we can use the difference of the second and first trial modes as the second trial mode (if only two trial modes are used), that is

$$\psi_2'(\underline{\mathbf{r}}) = \delta\psi(\underline{\mathbf{r}}) = \psi_2(\underline{\mathbf{r}}) - \psi_1(\underline{\mathbf{r}}).$$
 (E-5)

However, here one must be careful in computing the leakage integral subject to section 5-2 of Chapter V, since Eqs. (4-19) or (5-14) do not hold for $\psi_2'(\underline{r})$. For the integral $< W_i^T(\underline{r}) \mid \nabla .D_2(\underline{r}, t) \nabla \mid \delta \psi(\underline{r}) >$, i = 1, 2 (with the familiar notation used throughout the dissertation) over the reactor volume, an appropriate expression may be found in the following way; write from Eq. (4-18),

$$< W_{i}^{T}(\underline{r}) | \nabla D_{2}(\underline{r}) \nabla | \psi_{2}(\underline{r}) > = < W_{i}^{T}(\underline{r}) | A_{2}'(\underline{r}) - \frac{F_{2}}{K_{2}}(\underline{r}) | \psi_{2}(\underline{r}) >, i = 1, 2.$$
(E-6)

Nothing changes if we add at the right hand side of Eq. (E-6) the quantity $\langle W_i^T(\underline{r}) | \nabla D_1(\underline{r}) \nabla - A_1(\underline{r}) + \frac{F_1}{k_1}(\underline{r}) | \psi_1(\underline{r}) \rangle$, i = 1, 2, that is equal to zero by definition. Next subtract from both sides of Eq. (E-6) the quantity $\langle W_i^T(\underline{r}) | \nabla D_2(\underline{r}) \nabla | \psi_1(\underline{r}) \rangle$, i = 1, 2. Also add and subtract at the same time, to and from the right hand side of

Eq. (E-6), the quantities
$$\langle W_i^T(\underline{r}) | A_2'(\underline{r}) | \psi_1(\underline{r}) \rangle$$
 and
 $\langle W_i^T(\underline{r}) | \frac{F_2}{k_2}(\underline{r}) | \psi_1(\underline{r}) \rangle$, $i = 1, 2$, to obtain

$$\langle W_{i}^{T}(\underline{r}) | \nabla D_{2}(\underline{r}) \nabla | \delta \psi(\underline{r}) \rangle = \langle W_{i}^{T}(\underline{r}) | A_{2}'(\underline{r}) - \frac{F_{2}}{K_{2}}(\underline{r})$$

$$\delta \psi(\underline{\mathbf{r}}) > + \langle W_{\underline{\mathbf{i}}}^{T}(\underline{\mathbf{r}}) - [\nabla D_{2}(\underline{\mathbf{r}}) \nabla - \nabla D_{1}(\underline{\mathbf{r}}) \nabla] + A_{2}(\underline{\mathbf{r}})$$

$$-A_{1}(\underline{r}) - \left[\frac{F_{2}}{k_{2}}(\underline{r}) - \frac{F_{1}}{k_{1}}(\underline{r})\right] | \psi_{1}(\underline{r}) \rangle, i = 1, 2. \quad (E-7)$$

Hence, if we wish to use the difference of the second and first trial modes as the second trial mode - to avoid an undesirable "almost" singular generation time matrix Λ , - we should compute the leakage integral associated with that second trial mode according to Eq. (E-7).

APPENDIX F

THE SOLUTION OF THE POINT KINETICS-TYPE OF EQUATIONS BY THE WEIGHTED RESIDUAL METHOD

We wanted to solve the system of equations

$$\Lambda \frac{dN(t)}{dt} = \left[\rho_{new}(t) - \overline{\beta}_{new}(t)\right] N(t) + \sum_{j=1}^{H} \lambda_{j}C_{j}(t),$$
(F-1)

$$\frac{dC_{j}(t)}{dt} = \overline{\beta}_{j_{new}} (t) N(t) - \lambda_{j}C_{j}.$$
 (F-2)

The solution we have adopted [11] proceeds as follows: Choose a trial function,

$$\overline{N}(t) = \sum_{k=0}^{K} A_{k}(t-t_{i})^{k}, \qquad (F-3)$$

for the time step: $t_i \leq t \leq t_{i+1}$, with unknown parameters; A_k 's (k = 1, ..., K), A_0 being $N(t_i)$. The bar on top of N(t)indicates an approximate expression.

Inserting Eq. (F-3) into Eq. (F-1) and Eq. (F-2) will give rise to time dependent residuals. We perform as many weighted integrals with those residuals as there are unknown parameters. One way of doing this is called subdomain weighting. We integrate the time dependent residuals first over the entire time step, then over half of the time step, and so forth as many times as the number of unknown parameters.

This way we will get a system of equations in K unknowns that will determine $\overline{N}(t)$ over $t_i \leq t \leq t_i + 1$. We then can carry out the same attack for the next time step.

The method proposed involves a way to select the time step (halving procedure) so that the convergence of the time coefficients is ensured.

THE (R,Z) CYLINDRICAL MODEL ADOPTED

APPENDIX G

THE MODEL

1	2	د	4 .	م	٨	,	R		n 11	1:	רו י	14	. 15	16	۱.	7 19	۱	0	20
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, ,			10	19	19	19	1 0	• 0	10	10	1.9	•8	1.9	1.9	19	1 7	18	21	
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The (r,z) cylindrical model, that we have adopted for the Reactivity and Transient Analysis of MITR-II is shown above. In this model 23 Compositions are shown (note that the composition number 22 does not appear, thus the numbering goes up to 24). Each composition is made of nuclei which are numbered from 1 up to 55 as they were input to the code Exterminator-II. Below is shown the composition numbers before the nuclei numbers they are made of. Below each nuclei number, is presented the nucleus that bears this number.

										268
1	-	l	2	4	3	12	55	· · ·	•	
		U5	U 8	Al	^H 2 ⁰		Al			
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		Al	^H 2 ⁰				U 5	U 8	Al	^H 2 ⁰
3		5	6	8	7	14	27	28	29	30
		U 5	U8	Al	H ₂ 0		U 5	U8	Ał	^H 2 ⁰
4		9	10	11	12	15	38	37		-
		U 5	U8	Al	^H 2 ⁰		Al	^H 2 ⁰		
5	2 	15	16	13	14	16	39			
		U 5	U8	Al	^H 2 ⁰		C			
6		17	18	20	19	17	40	41		
		U 5	U8	Al	^H 2 ⁰		^D 2 ⁰	Al		
7		21	22			18	42			
		D20	Al	•			^H 2 ⁰			
8		33				19	43	44		
		Pb					^H 2 ⁹	Al		
9)	35	34			20	45			
		Cđ	Al				^H 2 ⁰	•		
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ן י	1	54		24	1 50 19		Al	^H 2 ⁰		
		Al			Al H ₂ 0					

APPENDIX H

APPROXIMATE ATTENUATION COEFFICIENTS, ATT_{re}'s, FOR PRECHOSEN REGIONS OF THE D₂O REFLECTOR

To save computer time, we do not calculate the attenuation coefficient $\frac{1}{4\pi(r^2 + z^2)} - \Sigma_{\ell}(r^2 + z^2)^{\frac{1}{2}}$

(l = 1, ..., L) at every point (r, z). Instead we divide the reflector into regions within which a constant, approximate attenuation coefficient will be used.

To proceed, we make use of Fig. H-l to create the final Table H-l.

The macroscopic attenuation cross section is taken to be equal to 0.04 cm^{-1} , the value appropriate for photons emitted with an energy of 3 MeV.

The regions in question are rectangular and defined by four mesh point numbers; two in the r direction: INUI_{re}, INUF_{re}, and two in the z direction: INVI_{re}, INVF_{re}, as shown in Fig. H-2 (cf. Appendix G for the presentation of the mesh volume structure for MITR-II).

(See following page for Fig. H-2.)



Fig. H-1 The Attenuation Factor as a Function of the Distance \underline{r} of a Point in D₂O Medium, to a Central Point. The Attenuation Cross Section Σ , is Taken to be Equal to 0.04 cm⁻¹.





Attenuation Coefficient

Table H-1 The Constant Approximate Attenuation

	Coefficient	re re	, in ten D_2^C) Reflector	Regions
re	INUIre	INUFre	INVIre	INVFre	ATT re x 10 ⁵
1	1	8	31	34	4.
2	9	15	32	34	2.4
3	1	15	35	39	2.4
4	16	22	29	39	1.
5	23	27	23	39	1.
6	25	27	7	22	2.7
7	28	30	7	39	1.
8	1	30	40	44	1.
9	31	33	7	44	0.3
ho	1	33	45	47	0.3

EXTERMINATOR-II INPUT DATA (FIRST TRIAL SHAPE AND ITS ADJOINT)

APPENDIX I

BTAINING THE EIVER SHADE AND ITS AD INTAT THOMAS EVICEMENATOR 2	EXT20001
BIAINING THE FIRST SHAPE AND ITS AUJUINT THROUGH EXTERMINATOR 2	EXT20002
	EXT20003
/ THIGA YARMANI REGINN=335K.CLASS=C	EXT20004
**************************************	EXT20005
**************************************	EXT20006
$\pm MAIN = LINES=20.0 ADDS=30. TIME=30$	EXT20007
$\frac{1}{2}$ (ETHD 11A(1T-22)(4,10-22)(1)(2,0-1)(0)	EXT20008
+ SCIUP UNII-ZJIIIU-ZJIIIU-ZJIIU-ZJIIU-ZJIIU-ZJIIU-ZJIIU-ZJIIIU-ZJIIIIU-ZJIIU-ZJIIU-ZJIIU-ZJIIU-ZJIIU-ZJIIU-ZJIIU-ZJIIU-ZJII	EXT20000
VSTEDI EVEC E DELDEDCHUISEDELLE M7516 7728 EVTEDMI LANDINELIRIT	EXT20010
// FTAIFAUL AA HNIT-SYSDA.DISD=(NEW.DASS). Y	EXT20011
$\frac{1}{1000} = \frac{1}{1000} = 1$	EXT20012
7 = 000-(REC) = 00000000000000000000000000000000000	EXT20013
$\int DCB = (RECEM = \sqrt{BS_{*}} REC = 2404 \cdot B KS17E = 4812 \cdot SPACE = (TRK_{*}(20.10))$	EXT20014
$/C_{0}FI03F001$ DD UNIT=SYSDA.DISP=(NEW.PASS).	EXT20015
$DCB=(RECEM=VBS \cdot RECL=1604 \cdot BLKSI7E=3212) \cdot SPACE=(TRK \cdot (20.10))$	EXT20016
$/G_{\bullet}FT04F001$ DD UNIT=SYSDA.DISP=(NFW.PASS).	EXT20017
$DCB = (RECEM = VBS \cdot IRECI = 1604 \cdot BIKSI7E = 3212) \cdot SPACE = (TRK \cdot (20.10))$	EXT20018
$/G_{0}$ ET 09E 001 DD DSNAM E=USEREILE = M8696, 9441, DENGEA, KISI, DISP=(DLD, PASS)	EXT20019
$/G_{\circ}$ ET10E001 DD UNIT=SYSDA.DISP=(NEW.PASS).	EXT20020
$DCB = (RECEM = VS \cdot 1RECI = 1604 \cdot BIKS 17E = 1608) \cdot SPACE = (TRK \cdot (10 \cdot 5))$	EXT20021
$/G_{\bullet}FT11FDD1$ DD UNIT=SYSDA.DISP=(NFW.PASS).	FXT20022
$\int DCB = (RFCEM = VS \cdot 1 RFCI = 804 \cdot B1KS17F = 808) \cdot SPACF = (TRK \cdot (10.5))$	EXT20023
/G.SYSIN DD *	EXT20024
ITRII EQUILIBRIUM FLUX AND ADJUINT FLUX	EXT20025
	EXT20026
	EXT20027
60 48 40 3 28 55 89 0 1 1 0 1 0 0 1 0 0 0 01.0E-54.125E+171.0000001.30	EXT20028
•0	EXT20029
	EXT20030
0.160 4 5.080 7 7.62 8 2.54 20 1.27 25 .635 26 1.164 29 .635 34	EXT20031
.952 35 .997 42 1.27 45 3.492 45 15.24 48	EXT20032
.728 2 1.864 3 1.364 5 .317 7 1.614 11 .977 15 1.596 16 .954 19	EXT20033
159 20 .635 21 .159 22 .476 23 .687 26 .635 27 4.41 34 3.0 35	EXT20034
0.66 37 15.24 40	EXT20035
7 7 48 1 34 18 1 3 1 19 18 1 3 22 34 16 1 48 35 40	EXT20036

2 3 4 1 19 2 3 4 22 31	2 4 8 1 5	2 4 8 7 17	EXT20037
19 3 4 31 33 19 4 5 22 33	23 3 5 33 34	23 5 7 27 34	EXT20038
9 4 10 5 7 13 8 10 1 5	14 8 10 7 17	4 10 20 1 5	EXT20039
10 10 26 5 7 5 10 20 7 11	6 10 20 11 17	3 20 24 1 5	EXT20040
1 20 24 7 17 2 24 25 1 5	2 24 25 7 17	24 25 26 1 5	EXT20041-
24 25 26 7 17 2 26 29 1 17	9 1 10 20 21	21 1 21 19 20	EXT20042
21 10 21 20 21 21 1 21 21 22	11 4 27 17 18	11 4 24 18 19	EXT20043
11 21 22 19 21 12 5 19 22 23	12 5 19 26 27	15 1 48 34 35	EXT20044
12 30 31 1 5 2 30 31 5 8	17 31 32 5 8	12 31 32 8 10	EXT20045
2 31 32 10 11 17 32 33 10 11	12 32 33 11 13	2 32 33 13 14	EXT20046
17 33 34 13 14 12 33 34 14 16	12 32 33 16 17	17 32 33 17 18	EXT20047
2 31 32 17 18 12 30 31 18 20	12 29 30 20 21	2 28 29 20 21	EXT20048
17 28 29 21 23 12 27 28 22 23	12 25 27 23 24	2 24 25 23 24	EXT20049
17 24 25 24 25 12 22 24 24 25	12 20 22 25 26	2 19 20 25 26	EXT20050
17 19 20 26 27 20 32 33 14 16	20 31 32 11 17	20 30 31 8 18	EXT20051
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20 22 24 19 23 20 21 22 21 23	20 19 21 22 23	21 5 24 23 24	EXT20053
21 5 22 24 25 21 5 19 25 26	25 37 40 11 12	25 36 41 12 13	EXT20054
25 35 42 13 27 26 35 42 27 29	27 35 42 29 31	28 35 42 31 35	EXT20055
22 29 45 35 40 13 5 8 1 5	10 8 10 5 7	14 5 8 7 17	EXT20056
9 1 12 20 21 8 5 26 1 3	7 34 43 11 34	15 20 48 34 35	EXT20057
16 26 46 35 40			EXT20058
1 1 OUTER BJT. EDGE CORE		•	EXT20059
14.0160E-4 23.0227E-5 43.1628E-2	31.5404E-2		EXT20060
2 2 50% AL 50% H-2-0			EXT20061
32 0.03012 31 0.01655		•	EXT20062
3 3 INNER BUT. EDGE CORE			EXT20063
54.2235E-4 63.1790E-5 83.0150E-2	71.6367E-2		EXT20064
4 4 CENTRAL CORE			EXT20065
94.2235E-4 103.1790E-5 113.0150E-2	121.6367E-2		EXT20066
5 5 INTERM. CORE			- EXT20067
154-0160E-4 163-0227E-5 133-1628E-2	141.5404E-2		EXT20068
6 6 UUTER CORE			EXT20069
1/4.0160E-4 183.0227E-5 203.1628E-2	191.5404E-2		EXT20070
7 7 HEAVY WATER			EXT20071
21.0329146 22.0001521			EXT20072

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	88 LEAD	EXT20072
	33 •3295E-1	EXT20074
	9 9 15% CD 85% AL	EXT20075
	35 0.00696 34 0.051195	EX120076
	10 10 INNER CORE AL	EXT20077
	36 0.06023	EXT20078
	11 11 OUTER CORE AL	EXT20079
	54 0.06023	EXT20080
	12 12	EXT20081
	55 0.06023	EXT20082
	13 13 CENTRAL CORE	EXT20083
	234.2235E-4 243.1790E-5 253.0150E-2 261.6367E-2	EXT20084
	14 14 UUTER CORE	EXT20085
	274.0160E-4 283.0227E-5 293.1628E-2 301.5404E-2	EXT20086
	15 15 CURE TANK	EXT20087
	38 0.03012 37 0.01655	EX120088
	16 16 GRAPHITE	EXT20089
	39 •8334E-1	EXT20090
	17 17 50% D-2-0,50% AL	EXT20091
	40 0.01654 41 0.0312	EXT20092
	18 18 REFLECTOR H-2-D	EXT20093
	42 0.0334	EXT20094
··· •	19 19	EXT20095
	$43 \cdot 3143E - 1 \cdot 44 \cdot 3012E - 2$	EXT20096
	20 20	EX120097
	45.03340	EXT20098
		EX 120099
		EX120100
		EX120101
	53 •8334t=1	EX120102
	23 23	EX120103
	48 • UU6UZ3 41 • U3UU 18	EX120104
	24 24 50% AL 50% H-2-0	EX120105
	$\frac{1}{2} = \frac{1}{2} = \frac{1}$	EXT20106
	25 28 HEAVY WATER	EX120107
	51.0329146 52.0001621	EX120108 N
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EXT20109 1 1 EXT20110 2.0496E 01.6442E 06.5786E 02.5535E 0 EXT20111 0.0 4.7543E-30.0 EXT20112 1 2 EXT20113. EXT20114 4.0114E 12.6771E 14.4517E 12.4493E 0 0.0 0.0 4.4165E-3 EXT20115 1 3 EXT20116 4.3257E 23.4731E 24.4139E 22.4420E 0 EXT20117 0.0 0.0 0.0 EXT20118 2 1 EXT20119 3.7297E-11.1753E 06.5535E 01.1082E 0 EXT20120 0.0 5.7051E-30.0 EXT20121 2 2 EXT20122 3.0065E 10.0 2.6415E 10.0 EXT20123 5.2998E-3 0.0 0.0 EXT20124 2 3 EXT20125 1.8136E 00.0 9.1350E 00.0 EXT20126 0.0 0.0 0.0 EXT20127 3 1 EXT20128 3.9503E-30.0 7.4955E 00.0 EXT20129 0.0 2.1158E 00.0 EXT20130 -- 3 2 EXT20131 3.5490E-20.0 2.1705E 10.0 EXT20132 0.0 0.0 4.0400E 0 EXT20133 3 3 EXT20134 5.1425E-10.0 6.6503E 10.0 EXT20135 0.0 0.0 0.0 EXT20136 4 1 EXT20137 2.6894E 00.0 2.9585E-30.0 EXT20138 5.9904E-30.0 0.0 -EXT20139 4 2 EXT20140 1.2655E-20.0 1.3738E 00.0 EXT20141 0.0 0.0. 1.0158E-2 EXT20142 4 3 EXT20143 EXT20144 N 1.8107E-10.0 1.4662E 00.0

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0.0 0.0 EXT20145 0.0 5 1 EXT20146 2.0628E 01.6524E 06.6203E 02.5509E 0 EXT20147 0.0 4-8549E-30-0 EXT20148 5 2 EXT20149 4.0028E 12.6698E 14.4430E 12.4493E 0 EXT20150 0.0 0.0 4.3650E-3 EXT20151 5 3 EXT20152 4.3257E 23.4731E 24.4139E 22.4420E 0 EXT20153 0.0 0.0 0.0 EXT20154 6 1 EXT20155 3.7109E-11.1806E 06.6000E 01.0851E 0 EXT20156 5-8259E-30-0 0.0 EXT20157 6 2 EXT20158 3.0029E 10.0 2.6441E 10.0 EXT20159 0.0 0.0 5.2380E-3 EXT20160 6 3 EXT20161 1.8136E 00.0 9.1350E 00.0 EXT20162 0.0 . 0.0 0.0 EXT20163 7 1 EXT20164 7.5792E 00.0 EXT20165 2.1602E 00.0 0.0 EXT20166 7 2 EXT20167 3.5251E-20.0 / 2.1700E 10.0 EXT20168 0.0 4.0005E 0 0.0 EXT20169 7 3 EXT20170 5-1425E-10-0 6.6503E 10.0 EXT20171 0.0 0.0 0.0 EXT20172 8 1 EXT20173 2.9157E-30.0 2.6940E 00.0 EXT20174 0.0 6.1172E-30.0 ·EXT20175 8 2 EXT20176 1.2571E-20.0 1.3738E 00.0 EXT20177 0.0 0.0 1.0039E-2 EXT20178 8 3 EXT20179 1.8107E-10.0 1.4662E 00.0 EXT20180 N 77

EXT20181 0.0 . . 0 . 0 0.0 9 1 EXT20182 2.0673E 01.6554E 06.6321E 02.5507E 0 EXT20183 0.0 4.8837E-30.0 EXT20184 9 2 EXT20185 3.9510E 12.6289E 14.3917E 12.4493E 0 EXT20186 0.0 0.0 4.1198E-3 EXT20187 9 3 EXT20188 3.5922E 22.8708E 23.6822E 22.4420E 0 EXT20189 0.0 0.0 0.0 EXT20190 10 1 EXT20191 3.7225E-11.1723E 06.6127E 01.0832E 0 EXT20192 0.0 5.8604E-30.0 EXT20193 10 2 EXT20194 2.9694E 10.0 2.6478E 10.0 EXT20195 0.0 0.0 4.9437E-3 EXT20196 10 3 EXT20197 1.5204E 00.0 8.9890E 00.0 EXT20198 0.0 0.0 0.0 EXT20199 11 1 EXT20200 2.8423E-30.0 2.0861E 00.0 EXT20201 0.0 6-1535E-30-0 EXT20202 11 2 EXT20203 1.2288E-20.0 . 1.3768E 00.0 EXT20204 0.0 0.0 9.4755E-3 EXT20205 11 3 EXT20206 1.5807E-10.0 1.5366E 00.0 EXT20207 EXT20208 0.0 0.0 0.0 12 1 EXT20209 3.7547E-30.0 7.5854E 00.0 EXT20210 .EXT20211 0.0 2.1737E 00.0 12 2 EXT20212 3.4102E-20.0 2.1679E 10.0 EXT20213 3.8151E 0 EXT20214 0.0 0.0 EXT20215 12 3 4.2371E-10.0 5.7017E 10.0 EXT20216 N 1

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0.0 0.0 EXT20217 0.0 . 13 1 EXT20218 2.8870E-30.0 2.0843E 00.0 EXT20219 0.0 6.0604E-30.0 EXT20220 13 2 EXT20221-1.2215E-20.0 1.3735E 00.0 EXT20222 0.0 0.0 9.5483E-3 EXT20223 13 3 EXT20224 1.4447E 00.0 1.5239E-10.0 EXT20225 0.0 0.0 0.0 EXT20226 14 1 EXT20227 3.9168E-30.0 7.5053E 00.0 EXT20228 0.0 2.1406E 00.0 EXT20229 14 2 EXT20230 3.4244E-20.0 2.1681E 10.0 EXT20231 0.0 0.0 3.8391E 0 EXT20232 14 3 EXT20233 4.2913E-10.0 5.7570E 10.0 EXT20234 0.0 0.0 0.0 EXT20235 15 1 EXT20236 2.0574E 01.6495E 06.5969E 02.5533E 0 EXT20237 0.0 4.8099E-30.0 EXT20238 15 2 EXT20239 3.9558E 12.6331E 14.3966E 12.4493E 0 EXT20240 0.0 0.0 4.1514E-3 EXT20241 15 3 EXT20242 3.6349E 22.8750E 23.7247E 22.4420E 0 EXT20243 0.0 0.0 0.0 EXT20244 16 1 EXT20245 3.7487E-11.1616E 06.5724E 01.1062E 0 EXT20246 0.0 5.7719E-30.0 EXT20247 16 2 EXT20248 2.9713E 10.0 2.6461E 10.0 EXT20249 0.0 4.9817E-3 0.0 EXT20250 16 3 EXT20251 EXT20252 N 1.5387E 00.0 8.9989E 00.0 Ö

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0.0 0.0 0.0 17 1 2.0435E 01.6402E 06.5655E 02.5540E 0 4.69928-30.0 0.0 17 2 3.9946E 12.6633E 14.4358E 12.4493E 0 0.0 0.0 4.3124E-3 17 3 4.3257E 23.4731E 24.4139E 22.4420E 0 0.0 0.0 0.0 18 1 3.7332E-11.1740E 06.5409E 01.1131E 0 0.0 5-6390E-30-0 18 2 3.0008E 10.0 2.6450E 10.0 0.0 0.0 5.1748E-3 18 3 1.8136E 00.0 9.1350E 00.0 0.0 0.0 0.0 19 1 .9522E-30.0 7.4697E 00.0 2.0931E 00.0 0.0 19 2 3.5118E-20.0 2.1696E 10.0 0.0 0.0 3.9727E 0 19 3 6.6503E 10.0 •1425E-10.0 0.0 0.0 0.0 20 1 2.9535E-30.0 2.6908E 00.0 5.9209E-30.0 0.0 20 2 1.2521E-20.0 1.3738E 00.0 0.0 0.0 9.9184E-3 20 3 1.8107E-10.0 1.4662E 00.0

· EXT20253 EXT20254 EXT20255 EXT20256 EXT20257 EXT20258 EXT20259 EXT20260 EXT20261 EXT20262 -EXT20263 EXT20264 EXT20265 EXT20266 EXT20267 EXT20268 EXT20269 EXT20270 EXT20271 EXT20272 EXT20273 EXT20274 EXT20275 EXT20276 EXT20277 EXT20278 EXT20279 EXT20280 EXT20281 EXT20282 EXT20283 EXT20284 EXT20285 EXT20286 EXT20287 EXT20288 N

	0.0	0.0	0.0		EXT20289	
	2-4984E-	-30-0	7.0599F	0-0	EXT20291	
	0.0	6.7724E-1	10.0		FXT20292	
	21 2				FXT20293	•
	2-6314E-	-50.0	8-3280F	0.0	FXT20294	
	0.0	0.0	6-2333E-		FXT20295	
	21 3	•••	0125552		FXT20296	
	-8633E-	-40.0	1.2816F	0.0	FXT20297	
	0.0	0.0	0.0		EXT20298	an a
	22 1				EXT20299	
	3.06786-	-30.0	1.9218E	0.0	EXT20300	
	0.0	1.3768E-2	20.0		FXT20301	
	22 2				EXT20302	· · ·
	1.4949E-	20.0	1.3800E		EXT20303	•
	0.0	0.0	1.3621E-		EXT20304	-
	22 3				EXT20305	
	2.1166E-	-10.0	1.5991E	0.0	EXT20306	•
	0.0	0.0	0.0		EXT20307	•
	23 1				EXT20308	
• • •	2.0869E	01.6686E 0	06.6716E	2.5501E 0	EXT20309	
	0.0	5.0685E-3	30.0		EXT20310	
	. 23 2				EXT20311	
	3.9430E	12.6118E	14.3898E	2.4494E 0	EXT20312	
	0.0	0.0	3.8991E-		EXT20313	
	23 3				EXT20314	
•	3.5922E	22.8708E	23.6822E	2.4420E 0	EXT20315	· · · ·
	0.0	0.0	0.0		EXT20316	
	24 1				EXT20317	
	3.7523E-	11.1530E (06.6511E	1.0772E 0	EXT20318	
	0.0	6.0822E-3	30.0		EXT20319	•
	24 2				EXT20320	
	3.0006E	10.0	2.6662E		EXT20321	
	0.0	0.0	4.6789E-		EXT20322	÷
	24 3				EXT20323	
	1.5204E	00.0	8.9890E	0.0	EXT20324	281

	0.0	0.0	0.0			EXT20325
	25 1		· · · · · · · · · · · · · · · · · · ·			EXT20326
	2.8420E-	30.0	2.0792E	00.0		EXT20327
	0.0	6.3863E-	-30.0			EXT20328
	25 2					EXT20329
	1.2178E-	20.0	1.3767E	00.0		EXT20330
	0.0	0.0	8.9680E-	3		EXT20331
	25 3					EXT20332
	1.5807E-	10.0	1.5366E	00.0		EXT20333
	0.0	0.0	0.0			EXT20334
	26 1					EXT20335
	3.7140E-	-30.0	7.6215E	00.0		EXT20336
	0.0	2.2475E	00.0			EXT20337
	26 2					EXT20338
	3.3859E-	20.0	2.1662E	10.0		EXT20339
	0.0	0.0	3.7248E	0		EXT20340
	26 3					EXT20341
	4.2371E-	10.0	5.7017E	10.0		EXT20342
	0.0	0.0	0.0			EXT20343
	27 1					EXT20344
	2.0649E	01.6547E	06.6089E	02.5534E	0	EXT20345
	0.0	4.8899E-	-30.0		그는 것 같은 것 같은 것 같은 것 같은 것 같은 것 같은 것 같이 있는 것 같이 있는 것 같이 있는 것 같이 없다.	EXT20346
	27 2					EXT20347
÷.4	3.9739E	12.6425E	14.4168E	12.4493E	0	EXT20348
	0.0	0.0	4.1611E-	3		EXT20349
	27 3					EXT20350
	3.5922E	22.8708E	23.6822E	22.4420E		EXT20351
	0.0	0.0	0.0			EXT20352
	28 1					EXT20353
	3.7702E-	11.1495E	06.5831E	01.1079E		EXT20354
	0.0	5.8679E-	-30.0			EXT20355
	28 2					EXT20356
	2.9966E	10.0	2.6521E	10.0		EXT20357
	0.0	0.0	4.9933E-	•3		EXT20358
	28 3					EXT20359
	1.5204E	00.0	8.9890E	00.0		EXT20360

EXT20361 0.0 0.0 0.0 EXT20362 29 1 2.8845E-30.0 2.0809E 00.0 EXT20363 EXT20364 0.0 6.1613E-30.0 29 2 EXT20365 1.2459E-20.0 1.3771E 00.0 EXT20366 0.0 0.0 9.5705E-3 EXT20367 29 3 **FXT20368** 1.5807E-10.0 1.5366E 00.0 EXT20369 0.0 0.0 EXT20370-0.0 30 1 EXT20371 3.9034E-30.0 7.5048E 00.0 EXT20372 EXT20373 0.0 2.1711E 00.0 30 2 EXT20374 3.4601E-20.0 2.1684E 10.0 EXT20375 0.0 0.0 3.8759E 0 EXT20376 30 3 EXT20377 4.2371E-10.0 5.7017E 10.0 EXT20378 0.0 0.0 0.0 EXT20379 31 1 EXT20380 3-8287E-30-0 7.6889E 00.0 EXT20381 2.4438E 00.0 0.0 EXT20382 31 2 EXT20383 3.9349E-20.0 2.1969E 10.0 EXT20384 0.0 4.4186E 0 EXT20385 0.0 31 3 EXT20386 6.1276E-10.0 7.7699E 10.0 EXT20387 0.0 0.0 0.0 EXT20388 32 1 EXT20389 2.9243E-30.0 2.0593E 00.0 EXT20390 0.0 7.0140E-30.0 EXT20391 32 2 EXT20392 1.3678E-20.0 1.3785E 00.0 EXT20393 0.0 0.0 1.1265E-2 EXT20394 32 3 EXT20395 EXT20396 N 2.1166E-10.0 1.5991E 00.0 83

0.0 0.0 0.0 33 1 3.1042E-30.0 5.8792E 00.0 0.0 1.4549E-20.0 33 2 1.1134E 10.0 8.6206E-30.0 0.0 0.0 1.1662E-2 33 3 4.8000E-20.0 1.1130E 10.0 0.0 0.0 0.0 34 1 2.8500E-30.0 2.0590E 00.0 0.0 7.2065E-30.0 34 2 1.2342E-20.0 1.3770E 00.0 0.0 0.0 8.3502E-3 34 3 2.1166E-10.0 1.5991E 00.0 0.0 0.0 0.0 35 1 6.3567E 00.0 6.2660E 00.0 0.0 0.0 0.0 35 2 1.5368E 10.0 1.1086E 10.0 0.0 0.0 0.0 35 3 2.1407E 30.0 2.8590E 30.0 0.0 0.0 0.0 36 1 2.8564E-30.0 2.0846E 00.0 6.1598E-30.0 0.0 36 2 1-2340E-20-0 1.3769E 00.0 0.0 0.0 9.5172E-3 36 3 1.5807E-10.0 1.5366E 00.0

EXT20397 EXT20398 EXT20399 EXT20400 EXT20401 -EXT20402 EXT20403 EXT20404 EXT20405 EXT20406 EXT20407 EXT20408 EXT20409 EXT20410 EXT20411 EXT20412 EXT20413 EXT20414 EXT20415 EXT20416 EXT20417 EXT20418 EXT20419 EXT20420 EXT20421 EXT20422 EXT20423 EXT20424 EXT20425 EXT20426 EXT20427 EXT20428 EXT20429 EXT20430 EXT20431 EXT20432

0.0 0.0 0.0 37 1 2.2737E-30.0 1.0878E 10.0 0.0 6-2105E 00-0 37 2 5.2773E-20.0 2.2355E 10.0 0.0 6.5134E 0 0.0 37 3 .1276E-10.0 7.7699E 10.0 0.0 0.0 0.0 38 1 3.1166E-30.0 1.8247E 00.0 1.9097E-20.0 0.0 38 2 1.8242E-20.0 1.3841E 00.0 0.0 0.0 1.7807E-2 38 3 2.1166E-10.0 1.5991E 00.0 0.0 0.0 0.0 39 1 0.0 3.1137E 00.0 0.0 1.1280E-10.0 0.0 39 2 1.0297E-40.0 4.4031E 00.0 0.0 0.0 1.2428E-1 39 3 2.9912E-30.0 4.7187E 00.0 0.0 0.0 0.0 40 1 3.3897E-30.0 6.6839E 00.0 0.0 4.3475E-10.0 40 2 2.3374E-50.0 8.3113E 00.0 0.0 0.0 5.5817E-1 40 3 9.8633E-40.0 1.2816E 10.0

EXT20433 EXT20434 EXT20435 EXT20436 EXT20437 EXT20438 EXT20439 EXT20440 EXT20441 EXT20442 EXT20443 EXT20444 EXT20445 EXT20446 EXT20447 EXT20448 EXT20449 EXT20450 EXT20451 EXT20452 EXT20453 EXT20454 EXT20455 EXT20456 EXT20457 EXT20458 EXT20459 EXT20460 EXT20461 EXT20462 EXT20463 EXT20464 EXT20465 EXT20466 EXT20467 EXT20468

0.0 0.0 0.0 - 41 1 2.9910E-30.0 2.0228E 00.0 0.0 8-8093E-30-0 41 2 1.4062E-20.0 1.3789E 00.0 0.0 0.0 1.2100E-2 41 3 2.1166E-10.0 1.5991E 00.0 0.0 0.0 0.0 42 1 .3466E-30.0 7.3682E 00.0 0.0 2.4319E 00.0 42 2 4.2248E-20.0 2.2043E 10.0 4.8494E 0 0.0 0.0 42 3 6.1276E-10.0 7.7699E 10.0 0.0 0.0 0.0 43 1 .2438E-30.0 7.4581E 00.0 0.0 2.4766E 00.0 43 2 4.1398E-20.0 2.2015E 10.0 0.0 4.7066E 0 43 3 6.1276E-10.0 7.7699E 10.0 0.0 0.0 0.0 44 1 3.0467E-30.0 2.0394E 00.0 7.1607E-30.0 0.0 44 2 1.4371E-20.0 1.3794E 00.0 1.2011E-2 0.0 0.0 44 3 2.1166E-10.0 1.5991E 00.0

EXT20469 EXT20470 EXT20471 EXT20472 EXT20473 EXT20474 EXT20475 EXT20476 EXT20477 EXT20478 EXT20479 EXT20480 EXT20481 EXT20482 EXT20483 EXT20484 EXT20485 · EXT20486 .EXT20487 EXT20488 EXT20489 EXT20490 EXT20491. EXT20492 EXT20493 EXT20494 EXT20495 EXT20496 EXT20497 EXT20498 EXT20499 EXT20500 EXT20501 EXT20502 EXT20503 EXT20504 Ň
0.0 0.0 0.0 45 1 3.6428E-30.0 8.0176E 00.0 2.7762E 00.0 0.0 45 2 4.0418E-20.0 2.2003E 10.0 0.0 0.0 4.5923E 0 45 3 6.1276E-10.0 7.7699E 10.0 0.0 0.0 0.0 46 1 3.4945E-30.0 8.0340E 00.0 0.0 2.7121E 00.0 46 2 3.8902E-20.0 2.1953E 10.0 0.0 0.0 4.3424E 0 46 3 6.1276E-10.0 7.7699E 10.0 0.0 0.0 0.0 47 1 3.8794E-30.0 8.0138E 00.0 0.0 3.0305E 00.0 . 47 2 4.3928E-20.0 2.2099E 10.0 0.0 0.0 5.1276E 0 47 3 6.1276E-10.0 7.7699E 10.0 0.0 0.0 0.0 48 1 3.0827E-30.0 2.0098E 00.0 8.8612E-30.0 0.0 48 2 1.5235E-20.01.3804E 00.0 0.0 0.0 1.3473E-2 48 3 2.1166E-10.0 1.5991E 00.0

EXT20505 EXT20506 EXT20507 EXT20508 EXT20509 EXT20510 EXT20511 EXT20512 EXT20513 EXT20514. EXT20515 EXT20516 EXT20517 EXT20518 EXT20519 EXT20520 EXT20521 EXT20522 EXT20523 EXT20524 EXT20525 EXT20526 EXT20527 EXT20528 EXT20529 EXT20530 EXT20531 EXT20532 EXT20533 EXT20534 EXT20535 EXT20536 EXT20537 EXT20538 EXT20539 EXT20540

0.0 0.0 0.0 49 1 3.8567E-30.0 7.6667E 00.0 0.0 2.3724E 00.0 49 2 3.8773E-20.0 2.1957E 10.0 0.0 0.0 4.3394E 0 49 3 6.1276E-10.0 7.7699E 10.0 0.0 0.0 0.0 50 1 2.9202E-30.0 2.0670E 00.0 6.7902E-30.0 0.0 50 2 1.3484E-20.0 1.3783E 00.0 0.0 0.0 1.1070E-2 50 3 1.5991E 00.0 2.1166E-10.0 0.0 0.0 0.0 51 1 7.0489E 00.0 2.5773E-30.0 0.0 6.5528E-10.0 51 2 2.5709E-50.0 8.3246E 00.0 0.0 6.0911E-1 0.0 51 3 9-8633E-40-0 1.2816E 10.0 0.0 0.0 0.0 52 1 3.1038E-30.0 1.9280E 00.0 1.3310E-20.0 0.0 52 2 1.4689E-20.0 1.3797E 00.0 0.0 0.0 1.3308E-2 52 3 2.1166E-10.0 1.5991E 00.0

EXT20541 EXT20542 EXT20543 EXT20544 EXT20545 EXT20546 EXT20547 EXT20548 EXT20549 EXT20550 EXT20551 EXT20552 EXT20553 EXT20554 EXT20555 EXT20556 EXT20557 EXT20558 . EXT20559 EXT20560 EXT20561 EXT20562 EXT20563 EXT20564 EXT20565 EXT20566 EXT20567 EXT20568 EXT20569 EXT20570 EXT20571 EXT20572 EXT20573 EXT20574 EXT20575 EXT20576

0.0 0.0 0.0 53 1 0.0 0.0 3.1243E 00.0 1.1079E-10.0 0.0 53 2 1.0224E-40.0 4.4025E 00.0 0.0 1.2339E-1 0.0 53 3 2.9912E-30.0 4.7187E 00.0 0.0 0.0 0.0 54 1 2.8567E-30.0 2.0758E 00.0 6.6215E-30.0 0.0 54 2 1,290/E-20.0 1.3776E 00.0 0.0 0.0 1.0003E-2 54 3 2.1166E-10.0 1.5991E 00.0 0.0 0.0 0.0 55 1 2.9237E-30.0 2.0380E 00.0 8.1833E-30.0 0.0 55 2 1.3662E-20.0 1.3785E 00.0 0.0 0.0 -1-1252E-2 55 3 2.1166E-10.0 1.5991E 00.0 0.0 0.0 0.0 MITR11 EQUILIBRIUM ADJOINT FUNCTION 1

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1.990E-92.317E-74.545E-6

EXT20577 EXT20578 EXT20579 EXT20580 EXT20581 EXT20582 EXT20583 EXT20584 EXT20585 EXT20586 EXT20587 EXT20588 EXT20589 EXT20590 EXT20591 EXT20592 EXT20593 EXT20594 EXT20595 EXT20596 EXT20597 EXT20598 EXT20599 EXT20600 EXT20601 EXT20602 EXT20603 EXT20604 EXT20605 EXT20606 EXT20607 EXT20608 EXT20609 EXT20610 EXT20611

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EXT20612



APPENDIX J PROGRAM S1

(Photoneutrons Generated By Photons Having Had One and Only One Collision from U^{235} Fission Products on D₂0)

	// 'TOLGA YARMAN', CLASS=A	S1	000
	/*MITID USER=(M3696,9441)	S1	0002
•	/*SRI LOW	51	0003
	/*MAIN TIME=02, LINES=10	S1	0004
	//STEP1 EXEC FURCGO	S1	000
	//C.SYSIN DD *	S1	0000
	C PROGRAM S1	S1.	0007
	e Cara da la companya da contra da la con	S1 .	0008
•	C STUDY OF PHUTUNEUTRONS GENERATED BY PHOTONS HAVING HAD ONE AND ONLY ONE	S1	0009
	C COLLISIUN, FRUM AN ATOM OF U235 FISSIONNING IN THE MIDDLE OF AN INFINTE MEDIUM	S1	0010
	C OF D2O(CF. EQUATION A-22 OF APPENDIX A).	S1	001
		SI CI	0012
	DIMENSIUN A(5), SIGMA(5), UELIA(5), SIGU(5), SLAM(5)	51	001:
	U DATA ENDID NY DA EA/2 22522 10 2 0105-12 0 51/	51	0014
	C	51	001
	NAMELIST/IN/A.SIGMA.DELTA.SIGD.SLAN	SI	001
	NAMEL IST/AUT/SI	SI	0018
		. 51	0019
	READ(5.IN)	SI	0020
	SUM2=0.	S1	002
	DO 500 LP=1.4	S1	002
	AS=A(LP)/SIGMA(LP)	S1	002
	L1=LP+1	S1	0024
	SUM1=0.	S1	002
	DU 400 L=L1,5	S1	002
	PAR=(SLAM(L)/SLAM(LP))*(SLAM(L)/SLAM(LP))*	S1	002
	1((SLAM(LP)/SLAM(L))+(SLAM(L)/SLAM(LP))-1.+E0*E0*	Ş1	002
	2((1./EU)+(1./SLAM(L))-(1./SLAM(LP)))**2)*DELTA(L)/	S 1	002
	3(SLAM(L)*SLAM(L))*SIGD(L)/SIGMA(L)	S1	003
	SUM1=SUM1+PAR	S1	003
	400 CONTINUE	S1	003
	DEH=SUM1*AS	S 1	003
	SUM2=SUM2+DEH	S1	0034
	500 CUNTINUE	S1	003
	S1=SUM2*3.1416*SND2U*SND2U*NZ*RO*RO*E0	51	003

WRITE(6,0UT) STOP	S	1 0037
END	S	1 0039
/*	S	1 0040
//G.SYSIN DD *	S	1 0041
&IN A=0.0092, J.141, U.0518, 0.0804, 0.08,	S	1 0042
SIGMA=0.04,0.0306,0.0405,0.0424,0.0448,	S	1 0043
DELTA=2.,1.,0.25,0.25,0.27,	S	1 0044
SIGD=4.E-27,4.50E-27,3.4E-27,2.4E-27,1.2E-27	S	1 0045
SLAM=5.,3.5,2.875,2.625,2.365	S	1 0046
&END	S	1 0047
/*	S	1 0048

APPENDIX K

APPROXIMATE CORRECTION FACTORS FOR THE DELAYED NEUTRON FRACTIONS

We intended to approximate the Eq. (6-24) by applying a neutron balance argument to the already available fifteen-group Exterminator-II output for MITR-II.

The central idea of this method is to compute the ratio of the probability of causing fission of a delayed neutron to the probability of causing fission of a prompt neutron.

For this purpose neutrons born in the first six groups of a fifteen-group scheme are considered. These neutrons may cause fission, or may be absorbed, or may leak out of the core, or may scatter to a lower group. The probability for these events can be computed by a balance argument. The probability of causing fission of a neutron of group y in the core is for instance the number of fissions per sec. caused in the core by the neutrons of group g over the number of neutrons gained (or lost -if the reactor is at a steady state critical condition-) per sec. in the core in group g.

The neutrons born in group g are followed throughout their story until they become thermalized and the number of fissions caused by these neutrons is counted. The ratio \underline{of} the final number of fissions caused by the neutrons born in group g - during the thermalization process - to the number of neutrons born in group g give the global probability of causing fission of a neutron born in group g throughout its entire lifetime.

This probability PFISS(g), g=1, ..., 6, is computed for all the six groups of neutrons and averaged over the prompt neutron spectrum. This yields, PRTHP, the global probability of causing fission of a prompt fission neutron over a lifetime period.

Assuming that the delayed neutrons are born in the fifth end sixth energy group of the fifteen-group scheme, the correction factor that we seek is then

$$C_{F_{j}} = \frac{PFISS(5)}{PRTHP}$$
, j = 1, ... 5, (K-1)

$$C_{F_{G}} = \frac{PFISS(6)}{PRTHP} , \qquad (K-2)$$

where j refers to the jth delayed group.

The details of the calculations can be followed from the code written for this purpose (cf. Appendix L).

PFISS(g), $g = 1, \ldots, 6$, is shown in Table K-1.

Table K-1 PFISS(g), $g=1,\ldots,6$

 a	PFISS(g)	
 1	0.30629	
2	0.40506	
3	0.50895	
 4	0.57297	
 5	0.65779	
6	0.70902	

PRTHP is found to be 0.45959

To cross check this result the eigenvalue of the reactor may be computed by simply multiplying PRTHP by v, the average number of neutrons generated through the fission. If this is done a discrepancy of about 8% is found as compared to the eigenvalue given in the relevant Exterminator-II output. It is believed, this is due to the bad convergence of the fluxes.

Nevertheless it is anticipated that an error of the same order of magnitude may be introduced in each of the probabilities PFISS(g)'s. In this case C_F 's would not be affected j by the fact that we had to work with badly converged fluxes. APPENDIX L PROGRAM BTCR

(Like BETA - Delayed Neutron Fractions -Correction Factor)

		1997 - 1997 -	
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	그는 것 같아요. 그는 그는 것 같아요. 그는 것 같아요. 그는 것 같아요. 그는 것 같아. 그는 그는 것 같아. 그는 그는 것 같아. 그는 그는 것 같아. 그는 것 같아. 그는		
	// "TOLGA YARMAN", REGION=12EK, CLASS=A	BTCR0001	
	/*MITIC USER=(M8696,9441)	BTCR0002	
	/* SRI LOW	BTCR0003	
	/*MAIN LINES=20,CARDS=00,TIME=5	BTCR0004	
	//STEP1 EXEC FORCGC	BTCR0005	
	//C.SYSIN CD #	BTCR0006	•
	C PROGRAM ETCR	BTCR0007	
	ϵ , where ϵ is the second	BTCR0008	
	C THIS PROGRAM COMPUTES THE RATIO OF THE PROBABILITY OF A CELAYED NEUTRON (BORN	BTCR 0009	
	C WITHIN THE 5TH OR 6TH GROLP OF THE 15-GROUP SCHEME) TO CAUSE EISSION.TO THE	BTCR0010	
	C PROBABLIITY OF A FISSION NEUTRON TO CAUSE FISSSON_THIS RATIO WILL BE USED AS A	BTCR0011	
	C CORRECTION FACTOR FOR THE DELAYED NEUTRON FRACTIONS IN FEW GROUP SCHEME WHERE	BTCR0012	
	C FROMPT AND DELAYED NEUTRONS ARE BORN WITHIN THE SAME -FAST- GROUP	BTCR0013	
• ,-	C. 1	BTCR0014	
	COMMON/P/PST(15.29)	BTCR0015	
	COMMON/A/ ALEAK1(15) + ALEAK2(15) + ALEAK3(15) + SOLT(15)	BTCR0016	
	COMMON/ABS/APSP(15)	BTCR0017	
	COMMEN/S/SCAT(15.29.15)	BT CR0018	
	COMMON/ABC/AFSPC(15.7)	BTCR 0019	
	COMMON/FC/FISSC(15.7)	BT CR 00 20	
	CCMMCN/STC/STINC(15.7)	BTCR0021	
	COMMCN/OTC/OTSTC(15,7)	BTCR0022	
:::	COMMON/K B/K H IF(15), BE TA(6)	BTCR0023	
	COMMCN/SR/SRCE(15)	8TCR 0024	
	CCMMON/URTAK1/ALEAK(15),PLRC	BTCR 0025	
	CUMMEN/URTAK 2/PF(15), PLCR(14), PSR(14,15), PSC(14,15)	BTCR0026	
•	CCMMON/MSTUDY/MF,SRT,LLL,MH(14),KKK	BTCR 0027	
	C	BTCR0028	
•	CIMENSION SO(6), S1(6), S2(6), S3(6), S4(6), S5(6), S6(6), S7(6), S8(6),	BTCR0029	
	1S9(6), S10(5), S11(4), S12(3), S13(2), S(6, 15), C(6), STH(6), FIS(6), PFIS	BTCR 0030	
	25(6)	BTCR0031	
		BTCR0032	
	REAL KHIF	BTCR0033	
	C is the second s	BTCR0034	
	EQUIVALENCE (MH(1), NH1), (MH(2), MH2), (MH(3), MH3), (MH(4), MH4),	BTCR 0035	
	1(MH(5),MH5),(MH(6),MF6),(MH(7),MH7),(MH(8),MH8),(MH(9),MH9),	BTCR0036	

	2[MH(10], WH(0), (MH(11), MH11), (MH(12), MH12), (MH(13), WH13), (WH(14),	BTCP0037
	2 (10/ 10// PO20// CONTIN/ 11// CONTIN/ 12// PONT2// CONTIN/ 13// PONT3// CONTIN/	BTCR0038
C		BTCR0039
	FQUIVALENCE(SO(1),S(1,1))	BTCR0040
	EQUIVALENCE (S1(1),S(1.2))	BTCR0041
	EQUIVALENCE $(S2(1),S(1,3))$	BTCR0042
	EQUIVALENCE $(S3(1), S(1, 4))$	BTCR0043
	EQUIVALENCE $(S4(1), S(1, 5))$	BTCR0044
•	EQUIVALENCE (\$5(1), \$(1,6))	BTCR0045
	EQUIVALENCE (56(1), 5(1,7))	BTCR 0046
	EQUIVALENCE (S7(1),S(1,8))	BTCR0047
	EQUIVALENCE $(S8(1), S(1,9))$	BTCR0048
	EQUIVALENCE $(S9(1), S(1, 10))$	BTCR0049
74 A	EQUIVALENCE (S10(1), S(1, 11))	BT CR 0050
	EQUIVALENCE (S11(1),S(1,12))	BTCR0051
	EQUIVALENCE (S12(1), S(1, 13))	BTCR0052
	EQUIVALENCE (S13(1), S(1, 14))	BTCR0053
_	EQUIVALENCE (\$14,5(1,15))	BTCR 0054
C		BICKUU55
		BICRUUSO
	NAMELISI/LUISIH/SIH	BICKUUSI
	NAMELISI /OUISU/SU	BICRUUSO
•	NAMELISI/LUISI/SI	BICRUUSS
	NAMELIST/UUT22/32	BICROOCO
	NAMELIST/COTCJ/SJ	BTCR0062
•	NAMELIST/00134/34	BTCR0063
	NAMELIST/COTES/SS	BTCR0064
	NAMELIST/CUIST/S7	BTCR0065
	NAMELIST/DUTS8/S8	BTCR0066
·	NAMELIST/GUTS9/S9	BTCR0067
	NAMELIST/DUTS10/S10	BTCR0068
	NAMELIST/GUTS11/S11	BTCR0069
	NAMELIST/OUTS12/S12	BTCR 0070
	NAMELIST/CUTS13/S13	BTCR0071
	NAMELIST/UUTS14/S14	BTCR0072 N
		9 9
•		e
		•

NAMELIST/CUTF/FIS	BTCR007
NAMELIST/OUTFFS/PFISS	BTCR007
NAMELIST/UP RTHP/PRTHP	BTCR007
NAMELIST/CUTC1/C1	BTCR007
NAMELIST/OUTC2/C2	BT CROO7
NAMELIST/CUTE/BETA	BTCR007
	BTCR007
ALEAK(I); NUMBER OF NEUTRONS THAT LEAK OUT FROM GROUP I/SEC	BTCROOB
SOUT(I) ; NUMBER OF NEUTFINS THAT SCATTER OUT FROM GROUP I/SEC	BTCR008
ABSP(I); NUMBER OF NEUTRONS THAT ARE ABSORBED IN GROUF I/SEC	BTCR008
SCAT (MG, MC, MH) ; MACRUSCUPIC SCATTER ING CRUSS SECTION FROM GROUP MG INTO	BTCR003
GROUP MH IN COMPOSITION NC	BTCR008
KHIF ; CESCRIBES THE FISSION SPECTRUM	BTCR008
MC.EC.1 CURRESPONDS TO MATERIEL 1,2 TO 3,3 TO 4,4 TO 5,5 TO 6,6 TO 13,7 TO 14	BTCR008
GF THE CORE	BTCR008
ABSPC(I,MC); ABSORPTS /SEC, IN MATERIEL MC OF THE CORE, OF NEUTRONS OF GROUP I	BTCROOB
FISSC(I,MC); FISSIGNS/SEC CAUSED BY NEUTRONS OF GROUP I IN MATERIEL MC	BTCRCO8
STINC(I, MC); NUMBER OF NELTRONS SCATTERED IN GROUP I/SEC WITHIN THE MATERIEL	• BTCR009
MC OF THE CURE	- BT CR009
CTSTC(I,MC); NUMBER OF NELTRONS SCATTERED CUT OF GROUP I/SEC WITHIN THE	BTCR009
MATERIEL MC OF THE CORE	BTCR009
	BTCROOS
	BICROOS
EU 80 I=1,15	BTCROO9
80 ALEAK(I)=ALEAK1(I)+ALEAK2(I)+ALEAK3(I)	BICRCOS
	BICROUS
CALL PRUE	BICKOUS
	BICKUIU
MF=J F0 200 T−1 4	
$\begin{array}{c} LU DUU I=1_{P} D \\ IE LVVV LT I COOOOOOOO CO TO OOO \\ OOO OOOOOOOO CO TO OOO \\ OOO OOOOOOOO OOOOOOOO OOOOOOOO OOOOOOOO \\ OOOOOOOOOO OOOOOOOOO OOOOOOOO OOOOOOOOO OOOOOOOOO OOOOOOOOO OOOOOOOOO OOOOOOOOOO OOOOOOOOOOO OOOOOOOOOO OOOOOOOOOO OOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOO$	DICKULU
IF INNNELIEIUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU	
WKIIE(O)UUIKJ	DICKULU
	DICKULU
C7D CUNITINUE	BTCPAIA
SPT-A	

SUM2=0. **BTCR0109** BTCR0110 SUM3=0. SUM4=0. **BTCR0111** SUM5=0. BTCR0112 SUM6=0. BTCR0113 BTCR0114 SUM7=0. SUM8=0. BTCR0115 **BTCR0116** SUMS=0. SUM 10=0. BTCR0117 SUM11=0. BTCR0118 SUM12=0. **BTCR0119** SUM 13=0. BTCR0120 SUM14=0. **BTCR0121 C BTCR 0122** C YET NO COLLISION FOR NEUTRONS BORN IN ENERGY GROUP I THAT WOLLD SCATTER **BTCR0123** C THEM INTO A LOWER ENERGY GROUP: **BTCR C124** BTCR0125 С BTCR0126 SCO = SRCE(I)**BTCR0127** С C WE ARE INTERESTED IN THESE NEUTRONS EITHER CAUSING FISSION, **BTCR0128** BTCR0129 **BTCR0130** SUMC=SCO*PF(I) BTCR0131 6 C - C C OR LEAKING OUT OF THE COFE AND CONTINUING FROM THERE UN, **BTCR0132 BTCR0133** С SRO=SCO*PLCR (I) BTCR0134 **BTCR0135** С C OR SCATTERING(THAT MAY HAFPEN IN THE CORE OF IN THE REFLECTOF)-FIRST COLLISION BTCR0136 C IN I- INTO A LOWER ENERGY GROUP MH1, AND CONTINUING FROM THERE ON. **BTCR0137 BTCR 0138** С I1 = I + I- **ETCR0139** IF = I + MF**BTCR0140** CO 200 MH1=I1, IF BTCR0141 SC1=SCO*PSC(1,MH1) **BTCR0142** SUM1=SUM1+SC1*PF(MH1) **BTCR0143** BTCR0144 w С

