LA-4231

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PHENIX, a Two-Dimensional Diffusion-Burnup-Refueling Code

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IN REPLY
REFER TO:

TO: Holders of Report LA-4231

SUPPLEMENT

This supplement to