C THE REFLECTOR SOURCE OF GROUP MH1 IS FED BY NEUTRONS OF GROUP MH1 LEAKING BTCR0145 C FROM THE CORE AND NEUTRONS SCATTERING (IN THE REFLECTOR) INTO MH1 FROM UPPER BTCR0146 C GROUPS. FOWEVER IF MHI CURRESPONDS TO THE THERMAL GROUP (WHICH IS NOT TRUE AT BTCR0147 C THIS LEVEL EVEN IF I WERE 6 AND THERE WERE SCATTERING TO FIVE LOWER GROUPS; BTCR0148 C NEVERTHELESS WE WILL PERSLE THE THOUGHT TO INITIATE THE CHAIN OF REASONING) BTCR0149 C THERE WILL BE NO LEAKAGE CUT OF THE CORE, AND THERE WILL BE ONE FROM OUTSIDE **BTCR0150** C OF THE CORE INTO THE CORE FOR WHICH WE BUILD UP THE THERMAL BTCR0151 C REFLECTOR SOURCE TERM SRT. BTCR0152 С BTCR0153 IF (MH1.EQ.15) GO TO 5 BTCR0154 SR1=SC1*PLCR(MH1)+SRC*PSR(I,MH1) BTCR0155 GU TC 6 BTCR0156 5 SRT= SRT+SRO*PSR(I,MH.1) BTCR0157 C BTCR0158 C IF WE COUNT ON THE SECONE COLLISION TO BRING THE NEUTRON TO THE 15TH BTCR 0159 C GROUP (THE GREATEST), MH1 (WHERE THE SECOND COLLISION WILL EVENTUALLY BTCR0160 C CCCUR) CAN NOT BE BIGER THAN 14 (HERE AGAIN, WHILE MH1 IS NEVER GREATER BTCR0161 C THAN 14, WE WANT TO INITIATE THE CHAIN OF REASONING). BTCR0162 C - BTCR0163 6 IF (MH1.GT.14) GG TC 200 BTCR 0164 MH18=MH1+1 BTCR0165 MH1F=MH1+MF BTCR0166 CO 2CO MH2=MH1B,MH1F BTCR0167 C BTCR0168 C SECOND COLLISION IN MH1, STUDY OF MH2 BTCR0169 **BTCR0170** CALL STUDY(SC1, SR1, SC2, SR2, SUM2, 2, MH21, MH2F) BTCR0171 IF (LLL.EQ.O) GO TO 2CO BTCR0172 DO 200 MH3=MH21,MH2F BTCR0173 C BTCR0174 C AND SO CN BTCR0175 C BTCR0176 CALL STUDY(SC2,SR2,SC3,SR3,SUM3,3,MH31,MH3F) **BTCR0177** IF (LLL.EQ.0) GG TC 200 BTCR 0178 CO 200 MH4=MH31,MH3F BTCR0179 C BTCR0180

â	CALL STUDY SUSSESSESSESSESSESSESSESSESSESSESSESSESS	
â		BTCR0182
	1r (lllecqe0) 00 10 200	BTCR0183
6		BTCR0184
C	CALL STUDY (SCA. SPA. SCE. SP5. SUM5. 5. MH51. MH5E)	BTCR0185
	$T_{\text{CALL}} = 1001(3C_{\text{C}})(3$	BTCR0186
	IF ([[] EG 0] 60 10 200	BTCR0187
c	LU ZUU MAC-MEDI,MADE	BTCR0188
C	CALL STUDY SCE. SPE. SCE. SPE. SUNG. 6. MH61 . MH6E)	BTCR0189
		BTCR0190
	D0 200 MH7=MH61 MH6E	BTCR0191
c	bo 200 historia or finita	BTCR0192
U.	CALL STURY (SCA. SPA. SC7. SP7. SUM7. 7. MH71. MH7E)	BTCR0193
		BTCR0194
	IP ([[] = [] = 0) 88 18 288	BTCR0195
C		BTCR0196
C	CALL STUDY SC7.SR7.SCE.SR8.SUM8.8.MH81.MH8E)	BTCR0197
	TE (111 - EC-0) GO TO 200	BTCR0198
	DO 200 NH9= NH81 MH8E	BTCR0199
c		BTCR0200
C	CALL STURY (STR. SRR. STC. SRR. SUMP. S.MH91.ME9F)	BTCR0201
C		BTCR0202
.č	EVEN IF THE NEUTRON HAS BEEN SCATTERED ALWAYS TO THE CLOSEST GROUP STARTING	BTCR0203
Č.	FROM THE 6TH GROLP AFTER & COLLISIONS IT WOULD BE NOW AT THE 15 TH GROUP;	BTCR0204
Ċ.	THEN WE KEEP IT ASICE.	BTCR0205
č		BTCR0206
č	IF((I.EQ.6).CR.(LLL.E(.0)) GO TO 200	BTCR0207
	DU 200 MH10=MH91.MH9F	BTCR0208
C		BTCR 0209
č	CALL STUDY(SC9, SR9, SC10, SR10, SUM10, 10, MH101, MH10F)	BTCR0210
	IF((I.EQ.5).CR.(LLL.E(.0)) GU TO 200	BTCR 0211
	DO 200 MH11=MH101, MH1CF	BTCR0212
С		BTCR0213
•	CALL STUDY(SC10, SR10, SC11, SR11, SUM11, 11, MH111, MH11F)	BTCR0214
	IF((I.EQ.4).CR.(LLL.EC.0)) GO TO 200	BTCR0215
	CO 200 MH12=MH111, MH11F	BTCR0216 w
		03
	그는 것 같은 것 같	

С		BTCRO
	CALL STUDY(SC11, SR11, SC12, SR12, SUM12, 12, MH121, MH12F)	BTCRO
	IF((I.EQ.3).GR.(LLL.E(.0)) GU TO 200	BTCRO
	CO 200 MH13=MH121, MH12F	BTCRO
C		BTCRO
	CALL STUDY(SC12, SR 12, SC13, SR 13, SUM13, 13, MH131, MH13F)	BTCRO
	IF((I.EQ.2).CR.(LLL.E(.0)) GO TO 200	BTCRO
	CO 200 MF14=MH131, MH13F	ETCRO
C		BTCPO
	CALL STUDY(SC13,SR13,SC14,SR14,SUM14,14,MH141,MH14F)	BTCRO
200	CONTINUE	BTCRO
	STH(I)=SRT	BTCRO
	SO(I)=SUMO	BTCRO
1946 - 1 947	S1(I)=SUM1	BTCRO
	S2(I)=SUN2	BTCRO
	S3(I)=SUM3	BTCRO
	S4(I)=SUM4	BTCRO
	S5(I)=SUM5	BTCRO
	S6(I)=SUM6	BTCRO
•	S7(I)=SUM7	BTCRO
• • •	S8(I)=SUM8	BTCRO
	S9(I)=SUM9	BTCRO
	IF (I.EQ.6) GO TO 300	BTCRO
•	S10(I)=SUM10	BTCRO
•	1F (I.EQ.5) GO TO 300	BTCRO
	S11(I) = SUM11	BTCRO
•	IF (I.EQ.4) GU TO 306	BTCRO
•	S12(I)=SUM12	BTCRO
	IF (I.EQ.3) GO TO 30C	BTCRO
	S13(I)=SUM13	BTCRO
· · · · · ·	$IF (I \cdot EQ \cdot 2) GO TO 300$	BTCRO
	S14=SUM14	BTCRO
300	CONTINUE	BTCRO
	WRITE(6,GUTK)	BTCRO
	WRITE(6,OUTSTH)	BTCRO

```
WRITE(6, OUTS1)
                                                                                       BTCR0253
                                                                                       BTCR0254
      WRITE(6, OUTS2)
      WRITE(6, OUTS3)
                                                                                       BTCR0255
      WRITE(6, CUTS4)
                                                                                       BTCR0256
      WRITE(6,CUTS5)
                                                                                       BTCR0257 -
                                                                                       BTCR0258
      WRITE(6, CUTSE)
      WRITE(6, OUTS7)
                                                                                       BTCR0259
                                                                                       BTCR0260
      WRITE(6, CUTS8)
                                                                                       BTCR0261
      WRITE(6, CUTSS)
                                                                                       BTCR0262
      WRITE(6, CUTS10)
      hRITE(6,CUTS11)
                                                                                       BTCR0263
                                                                                       BTCR0264
      WRITE(6,CUTS12)
                                                                                       BTCR0265
      WRITE(6, GUTS13)
      WRITE(6, CUTS14)
                                                                                       BTCR0266
                                                                                       BTCR0267
С
C TOTAL NUMBER OF NEUTRONS THAT STARTED UP IN GROUP I(1.LE.I.LE.6)
                                                                                       BTCR0268
C AND CAUSE EVENTUALLY FISSION
                                                                                       BTCR0269
С
                                                                                       BTCR0270
      CO 500 I=1,6
                                                                                       BTCR 0271
      KCR = 17-1
                                                                                       BTCR0272
      SUM=0.
                                                                                       BTCR0273
                                                                                       BTCR0274
      CO 400 K=1,15
  IF (K.GE.KCR) GO TO 400
                                                                                       BTCR0275
                                                                                       BTCR0276
      SUM=SUM+S(I,K)
                                                                                       BTCR 0277
  400 CONTINUE
      FIS(I)=SUM+STH(I)*PLRC*PF(15)
                                                                                       BTCR0278
                                                                                       BTCR 0279
  500 CONTINUE
      WRITE(6, CUTF)
                                                                                       BTCR0280
                                                                                       BTCR0281
С
C THE PROBABILITY THAT A NEUTRON BORN IN GROUP I GIVES EVENTUALLY RISE TO A
                                                                                       BTCR 0282
                                                                                       -BTCR0283
C FISSION
                                                                                       BTCR0284
С
                                                                                       BTCR0285
      CO 510 I=1,6
  510 PFISS(I)=FIS(I)/SRCE(I)
                                                                                       BTCR0286
      WRITE(6, OUTPFS)
                                                                                       BTCR 0287
                                                                                       BTCR0288
                                                                                                 30
С
                                                                                                 Ū.
```

	NEU NE	TRUNS IN THIS SCHEME ARE SUPPSED TO BE BORN IN SIX ENERGY GROUPS AND WANT TO AVERAGE THE AECVE PROBABILITY OVER THE FISSION SPECTRUM;	BTCR0289 BTCR0290
C			BICR0291
		FRTHP=0.	ETCR0292
		Cũ 520 I=1,6	BTCR0293
	520	FRTHP=PRTHP+PFISS(I)*KHIF(I)	BTCR0294
		<pre>hRITE(6, UPRTHP)</pre>	BTCR0295
C	•		BTCR0296
C	THE	CORRECTION FACTOR WE ARE SEEKING FOR THE FRACTION OF DELAYED NEUTRONS	BTCR0297
C	CF	TNE NTH GRUUP (TIME WISE) IS FINALLY;	BTCR 0298
C			BTCR0299
		C1=PFISS(5)/PRTHP	BTCR0300
		C2=PFISS(4)/FRTHP	BTCR0301
·.		WRITE(6, OUTC1)	BTCR0302
		hRITE(6,CUTC2)	BTCR0303
		C(1)=C1	BTCR0304
		CO 66 M=2,6	BTCR0305
	66	C(M) =C2	BTCR0306
C		에는 것은	. BTCR0307
С	THE	CORRECTED BETA VALUES ARE THEN	BTCR0308
C			BTCR 0309
. •		CO 550 N=1,6	BTCR0310
• .	- 550	EETA(N)=EETA(N)*C(N)	BTCR0311
	•	WRITE(6,CLTB)	BTCR0312
	•	STUP	BTCR0313
•		END	BTCR 0314
•		PLOCK DATA	BTCR0315
C	,		BTCR0316
		COMMEN/P/ PSI1(15), PSI2(15), PSI3(15), PSI4(15), PSI5(15), PSI6(15),	BTCR0317
		1PSI7(15), PSIE(15), PSIS(15), PSI10(15), PSI11(15), PSI12(15), PSI13(15)	BTCR0318
		2), PSI14(15), FSI15(15), PSI16(15), PSI17(15), PSI18(15), PSI19(15),	BTCR0319
		2PSI 20(15), PSI 21(15), FSI 22(15), PSI 23(15), FSI 24(15), PSI 25(15), FSI 26	BTCR0320
		4(15),PSI27(15),PSI28(15),PSI29(15)	BTCR0321
		CGMMCN/A/ ALEAK1(15), ALEAK2(15), ALEAK3(15), SGUT(15)	BTCR 0322
		COMMON/ABS/AESP(15)	BTCR0323
	•	COMMEN/S/ SCAT1(15,29),SCAT2(15,29),SCAT3(15,29),SCAT4(15,29),	BTCR0324

1				· · ·
4				
9		SCATELLE 201 SCATELLE 201 SCATZLE 201 SCATDLE 201 SCATCLE 201		0.700.0355
	•	3SCAT 10(15,29), SCAT 11(15,26), SCAT 12(15,20), SCAT 3(15,29),		BTCD0224
,		4291, SCAT14(15, 20), SCAT15(15, 20)		BICRUSZO
		$\frac{42}{15} = \frac{42}{15} = 42$		BTCP0328
		14BSP(6(15), AFSP(7(15))		BTCR0329
		COMMON/EC/EISSCI(15) . EISSC2(15) . EISSC3(15) . EISSC4(15) . EISSC5(15) .		BTCR0330
		1FISSC6(15).FISSC7(15)		BTCR0331
		C(IMMEN/STC/STINC1(15),STINC2(15),STINC3(15),STINC4(15),STINC5(15),		BTCR0332
		1STINC6(15). STINC7(15)		BTCR0333
		COMMON/UTC/UTSTC1(15).0TSTC2(15).0TSTC3(15).0TSTC4(15).0TSTC5(15).		BTCR0334
		1CTSTC5(15),0TSTC7(15)		BTCR0335
		COMMON/KB/KHIF(15), BE1A(6)		BTCR0336
		COMMON/SR/SRCE(15)		BTCR0337
A.	C		¹ . 1	BTCR0338
10		REAL KHIF		BTCR0339
	С			BTCR0340
	С	AVERAGE FLUX IN MATERIEL NUMBERED 1 FOR 15 GROUPS		BTCR0341
	С			BTCR0342
		CATA PSI1/1.00737E13,2.23071E13,1.18319E13,1.76862E13,		BTCR0343
		11.78534E13,1.25523E13,5.69910E12,8.69193E12,8.34772E12,		BTCR0344
	•	25.54323E12, 4.87979E12, 5. 07788E12, 4. 51213E12, 3. 58995E12,	5 <u>.</u> .	BTCR0345
	÷ •	33.09949E13/		BTCR 0346
	Ç.			BTCR0347
	C	AVERAGE FLUX IN MATERIEL NUMBERED 2 FOR 15 GROUPS		BTCR0348
	, L	EATA DELLA 12020E11 1 (0/07E10 7 7700/E11 1 1050/E10		BTCR0349
	а ж	LATA PSIZ/ (• 13232E11, 1• 6268/E12, /• //294E11, 1• 16596E12,		BTCR0350
		11.30902E12,1.00939E12,8.29590E11,7.80258E11,7.85932E11,5.49627E11,	· • • • • •	BICR0351
	r	25• 00281E11, 5• 54657E11, 4• 83793E11, 3• 94693E11, 1• 05229E137		BTCR0352
	č			BICR0353
	C C	AND SU UK		BICR0354
	L.	DATA DE12/1 27551512 2 96700512 1 54420512 2 25010512		BICR0355
343		DATA FOID/IC/DDIELD/2007/70EID/1004629EID/20059919EID/ 12.26626613.1 60270813 1 20770E13 1 17005E13 1 10161813		DICKU350
		24 JUCZJELJ1107J(UELJ110JU(CELJ110L(UV)ELJ112201ELJ1 27 44244E12,4 52020E12,4 74225E12 5 00542512 4 34001612		BICKU357
		2 TO THUNE IZY COUZ 72 VEIZYCO TO 7072 JEIZ 970 70742E1Z940 14071E1Z9 33, 85021 E13/		BICKUJJO
	ſ	JJ. UJUCICIJI		BTCR0359
	v			DICKUSCU

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		CATA PSI4/1.71227E13,3.96525E13,2.05659E13,3.16724E13.	BTCR0361
		13.24365E13,2.31479E13,1.78172E13.1.58380E13.1.49665E13.9.74154F12.	BTCB0362
		28.41021E12, 8.58567E12, 7.50363E12, 5.84070E12, 2.68752F13/	BTCR0363
	С		BTCR0364
		DATA PS15/1.45549E13.3.25063E13.1.68575E13.2.54005E13.2.60652E13.	BTCR0345
		11. 85560E13. 1. 42987E13. 1. 27317E13. 1. 20567E13. 7. 64387E12. 6. 78769E12.	BTCP0266
		26.95031E12.6.08968E12.4.75007E12.2.16459E13/	BTCR0367
	C		BTCD0369
w.		DATA PSI6/9.88098812.2.21733813.1.14855813.1.72908813.1.75765813	BTCR0360
		11.22013613.9.39882617.8.39353612.8.03255612.5.30221612.	DICK0309
		24. 65178812.4.82862812.4.27763812.3.34948812.2.17280812/	BICRUSIU
	С		BICKUSTI
		DATA PS17/1-51137811-3.06027511-1-34240811-2-47204811	BICRU372
		15.05956E11.5.45318E11.5.28815E11.5.26320E11.5.46602E11.2.0200EE11.	BICRU373
		23.66978E11.4.08846E11.3.79416E11.3.52014E11.3.42642E12/	BICKU374
	C	25000, 0211, 10000,0211,557,410211,5572010211, 5.02043215/	BICRUSTS
		CATA PSTE/1, 20144E13, 2, 84534E13, 1, 50317E12, 2, 24070E12	BICRU376
		12.40741F13.1.73001F13.1.22255513.1.10002512.1.12124F12.5.2020F12.5.200F12.5.2020F12.5.200F12.5.	BICR0377
			BICR0378
	Ċ	200 334232 12, 0040 140212, 30 00104212, 4041432212, 2024088213/	BICR0379
20 ¹²	C	NATA DETC/1 50144E12 2 50444E12 1 77705E12 2 72725E12	ETCR0380
		13.05101512.2.36222613.1.64221512.1.9067(512.1.7(2)5512.1.17(2)512.1.17(2)512.17(2)512.1.17(2)512.1.17(2)512.1.17(2)512.17(2)512.1.17(2)512.1.17(2)512	BTCR0381
	Sec.	21. 066666512)1. 126225512 1. 00260512 (200614512 1. 16625512 1. 17805512)	BTCR0382
	Ċ	21.00044E12,1.13439E12,1.00288E12,6.22961E11, 3.50013E11/	BTCR0383
	C .	DATA DELIGAL EXALTERS 2 CONTOURS 1 OF CONTOURS 2 PROPERTY	BTCR0384
		LATA PSILU/1.5041/E13,3.601/0E13,1.85488E13,2.83327E13,	BTCR0385
		12.91652E13, 2.08403E13, 1.61003E13, 1.43636E13, 1.36231E13, 8.8824E12,	BTCR0386
	C	2 1• E9509E12, 7•88080E12, 6• 89826E12, 5• 35424E12, 2•67592E13/	BTCR0387
- A	C		BTCR0388
		LATA PS111/4.65987E12,1.07289E13,5.55235E12,8.48465E12,	BTCR 03 E9
		19.05601E12,6.63210E12,5.29852E12,4.85433E12,4.74320E12,3.19684E12,	BTCR0390
	-	22.85435E12,3.00461E12,2.67725E12,2.03224E12,1.5244 <i>E</i> E13/	BTCR0391
	C		BTCR0392
		LATA PSI12/2.44550E12,5.57977E12,2.66179E12,4.24124E12,	BTCR0393
		15.48086E12,4.46704E12,3.71362E12,3.47187E12, 3.46546E12, 2.41814E12,	BTCR0394
		22. 20282E12, 2.36435E12, 2.13292E12, 1.74126E12, 5.40822E13/	BTCR0395
12	C		BTCR0396
			8

23.79062E12,3.31885E12,2.39604E12,7.04389E12/ C DATA PSI14/5.51701E12,1.26775E13,6.30738E12,9.52943E12, 19.88196E12,7.09271E12,5.52900E12,4.97879E12,4.76316E12, 23.12083E12,2.72414E12,2.81461E12,2.48035E12,1.89559E12, 37.84C37E12/	BTCR0399 BTCR0400 BTCR0401 BTCR0402 BTCR0403 BTCR0404 BTCR0404 BTCR0405 BTCR0406 BTCR0406
C DATA PSI14/5.51701E12,1.26775E13,6.30738E12,9.52943E12, 19.88196E12,7.09271E12,5.52900E12,4.97879E12,4.76316E12, 23.12083E12,2.72414E12,2.81461E12,2.48035E12,1.89555E12, 37.84C37E12/	BTCR0400 BTCR0401 BTCR0402 BTCR0403 BTCR0404 BTCR0404 BTCR0405 BTCR0406 BTCR0406
DATA PSI14/5.51701E12,1.26775E13,6.30738E12,9.52943E12, 19.88196E12,7.09271E12,5.52900E12,4.97879E12,4.76316E12, 23.12083E12,2.72414E12,2.81461E12,2.48035E12,1.89555E12, 37.84C37E12/	BTCR0401 BTCR0402 BTCR0403 BTCR0404 BTCR0405 BTCR0405 BTCR0406 BTCR0407
19.88196E12, 7.09271E12, 5.52900E12, 4.97879E12, 4.76316E12, 23.12083E12, 2.72414E12, 2.81461E12, 2.48035E12, 1.89555E12, 37.84037E12/	BTCR0402 BTCR0403 BTCR0404 BTCR0405 BTCR0406 BTCR0406
23. 12083E12, 2.72414E12, 2.81461E12, 2.48035E12, 1.89555E12, 37.84C37E12/	BTCR0403 BTCR0404 BTCR0405 BTCR0406 BTCR0406
23.12005E12,2.12414E12,2.01401E12,2.40055E12,1.69559E12, 37.84C37E12/ C	BTCR0403 BTCR0404 BTCR0405 BTCR0406 BTCR0406
	BTCR0405 BTCR0406 BTCR0406 BTCR0407
	BTCR0406 BTCR0406
CATA DETIRAT SECONDE & ESCALADO O 141000 - AREALDO	BTCR0400
LAIA P311372.08339229 13.0322829 2.0141929 13.0300129 1	B1680/407
18.45488E5,1.19461E10,1.51236E10,1.96665E10,2.52602E10,2.18789E10,	
22.29989210,2.84099210,2.90990210,2.10993210,9.946122127	BICKU4U8
	BICK0409
CATA PSI16/2.55197E8, E.86992E8, 3.67096E8, 6.17273E8,	BTCR0410
11.10516E5,1.46164E9,1.68106E9,2.08979E9,2.65010E9,2.21534E9,	BTCR0411
22• 33C90E 5, 2• E9865E 5, 2• 59767E 9, 2• 7395 5E 5, 2• 15733E12/	BTCR0412
C and the second se	BTCR0413
DATA PSI17/2.38627E12,5.21569E12,2.38901E12,3.90725E12,	BTCR0414
15.61735E12,4.70592E12,3.93748E12,3.66121E12,3.65511E12,2.57785E12,	BTCR0415
22.35870E12,2.55382E12,2.32249E12,2.01416E12,5.41901E13/	BTCR 0416
ny Construit a second secon	BTCR0417
DATA PSI18/9.99961E9,2.29717E10,8.79224E9,1.3CE77E10,	BTCR0418
11.48976E10,1.19969E10,1.02758E10,1.00958E10,1.06745E10,7.79902E9,	BTCR0419
27.36367E9,8.15255E9,7.61416E9,6.31105E9,3.68421E11/	BTCR0420
\mathbf{C} , where \mathbf{C} is the set of the set	BTCR0421
DATA PSI15/4.69802E10,1.07163E11,4.26929E10,6.39392E10,	BTCR0422
17.26767E10, 5.90273E10, 5.03304E10, 4.92060E10, 5.15745E10, 3.72584E1C,	BTCR0423
23.49577E10,3.84597E10,3.56174E10,2.88146E10,1.76375E12/	BTCR 0424
enti C in the second se	BTCR0425
CATA PSI20/2.92986E12,6.48734E12,3.10695E12,4.E3535E12,	BTCR0426
15,88415E12,4,82943E12,4,09801E12,3,92453E12,4,00831E12,2,84567E12,	BTCR0427
22. 61498E12, 2.82121E12, 2. 57460E12, 2. 15952E12, 8. 82265E13/	BTCR0428
	BTCR0429
DATA PSI21/2.79272E12,6.41947E12,3.15487E12,4.53465E12,	BTCR0430
14.93872E12,4.76330E12,3.96308E12,3.7296CE12,3.73572E12,2.59872E12,	BTCR0431
22.35888E12, 2.51551E12, 2.26435E12, 1.81786E12, 4.46644E13/	BTCR 0432 4

ſ		BTCP0433
Ċ	CATA PSI22/15*0./	BTCR0434
L	DATA PSI23/7.30400E10,1.59244E11,6.33609E10,1.00316E11,	BTCR0436
	11.33994E11, 1.17226E11, 1. C5928E11, 1. 07670E11, 1. 16894E11, 8.71505E10, 28.33669E10, 9.36818E10, 8.86947E10, 7.66278E10, 8.54001E12/	BTCR0437 BTCR0438
C		BTCR0439
	LATA PS12476.57385E12,1.46396E13,7.38030E12,1.12008E13, 11.19848E13,9.05311E12,7.3486E12.6.83381E12,6.80922E12,4.72257E12,	BICR0440 BTCR0441
	24.25975E12, 4.50770E12, 4.05123E12, 3.32159E12, 7.32432E13/	BTCR0442
C	DATA PSI 25/5.79924E11.1.14494F12.4.82339F11. 9.10516F11.	BTCR0443 BTCR0444
	11.93840E12,2.04278E12,1.50154E12,1.82458E12,1.E384CE12,1.31154E12,	BTCR0445
r	21.21184E12,1.34153E12,1.23831E12,1.14720E12,8.E778CE13/	BTCR0446
	CATA PSI26/1.90676E11,3.45018E11,1.42709E11,2.8885CE11,	BTCR0441
	17.49514E11,9.43641E11,9.88051E11,1.01437E12,1.06279E12,7.74108E11,	BTCR0449
C	21.24443511,0.12901214,1.30314511,1.13032511,1.103325137	BTCRC451
	DATA PSI27/5.44443E1C,9.02989E10,3.67989E10,7.64669E10,	BTCR0452
	12.22783E11, 3.26632E11, 3.68721E11, 4.39476E11, 4.5538CE11, 3.77230E11, 23.64C96F11.4.20310F11.4.01508F11.3.85550F11.5.44373F13/	BICR0453 BTCR0454
C		BT CR0455
	CATA PSI28/1.09570E10,1.73024E10,6.98252E9,1.44094E10, 14.28526F10.6.84570F10.8.99937F10.1.12109F11.1.38318F11.1.12020F11.	BTCR0456 BTCR0457
•	21.13418E11, 1.36955E11, 1. 36171E11, 1. 33562E11, 3. 27973E13/	BTCR0458
C	FATA DE 120/4 2172450 1 0224450 7 7520256 1 2052256	BTCR0459
· · · · ·	12.28654E9,2.57064E9,3.35040E9,4.08927E9,5.08521E9,4.20670E9,	BTCR0461
- -	24.39746E9,5.45074E9,5.63666E9,5.16516E9,3.58462E12/	BTCR0462
	VERALL TOP LEAKAGE FOR 15 GROUPS	BICR0464
C		BTCR0465
	DATA ALEAKI/1.889440E13,3.153295E13,5.987261E12,6.845539E12, 15.600768E12.3.23459E12.2.337579E12.2.154750E12.2.169184E12.	BICR0466 BTCR0467
	21.524452E12,1.466040E12,1.650620E12,1.475029E12,9.352717E11,	BTCR0468
•		

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•		
	35. 824966E14/	BTCR0469
(C second a second se	BTCR0470
1	C CVERALL RIHGT LEAKAGE FOR 15 GROUPS	BTCR0471
ł	${f C}$	BTCR0472
	CATA ALEAK2/4.552575E11, 3.632165E12, 1.019874E12, 1.368641E12,	BTCR0473
	11.947569E12,2.153000E12,2.277313E12,2.747096E12,3.229789E12,	BTCRC474
	22.561373E12,2.579727E12,3.016094E12,3.028231E12,2.669834E12,	BTCR0475
	35.464075E15/	BTCR0476
(f c is a second sec	BTCR0477
(C OVERALL BOTTOM LEAKAGE FCR 15 GROUPS	BTCR0478
(Contra de la companya de la construcción de la construcción de la construcción de la construcción de la constru	BTCR 0479
	DATA ALEAK3/1.221791E12,1.807827E12,4.596729E11,7.703967E11,	BTCR0480
	11.99357E12, 3.489477E12, 4.676534E12, 6.200280E12, 8.251115E12,	BTCR0481
	27.073027E12.7.513418E12.9.545074E12.9.946090E12.8.713511E12.	BTCR0482
	39.291814E15/	BTCR0483
· (${f c}$. The first of the second s	BTCR0484
(C OVERALL ABSORPTION FOR 15 GROUPS	BTCR0485
	${f c}$. The state of the st	BTCR0486
•	CATA ABSP/1.88522E15.1.662308E15.9.366816E14.1.514466E15.	. BTCR0487
	11.855078E15, 1.978965E15, 2.041348E15, 3.105764E15, 6.613305E15,	BTCR0488
	21.020215E16, 8.413368E15, 7.673170E15, 6.26CE98E15, 1.C51310E16,	BTCR0489
	33.176098E17/	BTCR0450
· · · •		BTCR0491
· (COVERALL SCATTERING OUT FUR 15 GROUPS	BTCR0492
(BTCR0493
	CATA SOUT/7.552307E16.1.867122E17.1.566322E17.2.434807E17.	BTCR0494
	13.155958E17.3.362193E17.3.297101E17.3.235994E17.3.183894E17.	BTCR0495
	22. 671682E17, 2. 505562E17, 2. 581691E17, 2. 433807E17, 2. 187724E17,	BTCR0496
	30./	ETCR0497
	${f C}$. The second	BTCRC458
(C MACRESCOPIC SCATTERING CRESS SECTIONS FROM GROUP 1 INTE FIFTEEN GROUPS FOR	BTCR0499
(C 29 MATERIELS	BTCR0500
(f c . The second se	BTCR0501
	EATA SCAT1/435*0./	BTCR0502
- 	${f c}$. The second	BTCR0503
	CATA SCAT2/5.06E-2, 14*0.,4.93E-2, 14*0.,5.16E-2, 14*0.,4.91E-2,	BTCR0504
		ц ц
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$ \begin{array}{llllllllllllllllllllllllllllllllllll$				
$ \begin{array}{llllllllllllllllllllllllllllllllllll$				
$ \begin{array}{llllllllllllllllllllllllllllllllllll$		114*0.,4. ECE-2,14*0.,5.06E-2,14*0.,4.56E-2,14*0.,2.31E-3,		BTCR0505
$ 314 \pm 0, 4 512 - 2.14 \pm 0, 4 60 \pm 2 14 \pm 0, 4 532 - 2.14 \pm 0, 4 29 \pm 2., 8 TCR 0507 414 \pm 0 4 235 - 2.14 \pm 0, 15 \pm 0, 6 555 - 2., 14 \pm 0, 6 555 - 2., 8 TCR 0507 614 \pm 0, 6 555 - 2.14 \pm 0, 15 \pm 0, 6 24 \pm -2.14 \pm 0, 6 552 - 2., 8 TCR 0507 614 \pm 0, 6 555 - 2.14 \pm 0, 4 565 - 2., 14 \pm 0, 6 625 \pm 2., 8 TCR 0510 714 \pm 0, 4 565 - 2.14 \pm 0, 4 565 - 2., 13 \pm 0, 1 055 - 2., 13 \pm 0, 1 165 - 2., 2.04 \pm -3., 8 TCR 0514 714 \pm 0, 6 - 52 \pm -2.1 \pm 0, 1 32 \pm 2 2.1 + 0, 1 055 - 2., 2.04 \pm -3., 8 TCR 0515 715 - 0 0 0 0 10 0 2 3 255 - 2., 13 \pm 0, 1 56 \pm -2., 13 \pm 0, 8 TCR 0515 715 - 0 0 0 0 0 0 0 0$		214*0., 2.87E-2, 14*0., 3.37E-2, 14*0., 3.37E-2, 14*C., 3.37E-2,		BTCR 0506
$ \begin{array}{lllllllllllllllllllllllllllllllllll$		314*0.,4.91E-2,14*0.,4.80E-2,14*0.,4.93E-2,14+0.,4.29E-2,		BTCR 0507
$ \begin{array}{llllllllllllllllllllllllllllllllllll$		414*0.,4.23E-2,14*0., 6.55E-2,14*0.,6.33E-2,14*C.,6.55E-2,		BTCR0508
614*0., 4. \$6E= 2, 14*0., 4. \$6E= 2, 14*0., 4. \$6E= 2, BT CR0510 714*0., 4. \$6E= 2, 14*0., 4. 29E= 2, 14*0., 1. 69E= 2, 3. 29E= 2, 13*0., 1. 16E= 2. BT CR0511 CATA SCAT3/1.13E= 2, 3. 63E= 2, 13*0., 1. 09E= 2, 3. 29E= 2, 13*0., 1. 16E= 2. BT CR0513 13. 73E= 2, 13*0., 1.10E= 2, 3. 26E= 2, 13*0., 1.07E= 2, 3. 16E= 2, 13*0., 1.60E= 2. BT CR0514 11.13E= 2, 3. 63E= 2, 13*0., 1.02E= 2, 4.15E= 2, 13*0., 6.02E= 3. BT CR0516 313*0., 5.12E= 2, 1.10E= 2, 13*0., 6.02E= 3, 1.38E= 2, 13*0., 6.02E= 2. BT CR0516 41.38E= 2, 13*0., 1.00E= 2, 3.22E= 2, 13*0., 1.55E= 2, 13*0., 8.02E= 2, 13*0., 1.53E= 2, 13*0., 1.50E= 2, 13*0., 1.60E= 2, 5.25E= 2, 13*0., 1.53E= 2, 13*0., 1.53E= 2, 13*0., 1.50E= 2, 13*0., 1.50E= 2, 13*0., 1.50E= 2, 13*0., 1.60E= 2, 5.25E= 2, 13*0., 1.32E= 2, 4.15E= 2, 13*0., 1.52E= 2, 13*0., 1.32E= 2, 4.15E= 2, 13*0., 1.52E= 2, 13*0., 1.32E= 2, 4.5E= 2, 13*0., 1.32E= 2, 4.25E= 2, 13*0., 1.32E= 2, 4.5E= 2, 13*0., 1.32E= 2, 4.5E= 2, 13*0., 1.32E= 2, 4.5E= 2, 13*0., 1.32E= 2, 4.45E= 2, 2.5E= 2, 13*0., 1.32E= 2, 4.45E= 2, 12*0., 1.5E= 2, 12*0., 8.58E= 3, 2.6E= 2, 12*0., 8.58E= 3, 2.6E= 2, 8.58E= 2, 8.5E= 2, 8.5E		514*0.,6.55E-2,14*0.,15*0.,6.24E-2,14*0.,6.23E-2,		BTCR 05 09
$ \begin{array}{llllllllllllllllllllllllllllllllllll$		614×0.,4.96E-2,14×0.,4.56E-2,14×0.,4.96E-2,		BTCR0510
$ \begin{array}{llllllllllllllllllllllllllllllllllll$		714=0.,4.96E-2,14=0.,4.29E-2,14=0./		BTCR0511
CATA SCAT3/1.13E-2, 3.63E-2, 13*0., 1.05E-2, 3.25E-2, 13*0., 1.6E-2,BTCR051313.73E-2, 13*0., 1.10E-2, 3.26E-2, 13*0., 1.07E-2, 3.16E-2, 13*0.,BTCR051421.31E-2, 3.63E-2, 13*0., 1.32E-2, 4.15E-2, 13*0., 1.58E-2, 2.04E-3,BTCR0516313*0., 5.12E-3, 1.18E-2, 13*0., 6.02E-3, 1.38E-2, 13*0., 6.02E-3,BTCR051641.38E-2, 13*0., 6.02E-3, 1.38E-2, 13*0., 1.10E-2, 2.28E-2, 13*0.,BTCR0518613*0., 9.74E-3, 2.80E-2, 13*0., 1.60E-2, 5.25E-2, 13*0., 1.53E-2,BTCR051975.01E-2, 13*0., 1.50E-2, 13*0., 1.60E-2, 5.25E-2, 13*0., 1.52E-2,BTCR052194.15E-2, 13*0., 1.50E-2, 13*0., 1.50E-2, 4.64E-2, 13*0.,BTCR052194.15E-2, 13*0., 1.32E-2, 4.61E-2, 13*0., 1.32E-2, 4.61E-2, 13*0.,BTCR052194.15E-2, 13*0., 1.32E-2, 2.62E-2, 13*0., 1.32E-2, 4.15E-2, 13*0.,BTCR052194.15E-2, 13*0., 1.50E-2, 2.62E-2, 12*0., 8.81E-3, 2.61E-2, 8.58E-2,BTCR052211.32E-2, 4.15E-2, 14*0., 2.62E-2, 12*0., 8.81E-3, 2.61E-2, 8.58E-2,BTCR0524CATA SCAT4/8.58E-3, 2.65E-2, 8.20E-2, 12*0., 8.81E-3, 2.61E-2, 8.58E-2,BTCR052512*0., 9.01E-3, 2.95E-2, 8.57E-2, 12*0., 8.68E-3, 2.62E-2, 8.58E-2,BTCR0526212*0., 9.01E-3, 2.95E-2, 8.57E-2, 12*0., 8.68E-3, 2.62E-2, 8.58E-2,BTCR052612*0., 9.01E-3, 2.95E-2, 1.94E-2, 1.2*0., 9.03E-3, 2.62E-2, 8.58E-2,BTCR052612*0., 1.61E-3, 6.62E-3, 2.29E-2, 12*0., 8.60E-3, 2.55E-2, 8.56E-2,BTCR052812*0., 1.61E-3, 6.62E-3, 2.29E-2, 12*0., 8.60E-3, 2.25E-2,BTCR052812*0., 1.61E-3, 6.62E-3, 2.29E-2, 12*0., 1.68E-3, 2.25E-2,BTCR053012*0., 1.61E-3, 6.62E-3, 2.29E-2, 12*0., 1.60E-2, 4.61E-2, 1.50E-1,BTCR053312*0., 1.61E-3				BTCR0512
13.73E-2,13*0.,10E-2,3.26E-2,13*0.,107E-2,2.16E-2,13*0.,BTCR051421.13E-2,3.63E-2,13*0.,1.32E-2,4.15E-2,13*0.,1.60E-2,3.28E-2,13*0.,BTCR051641.38E-2,13*0.,6.02E-3,1.38E-2,13*0.,1.10E-2,3.28E-2,13*0.,BTCR051641.38E-2,13*0.,6.02E-3,1.38E-2,13*0.,1.10E-2,3.28E-2,13*0.,BTCR051661.38E-2,13*0.,1.60E-2,3.29E-2,14*0.,2.62E-2,BTCR051861.3*0.,9.74E-3,2.80E-2,13*0.,1.60E-2,5.25E-2,13*0.,S3E-2,815×0.,1.50E-2,4.86E-2,13*0.,1.50E-2,4.86E-2,13*0.,BTCR0520815×0.,1.50E-2,4.86E-2,13*0.,1.50E-2,4.86E-2,13*0.,BTCR052194.15E-2,13*0.,1.62E-2,13*0.,1.50E-2,4.86E-2,13*0.,BTCR052111.32E-2,4.15E-2,14*0.,2.62E-2,13*0.,1.32E-2,BTCR052111.32E-2,4.15E-2,14*0.,2.62E-2,12*0.,8.81E-3,2.61E-2,8.58E-2,BTCR0523BTCR0525BTCR052611.2*0.,9.01E-3,2.95E-2,8.55E-2,8.20E-2,12*0.,8.81E-3,2.61E-2,8.58E-2,BTCR0526212*0.,9.01E-3,2.95E-2,8.55E-2,8.20E-2,12*0.,8.81E-3,2.61E-2,8.58E-2,BTCR0526212*0.,9.01E-3,2.95E-2,8.15E-2,12*0.,8.81E-3,2.61E-2,8.58E-2,BTCR0526212*0.,9.01E-3,2.95E-2,8.15E-2,12*0.,8.81E-3,2.62E-2,8.58E-2,BTCR0526212*0.,9.01E-3,2.95E-2,8.15E-2,12*0.,8.81E-3,2.62E-2,8.58E-2,BTCR052812*0.,1.54E-3,5.62E-3,2.95E-2,12*0.,8.681E-3,2.65E-2,8.58E-2,BTCR0528212*0.,9.01E-3,2.95E-2,8.15E-2,12*0.,8.681E-3,2.65E-2,8.58E-2,BTCR0528212*0.,9.01E-3,2.95E-2,8.15E-2,12*0.,8.60E-3,2.55E-2,8.58E-2,BTCR0528212*0.,9.01E-3,2.62E-3,2.29E-2,12*0.,8.60E-3,2.55E-2,8.58E-2,8.58E-2,8.58E-2,8.58E-2,8.58E-2,8.58E-3,8.58E-3,8.58E-3,8.58E-3,8.58E-3,8.58E-3,8.58E-3,8.58E-3,8.58E-3,8.58E-3,8.58E-3,8.58E-3,8.58E-3,8.58E-3,8.58E-3,8.58E-3		CATA SCAT3/1.13E-2,3.63E-2,13*0.,1.09E-2,3.29E-2,13*0.,1.16E-2,		BTCR0513
$\begin{array}{llllllllllllllllllllllllllllllllllll$		13.73E-2,13*0.,1.10E-2,3.28E-2,13*0.,1.07E-2,3.16E-2,13*0.,		BTCR0514
$\begin{array}{llllllllllllllllllllllllllllllllllll$		21.13E-2,3.63E-2,13*0.,1.32E-2,4.15E-2,13*0.,1.58E-2,2.04E-3,		etcroj15
41.38E-2,13*0.,6.022-3,1.38E-2,13*0.,1.10E-2,3.28E-2,13*0., BTCR0518 51.07E-2,3.16E-2,13*0.,1.09E-2,3.29E-2,124*0.,2.62E-2, BTCR0518 613*0.,9.74E-3,2.80E-2,13*0.,1.60E-2,5.25E-2,13*0.,1.53E-2, BTCR0519 75.01E-2,13*0.,1.60E-2,5.25E-2,13*0.,1.60E-2,5.25E-2,13*0., BTCR0520 815*0.,1.50E-2,4.86E-2,13*0.,1.50E-2,4.86E-2,13*0., BTCR0521 94.15E-2,13*0.,1.32E-2,4.15E-2,13*0., BTCR0523 94.15E-2,14*0.,2.62E-2,13*0., BTCR0523 94.15E-2,14*0.,2.62E-2,13*0., BTCR0523 94.15E-2,14*0.,2.62E-2,13*0., BTCR0523 94.15E-2,14*0.,2.62E-2,13*0., BTCR0523 94.15E-2,14*0.,2.62E-2,12*0.,8.61E-3,2.61E-2,8.58E-2, BTCR0523 94.15E-2,14*0.,9.2.62E-2,12*0.,9.03E-3,2.62E-2,8.53E-2, BTCR0525 12*0.,9.01E-3,2.95E-2,8.57E-2,12*0.,9.03E-3,2.62E-2,8.53E-2, BTCR0526 212*0.,9.01E-3,2.95E-2,8.57E-2,12*0.,9.03E-3,2.62E-2,8.53E-2, BTCR0527 12*0.,9.01E-3,2.95E-2,8.57E-2,12*0.,9.03E-3,2.62E-2,8.53E-2, BTCR0528 412*0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.84E-3,6.62E-3,2.29E-2, BTCR0528 412*0.,1.64E-3,5.63E-3,1.94E-2,12*0.,1.84E-3,6.62E-3,2.29E-2, BTCR0530 612*0.,9.03E-3,2.62E-2,8.53E-2,12*0.,1.81E-3,6.62E-3,2.29E-2, BTCR0530 612*0.,9.03E-3,2.62E-2,8.53E-2,12*0.,1.60E-2,4		313*0., 5.12E-2, 1.18E-2, 13*0., 6.02E-3, 1.38E-2, 13*0., 6.02E-2,		BTCR0516
51.07E-2,3.16E-2,13*0.,1.09E-2,3.29E-2,14*0.,2.62E-2, BTCR0518 613*0.,9.74E-3,2.80E-2,13*0.,1.60E-2,5.25E-2,13*0.,1.53E-2, BTCR0519 75.01E-2,13*0.,1.60E-2,5.25E-2,13*0.,1.60E-2,5.25E-2,13*0., BTCR0520 815*0.,1.50E-2,4.86E-2,13*0.,1.50E-2,4.86E-2,13*0.,1.32E-2, BTCR0521 94.15E-2,13*0.,1.32E-2,4.15E-2,13*0.,1.32E-2,4.15E-2,13*0., BTCR0521 11.32E-2,4.15E-2,14*0.,2.62E-2,13*0., BTCR052 CATA SCAT4/8.58E-3,2.65E-2,8.20E-2,12*0.,8.81E-3,2.61E-2,8.58E-2, BTCR0525 12*0.,9.01E-3,2.95E-2,8.20E-2,12*0.,8.81E-3,2.61E-2,8.58E-2, BTCR0525 12*0.,9.01E-3,2.95E-2,8.50E-2,8.20E-2,12*0.,8.81E-3,2.61E-2,8.58E-2, BTCR0525 12*0.,9.01E-3,2.95E-2,8.55E-2,8.20E-2,12*0.,8.81E-3,2.61E-2,8.58E-2, BTCR0525 12*0.,9.01E-3,2.95E-2,8.15E-2,12*0.,8.81E-3,2.61E-2,8.58E-2, BTCR0526 212*0.,8.60E-3,2.50E-2,8.15E-2,12*0.,8.658E-3,2.62E-2,8.53E-2, BTCR0527 312*0.,1.7E-2,4.17E-2,1.05E-1,12*0.,8.658E-3,2.62E-2,8.52E-2, BTCR0528 412*0.,1.54E-3,5.63E-3,1.94E-2,12*0.,8.60E-3,2.50E-2,8.15E-2, BTCR0530 612*0.,9.03E-3,2.62E-2,12*0.,8.60E-3,2.50E-2,8.15E-2, BTCR0531 712*0.,8.81E-3,2.61E-2,6.45E-2,12*0.,8.60E-3,2.50E-2,8.15E-2, BTCR0531 712*0.,9.03E-3,2.62E-2,8.52E-2,12*0.,8.60E-3,2.50E-2,8.15E-2, BTCR0533 712*0.,		41.38E-2,13*0.,6.02E-3,1.38E-2,13*0.,1.10E-2,3.28E-2,13#0.,		BTCR 0517
613*0.9.9.74E-3,2.80E-2,13*0.,1.60E-2,5.25E-2,13*0.,1.53E-2, BTCR0519 75.01E-2,13*0.,1.60E-2,5.25E-2,13*0.,1.60E-2,5.25E-2,13*0., BTCR0520 815*0.1.50E-2,4.86E-2,13*0.,1.50E-2,4.86E-2,13*0., B3E 94.15E-2,13*0.,1.62E-2,4.15E-2,13*0., BTCR0521 11.32E-2,4.15E-2,14*0.,2.62E-2,13*0., BTCR0522 11.32E-2,4.15E-2,14*0.,2.62E-2,13*0., BTCR0522 CATA SCAT4/8.58E-3,2.65E-2,8.20E-2,12*0.,8.81E-3,2.61E-2,8.58E-2, BTCR0523 BTCR0523 BTCR0523 12*0.,9.01E-2,2.95E-2,8.57E-2,12*0.,8.81E-3,2.62E-2,8.53E-2, BTCR0526 212*0.,9.01E-3,2.905E-2,8.57E-2,12*0.,8.658E-3,2.62E-2,8.53E-2, BTCR0527 312*0.,1.76E-2,4.17E-2,1.05E-1,12*0.,1.34E-2,8.57E-3,2.40E-3, BTCR0528 412*0.,1.54E-3,5.63E-3,2.92E-2,12*0.,8.58E-3,2.50E-2,8.57E-3,2.40E-3, BTCR0528 512*0.,1.81E-3,6.62E-3,2.29E-2,12*0.,1.81E-3,6.62E-3,2.29E-2, BTCR0528 512*0.,1.81E-3,2.61E-2,8.53E-2,12*0.,8.60E-3,2.50E-2,8.15E-2, BTCR0531 712*0.,8.81E-3,2.61E-2,8.56E-2,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0533 812*0.,9.87E-2,2.44E+2,6.45E-2,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0533 812*0.,9.87E-2,4.17E-2,1.90E-1,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0533 812*0.,1.60E-2,4.61E-2,1.50E-1,2*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0535 <t< td=""><td></td><td>51.07E-2,3.16E-2,13*0.,1.09E-2,3.29E-2,14*0.,2.62E-2,</td><td></td><td>BTCR0518</td></t<>		51.07E-2,3.16E-2,13*0.,1.09E-2,3.29E-2,14*0.,2.62E-2,		BTCR0518
75.01E-2,13*0.,1.60E-2,5.25E-2,13*0.,1.60E-2,5.25E-2,13*0., BTCR0520 815*0.,1.50E-2,4.86E-2,13*0.,1.50E-2,4.86E-2,13*0.,1.32E-2, BTCR0521 94.15E-2,13*0.,1.32E-2,4.15E-2,13*0.,1.32E-2,4.15E-2,13*0., BTCR0522 11.32E-2,4.15E-2,14*0.,2.62E-2,13*0./ BTCR0523 CATA SCAT4/8.58E-3,2.65E-2,8.20E-2,12*0.,8.81E-3,2.62E-2,8.53E-2, BTCR0526 12*0.,9.01E-3,2.99E-2,8.57E-2,12*0.,8.81E-3,2.62E-2,8.53E-2, BTCR0526 212*0.,8.60E-3,2.50E-2,8.57E-2,12*0.,8.53E-3,2.62E-2,8.53E-2, BTCR0526 212*0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.34E-2,8.57E-3,2.40E-3, BTCR0527 312*0.,1.54E-3,5.63E-2,1.94E-2,12*0.,8.58E-3,2.62E-2,8.53E-2, BTCR0527 512*0.,1.54E-3,2.50E-2,8.57E-2,12*0.,8.55E-3,2.62E-2,8.53E-2, BTCR0527 512*0.,1.54E-3,5.63E-2,1.94E-2,12*0.,1.84E-3,6.62E-3,2.29E-2, BTCR0527 512*0.,1.54E-3,2.62E-2,8.53E-2,12*0.,1.81E-3,6.62E-3,2.29E-2, BTCR0530 612*0.,9.03E-3,2.62E-2,8.53E-2,12*0.,1.81E-3,6.62E-3,2.29E-2, BTCR0531 712*0.,8.81E-3,2.61E-2,8.53E-2,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0532 812*0.,9.87E-3,2.44E-2,6.45E-2,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0533 712*0.,8.81E-3,2.61E-2,1.50E-1,2*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0534 712*0.,1.60E-2,4.61E-2,1.50E-1,2*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0535 71.4		613*0.,9.74E-3,2.80E-2,13*0.,1.60E-2,5.25E-2,13*0.,1.53E-2,		BTCR0519
815*0., 1. 50E-2, 4. 86E-2, 13*0., 1. 50E-2, 4. 86E-2, 13*0., 1. 32E-2, BTCR0521 94. 15E-2, 13*0., 1. 32E-2, 4. 15E-2, 13*0., 1. 32E-2, 4. 15E-2, 13*0., BTCR0522 11. 32E-2, 4. 15E-2, 14*0., 2. 62E-2, 13*0./ BTCR0523 CATA SCAT4/8.58E-3, 2. 65E-2, 8. 20E-2, 12*0., 8. 81E-3, 2. 61E-2, 8. 58E-2, BTCR0524 CATA SCAT4/8.58E-3, 2. 65E-2, 8. 57E-2, 12*0., 8. 68E-3, 2. 62E-2, 8. 53E-2, BTCR0526 12*0., 9. 01E-3, 2. 95E-2, 8. 57E-2, 12*0., 8. 68E-3, 2. 62E-2, 8. 53E-2, BTCR0526 212*0., 18.60E-3, 2.50E-2, 8. 15E-2, 12*0., 8. 68E-3, 2. 65E-2, 8. 52E-2, BTCR0527 312*0., 1. 76E-2, 4. 17E-2, 1. 05E-1, 12*0., 1. 34E-2, 8. 57E-3, 2. 40E-3, BTCR0528 412*0., 1. 54E-3, 5. 63E-2, 1. 94E-2, 12*0., 1. 61E-3, 6. 62E-3, 2. 29E-2, BTCR0529 512*0., 1. 81E-3, 6. 62E-3, 2. 29E-2, 12*0., 1. 81E-3, 6. 62E-3, 2. 29E-2, BTCR0530 612*0., 9. 03E-3, 2. 62E-2, 8. 53E-2, 12*0., 1. 81E-3, 6. 62E-3, 2. 29E-2, BTCR0531 712*0., 8. 81E-3, 2. 61E-2, 8. 53E-2, 12*0., 1. 60E-2, 4. 61E-2, 1. 50E-1, BTCR0532 812*0., 9. 67E-3, 2. 44E-2, 1. 50E-1, 12*0., 1. 60E-2, 4. 61E-2, 1. 50E-1, BTCR0533 812*0., 1. 51E-2, 4. 37E-2, 1. 42E-1, 12*0., 1. 60E-2, 4. 61E-2, 1. 50E-1, BTCR0534 112*0., 1. 60E-2, 4. 61E-2, 1. 50E-1, 12*0., 1. 60E-2, 4. 61E-2, 1. 50E-1, BTCR0535 21. 46E-2, 4. 22E-2, 1. 37E-1, 12*0., 1. 78E-2, 4. 17E		75.01E-2,13*0.,1.60E-2,5.25E-2,13*0.,1.60E-2,5.25E-2,13*0.,		BTCR0520
94. 15E-2, 13*0., 1. 32E-2, 4. 15E-2, 13*0., 1. 32E-2, 4. 15E-2, 13*0.,BTCR052211. 32E-2, 4. 15E-2, 14*0., 2. 62E-2, 13*0./BTCR0523CATA SCAT4/8.58E-3, 2. 65E-2, 8. 20E-2, 12*0., 8.81E-3, 2.61E-2, 8.58E-2,BTCR052512*0., 9.01E-3, 2.95E-2, 8.57E-2, 12*0., 9.03E-3, 2.62E-2, 8.53E-2,BTCR0526212*0., 8.60E-3, 2.50E-2, 8.15E-2, 12*0., 9.03E-3, 2.62E-2, 8.53E-2,BTCR0527312*0., 1. 78E-2, 4.17E-2, 1.05E-1, 12*0., 1.34E-2, 8.57E-3, 2.40E-3,BTCR0528412*0., 1. 54E-3, 5.63E-2, 1.94E-2, 12*0., 1.81E-3, 6.62E-3, 2.29E-2,BTCR0529512*0., 1. 81E-3, 6.62E-3, 2.29E-2, 12*0., 1.81E-3, 6.62E-3, 2.29E-2,BTCR0520512*0., 9.03E-3, 2.61E-2, 8.53E-2, 12*0., 1.81E-3, 6.62E-3, 2.29E-2,BTCR0530612*0., 9.03E-3, 2.61E-2, 8.53E-2, 12*0., 1.80E-3, 2.50E-2, 8.15E-2,BTCR0531712*0., 8.81E-3, 2.61E-2, 1.2*0., 1.60E-2, 4.61E-2, 1.50E-1,BTCR0532812*0., 9.87E-3, 2.44E-2, 6.45E-2, 12*0., 1.60E-2, 4.61E-2, 1.50E-1,BTCR0533512*0., 1.51E-2, 4.37E-2, 1.42E-1, 12*0., 1.60E-2, 4.61E-2, 1.50E-1,BTCR0534112*0., 1.60E-2, 4.61E-2, 1.50E-1, 27*0.,BTCR053521.46E-2, 4.22E-2, 1.37E-1, 12*0., 1.45E-2, 4.21E-2, 1.37E-1,BTCR0536312*0., 1.78E-2, 4.17E-2, 1.05E-1, 12*0., 1.78E-2, 4.17E-2, 1.05E-1,BTCR0536312*0., 1.78E-2, 4.17E-2, 1.05E-1, 12*0., 1.78E-2, 4.17E-2, 1.05E-1,BTCR053632*0., 7.13E-2, 12*0./BTCR0539BTCR0539BTCR0540BTCR0540		815*0•, 1•50E-2, 4•86E-2, 13*0•, 1•50E-2, 4•86E-2, 13*0•, 1•32E-2,		BTCR0521
11. $32E-2, 4.15E-2, 14*0., 2.62E-2, 13*0.7$ BTCR0523CATA SCAT4/8.58E-3, 2.65E-2, 8.20E-2, 12*0., 8.61E-3, 2.61E-2, 8.58E-2,BTCR0525112*0., 9.01E-3, 2.95E-2, 8.57E-2, 12*0., 9.03E-3, 2.62E-2, 8.53E-2,BTCR0526212*0., 8.60E-3, 2.50E-2, 8.15E-2, 12*0., 8.65E-3, 2.65E-2, 8.20E-2,BTCR0526212*0., 1.7EE-2, 4.17E-2, 1.05E-1, 12*0., 1.34E-2, 8.57E-3, 2.40E-3,BTCR0527312*0., 1.54E-3, 5.63E-3, 1.94E-2, 12*0., 1.81E-3, 6.62E-3, 2.29E-2,BTCR0528412*0., 1.81E-3, 6.62E-3, 2.29E-2, 12*0., 1.81E-3, 6.62E-3, 2.29E-2,BTCR0529512*0., 1.81E-3, 6.62E-3, 2.29E-2, 12*0., 1.81E-3, 6.62E-3, 2.29E-2,BTCR0530612*0., 9.03E-3, 2.62E-2, 8.53E-2, 12*0., 8.60E-3, 2.50E-2, 8.15E-2,BTCR0531712*0., 8.81E-3, 2.61E-2, 8.58E-2, 12*0., 1.60E-2, 4.61E-2, 1.50E-1,BTCR0532812*0., 9.87E-3, 2.44E-2, 6.45E-2, 12*0., 1.60E-2, 4.61E-2, 1.50E-1,BTCR0533512*0., 1.60E-2, 4.61E-2, 1.50E-1, 27*0.,BTCR053521.46E-2, 4.22E-2, 1.37E-1, 12*0., 1.65E-2, 4.21E-2, 1.37E-1,BTCR0536312*0., 1.76E-2, 4.17E-2, 1.05E-1, 12*0., 1.67E-2, 4.17E-2, 1.05E-1,BTCR053752*0., 7.13E-2, 12*0./BTCR0539BTCR0539BTCR0530BTCR0530BTCR0530BTCR0530BTCR0530BTCR0530		94.15E-2,13*0.,1.32E-2,4.15E-2,13*0.,1.32E-2,4.15E-2,13*0.,		BTCR 0522
$\begin{array}{llllllllllllllllllllllllllllllllllll$		11.32E-2,4.15E-2,14~0.,2.62E-2,13×0./	•	BTCR0523
CATA SCAT4/8.58E-3,2.65E-2,8.20E-2,12*0.,8.81E-3,2.61E-2,8.58E-2, BICR0525 112*0.,9.01E-3,2.95E-2,8.57E-2,12*0.,8.05E-3,2.62E-2,8.53E-2, BTCR0526 212*0.,8.60E-3,2.50E-2,8.15E-2,12*0.,8.58E-3,2.62E-2,8.53E-2, BTCR0527 312*0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.34E-2,8.57E-3,2.40E-3, BTCR0528 412*0.,1.54E-3,5.63E-3,1.94E-2,12*0.,1.84E-3,6.62E-3,2.29E-2, BTCR0528 412*0.,1.64E-3,5.63E-3,1.94E-2,12*0.,1.81E-3,6.62E-3,2.29E-2, BTCR0528 512*0.,1.81E-3,6.62E-3,2.29E-2,12*0.,1.81E-3,6.62E-3,2.29E-2, BTCR0529 512*0.,1.81E-3,2.61E-2,8.53E-2,12*0.,8.60E-3,2.50E-2,8.15E-2, BTCR0530 612*0.,9.03E-3,2.62E-2,8.53E-2,12*0.,8.60E-3,2.50E-2,8.15E-2, BTCR0531 712*0.,8.81E-3,2.61E-2,6.56E-2,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0532 812*0.,9.87E-3,2.44E-2,6.45E-2,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0533 512*0.,1.51E-2,4.37E-2,1.42E-1,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0535 21.46E-2,4.22E-2,1.37E-1,27*0., BTCR0535 21.46E-2,4.17E-2,1.05E-1,12*0.,1.78E-2,4.17E-2,1.05E-1,12*0., BTCR0537 412*0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.78E-2,4.17E-2,1.05E-1,12*0., BTCR0538 52*0.,7.13E-2,12*0./ BTCR0540 BTCR0540				BICR0524
112*0.,9.012-3,2.992-2,8.572-2,12*0.,9.032-3,2.022-2,8.532-2, BTCR0526 212*0.,8.602-3,2.50E-2,8.15E-2,12*0.,8.58E-3,2.62E-2,8.52E-2,8.20E-2, BTCR0527 312*0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.34E-2,8.57E-3,2.40E-3, BTCR0528 412*0.,1.54E-3,5.63E-2,1.94E-2,12*0.,1.81E-3,6.62E-3,2.29E-2, BTCR0529 512*0.,1.81E-3,6.62E-3,2.29E-2,12*0.,1.81E-3,6.62E-3,2.29E-2, BTCR0529 512*0.,1.81E-3,6.62E-3,2.29E-2,12*0.,1.81E-3,6.62E-3,2.29E-2, BTCR0530 612*0.,9.03E-3,2.62E-2,8.53E-2,12*0.,8.60E-3,2.50E-2,8.15E-2, BTCR0531 712*0.,8.81E-3,2.61E-2,8.58E-2,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0532 812*0.,9.87E-3,2.44E-2,6.45E-2,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0533 512*0.,1.51E-2,4.37E-2,1.42E-1,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0534 112*0.,1.60E-2,4.61E-2,1.50E-1,27*0., BTCR0535 21.46E-2,4.22E-2,1.37E-1,12*0.,1.45E-2,4.21E-2,1.37E-1, BTCR0536 312*0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.78E-2,4.17E-2,1.05E-1,12*0., BTCR0537 412*0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.78E-2,4.17E-2,1.05E-1,12*0., BTCR0538 52*0.,7.13E-2,12*0./ BTCR0540 BTCR0540		$\frac{1}{2} \frac{1}{2} \frac{1}$		BICRU525
212*0., 8.802-3, 2.302-2, 8.132-2, 12*0., 8.322-2, 8.522-2, 8.202-2, BTCR0528 312*0., 1. 782-2, 4.172-2, 1.052-1, 12*0., 1.61E-3, 6.62E-3, 2.40E-3, BTCR0528 412*0., 1.54E-3, 5.632-3, 1.94E-2, 12*0., 1.61E-3, 6.62E-3, 2.29E-2, BTCR0529 512*0., 1.81E-3, 6.62E-3, 2.29E-2, 12*0., 1.61E-3, 6.62E-3, 2.29E-2, BTCR0530 612*0., 9.03E-3, 2.62E-2, 8.53E-2, 12*0., 8.60E-3, 2.50E-2, 8.15E-2, BTCR0531 712*0., 8.81E-3, 2.61E-2, 8.58E-2, 12*0., 8.60E-3, 2.50E-2, 8.15E-2, BTCR0531 712*0., 9.03E-3, 2.64E-2, 6.45E-2, 12*0., 1.60E-2, 4.61E-2, 1.50E-1, BTCR0532 812*0., 9.67E-3, 2.44E-2, 6.45E-2, 12*0., 1.60E-2, 4.61E-2, 1.50E-1, BTCR0533 512*0., 1.51E-2, 4.37E-2, 1.42E-1, 12*0., 1.60E-2, 4.61E-2, 1.50E-1, BTCR0534 112*0., 1.60E-2, 4.61E-2, 1.50E-1, 27*0., BTCR0535 21.46E-2, 4.22E-2, 1.37E-1, 12*0., 1.45E-2, 4.21E-2, 1.37E-1, BTCR0536 312*0., 1.78E-2, 4.17E-2, 1.05E-1, 12*0., 1.78E-2, 4.17E-2, 1.05E-1, BTCR0537 412*0., 1.678E-2, 4.17E-2, 1.05E-1, 12*0., 1.678E-2, 4.17E-2, 1.05E-1, BTCR0538 52*0., 7.13E-2, 12*0./ BTCR0540 BTCR0540		112#Ue; Ye UIC= 3; Ze YOC= Z; de J/C= Z; 12#Ue; Ye UJC= J; Ze CZC= Z; de JJC= Z; 212:0 0 40E= 7 7 50E= 7 9 15E= 7 1240 9 50E= 7 7 4EE= 7 6 20E= 7		
12*00; 12*10; 12*10; 12*00; 12:3; 10:3; 12*20; 10:3; 12*20; 10:12*3; 10:12*0; 10:3; 12*0; 10:3; 12*0; 10:3; 12*0; 10:3; 12*0; 10:3; 12*0; 10:3; 10:3; 12*0; 10:3; 10:3; 12*0; 10:3; 10:3; 12*0; 10:3; 10:3; 12*0; 10:3; 10:3; 12*0; 10:3; 10:3; 12*0; 10:3; 10:3; 12*0; 10:3; 10:3; 12*0; 10:3;	÷	212*0 • 1 765-3 & 175-3 1 655-1 12*0 1 245-3 9 575-2 2 405-2 312*0 1 765-3 & 175-3 1 655-1 12*0 1 245-3 9 575-2 2 405-2		BICRUSZI BTCROS28
412+0.,1.8342-3,5.032-2,12+0.,1.812-3,6.622-3,2.292-2, BTCR0527 512*0.,1.81E-3,6.622-3,2.29E-2,12*0.,1.81E-3,6.62E-3,2.29E-2, BTCR0530 612*0.,9.03E-3,2.62E-2,8.53E-2,12*0.,8.60E-3,2.50E-2,8.15E-2, BTCR0531 712*0.,8.81E-3,2.61E-2,8.58E-2,12*0.,7.13E-2, BTCR0532 812*0.,9.87E-3,2.64E-2,6.45E-2,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0533 912*0.,1.51E-2,4.37E-2,1.42E-1,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0534 112*0.,1.60E-2,4.61E-2,1.50E-1,27*0., BTCR0535 21.46E-2,4.22E-2,1.37E-1,12*0.,1.45E-2,4.21E-2,1.37E-1, BTCR0536 312*0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.45E-2,4.21E-2,1.37E-1, BTCR0537 412*0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.78E-2,4.17E-2,1.05E-1,12*0., BTCR0538 52*0.,7.13E-2,12*0./ BTCR0540 BTCR0539		$ \begin{array}{c} -51240 \\ -51240 \\ -1 \\ -545 \\ -2 \\ -5 \\ -5 \\ -5 \\ -5 \\ -5 \\ -5 \\ -$		BTCR0520
612*0.,9.03E-3,2.62E-2,8.53E-2,12*0.,8.60E-3,2.50E-2,8.15E-2, BTCR0531 712*0.,8.81E-3,2.61E-2,8.58E-2,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0532 812*0.,9.87E-3,2.44E-2,6.45E-2,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0533 512*0.,1.51E-2,4.37E-2,1.42E-1,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0534 112*0.,1.60E-2,4.61E-2,1.50E-1,27*0., BTCR0535 21.46E-2,4.22E-2,1.37E-1,12*0.,1.45E-2,4.21E-2,1.37E-1, BTCR0536 312*0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.78E-2,4.17E-2,1.05E-1, BTCR0537 412*0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.78E-2,4.17E-2,1.05E-1, BTCR0537 BTCR0537 BTCR0537 52*0.,7.13E-2,12*0./ BTCR0540				BTCP 0530
712*0.,8.81E-3,2.61E-2,8.58E-2,14*0.,7.13E-2, BTCR0532 812*0.,9.87E-3,2.44E-2,6.45E-2,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0533 512*0.,1.51E-2,4.37E-2,1.42E-1,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0534 112*0.,1.60E-2,4.61E-2,1.50E-1,27*0., BTCR0535 21.46E-2,4.22E-2,1.37E-1,12*0.,1.45E-2,4.21E-2,1.37E-1, BTCR0536 312*0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.78E-2,4.17E-2,1.05E-1, BTCR0537 412*0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.78E-2,4.17E-2,1.05E-1, BTCR0538 52*0.,7.13E-2,12*0./ BTCR0540		512×0.5 $f_{10} = 0.2 \times 0.5$ $f_{10} = 0.5$ f_{1		BTCR0531
812*0.,9.87E-3,2.44E-2,6.45E-2,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0533 \$12*0.,1.51E-2,4.37E-2,1.42E-1,12*0.,1.60E-2,4.61E-2,1.50E-1, BTCR0534 112*0.,1.60E-2,4.61E-2,1.50E-1,27*0., BTCR0535 21.46E-2,4.22E-2,1.37E-1,12*0.,1.45E-2,4.21E-2,1.37E-1, BTCR0536 312*0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.78E-2,4.17E-2,1.05E-1, BTCR0537 412*0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.78E-2,4.17E-2,1.05E-1, BTCR0538 52*0.,7.13E-2,12*0./ BTCR0540		712#08.815-3.2.615-7.8.585-2.14#07.135-2.		BTCR0532
\$12*0., 1.51E-2, 4.37E-2, 1.42E-1, 12*0., 1.60E-2, 4.61E-2, 1.50E-1, BTCR0534 \$12*0., 1.60E-2, 4.61E-2, 1.50E-1, 27*0., BTCR0535 \$21.46E-2, 4.22E-2, 1.37E-1, 12*0., 1.45E-2, 4.21E-2, 1.37E-1, BTCR0536 \$312*0., 1.78E-2, 4.17E-2, 1.05E-1, 12*0., 1.78E-2, 4.17E-2, 1.05E-1, BTCR0537 \$412*0., 1.78E-2, 4.17E-2, 1.05E-1, 12*0., 1.78E-2, 4.17E-2, 1.05E-1, BTCR0538 \$52*0., 7.13E-2, 12*0./ BTCR0540		812*0.9, $87E - 3.2.44E - 2.6.45E - 2.12*0.13E - 2.4.61E - 2.1.50E - 1.$		BTCR0533
112*0., 1.60E-2,4.61E-2,1.50E-1,27*0., BTCR0535 21.46E-2,4.22E-2,1.37E-1,12*0.,1.45E-2,4.21E-2,1.37E-1, BTCR0536 312*0., 1.78E-2,4.17E-2,1.05E-1,12*0.,1.78E-2,4.17E-2,1.05E-1, BTCR0537 412*0., 1.78E-2,4.17E-2,1.05E-1,12*0.,1.78E-2,4.17E-2,1.05E-1,12*0., BTCR0538 52*0., 7.13E-2,12*0./ BTCR0540		(12*01.5)		BTCR0534
21. 46E-2, 4. 22E-2, 1. 37E-1, 12*0., 1. 45E-2, 4. 21E-2, 1. 37E-1, 312*0., 1. 78E-2, 4. 17E-2, 1. 05E-1, 12*0., 1. 78E-2, 4. 17E-2, 1. 05E-1, 412*0., 1. 78E-2, 4. 17E-2, 1. 05E-1, 12*0., 1. 78E-2, 4. 17E-2, 1. 05E-1, 12*0., 52*0., 7. 13E-2, 12*0./ BTCR0539 BTCR0540		112*01.60E-2.4.61E-2.1.50E-1.27*0	· · · ·	BTCR0535
312*0., 1.78E-2,4.17E-2,1.05E-1,12*0.,1.78E-2,4.17E-2,1.05E-1, 412#0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.78E-2,4.17E-2,1.05E-1,12*0., 52*0.,7.13E-2,12*0./ BTCR0539 BTCR0540 F	,	$21_{2}46t-2.4.22t-2.1.37t-1.12+0.1.45t-2.4.21t-2.1.37t-1.$		BTCR0536
412#0.,1.78E-2,4.17E-2,1.05E-1,12*0.,1.78E-2,4.17E-2,1.05E-1,12*0., BTCR0538 52*0.,7.13E-2,12*0./ BTCR0540 F		312*01.78E-2.4.17E-2.1.05E-1.12*01.78E-2.4.17E-2.1.05E-1.		BTCR0537
52*0•,7•13E-2,12*0•/ BTCR0539 BTCR0540		412#0.,1.78E-2.4.17E-2.1.05E-1.12*01.78E-2.4.17E-2.1.05E-1.12*0		BTCR 0538
BTCR0540		52*0.,7.13E-2,12*0./		BTCR0539
	•			BTCR0540

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	DATA SCAT5/4.63E-3.1.41E-2.3.87E-2.1.04E-1.11*04.77E-3.1.43E-2.	BTCR 0541	
		BICR0543	
	$24_{0}92E^{-}3_{1}E_{0}44E^{-}2_{1}3_{0}50E^{-}2_{1}E_{0}9E^{-}1_{1}E_{1}E_{0}E_{2}E^{-}2_{1}E_{0}E^{-}E_{1}E_{0}E^{-}E_{1}E_{1}E_{0}E^{-}E_{1}E^{-}E_{1}E^{-}E_{1}E^{-}E_{1}E^{-}E_{1}E^{-}E_{1}E^{-}E_{1}E^{-}E_{1}E^{-}E_{1}E^{-}E_{1}E^{-}E_{1}E^{-}E_{1}E^{-}E_{1}E^{-}E_{1}E^{-}E_{1}E^{-}E^{-}E_{1}E^{-}E^{-}E^{-}E^{-}E^{-}E^{-}E^{-}E^{-$	BTCR0544	
	$\frac{310}{4} - \frac{1}{1} + $	BTCR0545	
	$42_0212-2_10_0352-2_11_0382-1_111+0_0_15_0222-5_15_0252-5_14_0202-5_12022222-5_12022222222222222222222222222222222222$	BTCP0546	
	$512 \times 0_{0}, 1_{0} \cup 22 \times 3, (01/2 \times 3, 10.202 \times 2, 12.40 \times 3, 10.202 \times 3, 10.202 \times 2, 1$	BTCR0547	
		BTCDOSAR	
	[4.92E-3, 1.44E-2, 3.96E-2, 1.09E-1, 11 ² 0.4.63E-3, 1. 36E-2, 3. ((E-2)	BICROSAG	
	81.042-1,11*0.,4.772-3,1.432-2,3.982-2,1.102-1,14*0.,	BTCROSED.	
	95.03E-2,11#0.,3.64E-4,1.1/E-2,3.62E-2,7.14E-2,11#0.,9.62E-3,	BICRUSSU	
	12.77E-2,7.19t-2,2.07t-1,11*0.,9.05t-3,2.t1t-2,t.81t-2,1.50t-1,	BICKUSSI	
	211*0., 9. 62E-3, 2. 77E-2, 7. 19E-2, 2. 07E-1, 11*0., 9.62E-3, 2.77E-2,	BICRUSSZ	
	37.19E-2,2.07E-1,2640.,8.66E-3,2.51E-2,6.56E-2,	BTCR0553	
	41.88E-1,11#0.,8.66E-3,2.51E-2,6.55E-2,1.88E-1,11*0.,7.24E-4,	BTCR0554	
	52.20E-2,6.35E-2,1.38E-1,11*0.,7.24E-4,2.21E-2,6.35E-2,1.38E-1,	BTCR0555	
	611*0.,7.24E-4,2.21E-2,6.34E-2,1.38E-1,11*0.,7.24E-4,2.21E-2,	BICR0556	
	76.35E-2,1.38E-1,14×0.,5.03E-2,11×0./	BTCR0557	
		BTCR0558	
	DATA SCAT6/1.54E-3,3.66E-3,9.65E-3,2.41E-2,1.36E-1,10*0.,1.62E-3,	BTCR 0559	
	13. 87E-3, 1.02E-2, 2. 58E-2, 1.43E-1, 10×0., 1.63E-3, 3.88E-3, 1.02E-2,	BTCR 0560	
	22.56E-2, 1.43E-1, 10#0., 1.63E-3, 3.86E-3, 1.01E-2, 2.56E-2, 1.42E-1,	BTCR0561	
	310*0.,1.54E-3,3.63c-3,9.59E-3,2.41E-2,1.34E-1,10*0.,1.54E-3,	BTCR0562	
	43.66E-3, 9.65E-3, 2.41E-2, 1.36E-1, 13#0., 1.40E-2, 9.91E-2, 10*0.,	BTCR0563	
	52*1.32E-3,3.62E-3,0.,3.46E-3,14*C.,7.17E-3,14*C.,8.43E-3,	BTCR 0564	
	614*0.,8.43E-3,14*0.,E.43E-3,10*0.,1.63E-3,3.86E-3,1.01E-2,	BTCR0565	
	72.56E-2,1.42E-1,10*0.,1.54E-3,3.63E-3,5.59E-3,2.41E-2,1.34E-1,	BTCR0566	
	810*0.,1.62E-3,3.87E-3,1.02E-2,2.58E-2,1.43E-1,14*0.,3.61E-2,	BTCR 0567	
	212*0., 3. 12E-4, 7. 01E-3, 5. 41E-2, 10*0., 3. 27E-3, 7. 75E-3, 2.00E-2,	BT CR 0568	
	15.22E-2,2.81E-1,10*0.,3.08E-3,7.29E-3,1.E9E-2,4.91E-2,2.65E-1,	BTCR0569	
	210*0., 3. 27E-3, 7. 75E-3, 2. 00E-2, 5. 22E-2, 2. 81E-1, 10*0., 3. 27E-3, 7.75E-	BTCR0570	- Sec S
	33, 2, COE-2, 5, 22E-2, 2, EIE-1, 25*0, , 2, 95E-3, 6, 98E-3, 1, EIE-2, 4, 70E-2,	BTCR0571	•
2	42.54E-1,10*0.,2.95E-3,6.98E-3,1.81E-2,4.69E-2,2.54E-1,13*0.,	BTCR0572	
	51.4CE-2.5.91E-2.13-0.1.4OE-2.9.91E-2.13*0.1.4OE-2.9.91E-2.	BTCR0573	
	$613 \times 0_{-1} + 40 = 2 \cdot 9_{-91} = 2 \cdot 14 \times 0_{-3} \cdot 61 = 2 \cdot 10 \times 0_{-1}$	BTCR0574	
	CIR CRITE CIRCUTE CIRCUTE CIRCUTE CIRCUTE	BTCR 0575	
ŝ	DATA SCAT7/06.16E-4.1.60E-3.4.07E-3.2.11E-2.1.93E-1.9*00.	BTCR0576	31
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	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	BTCR0577
	16.62E-4, 1.72E-3, 4.37E-3, 2.20E-2, 2.00E-1, 3.00 , 0.000 , 0	BTCR0578
	24.32E-3.2.24E-2.2.05E-1.10+0.00000000000000000000000000000000	BTCR0579
	32.03E-1,11*0.,1.00E-3,9.07E-3,2.01E-2,10,1E-1,10,0.00,00,00,00,00,00,00,00,00,00,00,00,	BTCR0580
	41.60E-3, 4.07E-3, 2.11E-2, 1.95E-1, 1940, 99, 50E 2, 114, 0.4, 22E-3, 1480, 4.22E-3, 1480, 1480, 1480, 1480, 1480, 1480, 14	BTCR0581
	52+0, ++ 04E-3,14+0, ,3,58E-3,14+0, ,4+22E-3,14+0, ,4+22E-3,12+1,14+0, ,4+22E-3,14+0, ,4+22E-3,14+0, ,4+22E-3,12+1,14+0, ,4+22E-3,12+1,14+0, ,4+22E-3,14+0, 0, 14+0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0	BTCR0582
	64. 22E-3, 10× 0., 0., 1.7 CE-3, 4. 32E-3, 2. 24E-2, 2. 05E-1, 1. 7 0.,	BTCR0583
	71.60E-3,4.07E-3,2.11E-2,1.91E-1,1040., 6.62E-4, 1.72E-5,4.57E 5,2.02	BTCR0584
	$8E-2, 2, 05E-1, 14 \neq 0, 3, 34E-2, 14 \neq 0, 5, 02E-2, 10 \neq 0, 1054E-3, 8, 20E-3, 20E-3, 20E-3, 20E-3, 20E-2, 8, 20E-2, 8, 20E-2, 8, 20E-2, 8, 20E-$	BTCR0585
	93.47E-3,8.82E-3,4.57E-2,4.10E-1,1040.,1.20E-3,5.27E-3,0.50E-3,	BTCR0586
	14.30E-2,3.86E-1,10=0.,1.34E-3,3.47E-3,8.82E-3,4.57E-2,6.57E-2	BTCR0587
	210×0., 1. 34E-3, 3.47E-3, 8. 82E-3, 4.57E-2, 4. 10E-1, 20+0.,	BTCR0588
	31. 20E-3, 3.13E-3, 7. 94E-3, 4.11E-2, 3. 70E-1, 1040., 1. 20E-3, 5. 15C 3,	BTCR0589
	47. 94E-3,4.11E-2,3. 70E-1,13*0.,7. 90E-4,9.50E-2,15+0.,7.90E 4,	BTCR0590
	59,56E-2,14*0.,9,56E-2,13*0.,7,90E-4,9,56E-2,	BTCR 0591
	614*0.,3.34E-2,9*0./	BTCR 0592
		BTCR0593
	EATA SCAT8/240., 3.70E-4, 6.78E-4, 3.80C-5, 5.22E-2, 2.55E 1,10.00,	BTCR 05 94
	13. 57E-4, 7.28E-4, 3.87E-3, 3.40E-2, 2. 50E-1, 22+0.4	BTCR0595
	23.83E-3, 3.42E-2, 2.47E-1, 10*0., 2* 0., 3.65E-5, 5.42E-2,	BTCR0596
	32.47E-1,12*0.,3.60E-3,3.22E-2,3.33E-1,12*0., 5.00E-5,	BTCR0597
	43, 22E-2, 2, 33E-1, 13*0, 12, 04E-3, 9, 75E-2, 14*0, 3, 76E-3,	BTCR0598
	54.45 = 3, 14*0., 3.22 = 2, 14*0., 3. 19 = 3, 14*0., 5. 19 = 3, 14*0.	BTCR0599
	$614 \times 0_{\circ}, 3_{\circ}, 79E-3, 12 \times 0_{\circ}, 3_{\circ}, 505E-3, 5042E-2, 2_{\circ}, 47E-2, 2_{\circ}, 50E-1, 14 \times 0_{\circ}, 50E-1, 5$	BTCR0600
	73. 60E-3, 3. 22E-2, 2. 33E-1, 12#0., 3. C/E-3, 5. 40E-2, 2. 50E 1, 14 400, 1	BTCR0601
	83.57E-2, 13*0., 1.02E-3, 5.09E-2, 11*0., 1.47E-5, 1.22E 5, 00 5 C 2, 2, 3, 5.09E-2, 1.11*0., 1.47E-3.	BTCR0602
	95.01E-1,11=0.,1.38E-3,1.39E-3,0.01E-2,4.12E-1,12E-0,5.E-1.23*0.	BTCR0603
	17.82E-3,6.98E-2,5.E-1,11#0.,1.47E-5,7.622E-5,C.50E 2750E 1725	BTCR0604
	23×0.,1.32E-3,7.04E-3, E.29E-2,4.51E-1,11*0.,10-2E 5,1002 5,	BTCR0605
	36.28E-2,4.51E-1,13 ²⁰ 0,2.04E-3,9.75E-2,1340,2.04E-3,57E-2.840.	BTCR0606
	413*0., 2.04E-3, 9.75E-2,13*0., 2.04E-3, 5.75E-2,14*0., 5.57E-2,14*0.	BTCR0607
	5 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	BTCR0608
	CATA SCAT9/5#0.,5.76E-3,4.16E-2,2.49E-1,1240.,6.19E-3,4.42E-2,	BTCR0609
	12.67E-1, 12*0.6.12E-3, 4.42E-2, 2.64E-1, 12*0.5.74E-2, 4.16E-2.	BTCR0610
	22.64E-1,12*0.,5.76E-3,4.16E-2,2.49E-1,1240.5.16E-3,4.10E-2,	BTCR0611
	32.49E-1,13*0.,2.44E-3,5.57E-2,14*0.,4.55E-3,14*0.,5.07E-3,	BTCR0612 W
•	414*0., 3.61E-3, 14+0., 3.61E-3, 14+0., 3.61E-3, 12*0., C. 12E-5, 4.42E-2,	4

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	52.64E-1,12*0.,5.76E-3,4.16E-2,2.49E-1,12*0.,6.19E-3,4.46E-2,	BTCR 06 13
	62.67E-1, 14*0., 3.57E-2, 13*0., 1. 22E-3, 5. 20E-2, 11*0., 1. 44E-3, 1. 25E-2,	BTCR0614
	79.01E-2,5.35E-1,11*0.,1.36E-3,1.17E-2,8.48E-2,5.04E-1,11+0.,	BTCR0615
	81.44E-3, 1.25E-2, 9. C1E-2, 5.35E-1, 11=0., 1.44E-3, 1.25E-2, 9.01E-2.	BTCB0616
	95.35E-1,26*0.,1.30E-3,1.12E-2,8.11E-2,4.82E-1.11*0.1.30E-3.	BTCR0617
	11.12E-2,8.11E-2,4.82E-1,13*0.,2.43E-3,9.97E-2.13*0.	BTCR0618
	22.43E-3, 5.97E-2,13×0.,2.43E-3,9.57E-2.13×0.,2.43E-3.9.97E-2.	BT CP 06 10
	314*0., 3. 57E-2, 7*0./	BTCR0619
C		BTCRUGZU
	CATA SCAT10/6*0 6. 44F-3. 3. 76F-2. 2. 13F-1. 12*0 6. 825-3. 4. 04 5-2	BICKUGZI
	12.29E-1,12*06.84E-3.3.99E-2.2.26E-1.12*06.64E-3.3.9CE-2	BICKU622
	$22 \cdot 26E - 1 \cdot 12 \times 0 \cdot 6 \cdot 44E - 3 \cdot 3 \cdot 76E - 2 \cdot 2 \cdot 13E - 1 \cdot 12 \times 0 \cdot 6 \cdot 44E - 3 \cdot 3 \cdot 76E - 2$	BICRU625
	$32 \cdot 13E - 1 \cdot 13 \times 0 \cdot 2 \cdot 43E - 3 \cdot 5 \cdot 01E - 2 \cdot 14 \times 0 \cdot 4 \cdot 65E - 3 \cdot 14 \times 0 \cdot 3 \cdot 07E - 2 \cdot 14 \times 0$	BICKU624
	43.61E-3.14*0.3.61E-3.14*0.3.61E-3.12*0.6.84E-3.3.60E-3.7.74E-1	BICKUB25
	512*0.6.44E-2.3.76E-2.2.13E-1.12*0.6.92E-3.4.04E-2.2.29E-1.14*0	BICKUD20
	63.57E-2, 13×0., 1.22E-3.4.72E-2.11+0., 1.98E-3. 1.40E-2.E. 15E-2.	BTCR0627
	74.58E-1,11#0.,1.86E-3,1.31E-2.7.67E-2.4.31E-1.	BTCR0620
	811#0., 1. 98E-3, 1. 40E-2, E. 15E-2.4. 58E-1.11#0. 1. 58E-3.1.40E-2.	BTCR0629
	98.15E-2,4.58E-1.6*0. 2080. 1.78E-3.1.26E-2.7.34E-2.4.13E-1.	BICRUBBU
	111*0., 1.78E-3.1.26E-2.7.33E-2.4.12E-1.13*02.44E-3.9.01E-2.13*0	- BICKUB31
	22.43E-3, 9.01E-2, 13.0.2.43E-3.9.01E-2, 13.0. 2.43E-3.9.01E-2, 14.0	BICRU032
	33.57E-2.6*0./	BICKUB33
C		BILRU634
	EATA SCAT11/6*01.87E-3.1.11E-2.5.92E-2.2.47E-1.11*0. 2.01E-2	BICR0635
	$11_{0}19E-2.6.35E-2.2.65E-1.11\pm0.1.69E-3.1.19E-3.4.39E-3.5.400E-3.4.39E-3.4.39E-3.4.39E-3.4.$	BICR0636
×	$211*0 \bullet 1 \bullet 99E = 3 \bullet 1 \bullet 18E = 2 \bullet 6 \bullet 28E = 2 \bullet 2 \bullet 63E = 1 \bullet 11*0 \bullet 1 \bullet 57E = 2 \bullet 1 \bullet 11E \bullet 2$	BICR0637
	$35_91E-2_2 \cdot 2_2 \cdot 47E-1_1 \cdot 1_2 \cdot 0_2 \cdot 1_2 \cdot 87E-3_1 \cdot 1_1E-2_5 \cdot C_1E-2_2 \cdot C_1E-2_$	BTCR0638
·	$41 \cdot 16F = 2 \cdot 1 \cdot 10F = 1 \cdot 14 \div 0 \cdot 4 \cdot 64F = 3 \cdot 14 \div 0 \cdot 4 \cdot 305 = 2 \cdot 14 \div 0 \cdot 5 \cdot 015 \cdot 3 \cdot 14 \div 0$	BTCR0639
	$55_06F - 3_14 \times 0_{-5} - 06F - 3_11 \times 0_{-1} - 06F - 3_1 - 10F - 2_4 - 20F - 3_0 - 06F - 3_14 \times 0_{-7}$	BICR0840
	$61_87E-3_111E-2_5_91E-2_2_47E-1_11*0_2_01E-2_1_10E-2_2_2_63E-1_11*0_1$	BTCR0641
	72.66E = 1.1480.5.02E = 2.1340.5.9EE = 2.5.702E = 2.13E0.4.04E = 2.0.02E = 2.1340.5.02E = 2.02E = 2.1340.5.02E = 2.1340.5.02	BTCRC642
	82.40E-2.1.28E-1.5.21E-1.11x0.2.62E-2.91	BTCR0643
	$S_{11} = 0$ $(1 + 0)$ $($	BTCR0644
	$\frac{11}{286} - \frac{15}{5} - \frac{316}{5} - \frac{15}{5} - \frac{15}{$	BTCR0645
	211 ± 0.3 , $65E-3$, $2\cdot1.5$, 10 ± 0.3 , 10 ± 0.3 , $10E-1$, $10E-2$, $10E-2$, $10E-1$, $4\cdot78E-1$, 211 ± 0.3 , $65E-3$, $2\cdot1.5$, $10E-1$, $4\cdot78E-1$, $10E-1$,	BTCR0646
	$31_{16} = 2_{1} = 1_{10} = 1$	BTCR0647
	Jie 102 - 2, 10102 - 1,15+ 00,10 102 - 2,10 102 - 1,13*00,1010E - 2,1010E - 1,14*0,	BTCR0648
		б

			BTCR0649
	45.02E-2,5*0./		BTCRC650
•		E-2.2.71E-1.10*0.,1.00E-3,	BICKU051
	DATA SCAT12/7*0.,3.76E-3,2.09E-2,8.50	3. 59F-3.2. 23E-2,8. 50E-2,	BICRUSSZ
	14.04E-3, 2.25E-2, 9.00E-2, 2.91E-1, 11.00	2.88E-1.11*0.3.76E-3,	BTCR0653
	22.886-1,11*0.,3.996-3,2.226-2,8.906-2	2 CGE-2.8.38E-2.2.71E-1,	BTCR0654
	32.09E-2, 8.38E-2, 2.71E-1, 11#0., 3. 10E-3	4-0 6 716-3.14+0. 5.54E-3,	BTCR0655
	413*0., 2.08E-2, 1.21E-1, 14*0., 4.65E-3, 1	4+0.,4.11L 3,1.4.90E-2.2.88E-1,	BTCR0656
	514*C., 5. 54E-3, 14*0., 5.54E-3, 11*0., 3.9	1080 1 01E-3.4.04E-3.	BTCR0657
	611=0., 3. 76E-3, 2. 09E-2, 8. 38E-2, 2. 71E-1	1240 1 045-2 6 355-2	BTCR0658
	72-25E-2.9.00E-2,2.91E-1,14=0.,5.52E-2	2,1340,10042 2,00002 -7	BT CR 0659
	810*0 2. 03E-3, 8. 15E-3, 4. 54E-2, 1. 82E-1	1,5. EIE-1,10+0.,10+10,10 - 10+10	BTCR0660
	97.67E-3.4.27E-2.1.71E-1.5.47E-1.10*0.	, 2. USE 5, C. 1925-1, 5, 815-1.	BTCR0661
	11.82E-1.5.81E-1,10+0.,2.03E-3,8.15E-3	3,4,542-2,1,022-1,9,0212 27	BTCR0662
	24*0. 15*0. 6+0. 1.83E-3,7.34E-3,4.09		BTCR0663
	31-83F-3.7.33E-3,4.09E-2,1.63E-1,5.24	E = 1, 13 = 0, 2, 08 = 2, 1, 21 = 21 = 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,	BTCR 0664
	413*C. 2. 08E-2, 1. 21E-1, 13*C., 2. 08E-2,	1.212-1,13*0.,2.002 27	BTCR0665
	51 21E-1. 14*0. 5. 52E-2,4*C./		BTCR0666
	DIOZIL IVII OUVER		BT CR0667
	CATA SCAT13/7*0. 1.60E-3,5.91E-3,2.4	0E-2,7.45E-2,2.52E-1,10+007	BTCR0668
	11 725-3. 6.35F-3.2.58E-2,8.00E-2,2.70	E-1, 10*0., 1. / UE-3, 0. 202-3,	BTCR0669
	11.72E-3, C. 91E-2.2.67E-1,10*0.,1.70E-	3,6.28E-3,2.55E-2,1.91C-2	BTCR0670
	22. 55E-2, 1. 10×0. 1. 60E-3.5. 91E-3, 2. 40E-	2,7.45E-2,2.52E-1,10+0.1	BTCR 0671
	52.07E-1, 10.01F-3.2.40E-2.7.45E-2, 2.52	E-1,13*0.,1.79E-2,1.102-1	BTCR0672
• •	\$1.00E-3, J. 14=0. 4.30E-3, 14=0.,5.	06E-3,14*0.,5.06E-3,14+0.,	BTCR0673
·. ·	514+0., + CAL 571-3.6. 28E-3, 2. 55E-	2,7.51E-2,2.67E-1,10*0.,	BTCR0674
	65.08E-3, 10.04, 11.2.40E-2.7.45E-2,2.52	E-1, 10*0., 1.72E-3, 0.35E-3,	BTCR0675
	11.00E-3, 5.91E 3,2. 70E-1.14*0.,5.13E-	·2,13*C., 9.COE-3,5.79E-2,	BTCR0676
	22.58E-2, C.00E-2,2.1, 28E-2.5, 21E-2, 1. 61E-	-1, 5.41E - 1, 10 = 0., 3.27E - 3,	BTCB0677
2	910*0 • , 3• 472-5,1•202 2750220 9E-1 • 10*0).,3.47E-3,1.28E-2,4.21E-2,	BTC80678
	11.21E-2,4.90E-2,3.92E 1,990-3.47E-3.1.28E-	-2, 5. 21E-2, 1. 61E-1, 5. 41E-1,	BTCR 0679
	21.612-1, 5.412-1, 1040., 5.412	9E-2, 1.45E-1, 4.87E-1, 10+0.	BTCR0680
	33*00,15*00,1*00,50150 3,100 2,100	7E-1,13*0.,1.79E-2,1.10E-1,	BTCROARI
	43.132-3, 1.152-2, 4.052-2, 1. 400-1.795-2,	1. 10E-1, 13*0., 1. 79E-2, 1. 10E-1,	DICK0001
	513*0.,1.792-2,1.102-1,15+0.,1.19		DICK0002
	614*0•,5•13E-2,3*0•/		BICKUDOD
С	CATA SCAT14/8#0.,2.96E-3,7.14E-3,2.	21E-2,7.28E-2,2.38E-1,10*0.,	BICKUOC4

C

С

	13.18E-3.7.68E-3.2.38E-2.7.82E-2.2.55E-1.10*0.3.14E-3.7.59E-3.	BTCR 0685
	22.35E-2, 7.74E-2, 2.52E-1, 10*0., 3. 14E-3, 7. 59E-3, 2. 35E-3, 7. 74E-2,	BTCR0686
	32.52E-1,10*0.,2.96E-3,7.14E-3,2.21E-2,7.28E-2,2.38E-1,10*0.,	BTCR0687
	42.96E-3,7.14E-3,2.21E-2,7.28E-2,2.38E-1,13*0.,2.03E-2,1.21E-1,	BTCR0688
	514#0+ 4+ 65E-3+ 14*0+ 4+81E-3+ 14*0+ 5+ 66E-3+ 14*C+ 5+ 66E-3+ 14*0+	BTCR0689
	65.66E-3,10*0.,3.14E-3,7.59E-3,2.35E-2,7.74E-2,2.52E-1,10*0.,	BTCR0650
	72.96E-3.7.14E-3.2.21E-2.7.28E-2.2.38E-1.10*0.,3.18E-3,7.67E-3,	BTCR0691
	82.38E-2.7.82E-2.2.55E-1.14*0.5.64E-2.13*0.1.02E-2.6.35E-2.	BTCR0692
	\$10*0.6.41E-3.1.55E-2.4.80E-2.1.58E-1.5.09E-1.10*0.6.03E-3,	BTCR0653
	11.46E-2.4.52E-2.1.49E-1.4.79E-1.10*06.41E-3.1.55E-2.4.E0E-2.	BTCR0694
	21.58E-1,5.09E-1,10*0.,6.41E-3,1.55E-2,4.E0E-2,1.58E-1,5.C9E-1,	BTCR0695
	32*0,,15*0,,8*0,,5,77E-3,1,39E-2,4,32E-2,1,42E-1,4,59E-1,10*0.,	BTCR0696
	45.77E-3, 1.39E-2, 4.32E-2, 1.42E-1, 4.58E-1, 1340., 2.03E-2, 1.21E-1,	BTCR0697
	513*0., 2. C3E-2, 1. 21E-1, 13*0., 2. 03E-2, 1. 21E-1, 13*0., 2. 03E-2,	BTCR 06 98
	61.21E-1,14*0.,5.64E-2,2*0./	BTCR0699
С		BTCR07C0
	DATA SCAT15/ S* 0.,4.80E-3,1.48E-2,4.83E-2,1.52E-1,4.21E-1,10*0.,	BTCR 07 01
	15.16E-3,1.59E-2,5.19E-2,1.63E-1,4.52E-1,10*0.,5.10E-3,1.57E-2,	BTCR0702
	25.132-2,1.61E-1,4.47E-1,10*0.,5.10E-3,1.57E-2,5.13E-2,1.61E-1,	BTCR0703
•	34.47E-1,10=0.,4.80E-3,1.48E-2,4.83E-2,1.51E-1,4.21E-1,10=0.,	BTCR0704
	44.80E-3,1.48E-2,4.82E-2,1.51E-1,4.21E-1,13*0.,1.79E-2,1.53E-1,	BTCR0705
	514*0.,4.64E-3,14*0.,5.89E-3,14*0.,6.93E-3,14*0.,6.53E-3,14*0.,	BTCR 0706
,	66.93E-3,10*0.,5.10E-3,1.57E-2,5.13E-2,1.61E-1,4.47E-1,10*0.,4.8E-3	BTCR0707
	7,1.48E-2,4.83E-2,1.52E-1,4.21E-1,10*0.,5.16E-3,1.59E-2,5.19E-2,	BTCR0708
	81.63E-1,4.52E-1,14+0.,6.77E-2,13*0.,9.00E-3,8.07E-2,10*0.,1.04E-2,	BT CR0709
	93.20E-2,1.05E-1,3.29E-1,9.06E-1,10*0.,9.E0E-3,3.02E-2,9.E6E-2,	BTCR0710
	13.10E-1,8.53E-1,10#0.,1.04E-2,3.20E-2,1.05E-1,3.29E-1,9.06E-1,	BTCR0711
	210*0., 1.04E-2, 3.20E-2, 1.05E-1, 3.29E-1, 9.C6E-1, 25*0., 9.38E-3,	BICR0712
	32.89E-2,9.44E-2,2.96E-1,8.17E-1,10*0.,9.37E-3,2.88E-2,9.43E-2,	BICRUTIS
	42.96E-1,8.16E-1,13*C.,1.79E-2,1.53E-1,13*C.,1.79E-2,1.53E-1,13*C.,	BICKU714
	51.79E-2,1.53E-1,13*0.,1.79E-2,1.53E-1,14*0.,6.78E-2,0./	BICRUTIS
С		BICKUTIC
С	FISSION SPECTRUM	BICRUTIT
С		BICKU/18
1	DATA KHIF/0.2040,0.3440,0.1680,0.1800,0.0900,0.0140,9*0./	BICKUTI9
С		EICKU720

C 1	HE BETA VALUES THAT ARE TO BE CORRECTED	BTCR072
C		BTCR072
	CATA BETA/0.215E-3, 1.424E-3, 1.274E-3, 2.568E-3, 0.748E-3,	BTCR072
	10.273E-3/	BTCR 0724
С		BTCR072
CC	VERALL ABSORPTIONS OVER THE CORE MATERIEL NUMBER 1	BTCR072
С		BTCR072
	CATA ABSPC1/4.905E13,3.634E13,1.863E13,2.839E13,3.67E13,5.035E13,	BTCR072
	16.210E13,1.112E14,2.515E14,4.124E14,3.528E14,3.236E14,2.461E14,	BTCR072
	23.411E14,1.6215E16/	BTCR073
С		BTCR073
	CATA ABS PC2/5.065E12,3.935E12,2.030E12,3.150E12,4.071E12,5.615E12,	BTCR 073
	16.974E12,1.250E13,2.E20E13,4.622E13,3.938E13,3.592E13,2.716E13,	BTCR073
	23.754E13,1.67832E15/	BTCR073
C		BTCR073
	CATA ABSPC3/7.480E13,5.821E13,2.982E13,4.652E13,6.C82E13,8.441E13,	BTCR073
	11.045E14,1.859E14,4.129E14,6.653E14,5.579E14,5.016E14,3.745E14,	BTCR 073
	25.01CE14,1.07130E16/	BTCR 073
С		BTCR073
	DATA ABSPC4/5.668E14,4.206E14,2.132E14,3.260E14,4.290E14,5.953E14,	BTCR 074
•	17.321E14,1.302E15,2.905E15,4.667E15,3.924E15,3.542E15,2.656E15,	BTCR074
	23.611E15,7.6C956E16/	BTCR074
. Ç.,		BTCR074
•	CATA ABSPC5/1.445E14,1.085E14,5.431E13,8.333E13,1.C86E14,1.470E14,	BTCR074
	11.807E14,3.223E14,7.267E14,1.184E15,1.010E15,9.240E14,7.C06E14,	BTCR074
	29.556E14,3.41424E16/	BTCR074
С		BTCR074
	DATA ABSPC6/2.478E13,1.962E13,9.749E12,1.528E13,2.030E13,2.885E13,	BTCR 074
	13.633E13,6.553E13,1.469E14,2.361E14,1.997E14,1.812E14,1.355E14,	BTCR074
	21.708E14,2.29734E15/	BTCR075
C		BTCR075
	CATA ABSPC7/2.418E14,1.824E14,8.\$79E13,1.376E14,1.830E14,2.561E14,	BTCR075
	13.186E14,5.731E14,1.292E15,2.090E15,1.772E15,1.614E15,1.218E15,	BTCR075
	21.625E15,3.07011E16/	BTCR075
C		BTCR075

	С		BTCD0757	
	• .	CATA FISSC1/1.701F13.3.365F13.1.686F13.3.314F13.2.586F13.3.510F13.	BTCDOTED	
	•	14.568E13.7.701E13.1.638E14.2.467E14.1.992E14.1.668E14.1.761E14	2TCD 0750	
		22.656F14.1.2F13FF16/	BICKUIJA	
	C		BICKU760	
		DATA FISSC2/1. 700512.3 650512 1 0/0512 2 601515 2 52/512 2 0//512	BICKU761	1
•		$15_{147} + 1030 + 1017 + 1017 + 1000 + 1217 + 10000 + 10000 + 1000 + 1000 + 1000 + 1000 + 1000 + 1000 + 1000 + 1$	BICRU762	
		22. 934E13. 1 22019E157	BICRU763	
	C C	220734113910327100137	BTCR0764	
		FATA ETERCIA (E(E12) E (C(E12) 2 (COE10) E (E) E10 (C) (C)	BTCR0765	
		LAIA FISSUS/20030E13; 50494E13; 20 692E13; 50451E13; 40 616E13;	BTCR0766	
		13.960E13,7.707E13,1.229E14,2.697E14,3.983E14,3.153E14,2.591E14,	BTCR 0767	
		22• C89E14, 3• 9 13E14, 8• 4359CE15/	BTCR0768	
	L.		BTCR0769	
		DATA FISSC4/1.966E14,3.969E14,1.921E14,3.806E14,3.369E14,4.160E14,	BTCR0770	
		15.385E14, 9.021E14, 1.852E15, 2.792E15, 2.215E15, 1.826E15, 1.500E15,	BTCR0771	
		22.812E15,5.98862E16/	BTCR0772	
	C		BTCR0773	
		CATA FISSC5/5.011E13, 1.004E14, 4. \$15E13, 5.729E13, 8.530E13, 1.027E14,	BTCR0774	
		11.329E14,2.233E14,4.722E14,7.087E14,5.701E14,4.764E14,5.C12E14,	BTCR 0775	
		27.441E14,2.69741E16/	BTCR0776	
•	C		BTCR0777	
• .	i ta	DATA FISSC6/8.710E12,1.851E13,8.710E12,1.790E13,1.607E13,2.037E13.	BTCR 0778	
		12.679E13,4.543E13,9.574E13,1.414E14,1.129E14,5.359E13.9.732E13.	BTCR0779	
		21.334E14,1.80902E15/	BTCR0780	
	C		BTCRO781	
	· .	CATA FISSC7/8.386E 13.1.721E14.8.C89E 13.1.607E14.1.438E14.1.789E14.	BTCP0782	
		12. 343E14. 3. 970E14. 8. 411E14. 1. 250E15. 1. 00 JE15. 8. 322E14. 8. 710E14.	87000783	
		21.263E15.2.41131E16/	ATCD0764	
	C		DICKUID4	
	C	EVERALL SCATTERINGS IN. IN CORE MATERIEL NUMBER 1	DICKUTOS	
	Č	CIENTEL CONTINUES INTENTEL NOTBER 1	BICKUICO	
		CATA STINCI/0. 1.424515.2.580515.4 725515 7 455515 9 542515	BICRUTAT	
1. A. 1.		18, 106E15, 7, 664E15, 7, 407E15, 6, 001E15, 5, 560E15, 7, 402CE15, 0, 042E15, 102CE15, 102	BICKUT88	
		24_507815.7.008815/	BICKU789	
	c		BICK0790	
		DATA STINCO (C. 1 (FOR 14 2 ZOOFLA F COLELE C COLELE C COLELE)	BTCR 0751	
		UATA STINUZ/ U. 11.457514,2. (23214,5.091215,8.221214,9.582214,	BTCR 07 92	نى س
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		19.195E14,8.711E14,8.415E14,6.904E14,6.277E14,6.3180E14,5.779E14,	BTCR0793
		25.050E14,7.933E14/	BTCR 07 54
	C		BTCR 07 95
		CATA STINC3/0.,2.051E15, 3.627E15,7.188E15,1.203E16,1.416E16,	BTCR0796
		11. 371E16, 1. 3C6E16, 1. 254E16, 1. 016E16, 9. 098E15, 9. 022E15, 8. 126E15,	BTCR075
		27.011E15,1.0E4E16/	BTCR079
	С		BTCR075
	•	DATA STINC4/C., 1.561E16, 2.667E16, 5.186E16, 8.452E16, 9.849E16,	BTCR080
•		19.487E16,9.034E16,8.686E16,7.055E16,6.318E16,6.274E16,5.666E16,	BTCR080
		24.901E16,7.552E16/	BTCR08C
	C ·		BTCROBO
		CATA STINC5/C.,4.195E15,7.689E15,1.390E16,2.1E2E16,2.522E16,	BTCR080
		12. 37CE16, 2. 232E16, 2. 150E16, 1. 761E16, 1. 595E16, 1. 604E16, 1. 469E16,	BTCR080
		21.285E16.2.0C3E16/	BTCR080
	С		BTCR080
		DATA STINC6/C., 6.794E14, 1.220E15, 2.377E15, 3.960E15, 4.715E15,	BTCR080
		14.667E15,4.522E15,4.4(4E15,3.510E15,3.227E15,3.219E15,2.924E15,	BTCR080
		22.532E15,3.754E15/	BTCR081
	С		- BTCR081
		DATA STINC7/C.,6.661E15,1.154E16,2.208E16,3.5ECE16,4.197E16,	BTCR081
		14.075E16,3.923E16,3.814E16,3.129E16,2.820E16,2.822E16,2.572E16,	BTCR081
		22.239E16, 3.434E16/	BTCR081
• • .	С		BTCR081
	C CI	VERALL SCATTERINGS OUT, IN CORE MATERIEL NUMBER 1	BTCR081
	С		BTCR081
		CATA OTSTC1/2.158E15,5.180E15,4.371E15,6.575E15,8.033E15,8.139E15,	BTCR 081
•		17.69E15,7.35CE15,7.04CE15,5.684E15,5.210E15,5.292E15,4.905E15,	BTCR081
		24.225E15.0./	BTCR082
	С		BTCR082
		CATA OTSTC2/2.227E14.5.535E14.4.750E14.7.352E14.9.031E14.9.249E14.	BTCR082
		18.738E14,8.349E14,7.\$76E14,6.434E14,5.877E14,5.942E14,5.485E14.	BTCR082
		24.711814.0./	BTCR082
	С		ETCR082
	-	DATA UTSTC3/3.161E15,7.531E15,6.878E15,1.082E16,1.338E16,1.3E1E16,	BTCR 082
		11. 309E16, 1. 242E16, 1. 171E16, 9. 263E15, 8. 327E15, 8. 297E15, 7. 565E15,	BTCR082
		26.374E15.0./	BTCR082

•

С		BTCR0829
	DATA OTSTC4/2.389E16, 5.472E16, 4.923E16, 7.527E16, 9.290E16, 9.553E16.	BTCR0830
	19.062E16,8.610E16,8.131E16,6.432E16,5.796E16.5.792E16.5.294E16.	BTCR0831
	24.471E16, C./	BTCR0832
С		BTCR0833
	CATA OTSTC5/6.356E15, 1.546E16, 1.274E16, 1.930E16, 2.374E16,	BTCR0834
	12.376E16.2.227E16.2.131E16.2.034E16.1.633E16.1.491E16.1.511E16.	BTCROB35
	21.396E16.1.1E4E16.0./	BTCR0836
С		BTCDOBS
-	DATA OTSTC6/1.047E15.2.538E15.2.248E15.3.555E15.4.465E15.	BTCROBAR
	14.722E15.4.551E15.4.377E15.4.155E15.3.287E15.2.680E15.2.567E15.	BTCR0000
	22.737F15.2.139F15.C./	BTCP0840
С		BTCD0941
	CATA OTSTC7/1-019F16-2-373F16-2-073F16-3-178F16-3-564F16-4-109F16-	BICRUOTI
	12. 944E16.3. 7E9E16.3. 615E16.2. 880E16.2. 618E16.2. 640E16.2. 427E16.	BTCDARAZ
	22.008F16.0./	BTCDOGAG
С		BTCD0845
č	TOTAL NUMBER OF NEUTRONS FORN IN VARIOUS GROUPS/SEC	BTCPOBA6
Ċ		DICKU040
	DATA SRCE/8.121976F16.1.369589F17.6.688654F16.	BTCD0840
	17.166452E16.3.5E3228E16.5.573905E15.5*0./	BTCDOBAG
С		DICKU047
Ϋ́,	FND .	
•	SUBROUTINE PROB	
C		
r	VARTCHS DRABARTITTES LE NEED	DICKU000
ř	TARIOUS IROUADILITILS AL ALL	DICKU854
Č	COMMEN/ORTAK1/ALEAK(15) PLRC	BICKU855
	COMMON / P / PSI(15,29)	DICKU030
	CEMMEN/A/AIFAK1(15) + AIFAK2(15) + AIFAK3(15) + SOUT(15)	
	CEMMEN/S/SCAT(15.29.15)	
	COMMON/ABC/AESPC(15.7)	DICKU039
	COMMEN/EC/EISSC(15.7)	
	COMMON/SIC/SILVC(15.7)	DIUKUSCI DTCD0040
	CEMMEN/DIC/DISIC(15.7)	
	$COMMEN/ORTAK2/PE(15) \cdot FLCR(14) \cdot PSR(14 \cdot 15) \cdot PSC(14 \cdot 15)$	DILKU003
		DICKUOC4

COMMON/SR/SRCE(15)	BTCR086
COMMCN/AES/AESP(15)	BICKUBO
그는 것 같은 것 같	BICKU86
CIMENSION TSTINC(15), TGC(15), TAB SPC(15), V(29),	BICRUSS
1SNR(15,15), SNC(15,15), SDR(15), SDC(15), TSCA(15,29), TUTSTC(15),	BICKOBC
2DENR(15), PSOLTC(14), PSOUTR(14)	BICROBI
	BTCR087
VOLUMES (FOR 29 MATERIELS)	BTCR 087
	BTCR087
CATA V/2.792E3,7.246E4,2.217E2,2.439E3,	BTCR087
12.233E4, E.384E3, 9.452E5, 2.412E3, 6.333E3, 1.011E3,	BTCR087
21.520E4, 9.395E3, 1.995E3, 2.513E4, 1.717E5,	BTCR087
35.381E6,7.915E2,2.090E5,6.271E4,4.991E3,	BTCR087
42.150E4, C., 1.048E5, 7.534E2, 1.031E4,	BTCR 087
51.776E4,1.519E4,2.918E4,5.692E5/	BICROST
	BICKUBE
NAMELIST/CUTSTC/TSTINC	BICRU88
NAMELIST/OUTPF/PF	BICKU88
NAMELIST/CUTFLC/PLCR	BICK088
NAMELIST/DUTFRC/FUTRC, FUTRCC	BTCR088
NAMELIST/CUTPRC/PLRC	BILKUBC
NAMELIST/OUTFSR/PSR	BICKUDO
NAMELIST/OUTPSC/PSC	DICKUGO
NAMELIST/UPSTC/PSOUTC	DICKUOC
NAMELIST/CPSTR/PSJUTR	DICKUDO
	DILKU07
COMPUTATION OF THE PROBABILITY THAT A NEUTRON OF ENERGY GROUP I	DICKUOY
CAUSES FISSION WHILE IT IS WITHIN THE ENERGY GROUP I	DICKUOJ
	DICNUD
$CO \ 3C \ I=1,15$	DIUKUOJ
SUMN=0.	DICKUBY
SUMD=0.	BICKU85
CO 20 M=1,7	BICKU85
SUMN=SUMN+FISSC(I,M)	BICKU85
SUMD=SUMD+STINC(I,M)	BICK089
20 CONTINUE	BTCR090
```
TSTINC(I)=SUMD
                                                                                     BTCR0901
      TGC(I) = SUND + SRCE(I)
                                                                                     BTCR0902
      PF(I)=SUMN/TGC(I)
                                                                                     BTCR0903
   30 CENTINUE
                                                                                     BTCR0904
С
                                                                                     BTCR0905
C TSTINC(I); TOTAL NUMBER OF NEUTRONS SCATTERED INTO ENERGY GROUP I
                                                                                     BTCR0906
C WITHIN THE CCRE/SEC
                                                                                     BTCR 0907
C TGC(I); TOTAL GAIN IN ENERGY GROUP I IN THE CORE /SEC
                                                                                     BTCR0908
C FF(I); PROBABILITY THAT A NEUTRON OF ENERGY GROUP I CAUSES FISSION WHILE IT
                                                                                     BTCR0909
C IS STILL IN ENERGY GROUP I
                                                                                     BTCR 0910
С
                                                                                     BTCR0911
      WRITE(6, CUTSTC)
                                                                                     BTCR0912
      WRITE(6, CUTPF)
                                                                                     BTCR0913
С
                                                                                     BTCR0914
C FRBABILITY THAT A NEUTRON OF ENERGY GROUP I LEAKS CUT OF THE CORE
                                                                                     BTCR0915
C
                                                                                     BTCR0916
      CO 31 I=1,15
                                                                                     BTCR 0917
      SUMA =0.
                                                                                     BTCR0918
      SUMD=0.
                                                                                    . BTCR0919
      CO 21 M=1.7
                                                                                     BTCR0920
      SUMA#SUMA+ABSPC(I.M)
                                                                                     BTCR0921
      SUMC=SUMC+OTSTC(I,M)
                                                                                     BTCR0922
   21 CONTINUE
                                                                                     BTCR0923
      TABSPC(I)=SUMA
                                                                                     BTCR0924
      TOTSTC(I)=SUNO
                                                                                     BTCR 0925
      FUITEC =- (SUMA+SUMO-TGC(I))
                                                                                     BTCR0926
      IF (I.EQ.15) GU TO 31
                                                                                     BTCR0927
      PLCR(I) = FUI TEC/TGC(I)
                                                                                     BTCR0928
   31 CUNTINUE
                                                                                     BTCR0929
      WRITE(6,CUTPLC)
                                                                                     BTCR0930
С
                                                                                     BTCR 0931
C ABSORPTION DUTSICE OF THE CORE FOR THERMAL NEUTRONS
                                                                                     BTCR0932
C
                                                                                     BTCR 0933
      ABSPR=ABSP(15)-TABSPC(15)
                                                                                     BTCR0934
С
                                                                                     BTCR0935
C SCATTERING INTO THE 15 TH GROUP OUTSIDE OF THE CORE
                                                                                     BTCR 0936
```

in de la constant de La constant de la cons	BTCR0937
SINTH=3.357790E17	BTCR0938
STINR=SINTH-7STINC(15)	BTCR 0939
	BTCR0940
C LEAKAGE FROM THE REFLECTOF REGION FOR THERMAL NEUTRUNS	BTCR 0941
${f C}_{i}$, and ${f C}_{i}$	BTCR0942
FUITR=-(AESPR-STINR)	BTCR0943
C C C C C C C C C C C C C C C C C C C	BTCR0944
C LEAKAGE FROM THE REFLECTOR TO THE CORE FOR THERMAL NEUTRONS	BTCR0945
, 이제 · · · · · · · · · · · · · · · · · ·	BTCRC946
FUTRC=FUITR-ALEAK(15)	BTCR 0947
${f C}$. The second	BTCR0948
C SAME LEAKAGE COMPUTED BASED ON THE NUMBERS RELEVANT TO THE CORE (CROS	S BTCR 0949
C CHECKING)	BTCR0950
	BTCR0951
FUTRCC=TABSPC(15)-TSTINC(15)	BTCR0952
WRITE(6, OUTFRC)	BTCR0953
	BTCR0954
C PROBABILITY THAT A THERMAL NEUTRON LEAKS FROM THE REFLECTOR TO THE CU	RE BICRU955
	BICKU956
PLRC=FUTRCC/STINR	BICRUSST
WRITE(6, LUIPRC)	BICKU958
	BTCR0959
C PRUBABILITY THAT A NEUTREN SCATTERS LUT OF GROUP I IN THE CURE AND IN	THE BICKU960
	BICKU961
	BICKU902 BTCD0043
$LU = \{2U \mid i = 1, i = 4, \dots, i = 1, j = 1, \dots, j = 1, \dots,$	
120 PSUUIK(1)=(SLUI(1)=)CISIL(1)//UENK(1)	D1CK0300
WK11E(0;UYS1() WDITE(4 CDSTC)	DILKUYOI BTCD0049
MRIIELOJLPJIPJ	DIUKU700 BTCD0040
U C COMPUTATION OF THE DOODAEN ITY DE CONTEDING FOOM CODUD MO TO COOUD A	
C IN THE CODE AND CUISIDE OF THE CODE WHEN THERE IS A SCATTEDING	
C IN THE CURE AND CUTSIDE OF THE CUREIMHEN THERE IS A SUPPLEKING	8TCD0072
ng na sa 🗣 na sa ng katalon ng pangang katalon ng katal	$uiunu712 \omega$

•					
		CC 32 MC=1,29	BT	CR0973	
		DD = 32 MG = 1, 14	BT	CR 0974	
		SUM=0.	BT	CR0975	
		CÜ 22 MH=1,15	BT	CR 0976	
	22	2 SUM=SUM+SCAT(MG,MC,MH)	BT	CR 0977	
	32	2 TSCA(MG, MC) = SUM	BT	CR0978	
		CO = 5C MG = 1, 14	BT	CR 0979	
	•	EO 50 MH=1, 15	BT	CR0980	
•		SUMNC=0.	BT	CR0981	
		SUMNR=C.	BT	CR0982	
		EO 45 MC = 1,29	BT	CR0983	
· •		IF ((MC.EQ.1).GR.(MC.EQ.3).OR.(MC.EQ.4).GR.(MC.EQ.6).OR.(MC.EQ.5).	BT	CR0984	
		1CR. (MC.EQ.13).OR. (MC.EQ.14)) GO TO 44	BT	CR0985	
		SUMNR=SUMNR+SCAT(MG, MC, MH)*V(MC) +PSI(MG, HC)	BT	CR0986	
		GO TE 45	BT	CROS87	
	-44	<pre>SUMNC=SUMNC+SCAT(MG, MC, MH)*V(MC)*PSI(MG, MC)</pre>	BT	CR0988	
	45	CONTINUE	BT	CR0989	
		SNR (MG, MH) = SLMNR	BT	CR0990	
	50) SNC(MG,MH)=SLMNC	. BT	CR0991	
	•	EU 60 MG=1,14	BT	CR0992	
		SUMDR=C.	BT	CR 0993	
.		SUMDC=0.	BT	CR0994	
	e teta e	CO 55 MC = 1,29	BT	CR 0995	
• . •	•	IF ((MC.EQ.1).OR.(MC.EQ.3).OR.(MC.EQ.4).CR.(MC.EQ.6).OR.(MC.EQ.5).	BT	CR 0996	
	•	1CR. (MC. EQ.13). OR. (MC. EQ. 14)) GO TO 54	BT	CR0997	
		SUMDR=SUNDR+FSI(MG,MC)*TSCA(MG,MC)*V(MC)	BT	CR0998	
	· · ·	CU TO 55	BT	CR0999	
·	54	SUMDC=SUMCC+FSI(MG,MC)*TSCA(MG,MC)*V(MC)	BT	CR1000	
	55	CONTINUE	BT	CR 1001	
		SDR (MG) = SUMDR	BT	CR1002	
	60	SDC(MG) = SUMDC	BT	CR1003	
	C		BT	CR1004	
	C FRO	BABILITY OF SCATTERING FROM MG TO MH IN THE CORE AND OUTSIDE OF THE COR	ξE BT	CR1005	
	C		BT	CR 1006	
	•	$CO \ 7C \ MG=1, 14$	BT	CR1007	
		CO 70 MH=1,15	BT	CR1008 ,	
				· · · · · · · · · · · · · · · · · · ·	1

		PSR(MG,MH)=SNR(MG,MH)/SDR(MG)*PSCUTR(MG)	BTCR 1009
	70	PSC(MG,MH)=SNC(MG,MH)/SDC(MG)*PSCUTC(MG)	BTCR1010
		WRITE(6, GUTPSR)	BICRIOII
		WRITE(6, OLTPSC)	BTCR 1012
		RETURN THE CONTRACT OF A DESCRIPTION OF A D	BTCR1013
		END	BTCR1014
		SUBROUTINE STUDY(SC1, SR1, SC2, SR2, SUM2, JJ, MH21, MH2F)	BTCR 1015
•			BTCR1016
		CCMMCN/MSTUDY/MF,SRT,LLL,MH(14),KKK	BTCR 1017
		COMMON/URTAK2/PF(15),FLCR(14),PSR(14,15),PSC(14,15)	BTCR1018
			BTCR1019
		MG1=MH(JJ-1)	BTCR 1020
		MG2=MH(JJ)	BTCR1021
t		SC2=SC1* PSC(MG1, MG2)	BTCR1022
		SUM2=SUM2+SC2+PF(MG2)	BTCR1023
		IF (MG2.EC.15) GO TO 5	BTCR1024
		SR2=SC2×PLCR(MG2)+SR1×PSR(MG1,MG2)	BTCR 1025
		CJ TO 6	BTCR1026
÷	5	SRT=SRT+SR1*FSR(MG1,M(2))	BTCR1027
	6	CO 7 J=1, JJ	BTCR 1028
		JN = 14 - JJ + J	BTCR1029
		IF (MH(J),GT.JN) GC TC 8	BTCR1030
• • *.	.7	CONTINUE	BTCR1031
•		MH21=MG2+1	BTCR1032
		MH2F=MG2+MF	BTCR 1033
		IF (MH2F.LE.15) GO TC 71	BTCR1034
		MH2F=15	BTCR1035
	71	LLL=1	BTCR 1036
		KKK=KKK+1	BTCR1037
		RETURN	BTCR1038
	8	LLL=0	BTCR 1039
		KKK=KKK+1	BTCR 1040
		RETURN	BTCR1041
			BTCR1042
â			BTCR 1043

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APPENDIX M PROGRAM INVA

(Like Averaged Inverse Velocity)

// 'TOLGA YARMAN' .CLASS=A.REGION=128K	INVA0001
/*MITID USER=(M8690,9441)	INVA0002
/*MAIN TIME=2,LINES=20,CARDS=0	INVA0003
/*SRI LOW	INVA0004
//STEP1 EXEC FURCGO	INVA0005
//C.SYSIN DD *	INVA0006
C PROGRAM INVA	INVA0007
C	INVACOOB
C COMPUTATION OF AN INVERSE VELOCITY	INVA0009
C	INVA0010
DIMENSIUN PSI1(15), PSI2(15), PSI3(15), PSI4(15), PSI5(15), PSI6(15), INVA0011
1PS17(15), PS18(15), PS19(15), PS110(15), PS111(15), PS112(15), PS113	(15 INVA0012
2),PSI14(15),PSI15(15),PSI16(15),PSI17(15),PSI18(15),PSI19(15),	INVA0013
3PSI20(15), PSI21(15), PSI22(15), PSI23(15), PSI24(15), PSI25(15), PS	126 INVA0014
4(15), PS127(15), PSI29(15), PSI28(15), PSI(15,29)	INVA0015
DIMENSIUN V(15), V1(15), NMGI(2), NMGF(2), V1AV(2), V11(2)	INVA0016
C	INVA0017
EQUIVALENCE (PSI1(1), PSI(1,1))	INVA0018
EQUIVALENCE (PSI2(1), PSI(1,2))	INVA0019
EQUIVALENCE (PSI3(1), PSI(1,3))	INVA0020
EQUIVALENCE (PSI4(1), PSI(1,4))	INVA0021
EQUIVALENCE (PSI5(1), PSI(1,5))	INVA0022
EQUIVALENCE (PSI6(1), PSI(1,6))	INVA0023
EQUIVALENCE (PSI7(1), PSI(1,7))	INVA0024
EQUIVALENCE (PSI8(1), PSI(1,8))	INVA0025
EQUIVALENCE (PSI9(1), PSI(1,9))	INVA0026
EQUIVALENCE (PSI10(1), PSI(1,10))	INVA0027
EQUIVALENCE (PSI11(1), PSI(1,11))	INVA0028
EQUIVALENCE (PSI12(1), PSI(1,12))	INVA0029
EQUIVALENCE (PSI13(1), PSI(1,13))	INVA0030
EQUIVALENCE (PSI14(1), PSI(1,14))	INVA0031
EQUIVALENCE (PSI15(1), PSI(1,15))	INVA0032
EQUIVALENCE (PSI16(1), PSI(1,16))	INVA0033
EQUIVALENCE $(PSI17(1), PSI(1, 17))$	INVA0034
EQUIVALENCE (PS118(1), PS1(1,18))	INVA0035
EQUIVALENCE (PSI19(1), PSI(1,19))	INVA0036
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	EQUIVALENCE (PSI20(1), PSI(1,20))	INVA0037
	EQUIVALENCE (PSI21(1), PSI(1,21))	INVA0038
	EQUIVALENCE (PSI22(1), PSI(1,22))	INVA0039
	EQUIVALENCE (PSI23(1), PSI(1,23))	INVADO40
	EQUIVALENCE (PSI24(1), PSI(1, 24))	INVA0041
	EQUIVALENCE (PSI25(1), PSI(1, 25))	INVA0042
	EQUIVALENCE (PSI26(1), PSI(1, 26))	INVA0043
	EQUIVALENCE (PSI27(1), PSI(1,27))	INVA0044
	EQUIVALENCE (PSI28(1), PSI(1,28))	INVA0045
	EQUIVALENCE (PS129(1), PS1(1,29))	INVA0046
		INVA0047
	NAMELIST/DUTO/V	INVA0048
	NAMELIST/UUT1/VIAV	INVA0049
	NAMELIST/UUT2/V11	INVA0050
		INVA0051
	DATA PS11/1.00737E13,2.23071E13,1.18319E13,1.76862E13,	INVA0052
	11.70534E13,1.25523E13,9.69910E12,8.69193E12,8.34772E12,	INVA0053
	25.54323E12,4.87979E12,5.07788E12,4.51213E12,3.58995E12,	INVA0054
	33.09949E13/	INVA0055
		INVA0056
	DATA PS12/7.13232E11,1.62687E12,7.77294E11,1.18596E12,	INVA0057
	11.30902E12, 1.00939E12, 8.29590E11, 7.80258E11, 7.85932E11, 5.49627E11,	INVA0058
	25.00281E11, 5.34657E11, 4.83793E11, 3.94693E11, 1.05229E13/	INVA0059
		INVA0060
	DATA PS13/1.27551E13,2.89790E13,1.54629E13,2.35919E13,	INVA0061
÷	12.38825E13,1.69370E13,1.3J778E13,1.17095E13,1.12181E13,	INVA0062
	27.44364E12,6.52920E12,6.76325E12,5.58542E12,4.74891E12,	INVA0063
	33.85021E13/	INVA0064
		INVA0065
	DATA PS14/1.71227E13,3.96525E13,2.05659E13,3.16724E13,	INVA0066
	13.24365E13,2.31479E13,1.78172E13,1.58380E13,1.49665E13,9.74154E12,	INVA0067
·	28.41021E12,8.58567E12,7.50363E12,5.84070E12,2.68752E13/	INVA0068
		INVA0069
	DATA PS15/1.45549E13, 3.29063E13, 1.68575E13, 2.54005E13, 2.60652E13,	INVA0070
	11.85560E13,1.42987E13,1.27317E13,1.20567E13,7.84387E12,6.78769E12,	INVA0071
	26.95031E12, 6.08968E12, 4.750C7E12, 2.16459E13/	INVA0072
		1.3

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C			TNUA0072	
Ŭ	DATA PS15/9-88098F12.2.21733F13.1.14855F13.1.72909F13.1.75745F13.		INVAUU73	
	11.22013E13.9.39882E12.8.39353E12.8.03255E12.5.30221E12		INVADO74	
	24-65178E12-4-82862E12-4-27763E12-3-24040E12-2-17200E12/		INVAUU75	
C	24.05110LL294.02002L1294.21105LL295.54940E1292.1720UE157		INVA0076	÷.,
, U	DATA DE17/1 51127511 2 04227511 1 24240511 2 47204511		INVAUUTT.	
	DATA PSI//I.SILS/EII,S.0002/EII,1.S4340EII,2.4/380EII,		INVA0078	×
	13.03930E11, 5.43318E11, 5.28815E11, 5.26329E11, 5.44502E11, 3.93885E11,		INVA0079	
C	23.609/8E11,4.03846E11,3.79416E11,3.52016E11,3.62643E13/		INVA0080	
C			INVA0081	
	DATA PS18/1.20144E13,2.84534E13,1.50317E13,2.36870E13,		INVA0082	
	12.40741E13,1.73901E13,1.33255E13,1.18493E13,1.12134E13,7.36938E12,		INVA0083	
	20.35423E12,0.40740E12,5.60764E12,4.41452E12,2.24688E13/		INVA0084	
C			INVA0085	
	DATA PS19/1.50146E12, 3.58446E12, 1.77785E12, 2.73737E12,		INVA0086	
	13.05101E12, 2.39223E12, 1.94321E12, 1.80874E12, 1.76625E12, 1.17805E12,		INVA0087	
	21.00644E12,1.13439E12,1.00268E12,6.22961E11,3.90013E11/		INVA0088	4 N.
С			INVA0089	
	DATA PS110/1.56417E13,3.60170E13,1.85488E13.2.83327E13.		INVA0090	3
	12.91862E13, 2.08403E13, 1.61003E13, 1.43636E13, 1. 36231E13, 8.8824E12.		INVA0091	
	27.69509E12,7.88080E12,6.83326E12,5.35424E12,2.67592E13/	•	INVA0092	
C		-*	INVA0093	
	DATA PS111/4.65987E12.1.07289E13.5.55235E12.8.48465E12.		INVA 0094	
	19.05601E12.6.63210E12.5.29852E12.4.85433E12.4.74320E12.3.19684E12.		INVA0095	
	22.85435E12.3.00461E12.2.67725E12.2.03224E12.1.92446E13/		INVADODA	
C			TNVA0090	
	DATA PS112/2,44550E12,5,57977E12,2,66179E12,4,24124E12		TNVA0097	
	15-48086F12-4-46704F12-3-71362F12-3-47187F12-3-46546F12-2-41814F12		1 NVA0098	
	22, 20282 + 12, 2, 36435 + 12, 2, 13292 + 12, 1, 74124 + 10, 400 + 0, 12, 2, 41014 + 12, 2, 2, 41014 + 12, 2, 13292 + 12, 1, 74124 + 12, 5, 400 + 0, 12, 2, 41014 + 12, 41014 +	•	1 NVA0099	
C	22.20202121212.0045521212.012721291.1412021295.40022215/		INVAULUU	1 .
C	DATA DELIZIO 02262512 1 62210512 0 21700512 1 221(2512 1 2221)512		INVAUIUI	
	$\frac{10}{669} \frac{669}{6612} \frac{7}{669} \frac{5202}{612} \frac{12}{69} \frac{10}{612} \frac{10}{69} \frac{10}{612} \frac{10}{61$		INVA0102	- <u>-</u>
	22 70042612 7 5100600E12 0 02197E12 0 49332E12 4 22344E12 3 07920E12		-INVA0103	
C	23.19002012,3.31003012,2.39004012,1.04389012/		INVA0104	
C			INVA0105	
	UATA PS114/5.51/01E12,1.26/75E13,6.30738E12,9.52943E12,		INVA0106	
	19.00190E12, 1.092/1E12, 5.52900E12, 4. 57879E12, 4. 76316E12,		INVA0107	
	23.12083E12,2.72414E12,2.81461E12,2.48035E12,1.89559E12,		INVA0108	w
			Ť.	30
				0

	c	37.84037E12/		v . a	INVA0109	
	Ľ,	0474 BELLEVO 0350350 E 5333050 2 1/1050 2 85/0150			INVAULU	
		UAIA PS115/2.83592E9;5.53228E9;2.1419E9;5.85001E9;			INVAULLE INVAULLE	
		18.45488E9, 1.19461E10, 1.51236E10, 1.96665E10, 2.58602E10, 2.18769E10,			INVAUL12	
		22.29989810,2.84099810,2.90990810,2.70993810,9.946188127		2	INVAULLS	
	C				INVAULL4	1915
		DATA PS116/2.55197E8,8.86992E8,3.67(96E8,6.17273E8,			INVAULIS	
		11.10915E9,1.45164E9,1.68106E9,2.08979E9,2.65010E9,2.21534E9,			INVAULIO	
2	1774	22.33090E9,2.89865E9,2.99767E9,2.73959E9,2.15733E12/			INVAOIIT	
	С				INVAOII8	
		DATA PS117/2.38627E12,5.21569E12,2.38901E12,3.90725E12,			INVA0119	
		15.61735E12, 4.70592E12, 3.93748E12, 3.66121E12, 3.65511E12, 2.57785E12,			INVA0120	
		22.35870E12,2.55382E12,2.32249E12,2.01416E12,9.41901E13/			INVA0121	
	C				INVA0122	÷.,
		DATA PS118/9.99961E9, 2.29717E10, 8.79224E9, 1.30877E10,			INVA0123	30
		11.48976E10,1.19969E10,1.02758E10,1.00958E10,1.06745E10,7.79902E9,			INVA0124	
-		27.36367E9,8.15255E9,7.61416E9,6.31105E9,3.68421E11/			INVA0125	
	С		÷.		INVA0126	
		DATA PS119/4.69802E10,1.07163E11,4.26929E10,6.39392E10,		· · ·	INVA0127	
		17.26767E10, 5.90273E10, 5.03304E10, 4.92060E10, 5.15745E10, 3.72584E10,			INVA0128	
		23.49577E10,3.84597E10,3.56174E10,2.88146E10,1.76375E12/	•		INVA0129	
*	С				INVA0130	
		DATA PS120/2.92986E12,0.48734E12,3.10695E12,4.83535E12,			INVA0131	
	• •	15.88415E12,4.82943E12,4.09801E12,3.92453E12,4.00831E12,2.84567E12,			INVA0132	. *
		22.61498E12, 2.82121E12, 2.57460E12, 2.15952E12, 8.82265E13/			INVA0133	•
	С				INVA0134	
		DATA PS121/2.79272E12,6.41947E12,3.15487E12,4.93465E12,			INVA0135	
		14.93672E12.4.76330E12.3.96308E12.3.72960E12.3.73572E12.2.59872E12.	· .		INVA0136	8
		22.35888E12.2.51551E12.2.2.435E12.1.81786E12.4.46644E13/			INVA0137	
	C				INVA0138	
	•	DATA PSI22/15+0./			INVA0139	а •2
· ·	C				INVA0140	
	v	DATA PS123/7.30400E10.1.59244E11.6.33609E10.1.00316E11.			INVA0141	
		11.33994F11.1.17226E11.1.05928E11.1.C7670E11.1.16894E11.8.71505E10.			INVA0142	•3
		28-33669E10-9-36818E10-8-86947E10-7-66278E10-8-54001E12/	5.0		INVA0143	
	C		e.		INVA0144	
	C C					ω ω
						Ë.

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	그는 것 같은 것 같은 것 같은 것 같은 것 같은 것 같은 것을 통해 집중에 가지 않는 것을 하는 것 같은 것 같			
	DATA PS124/6.57385E12.1.46396E13.7.38030E12.1.12008E13.		TNVA0145	
	11.19848E13,9.05311E12,7.3486E12,6.83381E12.6.80922E12.4.72257E12.		INVA0145	
	24.25975E12, 4.50770E12, 4.05123E12, 3.32159E12, 7.32432E13/		INVAD147	
			INVAO148	
	DATA PS125/5.79924E11,1.14494E12.4.82339E11.9.10516E11.		INVACIAG	
	11.93840E12, 2.04278E12.1.90154E12.1.82458E12.1.83840E12.1.31154E12.		TNVADIAS	
	21.21184E12, 1. 34153E12, 1. 23831F12, 1. 14720F12, 8, 87780F13/	S. 1.	INVAUL50	
			INVAU151	
	DATA PS120/1.90676F11.3.45018F11.1.42709F11.2.88850F11		INVAU152	10
	17.49914E11.9.43641E11.9.88051E11.1 01437E12 1 04270E12 7 74100E11		INVAU153	
	27.24443E11.8.12987E11.7.58574E11.7.15832E11.7.10227E12/		INVA0154	
			1NVA0155	
	DATA PS127/5-44443E10.9 02990E10.2 47090E10 7 44440E10		INVA0156	
	12.22783E11.3.26632E11.3.39771E11.4.26677E11.4.05200E11.3.77000E11.		INVA0157	
	23.64096E11.4.20310E11.4.01609E11.2.9EEE0E11.5.77230E11, 5.77230E11, 5.77230E12, 5.777230E12, 5.777230E12, 5.777230E12, 5.777230E12, 5.777230E12, 5.777230E12, 5.777230E12, 5.777230E12, 5.777230E12, 5.7777230E12, 5.7777230E12, 5.7777230E12, 5.77777230E12, 5.77777230E12, 5.777777777777777777777777777777777777		INVA0158	
	23.0103021194.2031021194.0130821193.83330021193.443/3213/		INVA0159	
	DATA PS128/1 09570510 1 72026510 6 5025250 1 44004510		INVA0160	
	14.28526E10.6.84570E10.8.99937E10.1.12100E11.1.20210E11.1.1000E11.1.1000E11.1.10000E11.1.10000E11.1.10000E11.1.10000E11.1.10000E11.1.10000E11.1.10000E11.1.10000E11.1.10000E11.1.10000E11.1.10000E11.1.10000E11.1.10000E11.1.10000E11.1.1000E11.1.1000E11.1.1000E11.1.1000E11.1000E11.1.1000E11.1.1000E11.1.1000E11.1.10		INVA0161	
	21.13418E11.1.36955E11.1.34171E11.1.22E(2511.2.27072514.2.27072514.1.2020E11,		INVA0162	
	21.13410L11,1.30499911,1.30171E11,1.33962E11,3.27973E137		INVA0163	
	DATA 85120/4 2172450 1 222450 7 750050 1 0050050		INVA0164	
	$\frac{12}{29} = 5450 + 0.70(450 - 2.050(050 - 4.0000750 - 5.000750))$		INVA0165	
	24.2030429,2.9706429,3.3504029,4.0892729,5.0852129,4.2067029,	10	INVA0166	
	24.39140E9, 5.45014E9, 5.63666E9, 5.16516E9, 3.58462E12/		INVA0167	
	DATA MODESCO 10 DEC 11 DEC 10 DEC		INVA0168	
	DATA V/28.5E8,19.9E8,14.7E8,11.0E8,6.7E8,2.9E8,1.14E8,		INVA0169	
	10.4828, 0.20628, 0.10128, 0.056628, 0.031928, 0.017928, 0.010928,		INVAO170	
	20.004E+087		INVA0171	
			INVA0172	į.
	DATA NM61/1,8/		INVA0173	
		1	INVA0174	
	DATA NMGF/7,14/		INVA0175	
			INVA0176	
	DU 100 MG=1,15		INVA0177	
100	V1(MG) = 1./V(MG)	6 - C	INVA0178	
	DU 300 K=1,2		INVA0179	
	MGI=NMGI(K)		INVAD180	

	NOT NUCCIUN			INVA0181
				INVA0182
•	SUMN=U.			INVA0183
	SUMD=0.			INVAD184
	DO 200 MM = 1,29			INVACIOT
	DU 200 MG=MGI,MGF			INVAULOS
	SUMN=SUMN+V1(MG)*PSI(MG,MM)			INVAUL86
	SUMD=SUMD+PS11MG.MM)			INVA0187
200	CONTINUE			INVA0188
200	VIANA VIESTIMN / SHMD			INVA0189
	VIAV(K)-SUMAYSUMD			INVA0190
	VII(K) = 1.7VIAV(K)			INVA0131
300	CONTINUE			T NIV A 0102
	WRITE(6,JUTO)			INVAUL92
	WRITE(6, JUT1)		·	1NVA0193
	WRITE(6,0UI2)			INVA0194
	STOP	2. 7.	643	INVA0195
	END			INVA0196
1.34	LIND			INVA0197
/*				

APPENDIX N

BRIEF DESCRIPTION OF THE INPUT TO OZAN

All the input is in NAMELIST format. That is the class name is introduced by an ampersand sign in the column 2 and the class is terminated by a card bearing & END in columns 2 to 5.

A complete listing of the input is shown in Appendix O. The input consists of (in this order)

Card type 1, class name INNM;

NMODES: number of trial shapes;

NOEKIN may be input 1 if the cross sections are ready on tapes to be used by OZAN. A zero indicates that the cross sections will be prepared on tapes throughout the run;

KSREX: 1 for this variable indicates that the eigenvalue(s) for the trial shape(s) will be computed in an integral sense by OZAN. If 0 is input the eigenvalue(s) must be supplied in card INSKEF (see below);

KSR02: 1 for this variable indicates that an eigenvalue for the first trial shape will be computed to compensate the photoneutrons and make the (11) element of the initial value of the reactivity matrix vanish if the reactor is critical at the beginning of the transient. If 0 is input the eigenvalue of the critical reactor must be supplied in card INSKOZ (see below); COEFIC: The correction factor for the photoneutrons. If this number is input 0, the photoneutrons will be ignored;

LFINAL: Denotes the number of the time zone(s);

INPC: 1 for this variable indicates that the initial value(s) of the first precursor amplitude function(s) will be input to the code (generally when the reactor is not at a steady state at the beginning of the transient). 0 indicates that the initial value(s) of the precursor amplitude function(s) will be computed in the code;

LPSN: 1 for this variable indicates that the absorption cross sections will be increased by OMEG X V1(MG) (Input in the next type of card, MG being the neutron group, MG = 1,2,3) for the computation in an integral sense of the eigenvalue of the second shape; otherwise 0 should be input;

LBYD: 1 for this parameter indicates that we intend to continue computations beyond the end of the time zone (TMAX; see below) established to study the transient with the proposed method;

Card type 2, class name INV1;

V1: Neutron inverse velocities, the first one belonging to the fast group;

OMEG: ω , the estimated inverse period that the reactor will assume by the end of the transient;

Card type 3, class name INHU;

HU: the mesh intervals in the r direction;

Card type 4, class name INHV;

HV: the mesh intervals in the z direction;

Card type 5, class name INYL;

YIEL: Relative yields of photons of interest, the first one belonging to the most energetic group of photons;

Card type 6, class name INYJ;

YIEJ: Probabilities of photoneutrons to show up in various - time wise - groups;

NZRO: Total number of photons of interest generated per fission of U^{235} ;

Card type 7, class name INBA;

BETA: the delayed neutron

NBETAl: number of delayed neutron group fraction(s);

NBETA2: number of delayed photoneutron group(s);

Card type 8, class name INF;

FIJ: the initial conditions for the time coefficients; FAMLAM: Decay constant(s) for the delayed neutron(s) [and photoneutron(s)];

Card type 9, class name INATT1;

ATT1: The attenuation coefficients for the various attenuation zones

Card type 10, class name INMVU;

An edit of the time dependent flux will be made for the region framed by the mesh points MV1, MVV in the z direction and, MU1, MUU in the r direction;

Card types 11,12,13,14, class names INUI, INUF, INVI, INVF;

MRUI (1), MRUF(1), MRVI(1), MRVF(1) are the mesh points framing the first attenuation zone (the first two numbers in the r direction and the last two ones in the z direction);

Card type 15, class name INGLK;

MGLK: Number of groups for D, $\Sigma_a, \nu \Sigma_F, \Sigma_F, SGCS_1$ (first group of photons), SGCS₂ (second group of photons), Σ_s , and Σ_D ;

Card type 16, Class name INDV;

MDVIC: Input output device numbers for in this order, D(0), $\Sigma_{a}(0)$, $\nu\Sigma_{F}(0)$, $\Sigma_{F}(0)$, SGCS₁(0), SGCS₂(0), $\Sigma_{s}(0)$,

 $\Sigma_{\rm D}(0)$, D(T), $\Sigma_{\rm s}(T)$, $\nu \Sigma_{\rm F}(T)$, $\Sigma_{\rm F}(T)$, SGCS₁(T),

 $SGCS_2(T), \Sigma_s(T), \Sigma_D(T), D_2, \Sigma_{a_2}, \nu \Sigma_{F_2}$

(Here enter three any numbers to fill a blank in the array), Σ_{s_2} , (another any number to fill a blank in the array), D_1 , Σ_{a_1} , $\nu \Sigma_{F_1}$, (any three numbers), Σ_{s_1} , (any number), where 1

0 stands for the beginning of the transient, T the end of the transient, 1 for the first trial shape and 2 for the second trial shape.

Card type 17, class name INT;

TMIN: time at which the transient starts;

IJUMP: After Every IJUMP times GONCA (the subroutine solving the multimode kinetics Equations) is called, the time

dependent solutions will be printed out;

TUP: is built up out of times at which a complete edit will be made;

NINT: Number of times a complete edit will be made; TUP (NINT) is the end of the time zone established for studying the transient with the proposed method;

NCM1: Degree of the polynomial expansion used in determining the time coefficients (cf. Appendix F);

EPS2: Criteria insuring the convergence of the time coefficients (1. E-1 is good enough for this purpose);

Card type 18, class name IN1;

X1: Macroscopic diffusion coefficients and cross sections in various materials. Input three (-group-) diffusion coefficients for all the materials. Do the same thing for Σ_a , $\nu\Sigma_F$, Σ_F , SGCS₁ and SGCS₂.

Card type 19, class name IN2;

X2: Macroscopic scattering cross sections in various materials. Input first the scattering cross section from group one to group 2 [$\Sigma_{s}(1+1)$], then the scattering cross section from group 2 to group 3 [$\Sigma_{s}(2+3)$] for the first material. Do the same thing for the other materials.

Card type 20, class name IN3:

X3: Macroscopic photoneutron reaction cross sections for various materials;

Card type 21, class name INCS;

NCS: If the first, or the second, or the third, or the seventh element of this array is 2, D_2 , or Σ_{a_2} , or $v\Sigma_{F_2}$ or Σ_{s_2} (in this order) - relative to the second trial shape - s_2 is the same as compared to D_1 , or Σ_{a_1} , or $v\Sigma_{F_1}$ or Σ_{s_1} (in this

order) - relative to the first trial shape. If 1 is input for any of these elements the corresponding cross sections relative to the second trial shape are not equal to those relative to the first trial shape.

Card type 22, class name INNCS;

ND=1, NSSGA=1, NUNSF=2, NSCRT=1, = 4Correspond to NCS (1) = 1, NCS(2) = 1, NCS(3) = 2, NCS(7) = 1 (see above Card type 21);

Card type 23, 24, 25, 26, class names INNRK1, INNRK2, INNRK3, INNRK7;

NRK1: Number of regions in which D_2 is different as compared to D_1 .

NRUI1(1), NRUF1(1), NRVI1(1), NRVF1(1)frame the first region (the first two numbers in the r direction, and the last two ones in the z direction) where D_2 is different as compared to D_1 . NRCC1(1) = 1 is the material number in this region;

XT1(1): the new diffusion coefficients relative to the trial shape in this region;

The same thing is repeated for INNRK2, INNRK3 and INNRK7 relative respectively to Σ_{a_2} , $\nu \Sigma_{F_2}$ and Σ_{s_2} . If any of D_2 ,

 Σ_{a_2} , $\nu \Sigma_{F_2}$ and Σ_{s_2} do not differ from those relative to the first trial shape, the corresponding cards can be dismissed;

Card type 27, class name INSKEF;

SKEF: The eigenvalue(s) of the trial shapes computed in an integral sense. This card is read in only if KSREX is 1 (cf. first type of cards);

Card type 28, class name INSKOZ;

SKOZN: Eigenvalue of the critical reactor, computed in an integral sense;

Card type 29, class name INCDNC;

CSC: This array has eight elements that correspond respectively to D, Σ_{a} , $\nu\Sigma_{F}$, Σ_{F} , SGCS₁, SGCS₂, Σ_{s} and Σ_{D} . If during the transient any of these cross section sets receive a ramp change 1 will be input in the place of the element of interest. Otherwise 2 will be input;

Card type 30, class name INDDNC;

DC, SIGAC, UNSFC, SIGFC, SGCSC, SCATC, SPNRC

These variables are treated the same way the elements of the CSC array (see above Card type 23) are treated. DC=1 will then mean that the diffusion coefficient-set receives a ramp change during the transient;

Card type 31, 32, 33, 34, 35, 36, 37, 38, class names INMRK1, INMRK2, INMRK3, INMRK4, INMRK5, INMRK6, INMRK7, INMRK8 (D, Σ_a , $\nu\Sigma_F$, Σ_F , SCGS₁, SGCS₂, Σ_s , Σ_D);

Confer Card type 21 with the only difference that the

values at the end of the transient, t = TUP(NINT), for those cross sections that vary during the transient will now be input.

Cards, for those cross sections that do not receive any change during the transient, can be dismissed;

Card types 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, class names INSPC, INSTP, INMSK1, INMSK2, INMSK3, INMSK4, INMSK5, INMSK6, INMSK7, INMSK8;

The test that is made for a ramp change through card types 29 up to 38 is now made for a step change.

If LBYD is greater than 1, then the class INT is repeated to characterize the output beyond the time TUP(NINT) input through the first INT (see above, card type A).

APPENDIX O

PROGRAM OZAN

ALONG WITH REQUIRED PREPARATIONS,

PROGRAM RHOL

(The Ramp Change Slope of the Reactivity Matrix Computed through a Perturbation type of Approach) ALLO Set Up (Like Allocate)

ALLUCATE SPACE TJ SAVE VARIOUS CROSS SECTIONS		ALL00001
		ALL00002
// ITOLCA MADMANA DESTON ADDIT OF THE		ALL00003
/*MITID USED=(M940/ 0//1)		ALL00004
$/ \times MAIN I INES=20 CADDE=00 TIME$		ALL00005
//STEP1 EYEC DCM-TEEDD1/		ALL00006
//DD1 DD DSNAME-USEDE DE MOVOV OVV1 FOR TH		ALL00007
// DCG=MIT. STANDARD SOURCE SDACE-11(00 / 50 St at at		ALL00008
// UNIT=3330.V $H = REE = PENTDISK OF CONSTRUCTION$	X	ALL00009
//DD2 DD DSNAME=USERETLE Mg606 $A641$ FCL CA		ALL00010
$// DCB=MIT_STANDARD SOURCE SPACE-11(00)/50 51 0000$		ALL00011
// UNIT=3330. VUL =REE=PENTDISK DISP (NEW CATION	Х	ALL00012
//DD3 DD DSNAME=USERETLE M8696 9461 EUN CC		ALL00013
// DCB=MIT.STANDARD, SOURCE, SPACE=(1400, 150, 51, D) CC1		ALL00014
// UNIT=3330.VII=REF=RENTDISK.DISP-(NEW CATLO)	X	ALL00015
//DD4 DD USNAME=USEREILE.M8690.9441 ESC AT		ALL00016
// DCB=MIT.STANDARD.SOURCE.SPACE=(1600.460.4) BLSC1		ALL00017
// UNIT=3330, VUL=REF=RENTDISK, DISP=(NEW_CATLC)	X	ALL00018
//DD14 DD DSNAME=USERFILE.M8696.9441.EOD IE		ALL00019
// DCB=MIT.STANDARD.SOURCE.SPACE=(1600-(50.5) PLSE)		ALL00020
// UNIT=3330, VUL=REF=RENTDISK, DISP=(NEW, CATLC)	X	ALL00021
1/DD15 DD DSNAME=USERFILE.M8696.9441_ESI_GA		ALL00022
// DCB=MIT.STANDARD.SOURCE.SPACE=(1600.(50.5).BLSE)		ALL00023
// UNIT=3330, VUL=REF=RENTDISK.UISP=(NEW.CATIG)	X	ALL00024
//DD16 DD USNAME=USERFILE.M8595.9441.FUN.SF.		ALL00025
// DCB=MIT.STANDARD.SOURCE, SPACE= (1600.150.5).RLSE).	v	ALL00026
// UNIT=3330, VOL=REF=RENTDISK, DISP=(NEW, CATLG)	× ·	ALL00027
//DU17 DD DSNAME=USERFILE.M8690.9441.FIS.GF.		ALL00028
// DCB=MIT.STANDARD.SOURCE,SPACE=(1600,(50,5),RLSE).	v	ALLU0029
// UNIT=3330, VUL=REF=RENTDISK, UISP=(NEW, CATLG)	^	ALL00030
//DD18 DD DSNAME=USERFILE.M8696.9441.TRD.IF.		ALL00031
// DCB=MIT.STANDARD.SOURCE,SPACE=(1600,(50,5),RLSE).	Y	ALL00032
// UNIT=3330, VUL=REF=RENTDISK, DISP=(NEW, CATLG)	^	ALL00033
//DD19 DD DSNAME=USERFILE.M8696.9441.TSI.GA.		ALL00034
// DCB=MIT.STANDARU.SOURCE, SPACE=(1600, (50,5), RLSE).	Y	ALL00035
	A	ALLUUU36 4

// UNIT-2220 VOL-DEE-DENTOLEY OF CO INCH OF CO			
1/10022 DD DSNAME-HEED FILE NOVOL OF (NEW, CATLG)			ALL00037
1/ DCP-MIT STANDADD COUDER PILE M8696.9441.FSC.AT,			ALL00038
// UNIT-2220 NON- 200 SUURCE, SPACE= (1600, (40, 4), RLSE),	Х		ALL00039
// UNIT=3330, VUL=REF=RENTDISK, DISP=(NEW, CATLG)			ALL00040
770023 DU USNAME=USERFILE.M8696.9441.TSC.AT,			41100041
// DCB=MIT.STANDARD.SOURCE,SPACE=(1600,(40,4),RLSE),	х		A1100042
// UNIT=3330, VJL=REF=RENTDISK, DISP=(NEW, CATLG)	· · ·		AL 1 00042
//UD24 DD USNAME=USERFILE.M8696.9441.FSG.CS.			ALL00045
// DCB=MIT.STANDARD.SOURCE, SPACE= (1600, (100, 10), BISE).	×		ALL00044
// UNIT=3330, VOL=REF=RENTDISK, DISP=(NEW.CATLG)	^		ALL00045
//DD26 DD USNAME=USERFILE.M8696.9441.ESP.NR.			ALLUUU46
// DCB=MIT.STANDARD.SDURCE.SPACE=(1600.140.4).PLSEN			ALL00047
// UNIT=3330.VUL=REF=RENTDISK.DISP-(NEW CATLC)	X		ALL00048
//DD28 DD DSNAME=USERFILE M8696 9661 HED IC			ALL00049
$//$ DLB=MIT_STANDARD_SOURCE_SPACE=(1400_4E0_E) or CEN			ALL00050
// UNIT=3330.V $H = REE = RENTDISK DISD - (NEW CATEO)$	х		ALL00051
//DD29 DD DSNAME=USEDETLE M9604 OZZI USZ CA			ALL00052
// DEBENIT STANDARD SCHREE CDARE // CO. / CO. St. St. St. St.			ALL00053
/(UNIT = 3330) MU = 61.(=0.(NTOT)(0.0160), (50.5), RLSE),	X	:	ALL00054
// ONIT-SSSO, VOL=REF=RENTDISK, DISP=(NEW, CATLG)			ALL00055
// DCB-MIT CLAND (DERFILE .M8690.9441.HSC.AT,			ALL00056
// DCD=MII.SIANDARD.SUURCE, SPACE=(160C, (40, 4), RLSE),	X		ALL00057
// UNII=3330, VUL=REF=RENTDISK, DISP=(NEW, CATLG)			ALL00058
17			ALL 00059

TRSF Set Up (Like Transfer)

TRANSFER VARIUUS FLUXES(FIRST SHAPE AND ITS ADJDINT.ETC) TO THE CORRESPONDING	TREEAAA
DATA SETS IN URDER TU MAKE USE OF THEM DURING THE DZAN RUN	TRSFUUUI
	TRSFUUUZ
	TRSF0003
// 'TULGA YARMAN', REGION=128K, CLASS=A	TRSF0004
/*MITID USER=(M8696,9441)	TRSF0005
/*MAIN LINES=20.CARDS=00.TIME=3	TRSF0006
/*SRI LOW	TRSF0007
//STEP1 EXEC FORCGO	TRSF0008
//C.SYSIN DD *	TRSF0009
C PROGRAM TRANSFER	TRSF0010
C	TRSF0011
C CUPY FRUM EXTERMINATOR 2'S DATA SET THE EIDST SHADE AND TTO ADJOINT WITH	TRSF0012
C NECESSARY MUDIFICATIONS ONTO TAPES WHICH WILL BE USED BY OTAN	TR SF 0013
C	TRSF0014
DIMENSION PSI(40.3.48). PHI(3.48.40)	TRSF0015
C	TRSF0016
REWIND 20	TRSF0017
DO 100 I=1,48	IRSF0018
READ(20) ((PSI(J-K-I)) $J=1.40$) $K=1.31$	IRSF0019
100 CUNTINUE	TRSF0020
1000 FURMAT(1P5E14.6)	TRSF0021
DO 200 MG=1,3	TRSF0022
DO 200 MV=1,48	1RSF0023
DO 200 MU = 1.40	TRSF0024
200 $PHI(MG,MV,MU) = PSI(MU,MG,MV)$	TRSF0025
DO 210 MG=1.3	TRSF0026
DO 210 MV=1.48	TRSF0027
210 $PHI(MG,MV,1) = PHI(MG,MV,2)$	TRSF0028
REWIND 10	TRSF0029
WRITE(10,1000) PHI	TRSE0030
REWIND 10	IRSF0031
DO 125 J=1.2	IRSF0032
READ(20)	TRSF0033
125 CONTINUE	IRSF0034
DO 150 1=1.48	TRSF0035
	TRSF0036
	4

		TRSF0037
	READ(20) ((PSI(J,K,I),J=1,40),K=1,3)	TRSF0038
150	CONTINUE	TRSF0039
	DU 300 MG=1,3	TRSF0040
	DO 300 MV=1,48	TRSF0041
	DO 300 MU=1,40	TR SF 0042
300	PHI(MG,MV,MU) = PSI(MU,MG,MV)	TRSF0043
	DU 310 MG=1,3	TRSF0044
	DU 310 MV=1,48	TR SF0045
310	PHI(MG, MV, 1) = PHI(MG, MV, 2)	TRSF0046
	REWIND 11	TRSF0047
	WRITE(11,1000) PHI	TRSF0048
	REWIND 11	TRSF0049
	STOP	TRSF0050
i.	END	TRSF0051
/*	DENCEA KISL DISP=(01 D. PASS)	TRSF0052
116.F	T20FU01 DD DSNAME=USERFILE.M8696.9441.DENGEA.NISTUDIST - TOLOT NOT	TR SF0053
116.F	TIOFOOL DD DSNAME=USERFILE.M8696.9441.ECP.SI,DISPECTO	TRSF0054
11G.F	TILFUOL DO DSNAME=USERFILE.M8696.9441.FQA.DJ,DISP-000	TRSF0055
/*		

PROGRAM OZAN

	이 가슴 옷에 가는 것 같아. 것 같아. 가는 것 같아. 아이는 것 같아. 나는 것 같아. 말했는 것이 있는 것 같아. 것이	
		and a second
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//	TOLGA YARMAN', PEGION=325K, CLASS=A	GZANOOOI
7# SP	ILGW	DZANCOCZ
/× 1	110 USER = (M8696, 9441)	DZAN0002
/ 3' M A	IN LINES=20, CARDS=30, TIME=25	07410000
// 51	EPI EXEC FORCGC	OZANCOOS
//(.	SYSIN DD *	GZANDOOG
C.	FRUGRAM OZAN	BZAN0008
С	그는 그는 것 같은 것 같	OZANODOZ
C	, UZAN,, MEANS POET IN TURKISH	UZANUUU8
C		07AN0009
8 5	COMMON/OZO/SIGA, UNSF, SGCS, SCAT, PSI, W	OZANCOIU
	COMMON/DZ11/C, DNC, KSRCZ, SKOZN, NDPSI, NDW, HU, HV, R	074N0011
	CCMMCN/0Z12/CC,SIGAC, UNSFC, SIGFC, SGCSC, SCATC, SFNRC, ATTC	UZANUU12
•	COMMON/OZ2/NMODES, II, KK	UZANUU13
	CCMMCN/0Z3/TMIN, TMAX	DZANU014
	COMMON/D Z4/NEETAL, NBETA2, NBETA, NBET1	OZANO015
	COMMON/OZEK/MGLK, MDVIC	02AN0018
	CCMMEN/UZETA/NHS,NHK,NHUI,NHUF,NHVI,NHVF,NHCC,X0Z	02AN0017
	COMMON/FOZI1/LLL, LFINAL, KSREX, FLAP1, ALAP1, DIFF1, SKFF	UZANU018
	COMMON/FOZIZ/ISD, ISSA, ISUF, ISSF, ISSG, ISST, ISSP, ISATT	CZANOD20
	CCMMEN/FUZ13/ND, NS IGA, NUNSF, NSCAT	07AN0020
	COMMON/DZ2FZ1/V1	0ZAN0021
24	CCMMEN/DZ3FZ1/GENTME	024N0022
	CCMMCN/DZ4FZ1/LAPN,VL/PN	0ZAN0023
	COMMON/FCFA/COEF, MCOF	DZANOU24
	COMMEN/DZFZ2/BETA, E, FMAR, VFMAR, BETR, VBETR, BEC11, BEC21	UZANUU25
	COMMON/F2F4/bSC, JNPC	UZANUU26
	COMMON/0Z1FZ3/NZR0,COEFIC,S1,YIEL,YIEJ,MRUI,MRUE,MRVI,MRVE,ATT	0ZAN0027
	CCMMEN/DZ2FZ3/PHPR,VPFPR,DPPR,VDPPR, BEC12, BEC22	02AN0028
	COMMON/UZFZ4/FIJ, FAMLAM, RUC1, RUC2, RUC3, BEC1, BEC2, BEC3, FAMERE, INPC	0ZAN0029
	COMMON/FZ4HT/BE	0ZAN0030
	CCMMCN/OZGON/IJUMP, EFS2, NCM1, NCOEF, RCJ, EATA, J3	OZANO031
	COMMON/DZGDHT/FAMCLM	07AN0032
	CCMMCN/GCZHT/FIF	UZANUU33
	COMMON/OZHST/ATT1,ATT2,MU1,MUU,MV1,MVV	UZAN0034
C		UZANUU 35
		UZANU036

	INTEGER C.DNC	
	INTEGER DOAS IGAC UNSEC STOFE SCATE SCORE CONDO ATTO	OZANOO37
	REAL NZRO	CZANOO38
	REAL LADN	DZANC039
<i>с</i>	NEAC LAPN	UZAN0040
	DINENSION STONIS (2. 20) CONTRACTOR	GZAN0041
	1 MERSION SIGA(3,47,39), SCAT(2,47,39), SGCS(2,3,47,39), HU(39),	OZANO042
	2NOVI (10), MRUI (10), ATT 1(2,10), ATT 1(10), ATT2(10), MRUI (10), MRUF (10),	CZANO043
	2) RVI(10), MRVF(10), YIEL(2), YIEJ(9), BETA(6), TUP(20), FIJ(2), FIF(2),	GZAN0044
	SNUW(2), NUPSI(2), SKEF(2), FAMLAM(15), FAMPRE(2, 15), FAMCLM(2, 15),	0 Z AN 0045
	4EECII(2,2,6), BEC21(2,2,6), BEC12(2,2,5), BEC22(2,2,9), DPPR(2,2),	UZAN0046
	DVDPPR(2,2), GENIME(2,2), BEC1(2,2,15), BEC2(2,2,15), BEC3(2,2,15),	DZAN0047
	OBATA12, 2, 15), RUC1(2, 2), RUC2(2, 2), RUC3(2, 2), RCJ(2, 2)	0ZAN0048
	UIMENSION PRULL (4,4), PHALF(4,4), BFULL(4), BHALF(4), BETR(2,2), VBETR	CZANO049
	1(2,2), LAPN(2,2), VLAPN(2,2), FMAR(2,2), VFMAR(2,2), PHPR(2,2), VPHPR	07AN0050
	2(2,2), MGLK(8), MDVIC(32), NHS(8), NHK(8), NC SCU(8), NHUI(20,8),	CZAN0051
	3NHUF (20,8), NEVI (20,8), NHVF (20,8), NHCC (20,8), X0Z (3,20,8)	C7AN0052
	DIMENSION PSI(3,43,4C), W(3,48,40), UNSF(3,47,39), S1(2,10),	D7AN0053
~	1CUEF (3,47,39), WSC(2), LEYC(5)	07AN0054
· · ·		· 074N0055
		07AN0056
~	LNU=2	GZAN0057
		07AN0058
	CLIKE CHANGE, DNC LIKE DOES NOT CHANGE (DURING THE TRANSIENT)	E74N0059
C		07AN0060
	NDPSI(1) = 10	07 AN 006 1
	NDPS1(2) = 12	07AN0062
	NDW(1) = 11	07AN0063
~	NDW(2) = 13	02AN0064
C		07400065
	NAMELIST/INNM/NMODES, NCEKIN, KSREX, KSRCZ, COEFIC, LFINAL, INFC, LPSN,	07 ANI 0066
	1LBYD .	074N0067
	NAMELIST/INV1/V1,OMEG	07410067
	NAMELIST/INHU/HU	02 AN 0000
	NAMELIST/INHV/HV	BZAN0089
	NAMELIST/INYL/YIEL	0740070
	NAMELIST/INYJ/YIEJ,NZFO	07AN0071
		ULANUU/2 (

NAMELISI/INBA/BETA, NEETAI, NBETA2	0ZAN 0073
PAPELIST / INF/FIJ, FAMLAN, FAMPRE	0ZAN0074
NAMELIST/INMVU/MVL,MVV,MUL,MUU	0ZAN 0075
NAMELISI/INATTI/ATTI	0ZAN0076
NAMELIST /IN ATT2/ATT2	OZANO077
NAMELISI/INUI/MRUI	DZAN0078
NAMELIST/INUF/MRUF	CZANO079
NAMELISI/INVI/MRVI	GZANOO80
NAMELIST/INVF/MRVF	OZANO081
NAMELIST/INGLK/MGLK	CZANO082
	OZAN CO83
C MOLKILT IS THE NUMBER OF GROUPS FOR D	0ZAN0084
	CZANO085
NAMELISI/INDV/MDVIC	DZAN0086
	GZANOO87
C POVICITY IS THE INPUT DUTPUT DEVICE FOR D AT THE BEGINNING OF THE TRA	NSIENT OZANOO88
	DZAN0089
NAMELISI / INSKEP/SKEP	CZANO090
NAMELIST/INSKUZ/SKUZ/	OZAN COS1
NAMELIST/INT/IMIN, IJUMP, TUP, NINT, NCM1, EPS2	UZAN0092
PEADLE TAAMA	DZAN0093
PEAD (D , INN)	OZAN0094
DEAD (E INLU)	OZAN0095
DEAD(E INHV)	OZANCOS6
DEAD(5, INHV)	0ZAN 0097
PEAD(E INVIN	OZAN0098
PEAD(5,1NTJ)	. OZANCOS9
READ (S. INE)	OZANO100
PEAD (5, INATI)	OZANO101
	OZANO102
DEAD (S INHIV)	CZANO103
READ(S,INUE)	CZANO104
PEAD(5, TNVT)	0ZAN 0105
DEAD (S INVI)	CZANO106
PEADIS INCLUS	0ZAN 01 07
NCAU(D)INGLNJ	OZANO108

	DEAC /E THOUS		
	PEAD (S INUV)		OZAN0109
r	REAU(D)IN()		UZANC110
1000	EG DM AT /TELL EL		OZANO111
1000			OZAN0112
600	FORMAT (IH., 20X, 'INPLT OPTIONS'///)		OZANO113
201	FURMAT (IH , THE NUMBER OF THE TRIAL FUNCTION(S) USED IS ', II)		17AN0114
602	FURMAT (1H , CROSS SECTION ARRAYS WILL BE SENT ON TAPES /)		17AN0115
603	FORMAT (1H , CROSS SECTION ARRAYS ARE SUFFOSEDLY READY ON TAPES //		BZANOL14
604	FORMAT (1H , 'A SEARCH FOR THE EIGENVALUE(S) OF THE TRIAL FUNCTION		07410117
	IS) WILL BE MADE TROUGH THE CODE!)		07 410119
605	FORMAT (1H , THE EIGENVALUE(S) OF THE TRIAL FUNCTION(S) ARE SUPPOS		07400110
	IEDLY KNOWN')		07AN0120
605	FORMAT (1H , CONSIDERING THE PHOTONEUTRONS A SEARCH FOR THE EIGENV		07 ANO121
	1 ALUE OF THE STEADY STATE SHAPE WILL BE MADE TREUGH THE CODE! /)		02AN0121
607	FORMAT (1H , THE PHOTONEUTRONS HAVE BEEN ESTIMATED TO BE NOT IMPOR		0ZAN0122
	TANT FOR THE TRANSIENT STUDIED //)		07 AN 01 24
608	FORMAT(1H , "IT HAS BEEN CHOSEN", 12, " TIME ZONE(S) FOR THE TRANSIEN		02AN0125
	IT STUDIED")		07AN0126
6 08 1	FORMAT (/1X, 'THE PRECURSOR CONCENTRATIONS WILL BE COMPUTED WITHIN		07400120
]	ITHE CODE //)	1.1	07AN0129
6082	FORMAT (1H , THE PRECLESSER CONCENTRATIONS ARE INPUT TO THE CODE!)		G7 ANO1 20
6083	FORMAT (1H , THE REACTOR WILL BE UNIFORMLY POISONED FOR CUMPUTATIO		02AN0129
· · · · · ·	IN CF THE EIGENVALUE CF THE SECUNC SHAPE //)		OZANOI 31
609	FORMAT('1H , 'THE INITIAL CONDITION FOR THE FIRST TRIAL FUNCTION IS		DZANOISI
·]	1 ',E11.5)		0ZAN0132
610	FORMAT(1H , THE INITIAL CONDITION FOR THE SECOND TRIAL FUNCTION IS		OZANO133
· 1	1 ',E11.5)		OZANO134
611	FORMAT (/1X, 'AN EDIT OF THE TIME DEPENDENT FLUX WILL BE MADE (IF NM		07AN0135
]	LODES.GT. 1)AT THE SELECTED POINT(S) LCCATED BETWEEN THE MESHES!//7X		0ZAN0130
2	2, 12, ', ', 12, ' IN THE Z DIRECTION AND '/7X, 12, ', 12, ' IN THE B FIRE		OLANOI31
. 3	BCTICN'//)		CZANO130
612	FORMAT(1X, FIRST TIME ZONE //7X, TIME ORIGIN IS AT . F10-8/7X, AND		UZANU139
1	LITUCE FUNCTIONS PRINTED AT INCREMENTS OF '. 12/7X. 'A CONFLETE EDIT		CZANOIAI
2	WILL BE MADE(IF NMCCES.GT.1) AT TIMES: 1/(7X.10(FA.6.2X))/(7X.10)		OZANO141
. 3	BF8.6,2X1)/)		OZANO142
6121	FORMAT (/7X, "THERE ARE THEN ", 12," TIME STEPS !///)		ULANU143
			ULANUI44

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승규가 친구에 집에 집에 있는 것이 같아. 이렇게 집에 집에 집에 있는 것이 같아. 이렇게 집에 있는 것이 같아. 이렇게 하는 것이 같아. 이렇게 많이 하는 것이 같아. 이렇게 많이 하는 것이 같아.	
이 같이 있는 것은 것은 것은 것이 같이 있는 것이 같이 있는 것이 같이 많이 많이 많이 있는 것이 없다. 것이 같이 많이 많이 많이 많이 없는 것이 없는 것이 없다. 것이 없는 것이 없는 것이 없는	
그는 것 같은 것 같	
620 FORMAT (1H1,////21X, 'SEARCH FOR THE EIGENVALUE (S) OF THE TRIAL F	OZAN0145
1UNCTION (S) •///)	OZANO146
621 FORMAT (/////1X, 'KEFF1=', F10.8, 4X,' KEFF2=', F10.8//)	0ZAN0147
622 FORMAT (1H1,////21X, 'SEARCH FOR THE EIGENVALUE OF THE STEADY STAT	OZANO148
1E SHAPE CONSIDERING THE PHOTONEUTRONS*///)	OZANO149
623 FORMAT (/////1X, 'KEFFCZAN=', F10, 8//)	OZAN0150
624 FORMAT(1H1, 'NEW TIME ZONE'/7X, 'TIME ORIGIN AT ', F10. 8/7X, 'AMPLITUD	OZAN0151
1E FUNCTIONS FRINTED AT INCREMENTS OF ', 12/7X, 'A COMPLETE EDIT WILL	OZAN0152
2 BE MADE(IF NMUDES.GT.1) AT TIMES; 1/(7X,10(FE.6,2X))/(7X,10(F8.6,	CZANO153
32X))/)	UZAN0154
7024 FORMAT (/////1X, 'THE REACTOR HAS ALREADY BLOWN UP '/7X, 'NO NEED TO	OZAN0155
1 CONTINUE')	OZANO156
7025 FORMAT (//////7X, 'THE CRITERIUM(EPS2) INSURING THE TIME DEPENDENT	0ZAN 0157
1 SOLUTION(S) TO CONVERGE , IS TOO SMALL .)	0ZAN0158
C	OZAN0159
WRITE (6,600)	OZANO160
WRITE (6,601) NMODES	OZANO161
IF (NOEKIN.EG.1) GO TC 613	OZANO162
WRITE(6,602)	OZAN0163
CO TO 614	CZAN0164
613 WRITE(6,603)	OZANC165
el4 IF (KSREX.EQ.1) GO TO e15	OZANO166
WRITE(6,605)	OZANO167
	OZAN0168
(1) WK11E(0, 604)	OZAN0169
CIO IF (KSRUZ-EU-I) GU (L 617	0ZAN0170
IF (CUEFIC.NE.U.) GU IU 618	0ZAN0171
WR 11 E(6,607)	GZAN0172
GUIL 618	OZAN 0173
617 WRITE(6,606)	OZANO174
618 WRITE(6,603) LFINAL	UZAN0175
IF (INPC.EQ.1) GU TO 6181	OZAN0176
WK11E(6, 6081)	CZANO177
	OZAN0178
6181 WKI (E(6,6082)	0ZAN 0179
618Z CONTINUE	GZANO180
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	IF UPEN SO ON OF THE MARK		
	$\frac{1}{10} (1000) = \frac{10000}{1000} = \frac{1000}{1000} = \frac{10000}{1000} = 10$	OZANO181	
6102	$\frac{1}{1} \frac{1}{1} \frac{1}$	OZANO182	
0192		CZAN0183	
	APTTELE ELON ET LON	OZAN 01 84	2
	WAIIE(0,010) FIJ(2)	OZANO185	
410	WRITE(0, 611) MVI, MVV, MUI, MUU	CZANO186	
619	WRITE(0,612) IMIN, IJUNF, (TUP(IT), IT=1, NINT)	OZANO187	
	WRITE(C, C121) NINT	OZANO188	
	NBETA=NBETA1+NBETA2	UZANO189	
	NBE11=NBE1A1+1	0ZAN0190	
•	LJ 2022 MR=1,10	GZAN0191	
2000	$A \vdash I \mid I $, MR) = $A \vdash I \mid (MR)$	OZAN C192	
2022	CUNTINUE	07AN0193	
	15 (ATTC . EQ. C) GO TO 1024	UZAN0194	
1024	GU IL 1025	DZAN0195	
1029	FEAL(5, INATI2)	0ZAN0196	
2022	Lu 2023 $MR=1,10$	OZANO197	
2025	$A \mid I \mid (2, MR) = A \mid I \mid 2(MR)$	UZAN 0198	
1025	CONTINUE	• CZAN0199	
		0ZAN 0200	
	CALCULATION OF R(MU)	0ZAN0201	
L		0ZAN0202	
	$F(1) = 0_{0}$	UZAN0203	
	$U_{1} = 1030 \text{ MU} = 2,40$	UZANU204	
1020	R(MU) = R(MU-1) + HU(MU-1)	0ZAN0205	
1000	UNTINUE	0ZAN 0206	
	11=NMODES	CZANO207	
	KK=11	OZAN 02 C8	
		0ZAN 0209	
		UZANO210	
	JNPC = I NPC	UZAN0211	
	IMAX = IUP(NINT)	UZAN0212	
	NDIM=NMUDES#NCM1	OZANO213	
	NUUEFENUMIFI	0ZAN0214	
-	IF UNDER INOEGOID GU TO 511	GZANO215	
· ·		UZANO216 W	
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		•.	

ст., к

c	CALL EKIN(COEFIC, SIGA, SGCS, SCAT)	0ZAN 0217
0	DEAD(14 1000) STCA	OZANO218
	PENTND 14	OZAN0219
		0ZAN0220
	WRITE(1,1000) SIGA	OZANO221
	REWIND 1	UZAN0222
	READ(15, 1000) SIGA	OZANO223
3	REWIND 15	OZANO224
	WRITE(2,1000) SIGA	OZANO225
	REWIND 2	CZANO226
· · · ·	READ(16,1000) SIGA	DZANC227
	REWIND 16	DZAN0228
	WRITE(3, 1000) SIGA	OZANO229
1	REWIND 3	0ZAN0230
	REAC(22,1000) SCAT	UZAN0231
	FEWIND 22	OZAN0232
	WRITE(4,1000) SCAT	0ZAN0233
	REWIND 4	GZAN0234
C ·		0ZAN 0235
. 511	CALL DATA3(DNC)	0ZAN0236
5	CALL THEEND (MGLK, MOVIC, DNC, SIGA, SCAT)	0ZAN0237
С		OZAN0238
· · · · ·	IF ((NMODES.EQ.1).OR. (LPSN.NE.1)) GO TO 5111	DZAN0239
C		OZAN0240
	CALL POISON(SIGA, OMEG, V1)	0ZAN0241
C		OZANO242
5111	CONTINUE	. DZAN0243
	IF (KSREX.EQ.1) GO TO 500	UZAN0244
	FEAD(5, INSKEF)	CZAN0245
	GD TC 502	OZAN0246
500	CONTINUE	UZANO247
	WRITE(6,620)	07AN0248
С		0ZAN0249
	CALL FILIZI	0ZAN0250
С		07AN0251
	WRITE(5,621) (SKEF(IS), IS=1, NMBDES)	07 ANO 252
		ω

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÷			
	50.7		
-	. 502	IF (KSRUZ.EQ.1) GD TC 504	OZAN0253
		PEADLE INCLOSI GUILI SUZI	0ZAN 0254
		CO TO FOX	0ZAN0255
	5021	CU 10 000 CK07N-CKCE(1)	UZAN0256
	5021	SNULR=SNEF(1)	0ZAN 0257
	-00	NSREA=U	OZANO258
0	•	FSRUZ=0	OZANO259
C	507	CALL DATA 20 DNC N	0ZAN0260
ſ	101	CALL DATAZIONUT	0ZAN0261
C.			DZAN0262
0	•		OZANO263
		CALL DASSINGSKE DAG NEWIG STOR SOCO CONTA	UZANO264
	500	CALL PASSINCENCIN MOVIC PARTICISICA, SECS, SCAT)	DZAN0265
	0 -	CALL DATALONGA MOVIC, DNC, SIGA, SGCS, SCAT, NC SCC)	DZANO266
		CALL STEPINGIK MOVIC INC SICA SCCS SCATA	OZANO267
C		CALL STEPTIOLK, MOVIC, LNC, SIGA, SULS, SLAT)	OZANO268
	·	TE (111. EC. 1) GO TO EC3	GZANO269
		READ(E.INT)	OZANC270
ě.		WRITE(6.624) TMIN, THEND (THD (TT) IT-1 NINT)	OZAN0271
		WRITE(6.6121) NINT	OZANO272
а.		TMAX=TUP (NINT)	OZAN0273
c			OZANO274
• •	503	CALL FTLT71	DZAN0275
	,	CALL FILIZ	0ZAN 0276
С			UZANOZ77
		IF (COEFIC.NE.O.) GO TO 508	UZAN 0278
÷.,		CC 520 I=1. II	UZANO279
		DO 520 K=1.KK	UZANO280
		$PHPR(I \cdot K) = 0$	UZANU281
		VPHPR(I,K)=0	UZANO282
	- X	EPPR(I,K)=0	UZANO283
		VDPPR(I, K) = 0	UZANO284
		D') 520 J=1.NPETA2	UZANO285
		BEC12(I.K.J)=0.	UZANO286
		EEC22(I, K, J) = 0	UZAN0287
			OZAN0288

	:20	CUNTINUE	OZAN0289
~		GU TC 510	DZAN0290
C			OZAN0291
	508	CALL FILIZ3	UZAN0292
	510	CALL FILIZA	UZAN0293
Ç			07AN 0294
		GO TO 512	17 AN 0295
	504	CONTINUE	07410206
		WRITE(6,622)	02AN0290
		I I = 1	02AN0291
		κ K = 1	02400290
C			07410299
		CALL FILIZ3	OZAN0300
С	1		UZANUSUI
		SKOZN=-FLAP1/(ALAP1-CIEF1-PHPR(1,1)-DPPR(1,1))	UZAN 0302
		WRITE(6,623) SKCZN	UZANU3U3
		II = N MODE S	07AN0304
		KK=NMODES	0ZAN0305
		60 TC 506	UZAN0306
	F12	TMA X = THP(1)	. UZAN0307
<i></i>		IF (MMM_EQ_0) GO TO 1004	0ZAN 0308
		C7 1093 1=1. II	0ZAN0309
2 ⁰⁰ 0	- 6	$E_{0}^{0} = 1093 \text{ K} = 1.4 \text{ K}$	0ZAN0310
	•	BOCI(I-K) = BOI(I-K)	UZAN0311
		DO = 1093 $I=1$ NRETA	CZAN0312
1	093	$\frac{1}{1} = \frac{1}{1} = \frac{1}$	OZAN0313
1	0.24	CONTINUE	CZAN0314
c 1	0.2.5	CONTINUE	OZAN0315
~		CALL CONCALNETM DEUL DUALE DEUL DUALES	0ZAN0316
r		CALL GUNCATINUIN, PFOLL, PHALF, BFULL, BHALF,	0ZAN0317
0		TE (12 CE 20) CC TC 5000	DZAN0318
	- X-		UZAN0319
		$\begin{array}{c} UU = 0 \\ U = 1 $	OZAN0320
E	041	FICH-FICITI	OZAN0321
2	0.41	10 (1ADS(FIFM)06E010E35)0UR, (ABS(FIFM)0LE010E-35)) GO TO 5800	0ZAN0322
C	,	IF INMUDES.EG.IJ GU IL 513	OZAN0323
6			17 110324
<u>_</u>	CALL HASAT(BATA, GENTME, ROJ)	0ZAN 0325	
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Ľ.		OZANO326	
	13 IF (NINI-LT-2) GU TU 7032	0ZAN0327	
	UJ 1032 NI=2, NINT	0ZAN 0328	
-		DZAN0329	
	IMA X = IUP(NI)	UZAN0330	
	10311=1,11	CZAN0331	
1	LU 1031 K=1, KK	OZAN0332	
	RUCl(I,K)=RCJ(I,K)	OZAN0333	
	LU 1031 J=1, NBETA	CZAN0334	
-	BFC1(I,K,J) = BATA(I,K,J)	0ZAN 0335	
10	131 CUNTINUE	02 AN 03 36	
С		07AN0337	
	CALL GUNCA(NEIM, PFULL, PHALF, BFULL, BHALF)	0ZAN0338	
C		CZAN0339	
	1F (J3.GE.30) GD TO 5900	OZAN0340	
	DO = 5C42 I = 1, II	0ZAN 0341	
	FIFM=FIF(I)	GZAN0342	
. 50	42 IF ((ABS(FIFM).GE.1.E35).GR. (ABS(FIFM).LE.1.E-35)) GO TO 5800	· DZAN0343	
0	IF (NMUDES.EC.1) GO TO 1C32	DZAN0344	
C		OZAN0345	
	CALL HASAT(BATA, GENTME, ROJ)	0ZAN0346	
· · C		CZAN0347	
10	32 CUNTINUE	GZAN0348	
7,0	32 CONTINUE	0ZAN 0349	
	IF (LBYD(LLL).EC.0) GC TO 1033	GZAN0350	
	READ(5,INT)	OZAN0351	
	WRITE(6,624) TMIN, IJUMP, (TUP(IT), IT=1, NINT)	JZAN0352	
	WRITE(6,6121) NINT	0ZAN0353	
	LBYD(LLL)=0	DZAN0354	
		0ZAN0355	
1.0	GU 10 512	UZAN0356	
1 C	33 IF (LLL. EQ. LFINAL) GC TO 5000	0ZAN 0357	
	LLL=LLL+1	DZAN0358	
~ ~	GJ 1 L 507	0ZAN 0359	
20	UU WKI (E(0, /024)	0ZAN0360,	
		ω (π	

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		그는 것 같은 것 같		
		CO TC 5000		0ZAN0361
	5900	WRITE(6,7025)		07AN0362
	5000	CONTINUE		07 AN 0363
		STCP		0ZAN0364
		END .		OZAN0365
		SUBRUUTINE EKIN(COEFIC.D.SGCS.SCAT)		07AN0366
	C			C7ANC367
	C THI	S SUBROUTINE WILL MAKE UP THE CROSS SECTION ARRAYS AND WILL SEND THE		07AN 0368
	C RES	ULTS TO THE DATA CELLS		07AN0369
	С			07AN0370
	С,,	EKIN ,, MEANS SEED IN TURKISH		0ZAN0371
	С			DZAN0372
	C A P	FOVERB SAYS ,,WHATSCEVER A MAN SOWETH THAT ALSO SHALL HE REAP,,		UZAN0373
	C '			CZAN0374
		CCMMCN/CZEK/MGLK,MCV1C		OZAN0375
	C			0ZAN0376
		DIMENSION X1(3,23,6),)2(2,23), X3(2,23), X(3,23,8), D(3,47,39),		OZAN0377
		1SGCS (2,3,47,39), SCAT (2,47,39), MGLK(8), MDVIC(32)	: 	OZANC378
	C			. DZAN0379
1	C CAT	A FOR D, SIGA, NUSIGF, SICF, SECONDARY GAMMA RAY CROSS SECTION		OZAN0380
	C PHO	TEN GROUP I AND PHOTON GROUP 2 (STEADY STATE)	• 1 Č	OZAN0381
	C	NAMEL TOT ATALA ANA		CZAN0382
- 4	<u>^</u>	NAMELISI/INI/X1		CZAN0383
	C FAT	A FOR SCATE SCATTER INC CROSS SECTION COTSADE AT TEL		OZAN0384
	CLAP	PUR SCAT; SCATTERING CRUSS SECTION (STEADY STATE)		CZAN0385
×	C	NAMELIST / IND 180		0ZAN0386
	C I	NAMELIST/INZ/XZ		UZANO387
	C DAT	A EOD SOND. DESTANCHIERN DEACTION COOSS SECTION (STEARY STATE)	· *	CZAN0388
	COAL	A TER SPAR, PETEREOTREN REACTION CRUSS SECTION (STEALY STATE)		UZANU389
	C	NANELIST / IN3/X3		CZANU390
	9000	FORMAT(7F11, 5)		OZAN0202
		READ(5.IN1)		07400392
		$READ(5 \cdot IN2)$		07410393
		READ(5, IN3)		07AN0395
	C .			07AN0396
				CERIOS SU

	C STE	EADY STATE PICTURE	07410357
	C		07410399
		CU 153 K=1,8	074N0399
		IF ((COEFIC.EQ.O.).ANC.((K.EQ.4).OR.(K.EC.5).OR.(K.EQ.6).OR.	07AN0400
		1 (K. EQ. 8))). GO TO 153	07400401
	2	NDEVC=MDVIC(K)	G7AN0402
		NGL=MGLK(K)	CZANO402
	· • .	IF (K.E0.7) CO TO 17	UZANU4U3
		IF (K.EQ.8) GO TO 18	
		DO 80 MC=1,23	0ZAN0405
		CC = 80 LG=1, MGL	OZANO400
		X(LG,MC,K) = X1(LG,MC,K)	0ZAN0407
	80	CONTINUE	UZANU4U8
	1	GU TE 20	UZAN0409
	17	00 85 MC=1,23	UZANU41U
		EO 85 LG=1, MGL	0ZAN 0411
		X(LG,MC,K) = X2(LG,MC)	07AN0412
	85	CONTINUE	0ZAN0415
	•	GƏ TU 20 .	07 ANO414
	18	DO 86 MC=1,23	• UZANU415
3.48		CO 86 LG=1, MGL	UZANU410
		X(LG,MC,K)=X3(LG,MC)	UZANU417 OZANO419
14	. 86	CONTINUE	07AN0418
	20	CO 250 L G=1, MGL	07AN0419
C		*	07AN0420
		CALL SU(K,LG,X,D)	0ZAN0421
C	5		07400422
	· ·	IF(K.EQ.5) GC TO 212	0ZAN0425
		IF(K.EQ.6) GC TO 214	C7AN0425
		IF (K.GT.6) GO TO 215	02410425
		IF (LG.LT.MGL) GO TO 250	07400420
		WRITE(MDEVC, 5000) D	C7 ANO4 20
		REWIND MEEVC	07AN0420
		CO TO 250	07AN0429
	212	CC 300 MV=1,47	07AN0430
		DO 3CO MU=1,39	07 4104 32
			ULANUM32 W

		SGCS(1,LG,MV,MU)=D(LG,MV,MU)	OZAN0433	
	300	CONTINUE	OZAN0434	
	N72 M67 116	GO TO 25C	OZAN 0435	
	214	E0 310 MV = 1,47	CZAN0436	
		DO 310 MU=1,39	OZAN 0437	
		SGCS(2,LG,MV,MU)=D(LG,MV,MU)	OZAN0438	÷
	310	CONTINUE	OZAN0439	
		IF (LG.LT.MGL) GO TO 250	OZAN0440	
		WRITE(MDEVC, SOOO) SGCS	CZAN0441	
		REWIND MEEVC	OZAN0442	8
		GD TC 250	OZAN0443	
	215	$CO_{315} MV = 1,47$	OZAN0444	
		DO 315 MU=1,39	UZAN 0445	
		SCAT(LG, MV, ML) = D(LG, MV, MU)	0ZAN0446	
	315	CONTINUE	UZAN0447	
		IF (LG.LT.MGL) GO TO 250	OZAN0448	
		WRITE(MDEVC, SOOO) SCAT	0ZAN0449	
		REWIND MEEVC	OZAN0450	
	250	CONTINUE	OZAN0451	
	153	CONTINUE	CZAN0452	۰.
·		RETURN	OZAN 0453	
		END	UZAN0454	
· • '	•	SUBROUTINE SU(K,LG,X,Y)	0ZAN0455	
C.			UZAN0456	
С	,,SL	J,, MEANS WATER IN TURKISH	OZAN0457	
С			GZAN0458	
		DIMENSION X(2,23,8), Y(3,47,39)	0ZAN 0459	
		DIMENSION MRUI(99), MRLF(99), MRVI(99), MRVF(99), MRCC(99)	0ZAN0460	
С			OZANC461	
С	FOR	MV=1,MU=1 THE CROSS SECTION OF THE 18TH MATERIEL IS SAID TO BELONG TO THE	0ZAN0462	
С	NESH	VOLUMES ENCLOSED IN MU=1, MU=18(IN THE R DIRECTION) AND MV=1, MV=2(IN THE Z	OZANO463	
C	DIRE	CTIGN)	OZAN0464	
С			OZAN0465	
		CATA MRUI/1, 19, 20, 21, 20, 22, 35, 34, 1, 22, 31, 33, 1, 7,	DZAN0466	
	. 1	22,1,3,5,7,17,23,22,26,27,3,5,6,7,11,3,7,3,7,3,7,1,23,22,	0ZAN0467	
	2	21, 23, 19, 18, 20, 17, 1, 8, 11, 14, 19, 17, 25, 26, 2*25, 3*24, 3*23, 22,	CZAN0468	
				36
				N

	320,21,22,20,18,19,17,16,17,13,14,15,10,11,12,13,5,6,7,8,5, 410,1,5,2*26,25,24,23,21,20,18,16,3*1,27,1/	0ZAN 0469 07AN 0470
		CZAN0471
	CATA MRUF/18,19,20,21,20,33,39,34,18,30,22,33,4,16,	0ZAN0472
	132, 2, 4, 6, 16, 18, 25, 22, 26, 32, 4, 5, 6, 10, 16, 4, 16, 4, 16, 4, 2*16, 24, 2*22,	0ZAN0473
ŝ	223,2*22,21,2*19,17,16,15,20,17,25,26,2*25,3*24,23,2*23,	CZANC474
	322, 20, 21, 22, 20, 18, 19, 17, 16, 17, 13, 14, 15, 10, 11, 12, 13, 5, 6, 7, 8, 9, 10,	UZAN0475
•	44,7,9*26,12,5,4,2*33/	CZAN0476
		DZAN 0477
	DATA MRVI/4#1,12,3#1,4#3,3#4,2#5,4,5,4,4*5,	0ZAN0478
	110,2*8,2*10,2*20,2*24,2*25,26,2*19,21,2*22,24,2*27,	0ZAN0479
	229, 30, 31, 32, 21, 24, 2*15, 20, 21, 22, 23, 2*24, 25, 26, 27, 3*28, 29, 2*30,	OZAN0480
	331, 2*32, 3*33, 4*32, 6*31, 2*30, 20, 21, 22, 25, 27, 29, 30, 31, 2*33,	CZAN0481
	432,31,7,34/	CZAN0482
		OZAN0483
	CATA MRVF/2,20,11,2+2C,2,2+47,3+3,6,3+4,25,9,7,9,	CZANO484
	123, 3#18, 5, 19, 2*25, 2*19, 2*23, 2*24, 2*25, 28, 21, 20, 21, 2*23, 26, 27,	OZAN0485
	228, 29, 30, 31, 32, 21, 26, 2*15, 20, 21, 22, 23, 2*24, 25, 26, 27, 3*28, 29,	0ZAN0486
	32*30,31,2*32,3*33,4*32,6*31,2*30,20,21,24,26,28,29,30,32,	. 0ZAN0487
	42#33,32,31,33,47/	OZAN0488
		CZAN0489
	LATA MRCC/18,21,9,2321,18,16,15, $232, 19, 22, 282, 19, 22, 282, 28, 29, 23, 23, 23, 23, 23, 24, 24, 24, 24, 24, 24, 24, 24, 24, 24$	GZAN0490
	119,8,13,9,14,11,21,2*12,22,4,2*10,5,6,3,1,2*2,2*23,2,21,2*20,	OZAN0491
	221,8*20,2*11,2,17,4*12,17,2,3*12,2,2*17,3*12,2,12,2*17,	CZAN0492
	· 32*12,17,2*12,2,3*17,2*12,2,12,2,14#7/	OZAN 0493
		0ZAN0494
	LU 90 MR = 1,95	UZAN0495
		OZAN0496
		0ZAN0497
		OZANC498
		DZAN 0499
		CZAN0500
	DU 90 MU=MUI MUE	0ZAN 0501
	DU YU MV = MVI • MVF	0ZAN0502
ċ	Y(LG,MV,FU) = X(LG,MCC,K)	GZAN0503
9	U CUNTINUE	DZAN0504

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RETURN	D74N0505
END	07400506
SUBBOUTINE DATAL (DNC)	074N0507
C	07AN0508
C STEP CHANGE AT THE REGINNING DE THE TIME STEP	DZANOSOG
	07400510
COMMON/ED712/ICD. ISSA. ISUE. ISSE. ISSC. ISST. ISSD. ISATT	07AN0511
COMMENTO ZELZZISDY ISSAY ISON Y ISSAY ISSAY ISSAY ISSAY ISSAY ISAN	UZANOSII OZANOSI2
1 VEHT 2. MEHT 2. MEHT 4. MEHT 4. MEHT 4. MEHT 7. MEHT 6. MEHET MEHED MEHED MEHED MEHED MEHED	UZANO512
2NCHER, MCHER, MCHER, MCHER, MCVII, MCVID MCVID MCVIA MCVIA MCVIA MCVIA	• UZANUSIS
ANSWER MOVEL NOVES NOVER MOVES NOVER NOVER NOVER NOVER MOVES MOVES	
AMOULS MOLET POULS MOLE MOLET MOLET MOLET VET VET VET VET VET VET VET VET VET V	• UZANUSIS
WHSCUSPHSCUP, HSCUSPHS	CZANOS 16
2/030	UZANUSIT
THIT & CED ONC	UZANUS 18
C INTEGER DIG	OZANOS 19
LUC STARY LOS STARY LOS STRRY LOS STRRY LOS STIRY HOTZMANIA	07AN0520
	OZANO521
	OZANO522
$\frac{1}{2} = \frac{1}{2} = \frac{1}$	UZANU523
2//MSUID(20//MSUI/(20//MSUIB(20)/MSUFI(20)/MSUF2(20)/MSUF3(20)/MSU	F UZAN0524
ANSWER 2019 HSUTS (2019 HSUFE (2019 HSUF (2019 HSUF 8(2019 HSV11(2019 HSV12(201 ANSWER 2010 HSUT 6(2019 HSUTE (2019 HSUTE (2019 HSUF 8(2019 HSV11(2019 HSV12(201	• UZAN0525
MMS VI 2(20), MS VIA(20), MS VID(20), MS VID(20), MS VI / (20), MS VIB(20), ENSVEL200, MSVE2(20), MSVE2(20), MSVE(200, MSVE(20), MSVE(20), MSVE(20),	UZAN 0526
3PSVF1(20),MSVF2(20),MSVF3(20),MSVF4(20),MSVF5(20),MSVF6(20),MSVF7	UZAN0527
2201, MSVF8(201, MSUL1(201, MSUL2(201, MSUL3(201, MSUL4(201, MSUL5(201,	UZAN 0528
1 M S C C C Z U I , M S C C I Z U I , M S C C 8 (Z U)	UZAN 0529
	0ZAN0530
EQUIVALENCE (XS7(1,1),XSS7(1,1)), (XS8(1,1),XSS8(1,1))	OZAN0531
	CZAN0532
NAMELIST/INSEC/ISTPU	UZAN0533
NAMELISI/INSIP/ISD, ISSA, ISUF, ISSF, ISSG, ISST, ISSP, ISATT	0ZAN 0534
NAMELISI/INMSKI/MSKI, MSUII, MSUF1, MSVI1, MSVF1, MSCC1, XS1	0ZAN0535
NAMELISI/INMSK2/MSK2, NSUI2, MSUF2, MSVI2, MSVF2, MSCC2, XS2	0ZAN 0536
NAMELIST/INMSK3/MSK3, MSUI3, MSUF3, MSVI3, MSVF3, MSCC3, XS3	0ZAN0537
NAMELIST/INMSK4/MSK4, NSUIA, MSUF4, MSVIA, MSVF4, NSCC4, XS4	07AN0538
NAMELIST/INMSK5/MSK5, NSUI5, MSUF5, MSVI5, MSVF5, MSCC5, XS5	OZAN 0539
NAMELIST/INMSK6/MSK6, MSUI6, MSUF6, MSVI6, MSVF6, MSCC6, XS6	CZAN0540
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		NAMELIST/INMSK7/MSK7,MSUI7,MSUF7,MSVI7,MSVF7,MSCC7,XS7 NAMELIST/INMSK8/MSK8,MSUI8,MSUF8,MSVI8,MSVF8,MSCC8,XS8	OZAN0541 OZAN0542	
C			CZAN0543	
C	MSK	I GIVES THE NUMBER OF FEGIONS IN WHICH DURING THE TRANSIENT D- THE	OZAN 0544	
С	CIF	FUSION COEFFICIENT- CHANGES.	0ZAN 0545	
С			OZAN0546	÷
С		(K.EQ.1 CORRES TO C)	OZAN0547	
С	·	(K. EQ. 2 CORRES TO SIGA)	UZAN0548	
C		(K.EQ.3 CORRES TO UNSE)	OZAN0549	
С		(K.EQ.4 CORRES TO SIGF)	0ZAN 0550	
С		(K. EQ.5 CORRES TO SECS -PHOTON GROUP 1-)	0ZAN0551	
C		(K.EQ.6 CURFES TO SECS -PHOTEN GROUP 2-)	OZAN0552	. C.
С		(K.EQ.7 CORRES TO SCAT)	0ZAN0553	
С		(K.EQ.8 CORFES TO SPAR)	CZAN0554	
C			OZAN0555	
C	THE	REGION MSK1(MR) IS BUFDERED BY MSUI1(MR), MSUF1(MR) (IN THE R DIRECTION)	0ZAN0556	
C	AND	MSVII(MR), MSVF1(MR) (IN THE Z DIRECTION), ENCLOSES THE MATERIEL MSCC1(MR).	OZAN0557	
C			DZAN0558	
С	XS1	IS THE NEW CROSS SECTION ARRAY FOR DIBEGINNING OF THE TRANSIENT -STEP	0ZAN0559	1.5
C	CHAI	NGE-)	OZAN0560	
J.			0ZAN0561	
		FEAD (5, INSPC)	OZAN0562	
		READ(5,INSTP)	DZAN0563	
•		IF (ISD.EQ.DAC) GO TO 704	UZAN0564	
		FEAD (5, INMSK1)	0ZAN0565	
1911	704	IF (ISSA.EQ.ENC) GO 1C 705	OZAN0566	
		REAC(5, INMSK2)	0ZAN0567	
	705	IF (ISUF .EQ.DNC) GG TO 706	UZAN0568	2
		READ(5, INMSK2)	0ZAN0569	
	706	IF (ISSF .EQ.CNC) GO TO 707	CZAN0570	1
		READ(5, INMSK4)	OZAN0571	•
	707	IF (ISSG .EQ.DNC) GO TO 708	0ZAN0572	
		FEAD (5, INMSK5)	GZAN0573	
		READ(5, INMSKE)	CZAN0574	
	708	IF (ISST .EQ.DNC) GO TO 709	CZAN0575	
		READ (5, INMSK7)	OZANC576	w
				6
				01

	-00	TE (ISSD - FO DNC) 60 10 710	OZAN057	7	
	109	DEADIS TUNKES	CZANO57	78	
\hat{x}	710		OZAN 057	79	
	110	DETUDN	DZAN058	30	
		RETURN	OZANO58	31	
		CURRENT NE DATA2 (DNC)	OZAN058	82	
~		SUBRUUTINE DETAZIONUT	CZAN058	83	
C	C 114	NOT THE FAD OF THE TINE STED-	OZANO5	84	
C	CHA	NGE -THE END UP THE TIPE STEP	OZAN 05	85	
C		COMMON TO THE STORE INSEC. STORE SGC SC . SCATE . SENRE .ATTE	DZAN05	86	
		COMMON/070701/ CSC MEK1, NRK2, MRK3, MRK4, MRK5, MRK6, MRK7, MRK8, MRUI1,	OZAN05	87	0
	•	WOULD MOUTE MOUTE MOLIE MRUTE MRUTE MRUTE MRUF1 MRUF2, MRUF3, MRUF4,	OZANO5	88	
	1	IMPOLICE MOULE NOULE, MOULE, M	OZANO5	89	
		2MRUPS, MRUPS, M	DZAN05	90	2
		AND CC2 MDCC4 NDCC5 MDCC6 MDCC7 MCCC8 XK1 XK2 XK3 XK4 XK5 XK6 XKK7	CZAN05	91	•
			CZAN05	92	
~		DANKO	OZAN05	93	
C		INT CCD PNC	CZAN05	94	
		INTEGER LNG	DZAN 05	\$5	ł
		INTEGER DU, STGAC, DNSTC, STOLOGOGOGOGOGOGOGOGOGOGOGOGOGOGOGOGOGOGO	OZAN05	96	
~		INTEGER CSC	OZAN05	97	
C		DIMENSION YK113,201, XK2(3,20), XK3(3,20), XK4(3,20), XK5(3,20),	OZAN 05	98	
		1 XK (12, 20), XK7(2, 20), XK7(2, 20), CSC(8), XKK7(3, 20), XKK8(3, 20)	OZAN05	99 .	
2	2.1.2	DIMENSION MELTI (20), NEUT2(20), MEUT3(20), NEUT4(20), MEUT5(20	DZAN C6	00	
2		2) MOUT (120) MOUT (20) MOUT 8(20) MOUT 1(20) MOUT 2(20) MOUT 3(20) MOUT	OZANO6	01	
	·	2), MRUIST 20), MRUIES (20), MRUES (20), MRUES (20), MRVI1(20), MRVI2(20),	OZAN06	02	
		AND VI 2/201, MRVIA (20), NEVIS (20), MRVIA (20), NRVIA (20), NRVI8 (20),	. OZAN06	03	
		SMRV12(20), MRVF2(20), NEVE3(20), MRVF4(20), NRVF5(20), NRVF6(20), NRVF7(CZANO6	04	
		(20) NOVER (20) MRCC1 (20), NRCC2 (20), MRCC3 (20), MRCC4 (20), MRCC5(20),	OZAN C6	05	
		5201, MRVF61201, MRCC11201, MRCC1(20)	OZANO6	06	
~		/MRCCC(201, MRCC1(201, MRCC0(201	OZANO6	07	
C	· ·	CONTRACT (CE () X 7 (1 - 1) - Y K 7 (1 - 1)) - (X K 8 (1 - 1) - X K K 8 (1 - 1))	OZANOG	808	
		EQUIVALENCE (ANT (1) 1) ANN (1 1) 1 (ANS (2) 2) ANN (1) 2)	CZANO6	09	
C		A A HEL TOT / THE CENCICS C	CZANOG	510	1
_		PAPELISI/ INCLINC/ CSC	DZANOE	511	
C		THE FIRST EVENT DE CSC	CZANOS	12	
C	11	THE FIRST ELEMENT OF USO BLOG INDURING THE TREASENT OF THE	sa Cini Ing	36	
				5	

С

1.74

					CZAN0613
С		THE STORE STORE UNGER STORE SCORE SCATC SPNRC ATTO			OZAN0614
		NAMELIST/INDENC/DC, SIGAC, UNSEC, SIGEC, SOCIESC, SCHOOS, MARKEN			CZAN0615
		NAMEL IST / INMRK 1/MRK 1, MRUI 1, MRUF 1, MRV 11, MRV 11, MRV 12, MRC 2, XK2			OZAN 0616
		NAMELIST/INMRK2/MRK2, NRU12, MRUF2, MRV12, MRVF2, MRVF2, MRVF2, MRVF2, MRVF2, MRVF2, MRVF3, M			OZAN0617
		NAMELIST/INMRK3/MRK3, MRUI3, MRUF3, MRVIS, MPVF4, NDCC4, XK4			DZAN0618
		NAMELIST/INMEK4/MRK4, MRU 14, MRUF4, MRV 14, MRVF4,			OZAN 0619
		NAMELIST/INMERS/MRK5, NRUIS, MRUES, MRVIS, MRVES, MEVES, NECCO, XK6			DZAN0620
		NAMELIST/INMRK6/MRK6, MRU16, MRUF6, MRV16, MRV16, MRVF6, MRCC7, XK7			OZAN0621
		NAMELIST/INMEK7/MRK7, NRU17, MRUF7, MRV17, MRV17, MRV17, MRCC17, MR			DZAN0622
		NAMELIST/INMRK8/MRK8, MRU18, MRUF8, MRV18, MRV	1991 - AM		CZAN0623
С					OZANG624
		READ (5, INCONC)	1. A. A. A.		OZAN0625
		READ(5, INDDNC)			0ZAN0626
	1	IF (CC.EC.DNC) GU TU 114	10		UZAN0627
		READ(5, INMERIA			CZANO628
	714	IF (SIGACAEVADNOT OUTO TIS			DZAN0629
		$\frac{1}{10} \frac{1}{10} \frac$			0ZAN0630
	115	IF (UNSFLECEDINC) GO IO IZO			OZAN0631
		$\frac{\text{REAU(3)}(1)}{10} = \frac{10}{10} = \frac{10}$			OZAN 0632
•	110	TEADIS INMOKA)			0ZAN0633
	717	$\frac{\text{READ(0)}(1)}{100000000000000000000000000000000000$			0ZAN0634
	11(PCAD(S.INMRK5)			UZAN0635
	· · ·	DEAD(S-INMRKA)			CZAN0636
	710	TE (SCATC-EC-DNC) GG TO 719			UZANU637
	110	DEAD(5.INNRK7)			UZAN 0638
÷.,	710	TE (SPNRC-ED-DNC) GU TO 720			UZANU639
	117	READ (5. INNEKS)			UZANUC4U
0.00	720	CONTINUE			07AN0662
	14.0	RF TURN			0ZAN0042
		FNΓ			07AN0645
		SUBROUTINE DATA3(DNC)			0ZAN0645
C				745	CZANO646
c	THE	END OF THE TRANSIENT			074N0647
č					07 ANO648
-		COMMON/FOZ13/ND, NSIGA, NUNSF, NSCAT			OLANO TO

		COMMON/DZDTA/ NCS ,NRK1,NRK2,NRK3,NRK4,NRK5,NRK6,NRK7,NRK8,NRUI1,	GZAN0649
		INRUI2, NRUI3, NRUI4, NPU 15, NRUI6, NRUI7, NRUI8, NRUF1, NRUF2, NRUF3, NRUF4,	OZAN0650
		2NRUF5, NRUF6, NRUF7, NRUF8, NRVI1, NRVI2, NRVI3, NRVI4, NRVI5, NRVI6, NRVI7,	0ZAN0651
		3NRV18, NRVF1, NRVF2, NRVF3, NRVF4, NRVF5, NRVF6, NRVF7, NRVF8, NRCC1, NRCC2,	OZAN0652
		4NRCC3, NRCC4, NRCC5, NRCC6, NRCC7, NRCC8, XT1, XT2, XT3, XT4, XT5, XT6, XTT7,	OZAN0653
		SXTT8	CZAN0654
С			OZANC655
	•	INTEGER DNC	DZAN 0656
С			GZAN0657
		DIMENSION XT1(3,20),XT2(3,20),XT3(3,20),XT4(3,20),XT5(3,20),	OZAN 0658
	0. C.S.	1XT6(3,20),XT7(2,20),XT8(2,20),NCS(8),XTT7(3,20),XTT8(3,20)	0ZAN0659
		CIMENSION NRUI1(20), NRUI2(20), NRUI3(20), NRUI4(20), NRUI5(20	OZAN0660
		2), NRUI6(20), NRUI7(20), NRUI8(20), NRUF1(20), NRUF2(20), NRUF3(20), NRUF	OZAN0661
		34(20), NRUF5(20), NRUF6(20), NRUF7(20), NRUF8(20), NRVI1(20), NRVI2(20),	GZAN0662
		4NRVI3(20), NRVI4(20), NFVI5(20), NRVI6(20), NRVI7(20), NRVI8(20),	OZAN0663
		5NR VF 1(20), NR VF 2(20), NF VF 3(20), NR VF4(20), NR VF 5(20), NR VF6(20), NR VF7(OZAN0664
		620), NRVF8(20), NRCC1(2C), NRCC2(20), NRCC3(2C), NRCC4(20), NRCC5(20),	CZAN0665
		7NRCC6(20), NRCC7(20), NFCC8(20)	OZAN0666
С		그는 것 같은 방법에 있는 것이 없다. 것 같은 것 같	0ZAN0667
		EQUIVALENCE(XT7(1,1),XTT7(1,1)),(XT8(1,1),XTTE(1,1))	DZANO668
-C			OZAN0669
· Ç	CAT	A RELIATED TO THE SECOND TRIAL FUNCTION IF NOT THE SAME AS COMPARED	0ZAN0670
C	10	THE STEADY STATE ONE	OZAN0671
С			0ZAN0672
		NAMELIST/INCS/NCS	GZAN0673
		NAMELIST/INNCS/ND, NS IGA, NUNS F, NS CAT	DZAN0674
		NAMELIST/INNRK1/NRK1, NRUI1, NRUF1, NRVI1, NRVF1, NRCC1, XT1	0ZAN0675
2		NAMELIST/INNPK2/NRK2, NRUI2, NRUF2, NRVI2, NRVF2, NRCC2, XT2	OZAN0676
		NAMELIST/INNFK3/NRK3, NRUI3, NRUF3, NRVI3, NRVF3, NFCC3, XT3	OZAN0677
		NAMELIST/INNRK7/NRK7, NRUI7, NRUF7, NRVI7, NRVF7, NRCC7, XT7	OZAN0678
С			0ZAN 0679
	Ċ	READ(5, INCS)	DZAN0680
		READ(5, INNCS)	OZAN0681
		IF (ND.EC.DNC) GO TO 725	0ZAN0682
		READ(5, INNRK1)	OZAN0683
	725	S IF (NSIGA.EQ.DNC) GC TO 726	OZAN0684

		READ (5, INNRK2)	OZAN 0685	
	726	IF (NUNSF.EQ.DNC) GO TO 727	OZAN0686	
<u>t:</u>		READ (5, INNRK3)	OZANO687	
	727	IF (NSCAT.EQ.DNC) GO TO 728	DZAN0688	
		REAC(5, INNRK7)	CZAN0689	
	728	CONTINUE	OZAN 0650	
		RETURN	OZAN0691	
	5 20	END	OZAN0592	
		SUBROUTINE STEP(MGLK, MEVIC, DNC, Y, SGCS, Z)	OZAN0693	
С			CZAN0694	
С	STEP	P CHANGE AT THE BEGINNING OF THE TIME STEP	OZAN0655	
C			CZAN0696	
्र		COMMON/DZCTA/ISTPC,MSK,MSUI,MSUF,MSVI,MSVF,MSCC,XS	0ZAN0697	
С			OZAN 0658	
		DIMENSION MDVIC(32), MSK(8), MSUI(20,8), MSLF(20,8), MSVI(20,8),	OZAN0699	
]	LMSVF (20, 8), MSCC (20, 8), XS (3, 20, 8), Y(3, 47, 39), SGCS (2, 3, 47, 39), Z(2,	OZANO700	
		247,35),ISTPC(8),MGLK(E)	OZAN0701	
С			0ZAN0702	
		INTEGER ENC	OZAN0703	
С			OZAN0704	
0	9000	FORMAT (7E11.5)	OZANO705	
		DO 153 K=1,8	OZAN0706	
	a.,	VDEVC=MDVIC(K)	0ZAN0707	
·		NGL=MGLK(K)	OZAN0708	
		IF (ISTPC(K).EC.DNC) CO TO 153	OZAN0709	
		IF (K.EQ.5) CD TO 853	OZAN0710	
		IF (K.EQ.6) GU TO 855	OZAN0711	
		IF (K.GT.6) GO TO 854	0ZAN0712	
		READ(MDEVC, 9000) Y	OZAN0713	
		REWIND MDEVC	OZAN0714	
		GU TC 855	OZAN0715	1.9
	853	READ (MDEVC, 9000) SGCS	OZAN0716	
		REWIND MDEVC	OZAN0717	
		GO TO 855	0ZAN0718	
	854	READ (MDEVC, 9000) Z	OZAN0719	
		REWIND MDEVC	0ZAN0720	
				-

			07410721
\$55	MRR=MSK(K)		OZANOTZI OZANOTZI
	TO 8000 LG=1.MGL		ULANUTZZ
	DO 320 MR=1. NRR		0 Z ANO7 24
	MUI=MSUI(MR,K)		07AN0725
	NUF=NSUF (MR,K)		07410725
	MVI = NSVI (MR . K)		ULANUTEO CZANOZZZ
	WVE=NSVE (MR.K)	김 정말 것 같은 것 같은 것 같은 것이 같아.	UZANUTZT OZANOZZR
	NCC=NSCC (NR + K)		02AN0720
	TO 320 MV=MVI, MVF	우리는 것이 많이	UZAN0720
	CG 320 MU=MUI,MUF		07AN0731
	IF (K.EQ.5) GU TO 412		07AN0732
	IF (K.EQ.6) GU TU 414		07AN0733
1	IF (K.GT.6) GD TO 415		07 410734
	GO TO 416		07AN0735
412	SGCS(1,LG,MV,MU)=XS(LG,MCC,K)	그는 그는 그는 것이 물건을 가지?	D7 ANO7 36
	GO TC 320		GZAN0737
414	SGCS(2,LG,MV,MU)=XS(LG,MCC,K)		OZANO738
e:	IF ((MR.LT.MRR).OR.(LG.LT.MGL)) GU TU 320	다 있는 것 같은 것을 많은 것이 있는 것을 했다.	07AN0739
	WRITE(MDEVC, 9000) SGCS		GZAN0740
	REWIND MCEVC	그 상품에서 가지 않았다. 그 것 이야한다.	0ZAN 0741
1. S	GU TC 153		0ZAN0742
415	Z(LG, MV, MU) = XS(LG, MCC, K)		OZANO743
i a tripp	IF ((MR.LT.MAR).OK.(LU.LI.MGL)) OU TO DEC		DZAN0744
	WRITE(MDEVC, SUUC) Z		GZAN0745
	REWIND MLEVC	이번 것이 있는 것 같아. 같아. 말 수 없는 것	DZAN0746
	$GU = \{C, 15, 5\}$		0ZAN 0747
416	Y(LG,MV,MU) = XS(LG,FGC,M)		CZAN0748
320	TE (IC IT MCI) GO TE 8000	이는 것은 것은 것을 수 있는 것이다.	0ZAN 0749
	$\frac{1}{10000000000000000000000000000000000$		OZAN0750
	CENTRD MDEVC		OZAN0751
000	CONTINUE		UZAN0752
152	CONTINUE		UZANO753
100	CETTICN		UZAN0754
	FND		UZANU755
1	SUBBOUTINE CHANGE(MGLK, MDVIC, DNC, Y, SGCS, Z, NC SCU)		UZANU196

c		07AN0757	
C CHANGE- THE END OF THE TIME STEP-		0ZAN 0758	
		DZAN0759	
COMMON/OZDTA/CSC,MRK,MRUI,MRUF,MRVI,MRVF,MRCC,XC		DZAN0760	
C		OZAN0761	
INTEGER CSC		OZANO762	
INTEGER DNC		OZAN0763	
C		DZAN0764	
CIMENSION MOVIC(32), MRK(8), MRUI(20,8), MRUF(20,8), MRVI(20,8),		GZAN0765	
1MRVF(20,8), MRCC(20,8), XC(3,20,8), Y(3,47,39), SCCS(2,3,47,39),		0ZAN0766	
27(2,47,39), NCSCU(8), CSC(8), MGLK(8)		CZANO767	
C		OZAN 0768	
9000 FORMAT(7E11.5)		OZAN0769	
CC 153 K=1,8		OZANO770	
MDEVC=MDVIC(K)		OZAN0771	
MGL=MGLK(K)		0ZAN0772	
IF(CSC(K).EC.DNC) GO TO 153		0ZAN0773	
IF (K.EQ.5) GD TO 853		OZAN0774	
IF (K.EQ.6) GO TO 855		CZAN0775	
IF (K.GT.6) GO TO 854		OZANC776	
READ(MDEVC, 9000) Y		OZAN0777	
REWIND MCEVC		OZAN0778	
GO TC 855		OZAN0779	
E53 READ(MDEVC, 9COO) SGCS		0ZAN0780	
REWIND MEEVC		OZAN0781	
GO TO 855		OZAN 0782	
854 REAC (MDEVC, 9000) Z		0ZAN0783	
REWIND MDEVC	· · ·	OZANO784	
E55 MRR = MRK(K)		UZAN0785	
MDEVC=MDVIC(K+8)		OZANO786	
DG = 8 COO LG=1, MGL		OZAN0787	
LU = 320 MR=1, MRR		OZAN0788	
$PU_{1} = PRU_{1} (PR, K)$		UZAN0789	
MUF = MRUF(MR,K)		0ZAN 0790	
MV I = MRVI(MR, K)		UZAN0791	
PVF = PRVF(PR, K)		0ZAN 0792	5
			~

Pres.

		MCC=MRCC (MR, K)		OZAN 0793
		CO 320 MV=MVI, MVF		OZAN0794
		DO 320 MU=MUI, MUF		DZAN0755
		IF (K.EQ.5) GC TO 412		07AN0796
		IF (K.EQ.6) CO TO 414		07AN0797
		IF (K.GT.6) GC TO 415		07AN0798
		CO TO 416		074N0799
	412	SGCS(1 + 1 G + MV + MU) = XC(1 G + MCC + K)		07480800
	,	GC TC 32C		07AN0801
	414	SGCS(2,LG,MV,MU)=XC(LG,MCC,K)		074N0802
		IF ((MR.LT. MER) - (R. (LG.LT. MGL)) GO TO 320		D7AN0803
		WRITE(MDEVC, SOOO) SGCS		07AN0304
		FEWIND MCEVC		07410805
124	i.	GO TC 8000		07AN 0806
	415	Z(LG,MV,MU) = XC(LG,MCC,K)		07AN0807
		IF ((MR.LT.MFR).DR.(LC.LT.MGL)) GU TO 320		CZAN0808
		WRITE(MDEVC, SOCO) Z		0ZAN 0809
		REWIND MEEVC		OZAN0810
		GU TE 8000 .		OZAN0811
3	416	Y(LG,MV,MU) = XC(LG,MCC,K)	•	0ZAN0912
$\times 22$	320	CONTINUE		UZAN0813
		IF (LG.LT.MGL) GO TO 8000		OZAN0814
	in an _{an a} n a	WRITE(MDEVC, SOOO) Y		OZAN0815
	се) — ¹ . К	REWIND MEEVC		OZANO816
	8000	CONTINUE		OZAN 0817
		NCSCO(K) = CSC(K)		CZAN0818
	153	CONTINUE		UZAN0819
		RETURN		0ZAN0320
		END		UZAN0821
		SUBRCUTINE THEEND (MGLK, MDVIC, DNC, Y, Z)		OZAN0822
	C			GZAN0823
	C THE	END CF THE TFANSIENT		OZAN0824
	С	그는 것 같은 것 같		0ZAN 0825
		COMMON/OZCTA/NCS,NRK,NRUI,NRUF,NRVI,NRVF,NRCC,XT		OZAN0826
	С.			OZAN 0827
		DIMENSION MDVIC(32), NFK(8), NRUI(20,8), NRUF(20,8), NRVI(20,8), NRVF(0ZAN0828 ,

NTEGER DNC GPMAT(7E11.5) O 153 K=1,8 E 4(K 50 K) OB (K 50 E) (D (K 50 K) BD (K 50 L) OD TO 150	OZAN 0830 OZAN 0831 OZAN 0832 OZAN 0833
CRMAT(7E11.5) O 153 K=1,8 E //K 50 A) OR /K 50 E) OR /K 50 A) OR /K 50 D) OR 70 150	0ZAN0832 0ZAN0833
$\begin{array}{c} 0 & 153 & \text{K=1,8} \\ \hline \\ $	0ZAN 0833
$\begin{array}{c} 153 \text{ K=1,8} \\ \hline \\ $	M M M M M M M M M M
	UZAN0834
E INCE IN TO DUCE OF TO 100	UZAN0835
PENC-NONIC(V) GL (L 103	0ZAN 0836
	UZAN0837
	OZAN 0838
SARIMEEVC. GCOOL V	UZAN0839
EAUTAD MEEVC	UZAN0840
O TO 855	UZANU841
EAC (MCEVC-9000) 7	07AN(0842
EWIND MDEVC	OZANORAA
RR=NRK(K)	0ZAN0844
DEVC=MDVIC(K+16)	074N0846
8 8000 LG=1.MGL	07 AN 08 47
0 321 MR=1. MRR	074N0848
UI=NRUI(MR,K)	0ZAN0849
UF=NRUF(MR,K)	07AN0850
VI=NRVI(MR,K)	CZANC851
VF=NRVF(MR,K)	UZAN 0852
CC=NRCC(MR,K)	0ZAN0853
0 321 MV=MVI, MVF	OZANC854
321 MU=MUI, MUF	0ZAN0355
F (K.NE.7) CO TO 856	0ZAN0856
(LG, MV, MU) = XT(LG, MCC, K)	OZAN0857
F((MR.LT.MRR).OR. (LG.LT.MGL)) GC TO 321	OZANOB58
RITE(MDEVC,9000) Z	0ZAN0859
EWIND MDEVC	OZAN0860
) TC 153	OZAN0861
(LG, MV, MU) = XT(LG, MCC, K)	DZAN 0862
ANT TAULE	07 ANI 09 62
JNA DNUE	ULAN UDD3
F (LG.LT.MGL) GO TO ECOO	0ZAN0864
	DEVC=MDVIC(K) GL=MGLK(K) F (K.EQ.7) GD TD 854 EAC(MCEVC,9C00) Y EWIND MCEVC G TO 855 EAC(MCEVC,9C00) Z EWIND MDEVC RR=NRK(K) DEVC=MDVIC(K+16) G 8000 LG=1,MGL G 321 MR=1,MRR UI=NRUI(MR,K) VF=NRUF(MR,K) VF=NRUF(MR,K) VF=NRVF(MR,K) VF=NRVF(MR,K) CC=NRCC(MR,K) G 321 MU=MUI,MUF F (K.NE.7) GD TD 856 (LG,MV,MU)=XT(LG,MCC,K) F((MR.LT_MRR).DR.(LG.LT.MGL)) GC TD 321 RITE(MDEVC.9000) Z EWIND MDEVC D TD 153 (LG,MV,MU)=XT(LG,MCC,K)

	WRITE(MDEVC, SOOO) Y	OZAN 0865
	REWIND MDEVC	OZAN0866
8 000	CONTINUE	DZAN0867
153	CONTINUE	OZAN0868
	PETURN .	QZAN0869
	END	QZAN0870
	SUBROUTINE PEISON(SIGA.OMEG.VI)	07AN 0871
C		07AN0372
C FOI	SCN THE REACTER UNIFERMLY	07AN0873
С		07 AN 0874
	EIMENSIUN SIGA(3.47.35).V1(3)	07AN0975
С		074N0876
1000	FORMAT (7E11.5)	07AN0877
	FEAD (29, 1000) SIGA	07AN0878
	REWIND 25	17 AN 0879
	CC 289 MG=1,3	D74N0880
	DO 289 MV=1,47	07AN0881
	CO 289 MU=1, 39	D74N0882
	$SIGA(MG, MV, MU) = SIGA(MC, MV, MU) + OMEG \approx V1(MG)$	07AN0883
289	CONTINUE	07 AN 0884
	WRITE(29,100C) SIGA	07AN0885
	REWIND 29	07AN0886
	RETURN	D7 AN 0887
	END	C74N0888
	SUBROUTINE PASS(NCSCC, ENC, MOVIC, E, SGCS, SCAT)	07AN C889
С		07AN0890
C THE	END OF THE FIRST TIME STEP IS THE BEGINNING OF THE SECOND ONE (NATURALLY)	07AN0391
С		07AN0892
	DIMENSION NC SKG(8), MEVIC (32), D(3,47,39), SGCS (2,3,47,39), SCAT (2,47,	074N0893
3	1391	07AN0854
С		0740 0855
	INTEGER ENC	07AN0896
С		07 AN 08 57
9000	FORMAT(7E11.5)	07 ANO8 98
	CO 153 K=1.8	02AN0890
	IF (NCSCC(K).EC.DNC) (0 TO 153	07410099
		ω united a

	MDEVC2=MCVIC(K+8)	07AN0901
	MDEVC1=MCVIC(K)	074N0902
	IF(K.EQ.5) GC TO 605	07AN0903
	IF (K.EQ.6) CO TO 153	07400904
	IF (K.GT.6) GO TO 606	07400005
	FEAD (MDE VC2, 5000) C	DZANOSOS
	REWIND MDEVC2	07 AN 0907
	WRITE(MDEVC1.9000) D	02 AN0901
	REWIND MCEVC1	UZANU908
	CO TO 153	0ZAN0909
605	FEAD (MDEVC2 . 9000) SGCS	OZANOSIU OZANOSII
•	REWIND MORVOS	OZANUSII
	WRITE (MDEVCL. 9000) SCCS	UZAN0912
	REWIND MORVOI	UZAN0913
	GO TO 153	0ZAN0914
606	FEAD (MDEVC2, SODO) SCAT	UZAN0915
000		DZAN0916
	WP TTELMDEVC1. 00001 SCAT	UZAN0917
	REWIND MEENCI	UZAN0918
152	CONTINUE	QZAN0919
100	DETIEN	OZ AN 0920
	B C L U KN	OZAN0921
		OZAN 0922
8	SUBRUUTINE FILIZI	OZAN0923
	THE C CHO SCHETCHE OLD ADDA ADDA ADDA	DZAN0924
	THIS SUBRUUTINE CALCULATES SOME OF THE COEFFICIENTS FOR THE FINAL POINT	GZAN0925
	KINETICS TYPE OF EQUATIONS(GENERATION TIME MATRIX AND LEAKAGE MATRIX)	0ZAN0926
		CZAN0927
	"FILIZ" MEANS "NYMPH" IN TURKISH	OZAN0928
		CZAN0929
	COMMON/OZO/SIGA, UNSF, SGCS, SCAT, PSI, W	DZAN 0930
	COMMON/OZ11/C, DNC, KSFCZ, SKOZN, NDFSI, NDW, HU, HV, R	- UZAN0931
•	CCMMCN/DZ12/EC, SIGAC, UNSFC, SIGFC, SGC SC, SCATC, SFNRC, ATTC	UZAN0932
	COMMON/FOZI1/LLL,LFIN/L,KSREX,FLAP1,ALAP1,DIFF1,SKEF	OZAN0933
	COMMON/FOZ12/ISD, ISSA, ISUF, ISSF, ISSG, ISST, ISSF, ISATT	0ZAN0934
	CCMMCN/FOZI3/NC, NSIGA, NUNSF, NSCAT	OZAN0935
· ·	COMMON/OZ2/NMODES, II, KK	07AN0936
		ω

	CCMMEN/0Z3/TMIN,TMAX	0ZAN0937
	CCMMEN/0Z2FZ1/V1	OZAN0938
	CCMMCN/DZ3FZ1/GENTME	OZAN 0939
	CUMMEN/OZ4FZ1/LAPN,VLAPN	0ZAN0940
~	CCMMCN/FCFA/CDEF, MCOF	UZANCS41
C		OZAN0942
	CIMENSION PSI(3,48,40),W(3,48,40),SIGA(3,47,35),UNSF(3,47,39),SCAT	OZAN0943
	1(2,47,39),COEF(3,47,39),HU(39),HV(47),R(40),V1(3),NDW(2),NDPSI(2),	0ZAN0944
	2SKEF(2), GENTME(2,2), LAPN(2,2), VLAPN(2,2), FLAP(2), ALAP(2), DIFFP(2),	0ZAN0945
G.,	3SGCS (2,3,47,39), SF(2,2), SA(2,2)	OZAN0946
С		0ZAN 0947
	REAL-LAPN	CZAN0948
	INTEGER C, DNC	OZAN0949
	INTEGER DC, SIGAC, UNSEC, SIGEC, SCATC, SGCSC, SPNRC, ATTC	UZAN0950
С		6ZAN0951
100	O FURMAT(7E115)	DZAN0952
200	O FORMAT(1PEE14.6)	CZAN0953
-2.	5 FORMAT (1H1, 'GENERATION TIME MATRIX'/)	0ZAN0954
62	6 FORMAT (1X, 2(E15.8,3))/(1X, 2(E15.8,3X))//)	. DZAN0955
62	7 FORMAT (/1X, 'LEAKAGE MATRIX(INITIAL VALUE)'/)	OZAN0956
62	8 FORMAT (/1X, 'LEAKAGE NATRIX (RAMP CHANGE SLOPE)'/)	0ZAN 0957
629	1 FORMAT(/1X, 'LEAKAGE INTEGRAL(S)'/)	DZAN0958
629	2 FOPMAT (/1X, 'ABSORPTICN INTEGRAL(S)'/)	0ZAN0959
629	3 FORMAT (/1X, 'FISSION INTEGRAL(S)'/)	OZAN0960
C		DZAN0961
1	IF (KSREX.EC.1) GO TC 58	DZAN0962
Ç		0ZAN 0963
C CAI	LCULATION OF THE GENERATION TIME MATRIX	0ZAN0964
С		OZAN 0965
	$U_0 = 2 = 1 = 1, 11$	UZAN0966
· · ·	$N = N \subseteq W (I)$	OZAN0967
C		0ZAN0968
C NDI	W LIKE INPUT DEVICE NUMEER FOR W	0ZAN0969
5		OZANGS70
	READINN, 2000) W	0ZAN 0971
	REWIND NN	0ZAN0972 W
		7

	$\Gamma \cap \mathcal{D} = \mathcal{V} - 1 = \mathcal{V} \mathcal{V}$		
		54	OZAN0973
Ċ	NN-NUPSI(K)		0ZAN 0974
ĉ	NODEL LIVE INCUT DEVICE NUMBER FOR DOT		CZAN0975
c	NUPSI LINE INPUT DEVICE NUMBER FUR PSI		OZAN 0976
C	READ (NAL 2000) DET		OZAN0977
	PEAL (NN, 2000) PSI		OZAN0978
c	PENIND NK		OZAN0979
C	CALL CTM (H DET HU LIN E HI CENT)		CZAN0980
r	CALL GIM(W, PSI, PU, HV, F, VI, GENI)		CZAN0981
C	2 CENTRELL KI-CENINI ERCO		DZAN0982
	$\frac{1}{10} \frac{1}{10} \frac$		OZANO983
	$\frac{1}{10}$		OZAN0984
	FR = CONTINUE		0ZAN0985
ſ	DO CONTINUE		OZAN0986
r	CALCH ATION OF THE LEAKACE MATRIX		OZANO987
č	CALCOLATION OF THE LEANAGE MAIRIX		OZAN0988
ć	AT THE RECTNNING OF THE TING STOP		OZAN0989
c	AT THE DEGIMINO OF THE TIME STEP		0ZAN 0950
1	TIMETMIN		0ZAN0991
	$103 \Gamma_{0} 4 K = 1 K K$		DZAN 0952
	N = N P S T (K)		0ZAN0993
	READ (NN. 2000) PSI		0ZAN0994
÷.	REWIND NN		DZAN0995
	$IE (K_{2}EC_{1}) CD TO 102$	이 같은 것을 알려 주셨다.	GZAN0996
	$IE (ND_EO_DNC) CO TO 102$		UZANC997
Ċ	11 THE REDITCY OF TU 102		UZAN0998
č	DIFFUSION COFFETCIENT ARRAY FOR THE SECOND TRIAL FUNCTION	. 영양 영양 가지 않는 것	UZAN0999
С	STATUS SELATICIEN ANALITICA THE SECOND TRIAL FUNCTION		UZANIUCU
	READ (28.1000) SIGA		UZANIOUI
	REWIND 26		UZAN1002
	IF (KSPEX_EQ_1) GO TO 170		UZAN 1003
	GU TO 106		02AN1004
C			UZAN1005
С	CIFFUSION COEFFICIENT ARRAY FOR THE FIRST TRIAL FUNCTION		0ZAN 1000
С			OZANIO07
			ULANLUUS

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	102	READ(1,1000) SIGA	07 AN 1009
		REWIND 1	0ZAN1010
		IF (KSREX.EQ.1) GO TC 109	07AN1011
	106	IF (TIME.EQ.TMAX) GO TO 107	0ZAN1012
С			UZAN1013
С	DIFF	FUSION COEFFICIENT ARRAY AT THE BEGINNING OF THE TIME STEP	OZAN 1014
С			07AN1015
	<i>.</i> :	READ(14,1000) UNSF	UZAN1016
		REWIND 14	DZAN 1017
		GO TO 109	GZAN1018
С			DZAN1019
С	CAT	T THE END OF THE TIME STEP	OZAN1020
С			QZAN1021
	107	READ(18,1000) LNSF	OZAN 1022
		REWIND 18	CZAN1023
С			OZAN1024
	109	CALL COF (KSREX, K, TIME, TMAX, LFINAL, ISD, DNC, ND, LLL, DC, TMIN, UNSF, SIGA	DZAN 1025
	1		GZAN1026
С			OZAN1027
•		IF (KSREX.EQ.0) GO TO 169	0ZAN1028
		IF (K.NE.1) GO TO 17C	OZAN1029
		READ(11,2000) W	OZAN 1030
ني ن ^ا		REWIND 11	OZAN1031
C			OZAN1032
	170	CALL FILIZO(h, PSI, SIGA, HU, HV, R, SUM25)	0ZAN 1033
C			0ZAN1034
	(40)	DIFF=SUM25#3.1416	OZAN1035
÷	1/0	DIFFP(K)=DIFF	0ZAN 1036
~	109	IF (K.EU.I) CU 10 112	OZAN1037
č	COVE	E COME & CUT OF ENTERNANCE & DUE OF LE LE COME	OZAN 1038
C	SONC	THE TOTAL STUDY IN A TUR 2 RUN OR ADJUSTED THROUGH OZAN AND IS THE KEFF	0ZAN1039
c	FAR	THE TRIAL FUNCTION IN QUESTION	0ZAN1040
ł,		SCHEE-CHEELH)	0ZAN 1041
		JONEF-SNEFINJ JE (ACICA CO DACA CO TO ANG	GZAN1042
	*	$\frac{17}{22} (NS10A_0 = U_0 U_1 U_1 U_1 U_1 U_1 U_1 U_1 U_1 U_1 U_1$	OZAN1043
		BLAUT2 7 10007 316A	0ZAN1044
			1

		REWIND 29	0ZAN1045
		14 PEAD (2, 1000) STCA	UZAN1046
	1	CENTAD 2	0ZAN1047
		A TE (NUNSE EO DAC) CE TO 11E	0ZAN1048
		PEAR(20 1000) INCC	OZAN 1049
		FEALIND 20	CZAN1050
			OZAN1051
	1	5 PEAR (2 1000) HNCC	0ZAN 1052
	1.	PENIND 2	0ZAN1053
		REWIND 3	0ZAN1054
	11	LO IF INSCALERODICI GU 10 171	0ZAN1055
		REAC(31,1000) SCAT	0ZAN1056
		REWIND 31	OZAN 1057
¥.			DZAN1058
	11	2 SSKEF=SKEF(K)	DZAN1059
		READ(2,1000) SIGA	OZAN 1060
		REWIND 2	CZAN1061
		REAU(3,1000) UNSF	0ZAN1062
		REWIND 3	0ZAN1063
		FEAD (4, 1000) SCAT	0ZAN1064
243		REWIND 4	0ZAN 1065
	17	$1 \ CO \ 4 \ I=1, II$	CZAN1066
		IF ((KSREX.EC.1).ANC.(I.NE.1)) GO TO 4	0ZAN1067
		IF (KSREX.EQ.1) GO TC 172	DZAN 1068
		NN=NCW(I)	CZAN1069
		READ (NN, 2000) W	0ZAN1070
		REWIND NN	07AN1071
	17	2 MCF1=1	07AN1072
		MCF2=1	07AN 1073
		IF ((TIME.EQ.TMAX).ANC. (UNSFC.EQ.DNC)) GC TO 62	074N1074
	С		0ZAN1075
		CALL FISS(W, FSI, UNSF, FL, HV, R, MCF1, SUM21)	07AN 1076
	С		07AN1077
		IF (KSREX.EQ.O) GD TE 61	07AN1070
		FLAP(K)=SUM21#1.5708	02 AN 1070
		IF (KSREX.EQ.1) GD TO 62	07AN1000
			ULANIUSU

	61	SUM21=SUM21/SSKEF				DZAN1081	
		SH(1,K)=SUM21				0ZAN1082	
	12	IF ((11ME.EQ.IMAX).ANE.(SIGAC.EQ.DNC).ANE.(SCATC.EQ.DNC)) GO	TO	11		OZAN1083	
~	52	CUNTINUE				0ZAN 1084	
, C						GZAN1085	2
-		CALL ABSP(W, PS1, SIGA, SCAT, HU, HV, R, MCF2, SUM22)				GZAN1086	
C						0ZAN 1087	
		SA(1, K)=SUM22				OZAN1088	
		IF (KSREX.EQ.O) GU TE 63				DZAN1089	
		ALAP(K)=SUM22-1.5708				0ZAN1090	*
		IF ((KSREX.EG.1).ANC.(K.EQ.KK)) GD TU 131	1.1			OZAN1091	
		IF (KSREX.EQ.1) GO TC 4				0ZAN1092	
	63	IF(TIME.EQ.TMAX) GO TO 11				0ZAN1093	
		$LAFN(I,K) = (SF(I,K)+S/(I,K)) \approx 1.5703$				GZAN1094	
		GU TC 4				OZAN 1095	
	11	$VLAPN(1, K) = ((SF(1, K) + SA(1, K)) * 1 \cdot 5708 - LAPN(1, K)) / (TMAX - TMIN)$				CZAN1096	
	4	CUNTINUE		а. ₁₀		0ZAN1097	
		IF (TIME.EQ.TMAX) GO TO 10	6.28			- 0ZAN1098	
		WRITE(6,627)				. UZAN1099	
		WRIIE(6, 626) ((LAPN(I,K),K=1,KK),I=1,II)			1 . L	0ZAN1100	
		IF (CC.EQ.DNC) GC TO 12				OZAN1101	
C		ATT THE ALL				0ZAN1102	
- C	<u>*</u>	PI IMAX				OZAN1103	
C	• ~ •					UZAN1104	
						0ZAN1105	
	10		80 <u>-</u>			0ZAN1106	
	10	WRI12(6,628)			·	OZAN1107	
		WKITE(0, 620) ((VLAPN(1,K),K=1,KK),I=1,II)			•	CZAN1108	
	12					OZAN1109	
	12	UU = 1.5 = 1 + 1 + 1				0ZAN 1110	
	1.2	$U_{1} = 13 K = 19 K K$			111 A.S.	0ZAN1111	
	10	$V \square P \square (I, K) = U_0$				OZAN1112	
	121					OZAN1113	
	101				1 e î	OZAN1114	
		$\frac{1}{1} \frac{1}{1} \frac{1}$				OZAN1115	
		ALARIAALAR(I)				0ZAN1116	
							ω

이는 - 아이에게 이는 것이다. 1995년 - 이가 아이에 나라 아이는 것이다.

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WRITE(6,6291) DZAN111 WRITE(6,6293) DZAN111 WRITE(6,6293) CZAN112 WRITE(6,6293) DZAN112 WRITE(6,6292) DZAN12 DZAN12 DZAN12 D2 24 K=1,KK DZAN12 C2 4 K=1,KK DZAN12 D2 24 K=1,KK DZAN12 C2 4 CONTINUE DZAN12 RETURN DZAN12 FND DZAN12 SUBROUTINE GTM(W,PSI,FU,HV,R,VI,GEN1) DZAN12 C 6E**EFATICN TIME MATRIX DZAN12 D IMENSION W(2,48,4C),FSI(3,48,40),HU(39),HV(47),R(40),VI(3) DZAN13 D 3 MG=1,3 CZAN13 SUM1=0, DZAN13 D 1 MV=2,47 DZAN13 MU=1 DZAN13 GEN=W(MG,MV,MU)*FSI(MG,MV,MU)*(HV(MV-1)+FV(MV))*HU(MU)*(F(MU)+HU(M DZAN13 DZAN13
<pre>WHITE(6,626)(DIFFP(I),I=1,II) WRITE(6,6293) WRITE(6,6293) WRITE(6,6292) WRITE(6,6292) WRITE(6,626)(ALAP(I),I=1,II) DO 24 K=1,KK CZAN112 CZAN113 C</pre>
WRITEL6,6293) CZAN111 WRITEL6,6293) CZAN112 WRITEL6,6292) CZAN112 WRITEL6,6292) CZAN12 D2 24 K=1,KK CZAN12 C2 54 K=1,KK CZAN12 C2 65 KEF(K)=FLAP(K)/(+EIFFP(K)-ALAP(K)) CZAN12 I4 CONTINUE FEURN CZAN12 I5 00 KCUTINE GTM(W,PSI,FU,HV,R,V1,GEN1) CZAN12 C 66 KEFATION TIME MATRIX CZAN12 C 70 JMENSION W(3,48,40,FSI(3,48,40),HU(39),HV(47),R(40),V1(3) CZAN13 C 70 JMENSION W(3,48,40,FSI(3,48,40),HU(39),HV(47),R(40),V1(3) CZAN13 C 70 JMENSION W(3,48,40,FSI(3,48,40),HU(39),HV(47),R(40),V1(3) CZAN13 C 70 J MG=1,3 CZAN13 C 70 J MG=1,3 CZAN13 C 70 J MV=2,47 CZAN13 MU=1 CZAN13 GEN=W(MG,MV,NU)*FSI(MG,MV,MU)*(HV(MV-1)+HV(MV))*HU(MU)*(F(MU)+HU(M CZAN13 </td
<pre>WRITE(6,625)(FLAP(I),I=1,II) WRITE(6,6292) WRITE(6,62</pre>
WRITE(6,6292) GZAN112 WRITE(6,626)(AL AP(I), 1=1, II) GZAN12 D2 24 K=1,KK GZAN12 24 SKEF(K)=FLAP(K)/(+CIFFP(K)-ALAP(K)) GZAN12 14 CONTINUE GZAN12 RETURN GZAN12 SUBROUTINE GTM(W,PSI,FU,HV,R,V1,GEN1) GZAN12 C GE**EFATION TIME MATRIX C DIMENSION W(3,48,4C),FSI(3,48,40),HU(39),HV(47),R(40),V1(3) C GEN1=0. C GEN1=0. C GEN1=0. C GZAN13 C GEN1=0. C GZAN13 C GZAN13 C GEN1=0. C GZAN13
WRITE(6,626)(ALAP(I), 1=1, II) DZAN112 CO 26 K=1,KK DZAN12 24 SKEF(K)=FLAP(K)/(+DIFFP(K)-ALAP(K)) DZAN12 I4 CONTINUE DZAN12 RETURN DZAN12 INC SUBROUTINE GTM(W,PSI,FU,HV,R,VI,GEN1) C GE**EFATION TIME MATRIX DIMENSION W(3,48,40),FSI(3,48,40),HU(39),HV(47),R(40),VI(3) DZAN113 C GEN1=0, C GEN1=0, CD 3 MG=1,3 SUM1=0, CO 1 MV=2,47 DZAN13 VU=1 GCAN113 GEN=W(MG,MV,NU)*FSI(MC,MV,MU)*(HV(MV-1)+FV(MV))*HU(MU)*(F(MU)+HU(M DZAN113
CD 24 K=1,KK 24 SKEF(K)= FLAP(K)/(+CIFFP(K)-ALAP(K)) 14 CONTINUE RETURN IND SUBROUTINE GTM(W,PSI,FU,HV,R,V1,GEN1) C C C C C C C C C C C C C
24 SKEF(K)=FLAP(K)/(+DIFFP(K)-ALAP(K)) 14 CDNTINUE RETURN IND IND SUBROUTINE GTM(W,PSI,FU,HV,R,V1,GEN1) C C C C C C C C C C C C C
14 CONTINUE RETURN END SUBROUTINE GTM(W, PSI, FU, HV, R, V1, GEN1) C C C C C C C C C C C C C
RETURN IND SUBROUTINE GTM(W,PSI,FU,HV,R,V1,GEN1) C C C C C C C C C C C C C
IND SUBROUTINE GTM(W, PSI, FU, HV, R, VI, GEN1) GZAN112 C GE*'EFATION TIME MATRIX GZAN112 C DIMENSION W(3,48,40), FSI(3,48,40), HU(39), HV(47), R(40), V1(3) GZAN113 C GEN1=0. GZAN113 C GEN1=0. GZAN113 C GEN1=0. GZAN113 CD 3 MG=1,3 GZAN113 SUM1=0. GZAN113 GZAN113 CD 1 MV=2,47 MU=1 GEN=W(MG, MV, NU)*FSI(MC, MV, MU)*(HV(MV-1)+FV(MV))*HU(MU)*(F(MU)+HU(M GZAN113 GZAN113 GZAN113 GZAN113 GZAN113
SUBROUTINE GTM(W,PSI,FU,HV,R,V1,GEN1) UZAN112 C GE*'EFATION TIME MATRIX UZAN112 C DIMENSION W(3,48,40),FSI(3,48,40),HU(39),HV(47),R(40),V1(3) UZAN113 C GEN1=0. UZAN113 C GEN1=0. UZAN113 CD 3 MG=1,3 UZAN13 UZAN113 SUM1=0. UZAN113 UZAN113 CO 1 MV=2,47 UZAN13 UZAN133 MU=1 GEN=W(MG,MV,NU)*FSI(MC,MV,MU)*(HV(MV-1)+FV(MV))*HU(MU)*(F(MU)+HU(M UZAN1134 U)/4) UZAN134 UZAN134
C C GE**EFATION TIME MATRIX DIMENSION W(3,48,40),FSI(3,48,40),HU(39),HV(47),R(40),V1(3) C GEN1=0. CO 3 MG=1,3 SUM1=0. CO 1 MV=2,47 MU=1 GEN=W(MG,MV,MU)*FSI(MC,MV,MU)*(HV(MV-1)+FV(MV))*HU(MU)*(R(MU)+HU(M UZAN113 OZAN11
C GE*EFATION TIME MATRIX C DIMENSION W(3,48,40),FSI(3,48,40),HU(39),HV(47),R(40),V1(3) C GEN1=0. CD 3 MG=1,3 SUM1=0. CO 1 MV=2,47 NU=1 GEN=W(MG,MV,NU)*FSI(MC,MV,MU)*(HV(MV-1)+FV(MV))*HU(MU)*(F(MU)+HU(M CZAN113
C DIMENSION W(3,48,4C), FSI(3,48,4O), HU(39), HV(47), R(4O), V1(3) C GEN1=0. CD 3 MG=1,3 SUM1=0. CO 1 MV=2,47 MU=1 GEN=W(MG,MV,PU)*FSI(MC,MV,MU)*(HV(MV-1)+FV(MV))*HU(MU)*(F(MU)+HU(M OZAN113 O
DIMENSION W(3,48,4C), FSI(3,48,4O), HU(39), HV(47), R(4O), V1(3) GEN1=0. CD 3 MG=1,3 SUM1=0. CO 1 MV=2,47 MU=1 GEN=W(MG,MV,NU)*FSI(MG,MV,MU)*(HV(MV-1)+FV(MV))*HU(MU)*(F(MU)+HU(M UZAN113
C GEN1=0. CD 3 MG=1,3 SUM1=0. CD 1 MV=2,47 MU=1 GEN=W(MG,MV,MU)*(HV(MV-1)+FV(MV))*HU(MU)*(F(MU)+HU(M UZAN113 OZA
GEN1=0. DZAN113 CD 3 MG=1,3 GZAN113 SUM1=0. DZAN113 CO 1 MV=2,47 OZAN113 MU=1 GEN=W(MG,MV,MU)*(HV(MV-1)+HV(MV))*HU(MU)*(F(MU)+HU(M GEN=W(MG,MV,MU)*FSI(MC,MV,MU)*(HV(MV-1)+HV(MV))*HU(MU)*(F(MU)+HU(M U2AN113 U2AN113
CD 3 MG=1,3 SUM1=0. CD 1 MV=2,47 MU=1 GEN=W(MG,MV,MU)*(HV(MV-1)+FV(MV))*HU(MU)*(F(MU)+HU(M DZAN113 OZAN114 OZAN113 OZAN11
SUM1=0. CO 1 MV=2,47 MU=1 GEN=W(MG,MV,MU)*(HV(MV-1)+FV(MV))*HU(MU)*(F(MU)+HU(M OZAN113 OZAN113 OZAN113 OZAN113 OZAN113 OZAN113
DO 1 MV=2,47 MU=1 GEN=W(MG,MV,MU)*FSI(MC,MV,MU)*(HV(MV-1)+FV(MV))*HU(MU)*(F(MU)+HU(M DZAN113 1U)/4)
NU=1 GEN=W(MG,MV,NU)*FSI(MC,MV,MU)*(HV(MV-1)+FV(MV))*HU(MU)*(F(MU)+HU(M UZAN113 1U)/4)
GEN=W(MG,MV,NU)*FSI(MG,MV,MU)*(HV(MV-1)+FV(MV))*HU(MU)*(F(MU)+HU(MU))*UZAN113
10)/4)
UZAN114
SUM1=SUM1+GEN
DO 1 MU=2,39
CEN=W(MG,MV,MU)*PSI(MG,MV,MU)*
1(HV(MV-1)+HV(MV))*(HU(MU-1)*(R(MU)-HU(MU-1)/4)+HU(MU)*
2(R(MU)+HU(MU)/4))
SUM1=SUM1+GEN
1 CONTINUE
3 GEN1=SUM1*V1 (MG)+GEN1
RETURN OZAN 114
END CZANII5
SUBROUTINE CEF(KSREX, K, TIME, TMAX, LFINAL, ISD, ENC, NE, LLL, DC, TMIN.D. 07AN115
1CPSI }

С			07AN1152
		COMMEN/FCFA/COEF.MCOF	0ZAN1155
C			07AN1155
		DIMENSION D(3.47.35), [PS1(3.47.39), COFE(3.47.30)	07AN1156
C		011101010101010111011101110111011100111011100111019111001	UZAN1150
-		INTECER INC	UZAN1157
C		INTECES DIO	UZANI158
C		NCOE-1	DZAN1159
	2	NUCFEL	0ZAN1160
		IF (KSREX-EQ.) GU IU 123	OZAN1161
		IF (KatQal) OU IU 120	OZAN1162
		IF (TIME EQ IMAX) GO TO 121	GZAN1163
		IF (LFINAL.EG.1) GD TC 122	GZAN1164
	13	5 DO 130 MV=1,47	0ZAN 1165
		EO 130 MU=1,39	OZAN1166
		CO 130 IK=1,3	OZAN1167
		COEF(IK, NV, MU)=D(IK, NV, MU)/DPSI(IK, MV, MU)	QZAN1168
	130) CONTINUE	0ZAN1169
		RETURN	07AN1170
	122	2 IF ((ISD.EQ.ENC).AND. (ND.EQ.DNC)) GO TO 123	07AN1171
		GC TC 135	07AN1172
	121	L IF (LFINAL.EC.1) GO TC 123	07AN1173
		IF (LLL.EQ.LFINAL) GC TO 123	07 AN1174
		G0 TC 135	07AN1175
	120) IF (TIME.NE. TMAX) GO TO 124	0ZAN1174
	÷.,	IE ((ISD - EQ - ENC) - AND - (DC - EQ - DNC) - AND - (111 - EQ - 11) CO TO 122	OZANI170
		GT TE 135	OZAN1177
	120	TE ((ISD. EQ. ENC), AND, (TMIN EQ. Q.)) CC TO 122	UZAN1178
	4 4	GO TC 135	UZANI179
	123	NCOE=O	UZAN1180
	A 64 4	RETURN	UZAN 1181
		END	UZAN1182
			OZAN1183
~		SUBRUUTINE FILIZU(W, FSI, D, HU, HV, R, SUM25)	0ZAN1184
C	Ent		OZAN1185
C	EQU	IVALENT OF THE LEAKAGE TERM FOR THE TRIAL FUNCTION IN QUESTION	OZAN1186
C			CZAN1187
		LIMENSIUN PSI(3,48,40),W(3,48,40),D(3,47,39),HU(39),HV(47),	GZAN1188

	1R(4C)	DZAN1189
С		0ZAN1190
	REAL LAP	0ZAN1191
С		0ZAN 1192
	SUM25=0.	QZAN1193
	DU 5 MG=1,3	07AN1194
	CO 5 MV = 2,47	07AN1195
	+V1 = HV(MV-1)	07AN1196
	HV2 = HV(MV)	07AN1197
	MU=1	07AN1109
	+U2 = +U(MU)	67AN1100
	HR2=R(MU)+HU(MU)/4	02AN1200
	FR4=R(MU)+HU(MU)/2	CZAN1201
	LAP=W(MG.NV.MU)*((D(NC.MV-1.MU)*HV1+C(MG.MV.MU)*HV2)*HPA*PSI/MC.	07AN1202
	1MV, MU+1) /HU2+(D(MG, MV-1, MU)*HU2*HR2)*PSI(MG, MV-1, MU)/HV1+(D(MG, MV-	07 AN 1202
	2NU) * HU 2* HR2) * PSI (MG • NV + 1 • MU) / HV 2- ((D(MG • NV - 1 • NU) * HV 1+ D(MG • MV • MU)	07AN1204
	3*HV2)*HR4/HU2+(D(MG,MV-1,MU)*HU2*HR2)/HV1+(D(MG,MV,MU)*HU2*HR2)/+V	17AN1205
	42)*PSI(MG,MV,MU))	0ZAN1205
	SUM25=SUM25+LAP	G74N1207
8	DO 5 MU=2,39	07 AN 1209
	FU1 = FU(MU-1)	07AN1200
	FU2=HU(MU)	07AN1210
$\sigma = z$	HR1=R(MU)-HU(MU-1)/4	07AN1211
•	HR2=R(MU)+HU(ML)/4	07AN1212
	+R3=R(MU)-HU(MU-1)/2	07AN1212
12 63	HR4 = R(MU) + HU(MU)/2	07AN1214
	LAP=W(MG,MV,MU)*((D(NG,MV-1,MU)*+V1+C(MG,MV,ML)*+V2)*HRA*PST(MG,	07AN1215
8	1MV, MU+1)/HU2+(D(MG, MV-1, MU)*HU2*HR2+D(MG.MV-1.MU-1)*HU1+HR1)*	02AN1216
	2PSI(MG, MV-1, MU)/HV1+(C(MG, MV-1, MU-1)*HV1+D(MG, MV, MU-1)*HV2)*	07AN1217
	3HR 3*PSI(MG, MV, MU-1)/HL1+(D(MG, MV, MU-1)*HL1*HR1+D(MG, MV, ML)*HU2*	07AN1218
	4HR2) #PSI (MG, MV+1, MU)/HV2-((D(MG, MV-1, MU) #HV1+D(MG, MV, MU) #HV2)*	07AN1219
	5HR4/HU2+(D(MG,MV-1,ML)*HU2*HR2+D(MG,MV-1,MU-1)*HU1*HR1)/HV1+	D7AN1220
	6(D(MG, MV-1, ML-1)*HV1+C(MG, MV, MU-1)*HV2)*FR3/HU1+(C(MG.MV.MU-1)*	07AN1221
	7HU1#HR1+D(MG,MV,MU)#HL2#HR2)/HV2)#PSI(MG.MV.ML))	07AN1222
	SUM25=SUM25+LAP	07AN1222
	5 CONTINUE	07 ANI 1024
		ULAN LZZA

....

	RETURN		0ZAN1225	
	SUPPOLITINE EISSIN, DST HINGE HIL HV D MCEL CUMPLA		UZANIZZO	
ſ	3000001110 1 133149P3190N3P9HU9HV9R9MCP193UM219		UZAN 1227	
C ET	S LIKE FISSION (DRODUCTION) INTECRATED DVED THE DEACTOR		UZAN1228	
C VOI	IME AFTER REING WEICHIED		UZAN 1229	
e voi	ALE ALLE DETUD RETOLICA		UZAN1230	
6	CONNENTECEN CONT. NOOF		0ZAN1231	
C	CLMMUN/FCFA/CDEF, MCDF		OZAN 1232	
Ċ.			CIZAN1233	
	LIMENSIUN W(3,48,40), FSI(3,48,40), UNSF(3,47,35), HU(35), HV(47),		0ZAN1234	
c	LR(40), UUEr(3,41,39)		OZAN 1235	
C			CZAN1236	
	SUM21=0.		0ZAN1237	
	IF ((MCFL.EQ.1).AND. (MCOF.EQ.1)) GO TO 14		0ZAN1238	
			CZAN1239	
	UF 12=1.		OZAN1240	
			OZAN1241	
			GZAN1242	
12	DU 7 MV = 5, 24		OZAN 1243	
	FV1 = FV(MV-1)	8 11 11 1	OZAN1244	
			OZAN1245	
	UU 7 MU = 3, 17		0ZAN1246	
14 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	WI=W(1, MV, MU)		OZAN1247	
285 1 <u>92</u> - C 11 1	PII = PSI(I, MV, MU)		OZAN1248	
	P12=P51(2,MV,MU)		OZAN1249	
	P13=P51(3,MV,MU)		OZAN1250	
	UF11=UNSF(1, NV-1, MU-1)		0ZAN 1251	
•	UF12=UNSF(1, MV, MU-1)		0ZAN1252	
	UF13=UNSF(1, VV-1, MU)		OZAN1253	
	UF13=UNSF(1, MV, MU)		OZAN1254	
	U = 21 = UNSF(2, NV = 1, MU = 1)		OZAN1255	
	UF22=UNSF(2, MV, MU-1)		CZAN1256	
	UF23 = UNSF(2, NV - 1, MU)		UZAN1257	
	UF24=UNSF(2, NV, MU)	N 25 N 3	OZAN1258	
с. С	UF31=UNSF(3, MV-1, MU-1)		GZAN1259	
	CF32=UNSF(3, NV, NU-1)		OZAN1260	
			384	
			•	

a. **	UF33=UNSF(3, MV-1, ML)	OZAN1261	
	UF34=UNSF(3, MV, MU)	CZAN1262	
	HRI = (R(MU) - HU(MU - 1)/4) * HU(MU - 1)	OZAN1263	
	HR 2 = (R(MU) + HU(MU)/4) * FU(MU)	OZAN1264	- 8
2	JF ((MCF1.EQ.0).OR, (MCUF.EQ.0)) GO TO 16	GZAN1265	ä
	CF11=COEF(1, NV-1, MU-1)	OZAN1266	
	(F12=CDEF(1,MV,MU-1))	UZAN1267	
¥	(F13=COEF(1,MV-1,MU))	CZAN1268	
	CF14=COEF(1,MV,MU)	0ZAN 1269	
	16 FIS=-W1*(((UF11*CF11*FV1+UF12*CF12*HV2)*HR1+(UF13*CF13*	QZAN1270	•
	1HV1+UF1&*CF1&*HV2)*HR2)*PI1+((UF21*CF11*FV1+UF22*CF12	07AN1271	
	2#HV2)#HR1+(UF23*CF13*FV1+UF24*CF14*HV2)*HR2)*PI2+	07AN1272	
	3((UF31*CF11#FV1+UF32*CF12*HV2)*HR1+(UF33*CF13*HV1+	07AN1273	
1 A .	2UF34*CF14*HV2)*HR2)*F13)	07AN1274	
100 mar 100 mar 100 mar 100 mar	SUM21=SUM21+FIS	07AN1275	
	? CONTINUE	07AN1276	
	RETURN	07 AN 1277	
	END	074N1278	
	SUBROUTINE AESP(W, PSI, SIGA, SCAT, FU, HV, R, MCF2, SUM22)	.07AN1270	
	C	07AN 1290	
· •	C ABSP LIKE ABSORPTION (AND ALSO SCATTERING) INTEGRATED OVER THE	07AN1281	
s V Æ	C REACTOR VOLUME AFTER BEING WEIGHTED	07AN1282	
		07AN1202	
	COMMEN/FCFA/COEF, MCDF	07AN1205	
	C	02AN1204	
	DIMENSION W(3,48,40), PSI(3,48,40), SIGA(3,47,39), SCAT(2,47,39),	02AN1285	
	1HU(39), HV(47), R(40), C(EF(3,47,39)	 07401200	
	C	 02AN1200	
	SUM22=0.	02401200	
	IF ((MCF2.EQ.1). ANC. (MCOF.EQ.1)) GO TO 16	07AN1209	
	(F11=1.	0ZAN1290	
	CF12=1.	0ZAN1291	
12	CF13=1.	07AN1202	
	(F14=1.	02AN1293	
	CF21=1.	OZANI 205	
	CF22=1.	OZAN1295	
		ULAN1290	38
			(11

(F23=1.	07AN1297
CF24=1.	07AN1298
CF31=1.	07AN1299
CF32=1.	(ZAN1300
CF33=1.	07AN1301
(F34=1.	07AN1302
16 CC 6 MV=2,47	07AN1303
+V1=HV(MV-1)	07AN 1304
FV2 = FV(MV)	C7AN1305
MU = 1	DZAN1306
$hl = W(1 \cdot MV \cdot MU)$	07AN1307
W2=W(2.MV.MU)	07AN1200
W3=W(3.MV.MU)	07AN1308
PII=PSI(1,MV,MU)	0ZAN1309
$FI2 = FSI(2 \cdot MV \cdot MU)$	07AN1311
PI3=PSI(3.MV.ML)	DZAN1311
SA13=SIGA(1, NV-1, MU)	07AN1312
$SA14 = SIGA(1 \cdot NV \cdot NU)$	07AN1313
$SA23 = SIGA(2 \cdot NV - 1 \cdot MU)$	0ZAN1314
SA24=SIGA(2.WV.MII)	UZANIJI
$SA33 = STGA(3 \cdot NV - 1 \cdot MI)$	UZAN1310
SA34 = STGA(3, MV, MII)	UZAN1317
$ST13=SCAT(1 \cdot NV-1 \cdot MU)$	UZAN1318
ST 14 = SC A T (1 - NV - MH)	UZANIJIA
ST23=SCAT(2, NV-1, MU)	UZAN 1320
ST24 = SCAT(2, NV, NII)	UZANI321
HR 2 = (R(MU) + HI(MU)/4) + HI(MU)	UZAN 1322
1E = I (MCE2 - E0 - 0) - 0R - INCOE - E0 - 011 - CO - TO - 18	· UZAN 1323
CE13=COEE(1, NV-1, ML)	UZAN1324
CE14=COEE(1,NV,MI)	UZAN 1325
CF23=COEF(2,WV-1,WU)	UZAN1326
CF24=C6EE(2,NV,NI)	UZAN1327
(F33=COFF(3, NV-1, MII))	UZAN 1328
CF34=COFE(3, NV, NII)	UZAN1329
18 ASB=(W1%((SA13+ST13))*(F13%HV1+(SA1A+ST1A)*(F1A*HV2)*DT1+	UZAN 1330
1W2% (-(ST13#CF23#HV1+ST14#CF24#EV2)#CF14//CCA34CF33/#CF34	UZAN 1331
2	ULANI 332

2HV1+(SA24+ST24)*CF24*+V2)*PI2)+W3*(-(ST23*CF33*HV1+	OZAN1333
4 FT3) 1xHD2	0ZAN1334
SUN22=SUN22+ACD	0ZAN1335
50 A MU=2-30	ŪZAN 1336
	OZAN1337
	OZAN 1338
	0ZAN 1339
	0ZAN1340
PII=PSI(I,MV,MU)	0ZAN 1341
P12=P51(2,MV,MU)	CZAN1342
PIJ=PSI(3,MV,MU)	OZAN1343
SAIJ = SIGA(1, MV - 1, MU)	0ZAN1344
SA14=SIGA(1, MV, MU)	0ZAN1345
SA23=SIGA(2, NV-1, MU)	OZAN1346
SAZA=SIGA(Z, MV, MU)	0ZAN1347
SADD-SIGA(S + MV - 1 + MU)	OZAN1348
SA 39 - SIGA(3, FV, FU) ST 13 = SC AT(1, FV - 1, MU)	UZAN 1349
STIA=SCAT(1, NV NIL)	0ZAN1350
ST23=SCAT(2, NV-1, MU)	- OZAN1351
ST26=SCAT(2, NV, MU)	0ZAN1352
$HR2 = \{R\{M\}\} + H\{M\}\} / A \} + L(M)$	ŰZAN1353
SA11=STCA/1, MV=1, MU=1	OZAN1354
SA12 = STCA(1, WV, MU = 1)	0ZAN1355
SA12 = S16P(1, PV, PO = 1) SA 21 = S16A(2, PV = 1, MI = 1)	OZAN1356
SA22=SIGA(2, NV, NU=1)	OZAN 1357
SA31 = STGA(3, N) = 1 MU = 1 N	0ZAN1358
SA32=SIGA(3, NV, MU-1)	OZAN1359
ST11=SCAT(1, NV-1, MU-1)	UZAN 1360
ST12=SCAT(1, NV, NU=1)	UZAN1361
$ST_{21} = SCAT(2, MV - 1, MI - 1)$	DZAN1362
$ST22 = SCAT I2 \cdot NV \cdot NU = 1 $	0ZAN1363
HR = (R(MI) - HI(MI) - I) (A) + HI(MI) = I	0ZAN1364
IE ((MCE2.E0.0), DE (NCD5.50.0)) CD TD 20	OZAN 1365
CF13=COME(1, NV-1, MIL)	. OZAN1366
$CE1\Delta=COEE(1,NV,MI)$	OZAN1367
CITALMORI (TANA) HOI	CZAN1368 ω

	CF23=C0EF(2, MV-1, MU)		QZAN1369
	CF24=CUEF(2, NV, MU)		OZAN1370
	CF33=CDEF(3, NV-1, MU)		OZAN 1371
	CF34=COEF(3, NV, MU)		OZAN1372
	CF11=C08F(1, NV-1, MU-1)		OZAN1373
	CF12=COEF(1,MV,MU-1)		CZAN1374
	CF21=COEF(2, NV-1, MU-1)		OZAN1375
	CF22=COEF(2,NV,MU-1)		0ZAN 1376
	CF31=COEF(3, NV-1, MU-1)		0ZAN1377
	CF32=COEF(3, NV, MU-1)		OZAN1378
	20 ASB=W1*(((SA11+ST11)*CF11*HV1+(SA12+ST12)*CF12*HV2)*HR1+((SA13+ST1		UZAN1379
	13)=CF13# HV1+(SA14+ST14)#CF14#HV2)#HR2)#PI1+W2#(-((ST11#CF21#HV1+ST		UZAN1380
	212#CF22#HV2)#HR1+(ST13#CF23#HV1+ST14#CF24#HV2)#HR2)#PI1+(((SA21+ST		OZAN1381
	321)*CF21*HV1+(SA22+ST22)*CF22#HV2)*HR1+((SA23+ST23)*CF23*HV1+(SA24		OZAN1382
	3+ST24)#CF24#FV2)#HR2)#PI2)+W3#(~((ST21#CF31#FV1+ST22#CF32#HV2)#HR1		OZAN1383
	4+(ST23*CF33*HV1+ST24*CF34*HV2)*HR2)*PI2+((SA31*CF31*HV1+SA32*CF32*		0ZAN1384
	5+V2)*HR1+(SA33*CF33*+V1+SA34*CF34*HV2)*HR2)*PI3)		OZAN1385
	SUM22=SUM22+ASB	: - · ·	UZAN1386
	6 CONTINUE		OZAN1387
	RETURN		OZAN1388
	END	n i sis	OZAN 1389
	SUBROUTINE FILIZ2		OZAN1390
С		•	OZAN1391
С	FISSION MATRIX AND ABSORFTION MATRIX		OZAN 1392
С			OZAN1393
e.	COMMON/OZO/SIGA, UNSF, SGCS, SCAT, PSI, W		OZAN1394
	COMMON/OZ11/C, DNC, KSRCZ, SKOZN, NDFSI, NDW, HU, HV, R	•	0ZAN1395
	CCMMCN/0Z12/EC, SIGAC, LNSFC, SIGFC, SGCSC, SCATC, SPNRC, ATTC	1 - Q - 1	UZAN1396
	CCMMEN/GZ2/NMODES, II, KK		OZAN1397
	COMMON/DZ3/TMIN,TMAX		OZAN1398
	CCMMCN/0Z4/NEETA1,NEETA2,NBETA,NEET1		. OZAN1399
	COMMON/OZFZ2/BETA, E, FMAR, VFMAR, BETR, VBETR, BEC11, BEC21		OZAN 1400
	COMMON/F2F4/WSC, JNPC		CZAN1401
C			OZAN1402
	DIMENSIUN PSI(3,48,40), W(3,48,40), SIGA(3,47,39), UNSF(3,47,39);		0ZAN 1403
	ISCAI (2,47,39), HU(39), FV(47), R(40), BETA(6), NDW(2), NDPSI(2),		GZAN1404

		18EC11(2,2,6), BEC21(2,2,6), BETR(2,2), VBETR(2,2), FMAR(2,2), VFMAR(2,2)	OZAN1405
	С	21430031243441434143F1242143A124214WSU121	0ZAN1406
		INTEGER C.DNC	UZAN1407
		INTEGER DC.SIGAC.UNSEC.SIGEC.SCATC.SCCSC.SDNDC.ATTC	UZAN 1408
	С	201 201 0010104040101 C43CA 10430C3C 43PNRC 44110	UZAN1409
	C	CALCULATION OF EMAR - TH LOMBANKI AND STONAST AND STONATO TYLINTECO ATED OVER	UZAN1410
	С.	THE REACTOR VOLUME-AND CALCULATION OF RECLI AND RECOLUTED OVER	UZAN1411
	C	The second and calcolation of Decil and Deczi(J=1,0)	UZAN1412
	1000	FORMAT (7E11, 5)	UZAN 1413
	2000	FOFMAT (195E14.6)	UZAN1414
	2001	FORMAT (1X.8812.5/(1X.8812.5))	UZANIAIS
	625	FORMAT (1X. 2(E15. B. 3x)/(1X. 2(E15. 8. 2Y))//)	UZAN 1416
	629	FORMAT (/1X. FISSION MINIS ABSORDITION MATRIXE INTITAL VALUENCE	UZAN1417
	630	FORMAT (/1X. FISSION NINUS ABSORFTION MATRIX INITIAL VALUE) //	UZAN1418
	631	FORMAT (/1X, DELAYED NEUTRON FRACTION MATRICES!/)	UZAN 1419
	6311	FURMAT (/1X, 'DELAYED NEUTRON FRACTIONS!/)	UZAN1420
	632	FORMAT (12X, 12, 3(26X, 12))	UZAN1421
	6321	FORMAT (1X, 4 (2(E12, 5, 1X), 2X))	UZAN1422
	6322	FORMAT (/1X, "RAMP CHANGE SLOPE OF THE DELAYED NEUTRON EPACTION MAT	UZAN1423
		IRICES'/)	UZAN 1424
	6323	FORMAT (/1X, RAMP CHANGE SLOPE OF THE DELAYED NEUTRON ERACTIONS ()	07AN1425
÷.,		FORMAT(/1X, 'PRODUCTION TERM WHICH WILL DIVIDE ALL THE MATRIX FLEME	07 AN 1420
		INTS'/)	02AN 1921
	С.		02411420
	С	AT THE BEGINNING OF THE TIME STEP	07 AN 1430
	C a		07AN1431
	а	MC F 1 = 0	07AN1432
		MCF2=0	07AN1433
		TIME=TMIN	07AN1434
		READ(15,1000) SIGA	0ZAN1435
	đ. 1	REWIND 15	0ZAN1436
		PEAD(16,1000) UNSF	OZAN 1437
		REWIND 16	UZAN1438
		READ (22, 1000) SCAT	OZAN1439
		REWIND 22	OZAN 1440

	158	$EO \ 121 \ I=1, II$	OZAN1441
÷.		N = N C W (I)	0ZAN1442
		READ (NN, 2000) W	0ZAN1443
		REWIND NN	0ZAN1444
		IF((NMODES.EC.1).OR. (TIME.EQ.TMAX).OR. (JNPC.EQ.O)) GO TO 159	OZAN1445
		hSC(I)=0	0ZAN 1446
C			0ZAN1447
	•	CALL WCOEF(I,W,HU,HV,F,WSC)	0ZAN 1448
C			OZAN1449
	111	WSC(I)=WSC(I)*1.5708	0ZAN1450
	159.	DU 151 K=1, KK	0ZAN 1451
		NN = NEPSI(K)	0ZAN1452
		READ (NN, 2000) PSI	0ZAN1453
		REWIND NN	07 AN 1454
		IF((TIME.EQ.TMAX).ANC.(UNSFC.EQ.DNC)) GD TD 56	CZAN1455
С			0ZAN1456
		CALL FISS(W, FSI, UNSF, FU, HV, R, MCF1, SUM61)	0ZAN1457
С		그는 그는 것은 것이 같은 것이 안 물건이 있다. 이렇게 가장에서 가장에 가장을 만들었다. 것이 많은 것이 나는 것이 많은 것이 없다.	0ZAN1458
a		SF(I,K) = -SUM61/SKOZN	, 0ZAN1459
		IF ((TIME.EQ.TMAX).ANE.(SIGAC.EQ.DNC).ANE.(SCATC.EG.ENC))	CZAN1460
		1GU TU 42	0ZAN1461
	56	CONTINUE	0ZAN 1462
· C	6 - S		0ZAN1463
		CALL ABSP(W, PSI, SIGA, SCAT, HU, HV, R, MCF2, SUM62)	DZ AN 1464
С	•		QZAN1465
		SA(I,K) = -SUM62	0ZAN1466
	393	IF (TIME.EQ. TMAX) GC 10 42	0ZAN1467
. x		FMAR (I,K)=(SF(I,K)+SA(I,K))#1.5708	CZAN1468
		EETR(I,K)=SF(I,K)*1.5708	CZAN1469
		IF ((I.EQ.1).AND.(K.EG.1)) GO TO 591	UZAN 1470
		GO TO 592 .	0ZAN1471
	591	E=BETR(I,K)	07AN1472
		hRITE(6,633)	0ZAN 1473
		WRITE(6,626) E	07AN1474
	592	CONTINUE	07 AN 1475
С			07AN1476

C DEI	AYED NEUTREN ERACTION AATOTY	1	
C	THIED REDIKUN PRACTIUN PATRIX		OZAN 1477
C .	DO 120 1-1 NECTAL		GZAN1478
120) $BE(1)(T_{*}K_{*}I) = BETA(I) \Rightarrow EETD(T_{*}K)$		OZAN1479
	CO TC 121		0ZAN1480
67	TE LISICAC EC PACI ANT LICCATE TO DUDAL OF THE		OZAN1481
	VEMAP(T, K)=((SELT K) ACATT K) ACATT K) GE TO 421		UZAN1482
	CO TC 422		0ZAN1483
421			OZAN1484
422	TE (INSEC = 0) DNCA CONTRACT		OZAN 1485
746	VRETRIE KIALSELLE KING STOR STOR STOR		0ZAN1486
	DO = 63 = 1 + 1 + 0 = 1 + 1 = 5708 - BETR(1,K))/(TMAX-TMIN)		OZAN1487
63	BEC21(I K I)-DETA(I)-BLOGTOLT HA		OZAN1488
0,	CO TC 121		OZAN1489
12	DO 126 1-1 NECTAL		OZAN1490
126	FEC21(T.K.1)-0		0ZAN1491
121	CONTINUE		GZAN1492
34.4	IE (TIME-EO TMAY) CO TO 64		OZAN 1493
	WRITE(6.620)		CZAN1494
	$kRTTE(\mathbf{A}, \mathbf{A}, \mathbf{C}, \mathbf{A}) = (I \in MAR(\mathbf{T}, \mathbf{K}), \mathbf{K} = \mathbf{I}, \mathbf{K} \in \mathbf{K})$		OZAN1495
	IE (NMODES = EC 1) CO TE (207)		0ZAN1496
	LA TELE AT 1	그 옷에서 물건이 드러졌다.	OZAN1497
	WRITE(6, 632) (1, 1-1, 4)		OZAN1498
	$\Gamma(0,7223,1-1,1)$		OZAN1499
7323	$WRITE(6, 6321) (((REC1))) \times (1) \times (1) \times (1) \times (1)$		OZAN1500
	$\frac{1}{1} = \frac{1}{1} = \frac{1}$		OZAN 1501
3.	DG = 5324 I - 1 II		0ZAN1502
6224	WRITE(6, 6221) ///DEC11/1 / 12 // 1 // -		OZAN1503
V 367	GO = TO (4328)		0ZAN 1504
6 227	LOITE(A 4211)		0ZAN1505
	WP TTE(6, 2001) ((())) COMPANY (()) = 0.550		OZAN1506
6328	$I = \{1 \in I \in A, Z \in D \}$ ((() $E \in I : (I, K, J), I = I, I I \}, K = I, KK \}, J = I, NBETA1) \}$		0ZAN1507
0.52.0	10 TO 43		OZAN1508
			OZAN 1509
	ΑΤ ΤΝΑΥ		CZAN1510
	HI IFAA		OZAN1511
			07AN1512

		20 B	
	TIMETMAY		07411512
	$IE (SIGAC_EO_DNC) GO TO 164$		UZAN1513
	READ(19,1000) SIGA		OZAN1514
	REWIND 19		UZAN1515
164	TE (INSEC. CO. DAC) CC TO 140		ULAN1510
AGY			UZAN1517
	EEUTAD 20		UZAN1518
140	TE ISCATO EO DACA CO TO 172		UZAN1519
100	DEAL/22 1000 CCAT		UZAN 1520
	REFLIZE IN SCAL		CZAN1521
172	REWINU 23		OZAN1522
112	CONTINUE CO TO 150		0ZAN 1523
61			UZAN1524
04	WRITELE (20) WENNED IT VN V-1 VVN T-1 TTN		UZAN 1525
	$\frac{1}{10} \frac{1}{10} \frac$		UZAN1526
	$\frac{1}{1} + \frac{1}{1} + \frac{1}$		UZAN1527
	MRIIC(0)CSZZJ $WDITC(4 422) (1 1-1 4)$		UZAN1528
	$P_{0} = (325 I - 1) II$		UZAN1529
6325	$\frac{1}{100} \frac{1}{100} \frac{1}$		UZAN1530
0325	$\frac{1}{10} \frac{1}{10} \frac$		0ZAN1531
	PO 4224 T-1 TT		UZAN1532
6.326	WRITE($4,4321$) (((REC21/T V I) V-1 VV) I-E NOTALL)		UZAN 1533
0.20	$K_1 = 10, 03211 ((000021(1, K, J), K = 1, KK), J = 5, NBE(F1))$		UZAN1534
4320			UZAN1535
C - Z 7	WRITE(6,2001) ((()RECSILT K I) T-1 TT) K-1 KKY I-1 NORTAIN)		UZAN 1536
6330	CENTINUE	한 일을 알고 있는 것을 받는 것을 받는 것을 받았다.	UZAN1537
0350	CONTRACT		UZAN 1538
43	PO = A = 1 + 1 T		UZAN 1539
			UZAN1540
			UZAN 1541
	PO 44 I-1 NECTAL		UZAN 1542
44			UZAN1543
45			UZAN 1544
7)	RETURN		UZAN1545
	END		ULAN 1946
	SUBROUTINE WODEE(I.W.HILEV.P.WSC)		02AN 1547
	SOURCOLLEE POULICLERSTUPENERSTOPENERSTOPENE		ULANID48

c	INTEGRATE THE WEIGHTING EINCTIONS ONTO THE OFFICE OF THE OFFICE	OZAN1549
C	THE WEIGHTING FENCTIONS OVER THE REACTER VOLUME-FIRST GROUP ONLY-	OZAN1550
	DIMENSION W (3.48.40) . HU (39) . HV (47) . P (40) WSC (3)	OZAN1551
C	1117107107710137791714179K14079W3C(2)	OZAN 1552
	SUM=0.	0ZAN1553
	MG = 1	CZAN1554
	EO = 3 MV = 2,47	UZAN 1555
	▶U = 1	0ZAN1556
	GE=W(MG, MV, MU)*(HV(MV-1)+HV(MV))*HU(MU)*(R(MU)+HU(MU)/4)	UZAN1557
	SUM=SUM+GE	UZAN 1558
	DO 3 MU=2,39	UZAN1559
	GE=W(MG, MV, MU)*(HV(MV-1)+HV(MV))*(HU(MU-1)*(R(MU)-HU(MU-1)//)+	UZAN 1560
	1+U(MU)*(R(MU)+HU(MU)/4))	UZAN1561
	SUM=SUM+GE	UZAN1562
	3 CONTINUE	02AN 1903
	hSC(I) = SUM	07AN1545
	RETURN	07AN1566
	END	074N1567
~	SUBROUTINE FILIZ3	07AN1568
0	EDGINET AND DELANED DISTRICTURE	CZAN1569
č.	THIS SUBDOUTINE TO CALLED TE TE TO DECEMBER OF	0ZAN1570
r.	IMPORTANT IN THE TRANSIENT OF IT IS BELIEVED THAT THE PHOTONEUTRONS ARE NOT UN	OZAN 1571
č	THE DRIANT IN THE TRANSIENT STUDIED(COEFIC.NE.O.)	CZAN1572
C	COMMONIATO/SICA UNCE COCC COAT DOT H	OZAN1573
	COMMENTOZOV STGATUN SFISCES, SEATIN NO STIN	OZAN 1574
	COMMON/0712/CC.SIGAC INSEC SIGEC SOCCE SCITE	OZAN1575
	COMMON /072/NMODES, IT KK	OZAN 1576
	COMMEN/073/THIN-TMAY	OZAN1577
	COMMON/074/NEETAL NEETA NEETA NEETA	OZAN1578
	COMMON/OZIFZ3/N7RO.COFFIC.SI.VIEL.VIEL.MOUT NOLE NOVE NOVE 1	DZAN 1579
	COMMON/OZZEZ3/PHPR.VELER.DPPR.VEDPR.BEC12.BEC22	0ZAN1580
С		OZAN1581
	REAL NZRO	UZAN1582
	INTEGER C, DNC	0ZAN1583
		OZAN1584 (

INTEGER DC, SIGAC, UNSFC, SIGFC, SCATC, SGCSC, SPNRC, ATTC		OZAN 1	
		OZAN1	
DIMENSION PSI(3,48,4C),W(3,48,40),SGCS(2,3,47,39),UNSF(3,47,39),		OZAN1	
1AII(2,10),AI(10),SCAI(2,47,397,HU(397,HV(47),R(40),MRUI(10),		UZANI	
2PROF(10), MRV1(10), MRVF(10), Y1EL(2), Y1EJ(5), NUW(2), NDPS1(2), 20HD2(2, 2), VDHD2(2, 2), FD0D(2, 2), VGD0D(2, 2), DFG12(2, 2, 0), DFG22(2),		UZANI	
$\frac{2}{2} = \frac{2}{2} = \frac{2}$		UZANI	
32977900002727900002727900001027900001027900041202910927951029107951640394795301 SUMA1/21 SUMA2/21		UZANI	
		UZANI	
1000 EURMAT (7E11-5)		OZANI	
2000 FORMAT(195-14.6)		UZANI UZANI	
2001 FORMAT (1X. 8F12, 5/(1), 8F12, 5))		DZAN1	
625 FORMAT (1X,2(E15.8.3X)/(1X.2(E15.8.3X))//)		NZAN1	
634 FURMAT (/1X, 'PRUMPT FLOTON PRODUCTION MATRIX'/)		07 AN 1	
535 FORMAT (/1X, 'DELAYED FHOTON PRODUCTION MATRIX'/)		OZAN1	
636 FORMAT(/1X, FROMPT PECTONEUTRON PRODUCTION MATRIX(INITIAL VALUE) /		DZANJ	
1)		OZAN1	
637 FORMAT (/1X, 'DELAYED FFOTONEUTRON PRODUCTION MATRIX(INITIAL VALUE)		OZAN1	
1'/)		OZ AN 1	
6371 FORMAT (/1X, 'DELAYED FHOTONEUTRON FRACTIONS'/)		OZAN1	
E38 FURMAT (71X, PROMPT FEDTONEUTRON PRODUCTION MATRIX(RAMP CHANGE SLO		OZAN1	
		OZAN 1	
COSY FORMAT (7.1%, 'DELAYED FFOTONEUTRUN PRODUCTION MATRIX(RAMP CHANGE SL		OZAN1	
640 EORMAT (/1Y IDELAVED EHOTOMETTEDN EDACTIEN MATOLOGGI/A		UZANI	
632 FORMAT (12X, 12, 3(26X, 12))		UZANI	
6321 FORMAT (1X, 4(2(F12, 5, 1X), 2X))		OZANI	
643 FORMAT (/1X, 'RAMP CHANGE SLOPE OF THE DELAYED PHOTONEUTRON ERACTIO	- 62 Y 1	OZANI	
1 MATRICES'/)		GZANI	
6431 FORMAT (/1X, "RAMP CHANGE SLOPE OF THE DELAYED PHOTONEUTRON ERACTIO		DZANI	
INS'/)		- CZANI	
		OZANI	
C AT TMIN		OZANI	
		OZANI	
MTI = 1		OZANI	
TIME=TMIN		OZANI	
		READ (24 1000) Seco	
------	---------------	--	-----------------
a 8		DEWIND 24	0ZAN1621
	r r	NEWIND 24	OZAN 1622
	C INS	E : THE EISSICH COOSS SECTION AND ME	0ZAN1623
	0 010	THE FISSIEN CRUSS SECTION ARREY	CZAN1624 .
	U	REAC(17, 1000) UNCE	0ZAN 1625
		DEWIND 17	0ZAN1626
	C	NEWIND IF	OZAN1627
	C THE	CHETCHEUTDON DEACTION COCCE COOTTON ADDA	0ZAN1628
	с ні <u>с</u>	THETENEOTRON REACTION CRUSS SECTION ARRAY	0ZAN1629
	Ŭ	REAC(26- 1000) SCAT	OZAN1630
		REWIND 26	0ZAN1631
	27	CONTINUE	OZAN1632
Sec.	- '	IE ((TIME EQ TMAX) AND (SCCCC FO DUC) AND (CORDER TO	0ZAN 1633
5. C		1291	0ZAN1634
15 C		CO 2956 K=1.KK	0ZAN1635
		$\Gamma_{0} = 2955 = 1.2$	0ZAN1636
	2955	$EHP1(K \cdot I) = 0$	UZAN1637
		$\Gamma P P 1 (K) = 0$	OZAN 1638
		N = N D P S I (K)	. 0ZAN1639
		READ(NN. 2000) PST	GZAN1640
		REWIND NN	OZAN 1641
		IE ((TIME-EQ-TMAX) AND (SCCSC EQ DUCL) OC TO DOG	0ZAN1642
	С	The second and senter is discord ounch of the 290	OZAN1643
		CALL PPNIK PST. SCCS. HILLY P. DUDIN	UZAN1644
	С		OZAN1645
		IF ((TIME FORTMAX) AND (SIEC FO DUCIN OF TO DE	OZAN 1646
	С		0ZAN1647
	290	CALL DPN1(PST-UNSE-HI HV P SUMP)	0ZAN1648
	С		OZAN 1649
		$DPP1(K) = SUMR \neq 1, 570R$	0ZAN1650
		IF (KSR07-F0-1) 60 TO 201	OZAN1651
		CPP1(K) = CPP1(K) / SKOZN	UZAN 1652
	2956	CONTINUE	OZAN1653
	291	CONTINUE	CZAN 1654
		WRITE(6.634)	0ZAN1655
			0ZAN1656 ω
			9
			01

		<pre>kRITE(6,626) ((PHP1(K,L),L=1,2), k=1, KK)</pre>	OZAN 1657		
		WR11E(6,635)	CZAN1658		
		WRITE(6,626) (UPP1(K),K=1,KK)	CZAN1659		
		IF ((TIME.EQ.TMAX). AND. (ATTC.EQ.DNC)) GC TO 7215	0ZAN 1660		
		LO 215 MR=1,10	CZAN1661		
0.02	215	$\Delta T(MR) = \Delta TT(MTI, MR)$	OZAN1662	2	
1	7215	CONTINUE	0ZAN 1663		
	81	CO 34 I=1,II	0ZAN1664		
		N = NDW(I)	OZAN 1665		
		REAC(NN, 2000) W	OZAN1666		
	04	FEWIND NN	OZAN1667		
Ç			OZAN 1668		
Ç		INTEGRATE OVER THE D2C REFLECTOR WITH APPROXIMATE ATTENUATION FACTORS	OZAN1669		
С			OZAN1670		3
		CO 3C8 K=1, KK	GZAN1671		
	308	SUM41(K) = 0	0ZAN1672		
		SUMS1=0.	OZAN1673		
		EO 33 MR = 1, 1C	OZAN1674		
		CC 309 K=1,KK	OZAN1675		
	309	SUM42(K) = 0	OZAN 1676		
		SUM92=0.	0ZAN1677		
		MUI = MRUI(MR)	OZAN1678		
	a	MUF = MRUF(MR)	OZAN 1679	· · · ·	
÷		VVI = VRVI(MR)	OZAN1680		
		MVF=MRVF(MR)	OZAN1681		
		L0 311 L=1, 2	OZAN1682		
		IF ((SPNRC.EC.CNC).ANI. (TIME.EQ.TMAX)) GC TO 310	OZAN1683		
~		SUM4=0.	OZAN 1684	1	
C	5		UZAN1685		
		LALL PUNZ(L, MUI, MUF, MVI, MVF, W, SCAT, HU, HV, R, SUMA)	OZAN1686		
Ç			OZAN1687		
		SUM4TL(L,MR,T)=SUM4	OZAN1688		
		SI(L,MR) = SUM4IL(L,MR,1)	OZAN 1689		
	310	SUM 92= SUM 41L(L, MR, 1) # YIEL(L) + SUM 92	OZAN1690		10
		LU 311 K=1,KK	OZAN16S1		
		$SUM4Z(K) = SUM41L(L, MR, I) \approx PHP1(K, L) + SUM4Z(K)$	OZAN 1692	ω	
			8 N 5 11	96	
				01	

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7	311	CONTINUE SUNCI-SUNCE AT (NO.) SUNCI	OZAN1693		
	*	20 22 K-1 KK	OZAN1694		
			DZ AN 1695		
	22	SUM41(K) = SUM42(K) = A1(MR) + SUM41(K)	0ZAN1696	1.1	
	55		UZAN1697	÷	
		LU 34 K=1, KK	OZAN1698		
~		IF (TIME.EQ.TMAX) GO TO 36	0ZAN1699		
C			OZAN1700		
C C		PHPR LIKE PROMPT PHOTONEUTRON PRODUCTION OVER THE REACTOR VOLUME	0ZAN1701		
C			0ZAN1702		
		PHPR(I,K)=SUM41(K)*1.5708*COEFIC	0ZAN 1703		
C	1.1.1.2		UZAN1704		
C		OPPR LIKE DELAYED PHOTONEUTRON PRODUCTION OVER THE REACTOR VOLUME	DZAN1705		
C			07AN1706		, i
		CPPR(I,K)=SUM91*NZRO#1.5708*DPP1(K)*COEFIC	0ZAN1707		
		IF (KSRDZ.EG.1) GD TC 35	07AN1708		
		CO TO 34	07AN1709		
	36	IF ((SGCSC.EC.DNC).ANE.(SPNRC.EQ.DNC)) CO TO 361	07AN1710		
•		VPHPR(I,K)=(SUM41(K)+1.5708#CUEFIC-PHPR(I,K))/(TMAX-TMIN)	. 07 AN 17 11		
	361	IF (ISGCSC.EG.DNC).ANC.(SIGFC.EQ.DNC)) GC TO 34	CZAN1712		
		$VDPPR(I,K) = (SUM91 \times NZFC \times 1.5708 - DPPR(I,K))/(TMAX-TMIN)$	OZAN1713		
		CO 88 J=1,NBETA2	0ZAN1714		
	- 88	<pre>EEC22(I,K,J)=YIEJ(J)*VCPPR(I,K)</pre>	07AN1715		
8	34	CUNTINUE	0ZAN 1716		
		IF (TIME.EQ.TMAX) GO TO 89	07AN1717		
	35	WRITE(6,636)	07AN1718		
		WRITE(6,626) ((PHPR(I,K),K=1,KK),I=1,II)	0Z AN 1719		
		WRITE(6,637)	C74N1720		ŝ
		WRITE(6,626) ((DPPR(I,K),K=1,KK),I=1,II)	0ZAN1721		
		IF (KSROZ.EQ.1) GO TO 391	0ZAN1722		
С			07AN1723		
С	SIN	CE THE SUMMATICN OF YIEJ(J) OVER J IS 1, DPPR(I,K) IS NATURALLY	07AN1724		
С	THE	TOTAL DELAYED PHOTONELTRON FRACTION MATRIX	07AN1725		
С			CZAN1726		1
		DO 85 I=1,II	0ZAN 1727		
		CO 85 K=1,KK	0ZAN1728		
		동안 물건에 가지 않는 것 같아요. 이렇게 잘 하는 것 같아요. 이렇게 하는 것 같아요. 이렇게 가지 않는 것 같아요. 이렇게 하는 것 같아요. 이렇게 아니 아요. 이렇게 하는 것 같아요.		39	
•				7	
		그는 것 같은 것 같	a * .		

C		07AN1729
С	CALCULATION OF BEC12 AND BEC22 (J=7.15)	07 AN 1730
С		07AN1731
	DO 85 J=1,NBETA2	07AN1732
85	BEC12(I,K,J)=DPPR(I,K)=YIEJ(J)	07AN1733
	IF (MODES.EC.1) GO TE 6344	B7AN1734
	WRITE(6,640)	07AN1735
5.5	WRITE(6, (22) (J.J=1.4)	07AN1736
	CO 6341 I=1.II	07AN1737
6341	WRITE(6,6321)(((BEC12(I,K,J),K=1,KK),J=1,4))	07AN 1738
	WRITE(6,632) (J,J=5,8)	07AN1739
	DO 6342 I=1, II	07AN1740
6342	WRITE(6,6321)(((BEC12(I,K,J),K=1,KK),J=5,8))	07AN1741
	WRITE(6,632) (J, J=9, NEETA2)	07AN1742
1 - P.	DC 6343 I=1, II	0ZAN 1743
6343	WRITE(6,6321)(((BEC12(I,K,J),K=1,KK),J=9,NBETA2))	0ZAN1744
	GO TC 6345	CZAN1745
6344	WRITE(6,6371)	0ZAN 1746
	WR ITE(6,2001) ((((BEC12(I,K,J),I=1,II),K=1,KK),J=1,NBETA2))	0ZAN1747
6345	CONTINUE	0ZAN1748
•	IF ((SGCSC.EG.DNC).ANC.(SPNRC.EQ.DNC).AND.(SIGFC.EG.DNC)) GO	TO 0ZAN1749
	137	0ZAN1750
C '		0ZAN 1751
C	AT TMAX	0ZAN1752
C ·		0ZAN1753
	MTI = 2	0ZAN 1754
	TIME=TMAX	0ZAN1755
	IF (SIGFC.EQ.DNC) GO TO 340	OZAN1756
	READ(21, 1000) UNSF	0ZAN 1757
	FEWIND 21	0ZAN1758
340	IF (SGCSC.EQ.DNC) GO 10 341	0ZAN 1759
	READ(25, 1000). SGCS	0ZAN1760
	REWIND 25	OZAN1761
	IF (SPNRC.EQ.DNC) GO 10 342	0ZAN 1762
341	READ(27, 1000) SCAT	0ZAN1763
	REWIND 27	DZAN1764
		ω

342	2 CONTINUE	0ZAN 1765
		0ZAN1766
85	WRITE(6,638)	0ZAN1767
	kRITE(6, 626) ((VPHPR(I,K),K=1,KK),I=1,II)	0ZAN1768
	WRITE(6,639)	07AN1769
	<pre>kRITE(6,626) ((VDPPR(1,K),K=1,KK),I=1,II)</pre>	07AN1770
	IF (NMODES.EC.1) GO TC 6346	07AN1771
	WRITE(6,643)	07AN1772
	WRITE(6, 632) (J, J=1, 4)	OZANIT72
	CO 7431 I=1, II	OZAN1775
7431	WRITE(6,6321)(((BEC22(I,K,J),K=1,KK), I=1,4))	UZAN1774
	WRITE(6,632) (J.J=5.8)	UZANITIS
	CO 6432 I=1. II	UZAN1776
6432	WRITEL6.632111118502211 K. 11 K-1 KK1 1-5 011	UZAN1777
	WR[TE[(A, A32)] (1, 1-9, NEETA2)]	OZAN 1778
	$\Gamma = 6433$ J=1.11	OZAN1779
6433	$WRITE(6.6321)((185022)(1 \times 1) \times 1 \times 1 \times 1 = 0 \times 10000000)$	OZAN1780
0 10 .	60 TE 6347	0ZAN1781
6366	WRITE(4.6421)	UZAN1782
0,540		- OZAN1783
6347	$K_{I} = (0, 2001) ((((Be(22(1,K,J),I=1,II),K=1,KK),J=1,NBETA2)))$	OZAN 1784
0.041	CONTINUE	OZAN1785
		OZAN1786
3.1		0ZAN1787
	LU 381 K=1,KK	OZAN1788
	VPHPR(1,K)=0	0ZAN 1789
	VDPPR(I,K)=0.	ÜZAN1790
	DD 391 J=1, NEETA2	0ZAN1751
. 381	$BEC 22(I, K, J) = 0_{o}$	0ZAN 1792
391	CONTINUE	07AN1793
	RETURN	07AN 1794
	ENIC	07AN1795
	SUBREUTINE PFN1(K, PS1, SGCS, HU, HV, R, PHP1)	07AN1766
С		(17 AN 17 C7
C PHP	LIKE PROMPT FHOTON PROCUCTION	02AN1700
С.		07AN1700
	DIMENSION PSI(3,48,40), SGCS(2,3,47.35) . HU(39) . HV(47) . P(40) . PUD1(2	07AN1200
	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	UZAN1800

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12)	CZAN1801
$r_{0} 29 l = 1.2$	0ZAN1802
SUN3=0	0ZAN1803
00 28 MC-1 2	0ZAN1804
	OZAN 1805
LU = 2C + 4V - 27 + 7	0ZAN1806
F V I = F V (M V - I)	OZAN1807
HV 2=HV(MV)	OZAN 1808
	0ZAN1809
PHP=PSI(NG, MV, MU)*((SCCS(L, MG, MV-1, MU)*HV(MV-1)+SCCS(L, MG, MV, MU)*H	OZAN1810
1V(MV))*HU(MU)*(R(ML)+HU(MU)/4))	0ZAN1811
SUM 3=SUM 3+PHP	07AN1812
CO 28 MU=2,39	07AN1813
HR1 = (R(MU) - HU(MU - 1)/4) * HU(MU - 1)	07AN1314
HR2 = (R(MU) + HU(MU)/4) * HU(MU)	07AN1815
PHP=PSI(MG, MV, MU)*((SGCS(L, MG, MV-1, MU-1)*HV1+SGCS(L, MG, MV, MU-1)	07AN 1816
1#HV2)#HR1+(SCCS(L,MG, NV-1, MU)#HV1+SGCS(L,MG, NV, MU)#HV2)#HR2)	07AN1817
SUM3=SUM3+PHF	07411818
28 CONTINUE	07 AN 1910
FHP1(K,L)=SUM3*1.5708	07AN1920
29 CONTINUE	07401020
RETURN	07AN1021
END	07AN1022
SUBROUTINE DENI (PSI . LASE . HU. HV. R. SUMA)	UZAN1823
	UZAN 1824
DPP LIKE DELAYED PHOTEN PRODUCTION	UZAN1825
	UZAN1826
CIMENSION PSI(3.48.40). UNSE(3.47.39) . HU(39) . HV(47) . P (40)	UZAN1827
	· UZAN1828
SUM 8=0.	UZAN 1829
CO 78 MG=1-3	UZAN 18 30
DO 78 MV = 5.24	0ZAN1831
CO 78 MH-2 17	OZAN 1832
	OZAN1833
1 HV (MV) 1 HUI MU 1 HO / K ((UPSF (MG, MV-1, MU-1) + V (MV-1) + UNSF (MG, MV, MU-1) +	OZAN 1834
2F(MC MV AU)*HV(MV-1)*(R(MU)-HU(MU-1)/4)+(UNSF(MG,MV-1,MU)*HV(MV-1)+UNS	OZAN1835
2 F (MO , MV , FU) * FV (MV)) * FU (MU) * (R (MU) + HU (MU) / 4))	OZAN1836

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	-	SUM8=SUM8+DPP		OZAN1837
8	18	CONTINUE		OZAN1838
		RETURN		GZAN1839
		END		OZAN 1840
		SUBRUUTINE PDN2(L, MLI, MUF, MVI, MVF, W, SCAT, HU, HV, R, SUM4)		OZAN1841
С				07AN1842
C	PHO	TONEUTRON REACTION INTEGRATION		07 AN 1843
С	5340			07AN1844
~		DIMENSION W(3,48,40), SCAT(2,47,39), HU(39), HV(47), R(40)		OZAN 1845
C				OZAN 1846
		DO 31 MV=MVI,MVF		CZAN1847
		IF (MUI.NE.1) GO TO 30		OZAN 1848
		MO= 1		UZAN1849
		FNR=W(1, MV, MU)*((SCAT(L, MV-1, MU)*HV(MV-1)+SCAT(L, MV, MU)*HV(MV))*HU		OZAN1850
		1(MU)*(R(MU)+HU(MU)/4))		OZAN 1851
		SUM4=SUM4+PNR		CZAN1852
	20		5	OZAN1853
	30	LU 31 MU=MUI,MUF		OZAN 1854
		PNR=W(1, MV, MU) * ((SCAT(L, MV-1, MU-1)*HV(MV-1)+SCAT(L, MV, MU-1)*HV(MV)		OZAN1855
	1.1	L) *HU(MU-1)*(R(MU)-HU(NU-1)/4)+(SCAT(L,MV-1,MU)*HV(MV-1)+SCAT(L,MV,		OZAN 1856
	4	2MU) #HV(MV)) #FU(MU) #(R(MU) +HU(MU) /4))		OZAN1857
3	21	SUMA + PNR		OZAN1858
14	31.	CONTINUE		OZAN 1859
		RETURN		CZAN1860
				OZAN1861
C		SUBRUUTINE FILIZA		OZAN1862
0	CTAI	L STED DECODE THE TIME DECEMBER POWERLE	·	OZAN1863
c	FINA	AL STEP BEFORE THE TIME DEPENDENT EQUATIONS		OZAN1864
C		CENNEN/072/NNCDEC II W		OZAN1865
		COMMENTAL NETTAL NETTAL NETTAL NETTAL NETTAL		OZAN1866
	.1	COMMONIO ZEZILICENTAL, NBEIAZ, NBEIA, NBEIL		DZAN 1867
				OZAN1868
		COMMON/DIETA C ENAD VENAD DETD VDETD DECL DECE		OZAN1869
		COMMENTOLEL ZIDETA, E, FMAR, VEMAR, BEIR, VBETR, BEC11, BEC21		0ZAN 1870
	×	COMMENTERED ANDC		OZAN1871
				OZAN 1872 .
				10

•

COMMON/OZFZ4/FIJ, FAMLAN, ROC1, ROC2, ROC3, BEC1, BEC2, BEC3, EANDRE, IND	C ()7 AN 1 972
COMMON/FZ4HT/BE	C UZAN1873
C	0ZAN1874
REAL LAPN	UZAN 1875
C	UZAN 1876
CIMENSION FIJ(2) . FAMLAM(15) . BEC11(2.2.6) . BEC211	UZAN1877
12.2.6) BEC12(2.2.9) BEC22(2.2.6) DDDD(2.2) VDDDD(2.2) CENTURY2	UZAN 1878
28EC1(2.2.15) - BEC2(2.2.15) - BEC3(2.2.15) - BEC3(2.2.15) - BEC2(2.2.15) - BEC2(2.2.15)), UZAN1879
3R0(3(2,2), RATA(2,2,15), RO(1/2,2), LADN(2,2), VIACA(2,2), RU(2(2,2))	OZAN1880
4VEMAR(2,2), PEPP(2,2), VOHDD(2,2), PETD(2,2), VLAFN(2,2), FMAR(2,2),	OZAN1881
585TA(6), WSC(2), RETRY (2, 2), DODOY (2, 2), VBEIR(2, 2), FAMFRE(2, 15), OZAN1882
C	OZAN 1883
2001 FURMAT (18,8512 5/(18 6512 51)	CZAN1884
626 FORMAT (11, 31, 21, 21, 51, 51, 31, 31, 31, 51, 51, 51, 51, 51, 51, 51, 51, 51, 5	OZAN1885
644 FORMAT (14) 21Y 15TNAL STED REFORE THE TIME DESCRIPTION FOR A THE REFORMENT	DZAN 1886
1/)	// OZAN1887
425 FORMAT (1H - ICENEDATION TIME MATOTYLAN	OZAN1888
645 FORNAT (/1X, THE DEALTING THE MATRIX /)	0ZAN1889
646 FORMAT (/1X, THE REACTIVITY MATRIX(INITIAL VALUE) /)	OZAN1890
647 FORMAT (/1X, IDELAYED ASUTOON (AND DUCTONSUTOON & STATTON AND DUCTONSUTOON & STATTON AND DUCTONSUTOON & STATTON	OZAN1851
INITIAL VALUENZA	(I OZAN1892
6471 ERRMAT (/1X, IDELAVED NEUTRONIAND DUDTCH CUTDON) EDITOR	OZAN1893
(632 EDRMAT (12X 12 3124X 12))	OZAN 1894
(32) = 000001 (120) 12000 (200) 12000 (120) (120) (1	0ZAN1895
$\frac{1}{448} = \frac{1}{100} $	OZAN 1896
1AMP CHANCE SLODENTAL	(R 0ZAN1897
AMP CHANGE SLUPE (1)	OZAN1898
1 CE SLODENICA DELAYED REUTRUN (AND PHOTONEUTRON) FRACTIONS (RAMP CH.	AN 0ZAN1899
AGE SLOPETTY TOTAL DELANCE NEW PRODUCTION	GZAN1900
6461 FURMAT (/IX, 'TUTAL DELAYED NEUTRON FRACTION MATRIX')	OZAN1901
222 FORMAT (/1X, 'IUTAL DELAYED PHOTONEUTRON FRACTICN MATRIX'/)	OZAN 1902
222 FURMAI (DX, 2(EL2.0, 1X)/)	-0ZAN1903
2221 FURMAL (//LX, 'INTEGRAL OF THE WEIGHTING FUNCTIONS OVER THE REACTOR	CZAN1904
IVULUME-FIRST GROUP ONLY-1/)	0ZAN 1905
113 FURMAT (/ 1X, ' INITIAL PRECURSOR AMPLITUDES '/)	0ZAN1906
	UZAN 1907
EE=U.	CZAN1908

			CC SC J=1.NBETA1	074012000	
		90	EE=BETA(J)+BE	0ZAN 1909	
	С			UZAN1910	
	č		CALCULATION OF ROCI AND POCO	UZAN1911	
	Č		oneodentiet er hoor pro hooz	UZAN 1912	
	Ŭ		DO 50 TEL.IT	UZAN1913	
				. OZAN1914	
	÷.,			ÜZAN 1915	
			POC2(I K) = VI APN(I, K) + FPAR(I, K) + PHPR(I, K) + DPPR(I, K)	OZAN1916	
			POC2(I,K) = V LAPA(I,K) + (FMAR(I,K) + VPMPR(I,K) + VCPPR(I,K))	OZAN 1917	
				0ZAN1918	
		•	CENTME(1,K) = CENTME(1,K)/E	GZAN1919	
i - 2			RU(1(1)K) = RU(1(1)K)/E	OZAN 1920	
	•			0ZAN1921	
			$\frac{DC(KX(1,K) = BC(K(1,K)) + EEEE}{EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE$	DZAN1922	
		50	$\frac{\text{UPPRX(1,K)} = \text{UPPR(1,K)}}{\text{CPLTINUE}}$	OZAN1923	
		50		0ZAN1924	
			WRI1E(0,044)	OZAN 1925	
			WRITE(6, 625)	0ZAN1926	
			WRITE(0,620) ((GENIME(1,K),K=1,KK), I=1,II)	- OZAN1927	
			WRITE(6, 645)	OZAN 1928	
			WX11E(6,626)((RUC1(1,K),K=1,KK),I=1,II)	CZAN1929	
			WRI12(6,645)	0ZAN1930	
		195	WRITE(6, 626) ((ROC2(I,K), K=1,KK), I=1, II)	UZAN1931	
			WR11E(6,6461)	OZAN1932	
			WRITE(6,626) ((BETRX(I,K),K=1,KK),I=1,II)	0ZAN 1933	
			WRITE(6, 6462)	0ZAN1934	
	•	32	WRITE(6,626) ((DPPRX(1,K),K=1,KK),I=1,II)	GZAN1935	
	ç			0ZAN 1936	
	6		CALCULATION OF BEC1 AND BEC2	UZAN1937	
	C			OZAN1938	
		÷	CU 99 I=1,II	0ZAN 1939	
			LU 99 K=1,KK	0ZAN1940	
			UU 98 J=1,NBETAL	OZAN 1941	
			EECI(I,K,J) = BECII(I,K,J)	0ZAN1942	
			EEC2(I,K,J) = EEC21(I,K,J)	GZAN1943	
			$BEC \exists (I, K, J) = C_{\bullet}$	DZAN 1944	
					-

	BEC1(I,K,J) = EEC1(I,K,J)/E		07AN1945
	PEC2(I,K,J) = ELC2(I,K,J)/E		07AN1946
98	CONTINUE		074N1947
	CD 99 J=NEET1,NEETA		OZAN1948
	JJ = J - NBETA1		DZAN 1949
	EEC1(I,K,J)=BEC12(I,K,JJ)		07AN1950
	BEC2(I, K, J) = BEC22(I, K, JJ)		07AN1951
	BEC1(I,K,J) = BEC1(I,K,J)/E		07AN1952
	BEC2(I,K,J) = EEC2(I,K,J)/E		07AN1953
	$B \equiv C \exists (I, K, J) = C_{\bullet}$		07AN 1954
99	CONTINUE		07AN1955
	IF (NMODES.EC.1) GO TE 6485		07AN1956
	WRITE(6,647)		07 AN 1957
	WR ITE(6,632) $(J, J=1, 4)$		0ZAN1958
	DO 7471 I=1,II	그 같은 것은 것 같아요.	0ZAN1959
7471	WRITE(6,6321)(((BEC1 (I,K,J),K=1,KK),J=1,4))		0ZAN1960
	WRITE(6,632) $(J,J=5,E)$		DZAN1961
	00 6472 I=1, II		07AN1962
6472	WRITE(6,6321)(((BEC1 (I,K,J),K=1,KK),J=5,8))		07AN1963
	WRITE(6,632) (J,J=9,12)		07AN1964
	DO 6473 I=1,II		07AN 1965
6473	WRITE(6,6321)(((BEC1 (I,K,J),K=1,KK),J=9,12))	그는 것은 이상 등 것이 없다.	07AN1966
	WRITE(6, 632) (J, J=13, 15)		D7AN1967
•	DO 6474 I=1, II		07 AN 1968
5474	WRITE(6,6321)(((BEC1 (I,K,J),K=1,KK),J=13,NBETA))		07AN1969
	WRITE(6,648)		07AN1970
	WRITE(6,632) $(J,J=1,4)$		07AN1971
	DO 7481 I=1, II		07AN1972
7481	WRITE(6, 6321)(((BEC2 (I, K, J), K=1, KK), J=1,4))		07 AN 1973
	WRITE(6,632) $(J, J=5, E)$	김 영상은 강경에서 가격	07AN1974
	DO 6482 I=1,II		07AN1975
6482	WRITE(6,6321)(((BEC2 (I,K,J),K=1,KK),J=5,8))	그는 사람이 가지 않는 것이 많이 많이 했다.	D7 AN 1976
	WRITE(6,632) (J,J=9,12)		07 AN1 977
	DO 6483 I=1,II		07AN1978
6483	WRITE(6,6321)(((BEC2 (I,K,J),K=1,KK),J=9,12))		0ZAN1979
	WRITE(6,632) (J,J=13,15)		07AN1980
			· · · · · · · · · · · · · · · · ·

	6484	DO $6484 I=1, II$ WRITE(6, 6321)(((BEC2 (I,K,J),K=1,KK), J=13,NBETA))		OZAN 1981	
		GU TC 6486		UZAN1982	
	6485	WRITE(6,6471)		UZAN1983)
		WRITE(6, 2001) ((((BEC1(I.K.J).I=1.TT).K=1.KK). I-1. NEETAL)		UZAN 1984	l
		WRITE(6,6481)		UZAN1985	li -
		WRITE(6,2001) ((((BEC2(I.K.1)) I=1.TI) K=1.KK) I=1 ABETAL)		UZAN1986	1
	6486	CONTINUE		UZAN 1987	
C				UZANISE8	é.
С		CALCULATION OF STEADY STATE PRECURSOR CONCENTRATIONS		UZAN 1989	1
С		STATE THEODINGS A CONCENTRATIONS		UZAN1990	ň.
		IF (INPC.EQ.1) GO TO 112		UZAN1951	
		CG 105 I=1, II		UZAN1992	
	1	DO 105 J=1, NPETA		UZAN1993	
	105	$FAMPRE(I, J) = C_{\bullet}$		UZAN1994	
		CC 110 J=1, NEETA		UZAN1995	
		DO 110 $I = 1, II$		UZAN1996	
		CO 110 K=1, KK		UZAN 1997	
	110	FAMPRE(I, J) = EEC1(I, K, J) * FIJ(I) / FAMLAM(J) + FAM PRE(T, J)		UZAN1998	÷.,
		GO TO 4959		UZAN1999	
	112	CONTINUE	승규는 것은 것은 가격이 있다.	02AN 2000	
		IF (NMGDES . EQ.1) GD 70 4999		UZAN2001	
× 3	1. a. e.	CD 499 J=1, NEETA		UZAN2002	
÷		IF (J.NE.NBETA) GD TC 498		UZAN2003	
		WRITE(6,2221)		UZANZUU4	
		WRITE(6,626)(WSC(I), I=1, II)		UZAN2005	
		FAMPRE(2, J) = FAMPRE(1, J) * WSC(2) / WSC(1)		UZAN2006	
		GO TO 499		UZANZUUT	
	498	FAMPRE(2, J) = FAMPRE(1, J) + BEC1(2, 1, J) / BEC1(1, 1, J)		0ZAN2008	
	499	CONTINUE		07AN2009	w a
. 2	\$99	WRITE(6,113)		02AN2010	
		DO 500 J=1,NEETA		UZAN2011	
	500	WRITE(6,222) (FAMPRE(I,J),I=1,II)		UZANZUIZ	
		PETURN		02AN2013	
		END		OZANZO14	
		SUBROUTINE GENCA(NDIM, PFULL, PHALF, BFULL, BHALF)		DZANZUID	
				ULANZU 10	4
					05

C		OZAN2017
Ċ	THIS SUBROUTINE WILL SOLVE THE POINT KINETIC TYPE OF EQUATIONS USING THE WEIG	H 0ZAN2018
С	TED RESIDUAL TECHNIQUE (SLEDOMAIN WEIGHTING)-ANL 7565 P.68-KNCWING THE MATRICE	S 0ZAN2019
С	EQUIVALENT TO THE CONVENTINAL GENERATION TIME(LAMBDA), REACTIVITY(RHO) AND THE	GZAN2020
С	DELAYED NEUTRON (ALSO THE LELAYED PHOTONEUTRON) GROUP FRACTIONS (BETA'S) IN OR-	0ZAN2021
С	LER TO GET THE UNKNOWM TIME COEFFICIENTS	CZAN2022
С		07AN2023
С	I HAVE BARROWED THIS SUBFOUTINE (WITH FEW CHANGES) FROM WEIRE	. 07AN 2024
C	THE ORIGINAL NAME OF THE SUBROUTINE WAS MOVER	07AN2025
С		07AN2026
С	,, GONCA ,, MEANS BUD IN TURKISH	07 AN 20 27
С		07AN2028
	COMMON/CZ2/NACDES, II, KK	07AN2029
	COMMON/OZ3/TMIN, TMAX	GZAN2030
	COMMON/024/NEETAL, NB ETA2, NBETA, NEET1	07AN2031
	COMMEN/0Z3FZ1/GENTME	07 AN 2032
	COMMON/OZFZ4/FIJ, FAMLAM, ROC1, ROC2, ROC3, BEC1, BEC2, BEC3, FAMPRE, INPC	07AN2033
	CCMMON/DZGON/IJUMP, EFS2, NCM1, NCDEF, ROJ, EATA, JJ33	17AN 2034
	COMMON/OZGOHT/FAMCLM	07AN2035
	C CMMCN/GOZHT/FIF	07AN2036
С		0ZAN2037
	DIMENSION FAMLAM(15), FAMPRE(2,15), FIJ(2), GENTME(2,2), BETA(6), ROC1(07AN2038
(i .)	12,2),ROC2(2,2),ROC3(2,2),BEC1(2,2,15),BEC2(2,2,15),BEC3(2,2,15),AC	OZAN2039
	2(5),Q(20,15,5),ROJ(2,2), BATA(2,2,15), FANCLM(2,15), SUMCI(2), SUMRO(2	07 AN 2040
	3,2,3), SUMB(2,2,3), CBURN(2,15), BINT(2,2,3), SUINIT(2), FIF(2), CCMP(6,	CZAN2041
	#2), PFULL (NDIM, NDIM), PHALF(NDIM, NCIM), BFULL (NDIM), BHALF(NCIM), COFE(0ZAN2042
	52, 2, 6), A(3, 2, 20), ENFLUL(6, 2), ENHALF(6, 2), SENFLL(2), SENHAF(2), SGN(0ZAN2043
	62), T(20, 8), I FOWR (30), CBURN(2, 15), SUMRB(2, 2, 3), EPS(2), BIFIJ(2),	07AN2044
	7SUMNB(2), TERMNB(2), ENEINT(2)	0ZAN2045
С		QZAN2046
	EQUIVALENCE (J3, JJ33)	0ZAN2047
С		0ZAN 2048
	450 FORMAT (35H THE TIME STEP IMPOSED IS TOO LARGE)	CZAN2049
	500 FORMAT(15H TIME=E18.10)	0ZAN 2050
	501 FORMAT(15H MAXIMUM ERFOR=E18.10)	0ZAN2051
	502 FORMAT(51H MODE AMPLITUDE FUNCTION ERRCR IN AMPLITUDE)	CZAN2052

· . . ·

504 FORMAT(18H TIME 1000 FORMAT(4H J3=I3 1001 FORMAT(1X, J3= 1500 FORMAT(1H1, //21) 1600 FORMAT(1H1, //21) 1600 FORMAT(////1X, C WRITE(6, 1500) NBET=NBETA NPP1=NMODES*NCOM IMAX=NCDEF+2 TJUMP=TMAX-TMIN EPS1=, 1*EPS2 TIME=TMIN TOME=TMIN ISTEP=1 ICUT=1 J3=1	STEP NUMBER 16) ',12) ,'THE TIME DEPENDENT FU PROGRAM RETURNED FROM S	UNCTION(S) '///) IMQ WITH NO RESULT')			UZAN20 UZAN20 UZAN20 UZAN20 UZAN20 UZAN20 UZAN20 UZAN20 UZAN20 UZAN20 UZAN20
1000 FORMAT (4H J3=I3 1001 FORMAT (1X, J3= 1500 FORMAT (1H1, //21) 1600 FORMAT (1H1, //21) 1600 FORMAT (////1X, C WRITE(6, 1500) NBET=NBETA NPP 1=NMODES*NCOM IMAX=NCDEF+2 TJUMP=TMAX=TMIN EPS 1=. 1*EPS 2 TIME=TMIN TCME=TMIN ISTEP=1 ICUT=1 J3=1	',I2) ,'THE TIME DEPENDENT FU PROGRAM RETURNED FROM S	UNCTION(S)'///) SIMQ WITH NO RESULT')			0ZAN20 0ZAN20 0ZAN20 0ZAN20 0ZAN20 0ZAN20 0ZAN20 0ZAN20 0ZAN20 0ZAN20
1 CO1 FORMAT (1X, J3= 1 500 FORMAT (1H1, //21) 1600 FORMAT (////1X, C WRITE(6, 1500) NBET=NBETA NPP1=NMODES*NCOM IMAX=NCDEF+2 TJUMP=TMAX-TMIN EPS1=.1*EPS2 TIME=TMIN TCME=TMIN ISTEP=1 ICUT=1 J3=1	',I2) ,'THE TIME DEPENDENT FU PROGRAM RETURNED FROM S	UNCTION(S) '///) IMQ WITH NO RESULT')			0ZAN2 0ZAN2 0ZAN2 0ZAN2 0ZAN2 0ZAN2 0ZAN2 0ZAN2 0ZAN2
1500 FORMAT(1H1,//21) 1600 FORMAT (////1X, C WRITE(6,1500) NBET=NBETA NPP1=NMODES#NCOM IMAX=NCDEF+2 TJUMP=TMAX-TMIN EPS1=.1*EPS2 TIME=TMIN TCME=TMIN ISTEP=1 ICUT=1 J3=1	,'THE TIME DEPENDENT FU PROGRAM RETURNED FROM S	UNCTION(S)'///) SIMQ WITH NO RESULT')			0ZAN20 0ZAN20 0ZAN20 0ZAN20 0ZAN20 0ZAN20 0ZAN20 0ZAN20
1600 FORMAT (////1X, C WRITE(6,1500) NBET=NBETA NPP1=NMODES*NCOM IMAX=NCDEF+2 TJUMP=TMAX-TMIN EPS1=,1**EPS2 TIME=TMIN TCME=TMIN ISTEP=1 ICUT=1 J3=1	PROGRAM RETURNED FROM S	INQ WITH NO RESULT!)			0ZAN20 0ZAN20 0ZAN20 0ZAN20 0ZAN20 0ZAN20 0ZAN20
C WRITE(6, 1500) NBET=NBETA NPP1=NMODES*NCOB IMAX=NCDEF+2 TJUMP=TMAX-TMIN EPS1=.1*EPS2 TIME=TMIN TCME=TMIN ISTEP=1 ICUT=1 J3=1	F				OZAN2 OZAN2 OZAN2 OZAN2 OZAN2
WRITE(6,1500) NBET=NBETA NPP1=NMODES*NCOM IMAX=NCDEF+2 TJUMP=TMAX-TMIN EPS1=.1*EPS2 TIME=TMIN TCME=TMIN ISTEP=1 ICUT=1 J3=1	F				OZANZ OZANZ OZANZ OZANZ
NBET=NBETA NPP1=NMODES#NCOM IMAX=NCDEF+2 TJUMP=TMAX-TMIN EPS1=,1*EPS2 TIME=TMIN TCME=TMIN ISTEP=1 ICUT=1 J3=1	F				OZAN2 OZAN2 OZAN2
NPP 1=NMODES#NCOM IMAX=NCDEF+2 TJUMP=TMAX-TMIN EPS1=, 1#EPS2 TIME=TMIN TCME=TMIN ISTEP=1 ICUT=1 J3=1	F				OZAN2
IM AX =N CD EF + 2 TJUMP=TMAX-TMIN EPS1=. 1* EPS2 TIME=TMIN TCME=TMIN ISTEP=1 ICUT=1 J3=1					OZAN2
TJUMP=TMAX-TMIN EPS1=,1*EPS2 TIME=TMIN TCME=TMIN ISTEP=1 ICUT=1 J3=1					CLANC
EPS1=.1*EPS2 TIME=TMIN TCME=TMIN ISTEP=1 ICUT=1 J3=1					NTAN2
TIME=TMIN TCME=TMIN ISTEP=1 ICUT=1 J3=1					NTAN2
TCME = TMIN ISTEP= 1 ICUT=1 J3= 1					OZAN2
ISTEP=1 ICUT=1 J3=1					DZAN2
ICUT=1 J3=1					(17 AN 2)
J3=1					OZAN2
			;		OZAN 2
J5=1					CZAN2
NPR1=1					OZANZ
J6=NCOEF					OZAN2
NN=1073741824					UZAN2
INC = 1073741 824					OZAN2
$FO(1) = I_0$					OZAN2
LU 81 I=2, IMAX					OZAN2
					OZAN2
81 20(1)=1./XI					OZAN2
00 11 IN=1, NMUDE				•	OZAN2
	5				UZAN2
					OZAN2
TAMOLNIL P, I J=PAP	PRE(IM, 1)*FAMLAM(I)				OZAN2
11 DO LITM TNI-DOCI	JIN IN 91N 91 P				OZAN2
					OZAN2
90 FO 61 1= 15, 16					OZAN 2
					OZAN2
1(3,1)=12X					UZAN2

·	DO 82 I=2,IMAX	0ZAN 2089
82	$T(J, I) = T(J, I-1) \Rightarrow T(J, 1)$	0ZAN2090
	DO 62 K=1,NBET	OZAN2091
	DO 12 $I=1, IMAX$	OZAN2092
12	$G(J, K, I) = O_{*}$	07AN2093
	X = FAMLAM(K) * T(J, 1)	DZAN2094
	IF(AES(X)-1.) 2,1,1	07AN2095
· 1	RX=1./FANLAM(K)	QZAN2096
	IF (.NOT.(X.GE.150.)) GO TO 15	D7 AN 2097
	WRITE(6,450)	DZAN2098
	PRINT 500,TONE	07AN2059
	GO TO 139	0ZAN2100
15	G(J, K, 1) = (1 - EXP(-X)) IRX	07AN2101
	DO 7 $JJ=2,IMAX$	0ZAN2102
14 T	XI=JJ	0ZAN2103
7	G(J,K,JJ) = (T(J,JJ-1) - (XI-1,) *Q(J,K,JJ-1)) *RX	0ZAN2104
	GO TC 62	07AN2105
2	SUM = AO(IMAX) * T(J, IMAX)	DZAN2106
	APS=SUM*1.E-20	07AN2107
	ACOEF=NCOEF	07 AN 2108
	FJ2=ACOEF+3.	0ZAN2109
41 10	TERM=SUM	0ZAN2110
· · 3	TERM =- X* TERM/FJ2	0ZAN2111
	IF (AES (TERM) - APS) 5, 5, 4	0ZAN2112
4	SUM=SUM+TERM	07AN2113
	FJ2=FJ2+1.	0ZAN2114
	GO TC 3	0ZAN2115
5	Q(J,K,IMAX) = SUM	OZAN 2116
	EC 8 JJ=2, IMAX	QZAN2117
e :	I2 = I MA X + 1 - J J	OZAN2118
P	XI = I 2	0ZAN2119
8	G(J,K,I2)=(T(J,I2)-FANLAM(K)*Q(J,K,I2+1))*AO(I2)	QZAN2120
62	CONTINUE	D7AN2121
61	TEX= •5*TEX	07AN2122
111	TSTEP=T(J3,1)	07AN2123
	J4 = J 3	N7 AN 2124
		SEMILLET D

1. S. S.

		OZAN2125
	$J_{2} = J_{3} - 1 + J_{1}$	OZAN2126
104	SUNCIA IMEL, MODES	OZAN2127
104		UZAN2128
	DO IO II=L, NCCEF	OZAN2129
	CO TO INEL, NMODES	OZAN2130
	LU IU IMEI, NMULES	0ZAN2131
	SUMRU(1M,1N,11)=A0(11)*T(J2,11)*R0J(IM,IN)+A0(11+1)*T(J2,11+1)*(R0	0ZAN 2132
10	1 C2(IM, IN)+2.*ROC3(IM, IN)*TIME)+AO(I1+2)*T(J2,I1+2)*ROC3(IM, IN)	CZAN2133
10	SUMB(IM, IN, II) = 0.	07AN2134
	UU CU I=I,NBE	07AN 2135
	LG BU IM=1, NMODES	D7AN2136
	CBURN(IM,I) = FANCLM(IN,I) * Q(J2,I,1)	07AN2137
	SUMCI(IM)=SUMCI(IM)+CEURN(IM,I)	07AN2138
	DC 80 IN=1, NMODES	02AN2130
	DO 8C Il=1, NCCEF	07AN2140
	EINT(IM, IN, I1)=BATA(IN, IN, I)*Q(J2, I, I1)+(BEC2(IM, IN, I)+2, *BEC3(IN,	07AN2140
	1 IN, I) *TIME) *Q(J2, I, 11+1) + BEC3(IM, IN, I) * Q(J2, I, I1+2)	07AN2142
	SUMB(IM, IN, I1) = SUMB(IM, IN, I1) + BINT(IM, IN, I1)	02AN2142
80	CONTINUE	02AN2145
	DO 105 I1=1, NCCEF	D74N2144
	CO 105 IN=1, MODES	07AN2145
	DO 105 IM=1, NMOCES	07AN2140
105	SUMRE(IM, IN, IL) = SUMRC(IM, IN, IL) - SUMB(IM, IN, IL)	07AN2147
	DO 106 IM=1, NMODES	02AN2140
	SUINIT(IM)=0.	07AN2199
	CO 1C7 IP=1, NMODES	07AN2150
	TEINIT=SUMRB(IM, IP, 1)*FIJ(IP)	02AN2151
107	SUINIT(IM)=SUINIT(IM)+TEINIT	02412152
	COMP(J1, IM) = SUINIT(IM) + SUMCI(IM)	07AN2155
	DO 106 IN=1, NMUDES	OLANZIO4
	DD 106 I1=2, NCOEF	07AN2122
106	COFE(IM, IN, I1)=GENTME(IM, IN) *T(J2, I1-1)-SUMRB(IM, IN, I1)	024112100
	CD 113 IM=1, NMCDES	07412151
	JK = 2	UZANZI 58
112	JL = JK - 1	UZAN 2159
		ULANZIOU .

		그는 것 같은 것 같			
		CO 114 IN=1. MODES		· · · ·	07412141
		LNMODS=(JL-1)*NMODES			07AN2161
		IY=LNMODS+IN			02AN2162
	114	A(J1,IM,IY) = COFE(IM,IN,JK)			07 AN 21 64
		IF(IY.EQ.NDIM) GO TO 113			02 AN 2164
	110	JK=JK+1			07 412105
		GO TC 112			07AN2167
	113	CONTINUE			UZANZICI DZANZICO
*	60	CONTINUE			ULAN2100
		DO 121 IY=1.NDIM			UZAN2109
		J1=1			0ZAN2170
	122	MNMODS=(J1-1)*NMODES			07AN2171
		DO 118 IM=1. NMODES			07AN2172
	'	IX=MNMODS+IM			ULAN2175
		IF (J1. EQ. NCDEF) GO TO 117			02AN2174
	119	PFULL(IX, IY) = A(J1, IM, IY)			024N2175
		BFULL(IX)=COMP(J1,IM)			D7AN2177
	117	IZ = I X- NMCDE S		105	07AN 2179
		IF(IZ.GT.0) CO TO 115			074N2179
•		GU TC 118			07AN2180
	115	PHALF(IZ, IY) = A(J1, IM, IY)	station a literature		07AN2181
		BHALF(IZ)=COMP(J1, IM)			07AN2182
, i, i	113	CONTINUE			07AN2183
		IF(IX.EQ.NPP1) GD TO 121			C74N2184
	120	J1 = J1 + 1			07AN2185
. I		GO TO 122			07 AN 2186
	121	CONTINUE	at		C7AN2187
C					0ZAN2188
С	SIMG	IS A GENERAL MATRIX INVERSION SUBROUTINE ACCOMPANIED BY THE	SOLUTION	OF	0ZAN2189
C	THE	LINEAR SYSTEM OF EQUATIONS		1.1	DZAN2190
C				е 13 м.	0ZAN2191
		CALL SIMC(PFULL, BFULL, ND IM, KS)			07AN2192
		CALL SIMG(PHALF, BHALF, NC IM, KS)			QZAN2193
С					UZAN2194
	* a:	IF (KS.EQ.0) GO TO 8000			QZAN2195
		WRITE(6,1600)			07AN2196
				1.15	

	RETURN	
8 000	CONTINUE	OZAN 2197
	J1 = 1	OZAN2198
124	MNMODS=(J1-1)*NMODES	DZAN 2199
	CO 123 IM=1. NMODES	0ZAN2200
	IX=MNMODS+IM	UZAN2201
	ENFULL (J1.TM) = BFULL (TX)	OZAN 2202
123	ENHALF(J1,TM) = PHALF(TX)	DZAN2203
	IF (IX-NDIM) 126.125.125	OZAN2204
126	J1 = J1 + 1	0ZAN2205
	GO TO 124	OZAN2206
125	CONTINUE	0ZAN 2207
	DO 128 IN=1 . NMODES	0ZAN2208
	SENFUL(IM)=FIJ(IM)	OZAN 2209
	SENHAF (IM)= FIJ (TM)	0ZAN2210
	C() 123 J1=1, NCM1	0ZAN2211
	TERFUL=ENFULL(J1,IM) #TSTEP##.11	OZAN 2212
	TERHAF=ENHALF(J1.IN) #TSTEP*# 11	0ZAN2213
	SENFUL(IM)=SENFLI(IM)+TERFLU	0ZAN2214
128	SENHAF (IM)= SENHAF (IM)+TERHAF	. 0ZAN 2215
	SEPS=0.	0ZAN2216
	SSQN=0.	OZAN 2217
	DO 127 IM=1. NMODES	OZAN 2218
·	EPS(IM) = (SENHAF(IM) - SENELL (IM))++2	0ZAN2219
	SON(IM)=(SENHAF(IM))4#2	OZAN2220
	SEPS=SEPS+EPS(IN)	UZAN2221
· · ·	SSQN=SSQN+SQN(TM)	UZAN2222
	EPS(IM)=EPS(IM)/SON(IM)	0ZAN 2223
127	CONTINUE	CZAN2224
1.0	EPSLON=SORT(SEPS/SSON)	0ZAN 2225
	EPSILN=EPSI ON	OZAN2226
а.	IF(EPSILN.GT.EPS2) GC TO 72	0ZAN2227
	IF(EPSILNALT FPSI) GO TO 62	OZAN2228
	GO TC 64	0ZAN2229
72	$J_{3}=J_{2}+1$	0ZAN2230
	FRINT 1000.13	OZAN 2231
		07AN2232

	73	IF(J3.LE.NPR1) GO TO 111	OZAN2233
		IF (J3.GT.30) GD TD 71	0ZAN 2234
		J5=J6+1	CZAN2235
		J6=J5	OZAN 2236
		NPR1=J3	CZAN2237
		GO TO 90	UZAN2238
	71	CONTINUE	0ZAN2239
	•	PRINT 1000, J3	0ZAN2240
		RETURN	0ZAN2241
	63	CONTINUE	DZAN 2242
		IF (J3.EQ.1) GQ TU 64	DZAN2243
		J 3= J 3=1	07AN2244
•		FRINT LOCC, J3	07AN2245
	64	TOME=TOME+TSTEP	07AN2246
		J2 = J4	D7AN2247
		CO 133 IM=1, NMCDES	07AN2248
		FIF(IM)=SENFUL(IM)	07AN2249
		FIFM=FIF(IM)	07AN2250
а.,		IT IME = ISTEP	07 AN 2251
		IF((ABS(FIFM).GE.1.E35).OR.(ABS(FIFM).LE.1.E-35)) GO TO 140	074N2252
		DO 65 I=1,NBET	07AN 2253
		SUMNE(IM)=0.	07AN2254
· · ·		TERMNB(IM)=0.	D7AN2255
• •		DBURN(IM,I) = FANCLM(IN,I) * O(.12,I,1)	07 AN 2256
	•	CU 91 IN=1, NMODES	02AN2250
×		CO 180 I1=1, NCUEF	074N2258
+2" 	180	BINT(IM, IN, I1)=BATA(IM, IN, I)*Q(J2, I, I1)+(BEC2(IM, IN, I)+2,*BEC3(IM,	07AN 2259
	1	L IN, I) *TIME) *Q(J2, I, I1+1)+BEC3(IM, IN, I)*C(J2, T, I1+2)	02AN2260
		BIFIJ(IM)=BINT(IM, IN, 1)*FIJ(IN)	17AN2261
		SUMNB(IM)=SUMNB(IM)+EIFIJ(IM)	D7AN2262
		EO 91 JM = 2.NCOEF	07412262
		ENBINT (IM) = EINT (IM, IN, JM) # ENFULL (JM-1.IN)	07AN2265
	91	TERMNB(IM) = TERMNB(IM) + ENEINT (IM)	07AN 2265
		SUMNE(IM)=SUMNB(IM)+TERMNB(IM)	D7AN2265
	. 2	FAMPRE(IM, I)=FAMPPE(IN, I)-DBURN(IM, I)+SUMNB(IM)	17AN2260
	65	FAMCLM(IN,I)=FAMPRE(IN,I)*FAMIAM(I)	07AN2201
			CLANZZCO

13	3 FIJ(IM) = FIF(IM)	QZAN2269
	IJUT=IJUMP*ICUT	07AN2270
	IF(ISTEP.EQ.IJOT) GO 10 135	0ZAN 2271
	CO TO 136	07AN2272
13	5 PRINT 504, ISTEP	07AN2273
	IOUT=IOUT+1	07 AN 2274
	FRINT 500, TUME	17AN2275
x	PRINT 501, EPSILN	07 AN 2276
	PRINT 502	02412210
	CO 137 IN=1, NMUDES	02AN227
	PRINT 503, IM, FIF(IM), EPS(IM)	07AN 2270
13	7 CONTINUE	02412219
13	6 ISTEP=ISTEP+1	07412200
	TIME=TIME+TSTEP	02AN2281
	TEMI=TIME-TMIN	07AN2282
x	DO 134 IN=1, NMODES	07AN2284
	CO 134 IN=1, NMODES	GZAN2204
	ROJ(IM, IN)=REC1(IM, IN)+TEMI#(ROC2(IM, IN)+TEMI#ROC3(IM, IN))	074N2286
	CO = 1.34 I = 1, NBET	D7 AN 2287
	EATA(IM, IN, I)=BEC1(IM, IN, I)+TEMI*(BEC2(IM, IN, I)+TEMI*BEC3(IM, IN, I)	07AN2288
4 **	1)	07412289
13	4 CONTINUE	07 AN 2290
m = r + 1	IPOWR(J3)=2**(J3-1)	07AN2291
	$IPOWR(J4) = 2^{2/2} (J4 - 1)$	D7 AN 2292
	IND=NN/IPOWR (J3)	C7AN2203
÷	INC=INC-NN/IFOWR(J4)	G7AN2294
	IF (TOME. GE. TMAX) GO TC 138	07AN 2295
	GO TC 68	C7AN2296
13	B ITIME=ISTEP-1	07AN22C7
14	D PRINT 504,ITIME	07AN2298
	FRINT 500, TOME	07AN2200
	PRINT 501, EPSILN	07AN2300
	PRINT 502	07AN2301
	CO 139 IM=1, NMODES	074N2302
	PRINT 503, IM, FIF(IM), EPS(IM)	17 AN 2302
139	CONTINUE	T7AN2304
		SCHRED VY

		RETURN	OZAN2305	
	68	CONTINUE	0ZAN 2306	
		IF(IND.LE.INC.) GD TD 73	0ZAN2307	
		IND=IND/2	OZAN2308	
		J3=J3+1	0ZAN 2309	
		FRINT 1001, J3	OZAN2310	
		GC TC 68	C7AN2311	
		END	07AN 2312	
		SUBROUTINE HASAT(BATA, GENTME, ROJ)	07AN2313	
С			074N2314	
С		THIS SUBROUTINE GIVES THE FINAL TIME DEPENDENT FLUX AT THE END OF THE	DZ AN 2315	
С		TRANSIENT AS WELL AS SOME OF THE CONVENTIONEL PARAMETERS WHICH ALLOW A	GZAN2316	
С		COMPARISON OF OUR RESULTS WITH THOSE DETAINED TROUGH A POINT KINETICS	07 AN 2317	
С		TYPE APPRCACH	07AN2318	
С			0ZAN2319	
С		,, HASAT ,, MEANS HARVEST IN TURKISH	07AN2320	
С			C74N2321	
		CCMMCN/0ZO/SIGA, UNSF, SECS, SCAT, PSI, W	07AN2322	
		COMMON/0Z11/C, DNC, KSFCZ, SKOZN, NDFSI, NDW, HU, HV, R	07AN2323	
		COMMON/0Z2/NMODES, II.KK	T7AN2324	
		COMMON/024/NEETAL, NBETA2, NBETA, NEETI	07AN2325	
		COMMON/FZ4HT/BE	07 AN 23 26	
	÷Č.,	CCMMCN/DZGDHT/FAMCLM	024N2320	
÷.,		CCMMCN/GCZHT/FIF	07412328	
		COMMON/DZHST/ATT1,ATT2.MU1.MUU.MV1.MVV	02AN2320	
С			07AN2320	
		DIMENSION PSI(3,48,4C).W(3,48,40).HU(39).HV(47).R(40).SICA(3.47.	07AN 2331	
	1	39), UNSE(3, 47, 39), SCAT(2, 47, 39), ATT1(10), ATT2(10),	07AN2332	· · ·
	2	EIF(2), BATA(2,2,15), CENTME(2,2), PATA1(2), RUL(2,2), RATAT(2),	07412332	
		PHLUX(3,48,4C), NDW(2), NDPSI(2), SGCS(2,3,47,3S), FANCIN(2,15),	07AN2334	
	4	SBET 4(2)	074N2335	
С			UZAN2332	
1	000	EORMAT (7E11.5)	ULAN 2330	
5	000	F(RMAT(1P5F14-6))	ULAN2331	
	64.9	FORMAT (1H1.////21X. TINE DEPENDENT EDUITSI)	UZAN2338	
E.	501	FORMAT (////1X. AMPLITIOF FUNCTION, 24YI-1.512 4/// DEACTIVITY -	0ZAN2339	
		21011 1777 247 AH LI 1001 1 OHOISON 724A- 9ELSOC///* REAU 11 VI 18 93	ULANZ340 A	
		그는 이번 것이 그 그는 것이 없는 것을 물러 가지 않는 것을 잘 만들었다. 그는 것이 것을 수 있는 것을 얻어 있다.	. 4	

	12X, '=', E13.6/' CMEGA', 37X, '=', E13.6//' GENERATION TIME', 27X, '=', E1	0ZAN2341
	23.6/ IUTAL DELAYED NEUTRON FRACTION', 12X, '=', E13.6/' TOTAL PRECUR	DZAN2342
	3 SUR ACT IV ITY ', 13X, '= ', E13.6/)	OZAN2343
651	FURMAT (1H1, 'TIME DEFENDENT FLUX GROUP ', 11/)	OZAN2344
652	FURMAI (8X, 12, 9(9X, 12))	DZAN2345
653	FURMAT (/1X, 12, 3X, 10(E9.3, 2X))	0ZAN2346
	$D \in L = C_{o}$	OZAN 2347
·	IF (KK NE .1) GO TO 179	QZAN2348
	FEAC(10,5000) PSI	QZAN2349
	REWIND 1C	0ZAN 2350
	LU 178 $MV = 1, 48$	GZAN2351
	DO 178 MU=1,40	0ZAN2352
	CO 178 MG=1,2	07AN2353
178	FHLUX(MG, MV, MU)=PSI(MC, MV, MU)*FIF(1)	07AN2354
	GC TC 192	07AN2355
179	CO = 160 MV = 1,48	07AN2356
	CO 180 MU=1,40	07AN2357
	DO = 180 MG = 1, 3	07 AN 2358
	PHLUX(MG, MV, MU)=0.	07AN2359
180	CONTINUE	07AN2360
	KK K = 0	07 AN 2361
	CO 190 K=1,KK	17 AN 2362
s d	KKK=K+1KKK	07AN2363
	NN=NCPSI(KKK)	02AN2364
6	READ(NN, 5000) PSI	07AN2365
	REWIND NN	07AN 2366
	[0 190 MV=1,48	07AN2367
	DO 190 MU=1,40	07 AN 2368
10.0.000 (10.000)	DO 190 MG=1,2	17 AN 2369
190	PHLUX(MG, MV, MU)=PSI(MG, MV, MU)*FIF(KKK)+PHLUX(MG, MV, MU)	D74N2370
192	CONTINUE	· 07AN 2371
	C0 60 K=1,KK	07AN2372
	SUM1=0.	074N2373
	DO 5C J=1,NBETA1	0ZAN 2374
	SUMI = SUMI + BATA(1, K, J)	OZAN2375
50	CONTINUE	0ZAN 2376

	SBETA(K) = SUM1	0ZAN 2377
	EATA1(K) = SUM1/BE	0ZAN2378
60	CONTINUE	OZAN 2379
	CO 7C K=1,KK	0ZAN2380
	SUM2=SBETA(K)	OZAN2381
	DD 65 J=NBET1, NBETA	OZAN2382
	SUM 2 = SUM 2 + BATA(1, K, J)	0ZAN2383
65	CONTINUE	UZAN2384
	BATAT(K) = SUM2	0ZAN 2385
70	CONTINUE	0ZAN2386
1.9	AMP=FIF(1)+GENTME(1,2)/GENTME(1,1)*FIF(2)	0ZAN2387
	CEN=BATA1(1) #FIF(1) + EATA1(2) #FIF(2)	OZAN2388
	GENN=AMP*GENTME(1,1)/EEN	0ZAN2389
	RHO=(ROJ(1,1)*FIF(1)+FOJ(1,2)*FIF(2))/DEN	0ZAN2390
	EETAT=(BATAT(1) = FIF(1) + BATAT(2) = FIF(2))/CEN	OZAN2391
	CO 230 J=1, NEETA	UZAN2392
	CEL=FAMCLM(1,J)+DEL	OZAN 2393
230	CONTINUE	CZAN2394
	ALFA=((RHC-BETAT)*AMF+DEL)/(GENN*AMP)	. 0ZAN2395
	WRITE(6,6501) AMP, RHC, ALFA, GENN, BETAT, DEL	0ZAN2396
	NX = (MUU - MU1 + 1) / 10	0ZAN2397
	NY = (NVV - NV1 + 1)/25	OZAN2398
•	$M \times 1 = M \times + 1$	CZAN2399
	PY1 = PY+1	CZAN2400
	NE X=MUU-MU1+1-MX*10	0ZAN 2401
	NEY=MVV-MV1+1-MY*25	OZAN2402
	DO 30 MG=1,3	OZAN 2403
	NUF = MU1-1	0ZAN 2404
	N U I = M U 1 - 1 0	UZAN2405
	DO 3C MXX=1, NX1	0ZAN2406
	IF ((MX.EQ.O).OR.(MXX.EQ.MX1)) GC TO 10	0ZAN2407
	NUI = MUI + 10	GZAN2408
	MUF=MUF+10	0ZAN 2409
10		CZAN2410
10		OZAN 2411
	MUI = MUI = NEX + I	0ZAN 2412

N N		
15	MV F = MV 1-1	07AN2412
	NVI=NV1-25	02AN2415
	EQ 30 MYY=1, NY1	07 AN 2415
	IF ((MY.EG.O).OR.(MYY.EQ.MY1)) GO TO 20	07AN2416
	VVI=VVI+25	07AN 2417
	MV F=MV F+ 25	17AN2419
	GD TC 25	07AN2410
. 20	MVF=MVF+NEY	07AN2419
	MVI=MVF-NEY+1	0ZAN2420
2.5	WRITE(6,651) MG	0ZAN2421
	WRITE(6,652) (NU,MU=NLI,MUF)	UZAN 24 22
	CC 30 MV=MVI, MVF	UZAN2423
	WRITE(6,653) MV, (PHLUX(MG,MV,MU), MU=MUT, MUF)	UZAN2424
: 30	CONTINUE	UZAN 2425
	RETURN	UZAN2426
	END	UZANZ427
13		UZAN 2428
//G.F	TIOFOOL DD DSNAME=USEFFILE.M8696.9441.FOP.ST. DISP-DID	UZAN2429
1/6.F	T11F001 DD DSNAME=USERFILE.M8696. 5441. FOA.DL.DISP-OLD	UZAN2430
// G. F	T12F001 DD DSNAME=USERFILE.M8696.9441.TRP.ST.DISP-CLD	UZAN2431
//G.F	T13F001 DD DSNAME=USERFILE.M3696.5441.TRA.DI. DISPECID	UZAN2432
// G. F	T14F001 DE DSNAME=USERFILE.M8696. 5441.FOD.IF.DISPECID	UZAN 2433
1/ C. F	T15F001 DE DSNAME=USERFILE.M8696. 5441.FSI.GA. DISPECID	UZAN2434
.//G.F	T 16FOCL DD D SNAME=USERFILE. M8696. 9441. FUN. SF. FISP=010	UZAN 2435
// Ca F	T17F001 DD DSNAME=USERFILE.M8696.5441.FIS.GE.DISP=DID	UZAN 2436
11G.F	T18F001 DD DSNAME=USEFFILE.M3696.9441.TBD.IF. DISPECID	UZAN2437
1/6.F	T19F001 DD DSNAME=USERFILE.M3696. 5441.TSL.GA.DISP-CLD	UZAN 2438
// G. F	22FOOL DD DSNAME=USERFILE.M8696.9441.FSC.AT.DISP=010	UZAN 2439
1/6.F	T23FOOL DD DSNAME=USERFILE.M3696.9441.TSC.AT.DISP=DID	UZANZ440
// (. F	124 FOOL DD DSNAME=USERFILE.M8696. 9441.FSG.CS.DISPECID	UZAN 2441
1/6.F	126FOOL DD DSNAME=USEFFILE.M8696. 5441.FSP.NB. DISP-DID	UZANZ442
1/6.F	TOIFOOI DD DSNAME=USERFILE.M8696. 9441.FOD.IE.DISPECID	UZAN 2443
// C. F	102F001 DD DSNAME=USERFILE.M8696. 5441.FST.GA.DISP=01D	UZAN 2444
1/6.F	O3FOOL DD DSNAME=USEFFILE, M8696, 9441, FUN, SE, DISP-CLD	UZAN2445
1/6.5	04F001 DD DSNAME=USERFILE.M8696. 5441.FSC.AT.DISPECID	UZAN 2446
1/G.F.	28F001 DD DSNAME=USERFILE.MB696.9441_HED.IE.DISP-01D	UZAN2447
	The second state in the se	UZAN2448

73	//C.FT29F001 DD D	D S	NAME=USERFILE.	M	8696. 9441.HSI.	GA	DISP=GLD				07AN 2449
а	// C. FT31F001 DC D	DS	NAME=USERFILE.	M	8696. 5441. HSC .	AT	DISP=010				07AN2450
18	//C.SYSIN CD *										07AN2451
	&INNM NMODES=2,N	NC	EKIN=1,KSFEX=1	,,	KSROZ=1,COEFIC	=1	O. LEINAL =1. IN	PC=	1.1 PSM	=1.	17 AN 2452
	LEYD=1									,	07AN2453
	8 E ND										024N2455
	& INV1 V1=0.19903	30	E-8,0.231703E-	-6	. C. 454545F-5. []	ME	G = 17, 262131				07412455
	& END				,						07412405
	& INHU										02AN2450
	HU= 3.7799997		, 1.863994		, 1.3639994		. 1.3639994		1.1		02AN2459
	0.31699997 ,	,	0.31699957	,	1.6139994		1.6139994		,		07 11 24 59
	1.6139994 ,	,	1.6139994	,	0.97700000		0.97700000				024N2459
	C.97700000 ,	,	C. 9770000C		1.5959997	÷.	0.55400000	1			024N2400
	C. 95400000 ,	,	C. 95400CCC	•	0.15899998		0.63495959	1			02AN2401
•	0.15899998 ,	,	0.475999955	,	0.68699998	,	0.68699998		1		17AN2463
	C.68699998 ,	,	0.63499955	,	4.4099998		4.4099998				07AN2464
	4.4099998 ,	,	4.40999558	,	4.4099998	•	4.4099998				07 AN 24 65
	4.4099998 ,		3.0000000	,	9.6599998	,	5.6555598				024N2465
	15.240000 ,		15.240000	,	15.240000			,			074N2467
	END.										17 AN 2468
	S INHV			•							024N2400
ŝ,	HV= 10.160000		, 10.160000		, 10.160000		. 5.0799999				07 AN 2470
• 1	5.0799999		5.0799999		7.6199999		2.5400000				02AN2470
3	2.5400000 ,	,	2.5400000	,	2.5400000		2.5400000	1			024N2471
	2.5400000 ,	•	2.54000CC	,	2.5400000		2.5400000				07 AN 2473
	2.5400000 ,	-	2.5400000	•	2.5400000		1.2695995		5 A .	소문 영상 소문	02AN2475
	1.2699955 ,	,	1.2699995		1.2699995		1.2699995		чС., <u>г</u> .	1	07AN2475
	0.63499999		1.1639996	,	1.1639996		1.1639996	1			024N2475
	0.63499999 ,	. 1	0.63499999	,	0.63499999	,	0.63499999				074N2477
	0.63499999		C. 95199996	,	0.99699998	,	0.99695958	÷			07AN2478
	0,99699998 ,		32269999	,	0.99699998	,	0,99699998				074N2479
	C.99699998 ,		1.2699995	,	1.2699995		1.2699995	÷.			07AN2480
	15.240000 ,		15.240000	,	15.240000			'			07 AN 2481
	& END			e V							074N2482
	& INYL										07 AN 2483
	YIEL = 0.23999995		, 0.7559999	9							07 AN 2484

		CZAN2485	
1		0ZAN2486	
	1 IEJ = 0.646999996 , 0.20249999 , 0.69699943E-01, 0.33399999E-01,	0ZAN2487	
	0.20499997E-01, $0.231000CCE-01$, $0.31E99998E-C2$, $C.1008C0CCE-C2$,	DZAN2488	
	$l_{\bullet} O $ $h ZRC = 0.5$	OZAN 2489	
	8 END	0ZAN2490	×.
	& INBA	07AN2491	
	BETA = 0.30099996E-03, 0.17090000E-02, 0.15289998E-02, 0.30820000E-02,	UZAN 2492	
	C.89799985E-03, C.32799994E-03, NBETA 1= 6, NBETA2= 9	CZAN2493	
	8 ENO	07AN 2454	
	εINF	07AN2495	
	FIJ= 0.41499995E-08, 0.0 ,FAMLAM= 0.1239998E-01, 0.30499998E-01.	UZAN2496	
	C.11099994 , C.301000CC , 1.1399994 , 3.0099993 ,	07AN2497	
	0.27699995 , C. 168999999E-C1, C. 48C99980E-C2, C. 14999998E-C2,	07AN2498	
	C. 42800000E-03, 0.11699955E-03, 0.43699958E-04, 0.3629558E-C5,	07AN2499	
	C.95599573E-13, FAMPRE= C.10100000E-10, 0.0 , 0.38459995E-10,	0ZAN 2500	
	0°0 , C. 20099391E-10, O. O , O. 23899993E-10,	QZAN2501	
	0.0 , 0.269999999E-11, 0.0 , 0.42099999E-12,	OZAN2502	2
	0.0 , C. 97999994E-12, O.O , O.10899996E-11,	. DZAN2503	÷
	0.0, $0.773999955-12$, 0.0 , $0.935999545-12$,	UZAN2504	
	C.O , C.18299997E-11, O.O , O.73199996E-11,	07AN2505	
	$C_{\circ}O$, $C_{\circ}26899993E-11$, $O_{\circ}O$, $O_{\circ}102CCOOOE-10$,	07AN2506	
e.	C.O. , 236.00000 , 0.0	07AN2507	
2	S END	07AN 2508	
	EINATTI ATT 1=0.4E-4, 2*0, 24E-4, 2*0.1E-4, 0.27E-4, 2*C.1E-4, 2*0.03E-4	0ZAN2509	
	8 € ND	07AN2510	
	8 INMVU MV1= 9,MVV=15,MU1=17,MUU=24	0ZAN2511	
į	& END	QZAN2512	
	& INUI MRUI=1, 9,1,16,23,25,28,1,31,1	OZAN 2513	
	8 EN D	07AN2514	a = c
	£ INUF MRUF=8,15,15,22,27,27,30,30,33,33	0ZAN2515	•
	S END	0ZAN2516	
	E INV I MRV I=31, 32, 35, 28, 23, 7, 7, 40, 7, 45	0ZAN2517	
	S ENU	OZAN 2518	
	δ INVF MRVF= 34, 34, 29, 39, 29, 22, 39, 44, 44, 47	0ZAN2519	
	& END	OZAN2520	•
			1
			9

				Residential of Charles Line
EINGLK MGLK=6*3,	2*2			OZAN2521
SEND				0ZAN2522
&INDV MOVIC=14,1	,16,17,2*24,22,	26, 18, 19, 20, 21, 2	*25,23,27,28,29,30,3*5,31	L,5, UZAN2523
1,2,3,3*5,4,5				0ZAN 2524
E END .				GZAN2525
& INT				0ZAN2526
TMIN= 0.0	,IJUMF=	15,TUP= 1.00	, 2.000000	, DZAN2527
3.0000000 ,	3.5,3.77 ,-	-0.72370051E 76,-	- C. 7237 CO51E 76,	0ZAN2528
- 0.723700512 76,-	-0.72370051E 76,	-0.72370051E 76,-	-0.72370051E 76,NINT=	OZAN 2529
5, NC M1	= 2, EP S	$2 = 1 \cdot E = 01$		0ZAN 2530
8 END				CZAN2531
&IN1				OZAN2532
X1= 1.6391191	, 0.84075296	, 0.26702499	, 1.7610798 , .	0ZAN2533
0.82282799 ,	0.24985999	1.6004200 ,	0.80091798 ,	0ZAN2534
C.25264597 ,	1.7538595 ,	0.80182099 ,	0.29360098 ,	OZ AN 2535
1.8078394 ,	0.84202498 ,	0.30796999 ,	1.6420193 ,	DZAN2536
0.34117997 ,	0.26702499 ,	1.4325495 ,	.1.2150497 ,	0ZAN2537
0.78571696 ,	1.7206993 ,	0.90859997 ,	0,90892595 ,	DZAN2538
2.2368097 ,	2.2575293	0.16682897E-C1,	2.6548691 ,	OZAN2539
4.0194197 ,	3.6016798 ,	2.6661196 ,	4.0172798 ,	OZAN2540
3.4609098 ,	2.7155800 ,	4.0147591 ,	3.4609098 ,	CZAN2541
1.7501698 ,	0.80236799 ,	0.29360098 ,	1.8089199 ,	OZAN2542
0.84150797	C. 310067CC ,	1.4184895 ,	0.80972195 ,	0ZAN 2543
0.24985999 ,	1.2845392 ,	0,90837896 ,	0.84762394 ,	0ZAN2544
1.9194298 ,	1.8468199 ,	1.2728996 ,	1.3544693 ,	0ZAN2545
0,45275295 ,	C.12844497 ,	1.3857098 ,	0.47886795 ,	CZAN2546
0.13622695 ,	1.2447691 ,	0.45357698 ,	0.12844497 ,	0ZAN2547
1.2422295 ,	C.45460955 ,	0.12844497 ,	1.3167696 ,	0ZAN 2548
0.49528897 ,	0.14204597 ,	0.93908399 ,	C.44860697 ,	CZAN2549
0.13706499	0.988813822-03,	0.17965499E-01,	0.18742299 ,	DZAN2550
0.15144500E-03,	C. 106321CCE-02,	0.16516399E-01,	0.10329299E-02,	DZAN2551
C.18816397E-01,	0.19662899 ,	0.11386098E-C2,	0.18559597E-C1,	UZAN2552
0.16346496 ,	C.989226868-03,	0.17698400E-01,	0,15745395 ,	OZAN2553
C.94003393E-03,	C.178863CCE-01,	0.17972100 ,	C. 827310878-C4,	0ZAN2554
C.32893495E-05,	0.371515532-04,	0.10228300E-C3,	0.28404780E-C3,	OZAN2555
C.15E15998-C2,	C. 44388499E-01,	0.10759300 ,	14.910100 ,	0ZAN 2556
				42
	,			0
	Contraction of the Second			

0-172040995-03-	C. 74323776-C3.	0.952054635-02	0 172059005-02		
C. 77738799E-03.	0.127482575-01.	0.176093995-03	0 622941018-02		JZANZ557
C. 12748257E- C1.	C. 1039795 EE-02	0.185284 COE=01	0 16346404		JZANZ558
C-99201780E-03-	0-17791968E-01.	0.15593467			JZAN 2559
G. 14228339E-02.	0.658636615-02.	0.0	0.959152005-05		JZANZ560
0.245285955-03.	C. 149355665-02	0 43 51 20 525 - 52	0.658152002-05,	1	JZAN2561
0-11576400E-04-	0.14110700000000000000000000000000000000	0 204441075-01	0.1602009796-02,		JZAN2562
0-134441685-02	C 108045675-01	0 121660005 02	0.108392878-14,		JZAN2563
0.204661975-01.	$C_{116715}C_{20}$	0.120032005-03,	0.134998002-02,	- C	JZAN2564
C. 135251995-03	0 141202005-02	0.123452308-12,	0.204861978-01,	l	JZAN2565
C-19776600E-02-	0.311677655-02,	0.177544005-01,	0.291815965-03,	(JZAN2566
0.34060895	0.0	0.112340992-02,	0.203329972-01,	l	JZAN 2567
0-182096995-02	0.276176665-01	0 25 920704	0.21(0050000.00)		JZAN2568
0.271648695-01	0 20409366	0.177025005 (2)	0.216805982-02,	L. L	JZAN 2569
0.28195298		0.1/302500E-(2,	0.25900196E-01,	(JZAN2570
C. 0	C 0	0.201971992-01,	0.34060895 ,	· · · · · · · · · · · · · · · · · · ·	JZAN2571
0.0	C 0 ,	0.0 ,	0.0 ,	C	JZAN2572
· · · · · · · · · · · · · · · · · · ·	,		G.O ,	(IZAN2573
C O	,	0.0 ,	C.C ,	() () () () () () () () () ()	JZAN2574
,	,	0.0 ,	0.0.,	. (ZAN 2575
0.20409709		0.18366198E-C2,	C.27019199E-01,		JZAN2576
0.0	0.113529988-02,	U.25992598E-01,	0.28154099 ,	C	JZAN2577
,	,	0.0 ,	0.0 ,	()ZAN 2578
,	0.0 ,	0.0 ,	0.0 ,	(JZAN2579
U. U	C.O ,	0.0 ,	0.0 ,	(DZAN 2580
,	C • O ,	C. O ,	C. C ,	C	ZAN2581
•••••••••••••••••••••••••••••••••••••••	0.0 ,	0.0 ,	0.C ,	(ZAN2582
C. U ,	C.O ,	0.0 ,	0.0 ,	. (ZAN 2583
0.0	C. O ,	0.0 ,	0.69583580E-C3,	() () () () () () () () () ()	ZAN2584
C.10751199E-01,	0.13947955 ,	0.0 ,	0.0 ,	(ZAN2585
0.0	C. 7354219CE-03,	0.11275899E-C1,	0.14668596 ,	C	ZAN2586
0.10543198E-02,	C.11103057E-C1,	0.12124795 ,	0.69754990E-C3,		ZAN2587
0.10574497E-01,	C.11545998 ,	0.69418992E-03,	0.10695796E-C1,	с. С	ZAN 2588
0.13947999 ,	0.0 ,	0.,0 ,	0.0 ,	C	ZAN2589
C.O ,	0.0 ,	0.0 ,	C.C ,		ZAN2590
C., O ,	C.O ,	0.0 ,	0.0 ,	0	ZAN2591
0.0 ,	0.0 ,	0.0	G.C ,	(ZAN2592

C.O ,	C.O ,	0.0 .	0.741365856- 03.	OZAN2593
0.110308978-01,	0.12124755 ,	0.69927284E-C3,	0.10612298E-01,	0ZAN2594
0.11529100 ,	C.0 ,	0.0	C. C .	07AN2595
C.O ,	0.0	0.0 ,	0.0 ,	OZAN2556
0.0 ,	C. O ,	0.0 ,	0.0 ,	OZAN 2597
C.O ,	0.0 ,	0.0 ,	0.0	DZAN2598
C. O ,	C, O ,	0.0	0.0	0ZAN2599
·C.O ,	C.0 ,	0.0	C. C ,	0ZAN2600
C. O ,	0.0 ,	0.0 ,	C. C ,	OZAN26C1
C.18389998-03,	C. 24020558E-02,	0.24629999E-01,	0.518899916-04,	0ZAN2602
0.15922000E-03,	0.22634999E-02,	0, 189999998- (3,	C. 25075998E-02.	0ZAN2603
C.25649COOE-01,	0.189999955E-03,	0.25079998E-02,	0.25649000E-01,	0ZAN 2604
0.18389999E-03,	C. 2402099EE- C2,	0.246299998-01,	0.18389999E-03,	0ZAN2605
C.24020993E-02,	0,24629355E-01,	0.82433995E-C4,	C. 17221992E-C5,	0ZAN2606
0.150219995-04,	C.51730995E-05,	0.14428800E-04,	0.80397993E-C4,	OZAN 2607
0.85492991E-02,	C. 20836998E-01,	2.8643999 ,	C. 6845 9955E-C4,	UZAN2608
C.31861640E-03,	0.45292899E-02,	0.684599958-04,	0.318616402-03,	CZAN2609
C.45252899E-C2,	C. 68459995E-04,	0.31861640E-C3,	0.45292899E-02,	OZAN 2610
0.18999999E-03,	0.25079998E-02,	0,256490COE-C1,	0.18389998-03,	CZAN2611
C.24020998E-02,	0.246299995-01,	0.51889991E-04,	0.159220002-03,	OZAN 2612
0.226349998-02,	C. 4535683(E-03,	0.54307578E-05,	0.18659195E-03,	0ZAN 2613
0.767150202-04,	C. 16548185E-03,	0.234766218-02,	C. 35671183E-C4,	0ZAN2614
0.0.	C.O.,	0.36990969E-05,	0.15933460E-C4,	OZAN 2615
0.226499999E-03,	C. 35671183E-C4,	0.0,	C.C ,	CZAN 26 16
0.35671183E-04,	0.0 ,	0.0 ,	0.38882892E-C4,	OZAN2617
C.31845761E-04,	C.4527C38CE-03,	0.68463400E-04,	0.31861593E-03,	UZAN 2618
0.45292862E-02,	0.37063519E-03,	0.62334538E-C2,	C. 67583025E-C1,	OZAN2619
C.25855988E-04,	0.120399902-03,	0.17126899E-02,	0.386821805-03,	OZAN 2620
C.65378174E-02,	C. 70840955E-C1,	0.38682180E-03,	0.65378174E-02,	OZAN2621
0.70840955E-01,	0.37063519E-03,	0.62334538E-02,	C. 67583025E-C1,	OZAN2622
C. 37063519E-C3,	G.62334538E-02,	0.67583025E-01,	C.13919998E-C6,	OZAN2623
0.64799895E-06,	C.92177997E-C5,	0.0 ,	C. C ,	0ZAN2624
0.0	0,10344677E-01,	0.251977008-01,	3.4759436 ,	OZAN2625
0.51737545E-C4,	C. 24091981E-03,	C. 34270864E-C2,	0.51737545E-04,	0ZAN 2626
0,24091981E-03,	0.34270864E-02,	0.51737545E-C4,	C, 24091981E-03,	0ZAN2627
0.34270864E-02,	0.3868218CE-03,	0.65378174E-02,	0.70840955=-01,	OZAN2628

.C. 37C63519E-C3, C. 623345	38E-02, 0.67583025E-01	• 0.25855988E-04.	07AN2629	
0.120399902-03, 0.171268	55E-02, 0.0	. C. 214080775-C5.	07AN2630	
C. 62225066E-C4, C. 268007	86E-04, 0.12479989E-03	0.177527998-02,	07AN2631	
0.46759973E-70, C.O	, 0.0	· 0.26312991E-05.	07AN2632	1
0.12047990E-04, 0.171382	77E-03, 0.46759973E-70	. 0.0	07AN2633	
C.O , C.467599	73E-70, 0.0	. 0.0	07AN2634	
0. 52113164E- C5, C. 240798	SE- 04, 0. 34253765E- C3	. C. 51737545E-04 .	07AN2635	
C.24C91931E-03, C.342708	64E-02		07AN2636	
S END			07AN 2637	
8 IN2			07AN2638	
X2= 0.32783300E-01, 0.625	55254E-01, 0.40656097E-	-01, 0.734669576-01,	07AN 2639	
0.35542600E-01, C.657807	59E-01, 0.35764698E-01	0.62729299E-01.	07AN2640	
0.331675978-01, 0.594412	SEE-01, 0.32431398E-01	0.615109598-01.	07AN2641	
C. 72293299E-C1, C.205188	55E-01, 0.47938898E-03.	0.38426300E-C3.	0ZAN 2642	
G. 36893692E-03, C. 427487	17E-C3, 0.37100399E-C3	, C. 57322090E-C3,	0ZAN2643	
C.39881282E-03, 0.602479	79E-03, 0.49287989E-C3	C. 67770784E-C3,	0ZAN2644	
0.36979698E-01, 0.612359	SEE-01, 0.33640597E-01	C.600088982-01,	0ZAN 2645	
0.10335898 , 0.108332	, 0.94007365E-C2	C.10357499E-C1,	CZAN2646	ĺ
C. 74656084E-02, C. 960964	71E-02, 0.81225395E-C1.	0.16196996 ,	- DZAN2647	
0.77860951E-01, 0.147963	. 94 , 0.92724979E-01	, 0.15338296 ,	0ZAN2648	
0.90584099E-01, 0.145035	9E , 0.91204584E-C1	, 0.15430897 ,	UZAN2649	
C. 71723163E-Cl, C.131109	CC .		0ZAN 2650	
S'EN D			0ZAN2651	2
£ IN3 X3=			UZAN2652	
12:0.,15.32E-5,7.501E-5,1	8*0. ,7.69E-5,3.76E-5,12	2*0.	OZAN 2653	
S END	a a sea a	· · ·	CZAN2654	
& INCS NCS=1,1,2,3*0,1,0			0ZAN 2655	
8 END			0ZAN2656	
& INNCS ND=1, NSIGA=1, NUNSF	= 2, NSCAT=1		0ZAN2657	
SEND .			0ZAN 2658	
& INNEK1 NEK1=1,NEUI1=20,N	RUF1=20, NRVI1=11, NRVF1=	=11, NRCC1=1,	0ZAN2659	
XT1=1.24223,4.5451	E-1, 1.28445E-01		UZAN2660	
SEND			0ZAN 2661	
& INNFK2 NRK2=1,NRUI2=20,N	RUF2=20, NRVI2=11, NRVF2=	=11,NRCC2=1,	GZAN2662	
XT2=1.16716E-4,1.2	9933E-3,2.04662E-02		0ZAN2663	
EEND			0ZAN2664	
			4 N	
			ω	

	& INNEK7 NEK7=1, NEUI7=20, NEUF7=20, NEVI7=11, NEVF7=11, NECC7=1, XT7=9.05841E-2,1.45036E-01		OZAN2665 OZAN2666
	SEND		0ZAN2667
	$G_{1NS} = G_{1NS} = 1 \cdot 0 \cdot 1 \cdot 3 \cdot 4 \cdot 3 \cdot 9 \cdot 0 \cdot 2 \cdot 3 \cdot 2 \cdot 4 \cdot 4$		UZAN2668
			OZAN2669
	& INSKUZ SKUZN=1.01/956/3		OZAN2670
	SENU		OZAN2671
	$a = 1 \times 1$		0ZAN 2672
	& END		OZAN2673
	& INDUNC DC=1, SIGAC=1, UNSFC=2, SIGFC=2, SGCSC=2, SCATC=1, SPNRC=2		OZAN 2674
	E END		OZAN2675
	E INMEKI MEK1=1, MEUI1=20, MEUF1=20, MEVI1=11, MEVF1=11, MECC1=1,		OZAN2676
	XK1=1.24223,4.5461E-1,1.28445E-01		OZAN 2677
	8 EN D		GZAN2678
	& INMEK2 MRK2=1, MRUI2=20, MRUF2=20, MRVI2=11, MRVF2=11, MRCC2=1,		OZAN2679
	XK2=1.16716E-4,1.29932E-3,2.04662E-02		0ZAN 2680
	δ END		UZAN2681
	& INMRK7 MRK7=1, MRUI7=20, MRUF7=20, MRVI7=11, MRVF7=11, MRCC7=1,		OZAN 2682
	XK7=9.05841E-2,1.45C36E-01		OZAN2683
	δ E ND		UZAN2684
	$\epsilon INSPC ISTPC = \epsilon + 2$		OZAN 2685
	S EN D		UZAN2686
	& INSTP ISE=2, ISSA=2, ISUF=2, ISSF=2, ISSE=2, ISSE=2, ISSE=2, ISATT=2		OZAN2687
	& END		OZAN 2688
	& INT		CZAN2689
52	TMIN= 3.77 ,IJUMF= 15,TUP= 5.0000000 , 7.0000000	,	DZAN2690
	-0.72370051E 76,-C.72370051E 76,-0.72370051E 76,-0.72370051E 76,NINT=		OZAN2691
5.0	4,NCM1= 2,EPS2= 1.E-01		OZAN2692
	& END		OZAN 2693
1			OZAN2694

DELT Set Up (Like Delete)

DELETE THE SPACE ALLICATED FOR VARIOUS CROSS SMAKE ANY FURTHER USE OF THEM	SECTIONS	IF IT	IS NOT	INTENDED	TO .	DELT0001 DELT0002
						DELTOOOS
						DEL10004
// 'TOLGA YARMAN', REGION=128K, CLASS=A						DELTOUOS
/*MITID USER=(M8696,9441)						DELTOOOS
/*SRI LUW						DELT0007
/*MAIN LINES=20, CARDS=00, TIME=3						DELTOOOS
//STEP1 EXEC PGM=1EFBR14						DELT0009
//DD1 DD DSNAME=USERFILE.M8696.9441.EQD.IF,						DELTOOIO
// DISP=(OLD, UELETE)						DELTOOII
//DD2 DD DSNAME=USERFILE.M8695.9441.ESI.GA,						DELT0012
// DISP=(ULD, DELETE)						DELT0013
//UD3 DD USNAME=USERFILE.M8696.9441.EUN.SF;						DELT0014
// DISP=(ULD, DELETE)						DELTOOIS
//UD4 DD DSNAME=USERFILE.M8696.9441.ESC.AT,						DELTOOIG
// DISP=(OLD, DELETE)		1111		50 S M		DELTOOT
//DU14 DD DSNAME=USERFILE.M8696.9441.FQD.IF,					3	DELIGOIS
// DISP=(ULD, UELETE)				· · · ·		DELT0019
//DD15 DD USNAME=USERFILE.M8696.9441.FSI.GA,						DELTOO20
// DISP=(ULD, UELETE)						DEL10021
//DD16 DD DSNAME=USERFILE.M8696.9441.FUN.SF,						DELTOO22
// DISP=(ULD,DELETE)	÷					DELT0023
//DD17 DD DSNAME=USERFILE.M8696.9441.FIS.GF,						DELT0024
// DISP=(ULD, DELETE)						DELT0025
//DD18 DD DSNAME=USERFILE.M8696.9441.TRD.IF,						DELT0026
// DISP=(ULD, DELETE)						DELTOO27
//DD19 DD DSNAME=USERFILE.M8696.9441.TSI.GA,					1.1	DELTOO28
// DISP=(ULD, DELETE)				•		DELTOO29
//DD22 DD DSNAME=USERFILE.M8696.9441.FSC.AT,						DELTOOSO
// DISP=(OLD, DELETE)						DELTOUSI
//DD23 DD DSNAME=USERFILE.M8696.9441.TSC.AT,						DELT0032
// DISP=(ULD, DELETE)						DELTOUSS
//DD24 DD DSNAME=USERFILE.M8696.9441.FSG.CS,						DEL10034
// DISP=(OLD, DELETE)						DELTOO35
//DD26 DD DSNAME=USERFILE.M8696.9441.FSP.NR,						DEL10036

// DISP=(OLD, DELETE)		DELT0037
//DD28 DD DSNAME=USERFILE.M8696.9441.HED.IF,		DELT0038
// DISP=(OLD, DELETE)		DELT0039
//DD29 DD USNAME=USERFILE.M8696.9441.HSI.GA,		DELT0040
// UISP=(ULD, UELLTE)		DELT0041
//DD31 DD DSNAME=USERFILE.M8696.9441.HSC.AT,		DELT0042
// DISP=(OLD, DELETE)		DELT0043
/*		DELT0044

PROGRAM RHOL

(The Ramp Change Slope of the Reactivity Matrix Computed Through a Perturbation Type of Approach)

```
RH010001
 // "TOLGA YARMAN", REGION=200K, CLASS=A
                                                                                      RH010002
 /*MITID USER=(M8696,9441)
                                                                                      RH010003
 /*SRI LOW
 /*MAIN LINES=20, CARDS=00, TIME=5
                                                                                      RH010004
                                                                                      RH010005
 //STEP1 EXEC FURCGO
                                                                                      RH010006
 //C.SYSIN DD *
                                                                                      RH010007
 C PROGRAM RHO1
                                                                                      RH010008
 C
                                                                                      RH010009
 C CALCULATION OF THE RAMP CHANGE SLOPE OF THE REACTIVITY MATRIX BY A
 C PERTURBATION TYPE OF APPROACH (IN ORDER TO CROSS CHECK ,, OZAN ,,)
                                                                                      RH010010
                                                                                      RH010011
 C
                                                                                      RH010012
       COMMON/FCFA/CUEF,MCUF
                                                                                      RH010013
 С
                                                                                      RH010014
       DIMENSIUN PSI(3,48,40),W(3,48,40),SIGA(3,47,39),
      1SCAT(2,47,39),HU(39),HV(47),R(40),ALFA(2,2),NDW(2),NDPSI(2),
                                                                                      RH010015
                                                                                      RH010016
       2COEF(3,47,39),D1(3),D2(3),ABO(2,2),DD(2,2)
 C
                                                                                      RH010017
                                                                                      RH010018
       DATA NDW/11,13/
                                                                                      RH010019
       DATA NDPS1/10,12/
       DATA DELT, J1, D2/3.77, 2.23681, 2.25753, 1.66829E-2, 1.24223,
                                                                                      RH010020
       14.54610E-1, 1.28445E-1/
                                                                                      RH010021
                                                                                      RH010022
 C
                                                                                      RH010023
1000 FORMAT (1P5E14.6)
                                                                                      RH010024
  2000 FORMAT (7E11.5)
                                                                                      RH010025
 С
                                                                                      RH010026
        NAMELIST/INHU/HU
                                                                                      RHC10027
        NAMELIST/INHV/HV
       NAMELIST/UUT/ALFA, ABO, DD
                                                                                      RH010028
                                                                                       RH010029
 С
                                                                                      RH010030
        READ(5, INHU)
                                                                                      RH010031
        READ(5, INHV)
                                                                                       RH010032
        R(1)=0.
                                                                                      RH010033
        DO 1030 MU=2,40
                                                                                       RH010034
        R(MU) = R(MU-1) + HU(MU-1)
                                                                                       RH010035
  1030 CUNTINUE
        SIGA(1, 11, 20) = -4.4271784E - 2
                                                                                       RH010035
```

NO

	SIGA(2, 11, 20) = -1.0629367E - 1
	S1GA(3,11,20) = -1.48896338E+01
	DU = 00 M G = 1 + 3
	$DU \ 040 \ MV = 10,12$
	S1GA(MG, MV, 19)=0.
	UEF(M0, MV, 19) = 0.
	SIGA(M0, MV, 21) = 0.
640	CUEF(MG, MV, 21) = 0.
	SIGA(MG, 10, 20) = 0.
	CUEF (MG, 10, 20)=0.
	SIGA(MG, 12, 20)=0.
650	COEF(MG, 12, 20) = 0.
	SCAT(1,11,20)=9.0215163E-2
•	SCAT(2,11,20)=1.44608512E-1
	DO 670 MG=1,2
	DO 660 MV = 10, 12
	SCAT(MG, MV, 19) = 0.
660	SCAT(MG, MV, 21) = 0.
	SCAT(MG, 10, 20) = 0.
670	SCAT(MG, 12, 20) = 0.
	MCDF=0
	MCF2=1
·	DO 100 1=1,2
	NN=NDW(1)
ć	READ(NN, 1000) W
	REWIND NN
	DO 100 K=1,2
9	MM=NDPSI(K)
	READ(MM,1000) PSI
	REWIND MM
	CALL ABSP(W, PSI, SIGA, SCAT, HU, HV, R, MCF2, SUM22)
	ABO(1,K)=-SUM22*1.5708/DELT
100	CONTINUE
	MCOF=1

C

С

RH010037 RH010038 RH010039 RH010040 RH010041 RH010042 RH010043 RH010044 RH01.0045 RH010046 RH010047 RH010048 RH010049 RH010050 RH010051 RH010052 RH010053 RH010054 RH010055 RH010056 RH010057 RH010058 RH010059 RH010060 RH010061 RH010062 RH010063 RH010064 RH010065 RH010066 RH010067 RH010068 RH010069 RH010070 RH010071 RH010072
DO 200 I=1,2 RH010073 RH010074 NN=NDW(I) READ(NN, 1000) W RH010075 RH010076 REWIND NN RH010077 DU 200 K=1,2 RH010078 MM=NDPS1(K) READ(MM, 1000) PSI RHC10079 RH010080 REWIND MM IF (K.EQ.1) GO TO 750 RHG10081 RHC10082 READ(29,2000) SIGA RH010083 **REWIND 29** READ(31,2000) SCAT RH010084 REWIND 31 RH010085 RH010086 DO. 500 MG=1,3 RH010087 COEF(MG, 11, 20) = (D2(MG) - D1(MG))/D2(MG)500 CONTINUE RH010088 GO TO 850 RH010089 750 CONTINUE RH010090 RH010091 READ(2,2000) SIGA **REWIND 2** RH010092 READ(4, 2000) SCAT RH010093 **REWIND 4** RH010094 RH010095 . DO 550 MG=1,3 550 COEF(MG, 11, 20) = (D2(MG) - D1(MG))/D1(MG)RH010096 RH010097 850 CONTINUE С RH010098 CALL ABSP(N, PSI, SIGA, SCAT, HU, HV, R, MCF2, SUM22) RH010099 RH010100 С RHC10101 DD(I,K)=SUM22*1.5708/DELT ALFA(I,K) = (ABO(I,K) + DD(I,K))RH010102 200 CONTINUE -RH010103 WRITE(6,OUT) RH010104 STOP RH010105 END RH010106 SUBROUTINE ABSP (W, PSI, SIGA, SCAT, HU, HV, R, MCF2, SUM22) RH010107 С RH010108 A

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CA	ABSP LIKE ABSORPTION (AND ALSO SCATTERING) INTEGRATED OVER TH	IE RH010109
CR	REACTOR VOLUME AFTER BEING WEIGHTED	RH010110
С		RH010111
	COMMON/FCFA/COEF, MCOF	RH010112
С		RH010113
	DIMENSION W13,48,40), PSI(3,48,40), SIGA(3,47,39), SCAT(2,	47,39), RH010114
-	1HU(39), HV(47), R(40), COEF(3, 47, 39)	RH010115
C .		RH010116
	SUM22=0.	RH010117
	IF ((MCF2.EQ.1).AND.(MCOF.EQ.1)) GO TO 16	RH010118
		RH010119
	CF12=1.	RH010120
		RHUIDIZI
	CE21-1	RH010122
	CF22=1.	
	CF23=1.	RH010124
	CF24=1.	RH010125
	CF31=1.	RH010123
	CF32=1.	RH010121
	CF33=1.	RH010129
	CF34=1.	RH010130
10#	16 DO 6 MV=11,12	RH010131
	HV1=HV(MV-1)	RH010132
	HV2=HV(MV)	RH010133
	DO 6 MU = 20, 21	RH010134
	W1=W(1,MV,MU)	RH010135
	W2=W(2, MV, MU)	RH010136
	W3=W(3,MV,MJ)	RH010137
	PI1=PS1(1, MV, MU)	RH010138
	P12=PS1(2, MV, MU)	RH010139
	PI3=PSI(3, MV, MU)	RH010140
	SA13=SIGA(1,MV-1,MU)	RH010141
	SA14=SIGA(1,MV,MU)	RH010142
	SA23 = SIGA(2, MV - 1, MU)	RH010143
	SAZ4=SIGA(2, MV, MU)	RH010144

	SA33 = SIGA(3, MV - 1, MU)			RH010145
	SA34=SIGA(3, MV, MU)			RH010146
	ST13=SCAT(1,MV-1,MU)			RHC10147
	ST14=SCAT(1,MV,MU)			RH010148
	ST23=SCAT(2,MV-1,MU)			RH010149
	ST24=SCAT(2,MV,MU)			RH010150
	HR2=(R(MU)+HU(MU)/4)*HU(MU)			RH010151
	SA11=SIGA(1,MV-1,MU-1)			RH010152
	SA12=SIGA(1,MV,MU-1)			RH010153
	SA21 = SIGA(2, MV - 1, MU - 1)			RH010154
	SA22=SIGA(2, MV, MU-1)			RH010155
5.14	SA31=SIGA(3,MV-1,MU-1)			RH010156
	SA32 = SIGA(3, MV, MU-1)			RH010157
	ST11 = SCAT(1, MV - 1, MU - 1)		n ^{ta} (f	RH010158
	ST12=SCAT(1,MV,MU-1)			RH010159
	ST21 = SCAT(2, MV - 1, MU - 1)			RH010160
	ST22=SCAT(2,MV,MU-1)			RH010161
	HR1 = (R(MU) - HU(MU - 1)/4) + HU(MU - 1)	1		RH010162
÷.,	IF ((MCH2.EQ.0).OR.(MCOF.EQ.0)) GO TO 20		5	RH010163
	CF13=CDEF(1,MV-1,MU)			RH010164
	CF14=CUEF(1,MV,MU)	r.		RH010165
	CF23=CDEF(2,MV-1,MU)			RH010166
÷.,	CF24=CUEF(2,MV,MU)			RH010167
1	CF33=CDEF(3,MV-1,MU)			RH010168
	CF34=CUEF(3,MV,MU)			RH010169
	CF11=CUEF(1, MV-1, MU-1)			RH010170
	CF12=COEF(1,MV,MU-1)			RH010171
\hat{e}_{ij}	CF21=COEF(2, MV-1, MU-1)	. •		RH010172
	CF22=CDEF(2,MV,MU-1)	÷		RH010173
	CF31=CDEF(3,MV-1,MU-1)			RHC10174
	CF32=COEF(3, MV, MU-1)			RH010175
-20	0 ASB=w1*(((SA11+ST11)*CF11*HV1+(SA12+ST12)*CF12*HV2)*HR1+((SA13+ST1	18		RH010176
	13)*CF13*HV1+(SA14+ST14)*CF14*HV2)*HR2)*PI1+W2*(-((ST11*CF21*HV1+ST			RH010177
	212*CF22*HV2)*HR1+(ST13*CF23*HV1+ST14*CF24*HV2)*HR2)*PI1+(((SA21+ST			RH010173
	321)*CF21*HV1+(SA22+ST22)*CF22*HV2)*HR1+((SA23+ST23)*CF23*HV1+(SA24			RH010179
•	3+ST24)*CF24*HV2)*HR2)*PI2)+W3*(-((ST21*CF31*HV1+ST22*CF32*HV2)*HR1			RH010180

4+(ST23*CF33*HV1+ST24*CF34*HV2)*HR2)*PI2+((SA31*CF31*HV1+SA32*CF32*	RH010181
5HV2)*HR1+(SA33*CF33*HV1+SA34*CF34*HV2)*HR2)*PI3)	RH010182
SUM22=SUM22+ASB	RHC10183
6 CUNTINUE	RH010184
RETURN	RH010185
END	RH010186
/*	RH010107
//G.FT10F001 DD DSNAME=USERFILE.M8696.9441.EQP.SI.DISP=01D	PH010100
//G.FT11F001 DD DSNAME=USERFILE.M8696.9441.FCA.D.I.DISP=01.D	RHUIUI08
//G.FT12F001 DD DSNAME=USERFILE.M8696.9441.TRP.SL.DISP=01D	RH010189
//G.FT13FUO1 DD DSNAME=USERFILE.M8696.9441.TRA DI.DISP-OLD	RH010190
//G.FT01F001 DD DSNAMF=USERFILE_M8696_9441_FOD_IE_DISP=0LD	RHUI0191
//G.FT02F001 DD DSNAME=USERFILE.M8696.9441.EST CA. DISP-OLD	RHU10192
//G.FT04F001 DD DSNAMF=USERFILE.M8696.9441 ESC AT DISD-OLD	RH010193
//G.FT28FUO1 DD DSNAME=USERFILE.M8696.9441 HED IE.DISP=0LD	RH010194
//G.FT29F001 DD DSNAMF=USERFILE.M8696.9441.HSL CA. DISP-DLD	RH010195
//G.FT31F001 DD DSNAME=USERFILE M8696 9641 HSC AT DISD-OLD	RHU10196
//G.SYSIN DD *	RH010197
£TNHU	RH010198
HU=3, 78, 1, 864, 2#1 364 2#0 217 4#1 414 4#0 077 1 504 010 054 0 150 5	RH010199
(1.159, 0.476, 2*0.697, 0.457, 7*6, (1.2.256, 7*0.977, 1.596, 3*0.954, 0.159, 0.635, 0.159, 0.159, 0.635, 0.159, 0.159, 0.635, 0.159, 0.159, 0.635, 0.159,	RH010200
SEND	RHC10201
EINHV	RH010202
$HV = 2 \pm 10$ 1/ 2±5 000 7 (2 1)±0 5/ 5/1 05 0 0 0	RH010203
π_{1} π_{1} π_{2} π_{2	RH010204
(TV+771)3*1+2*13+24	RH010205
GENU	RH010206
	RH010207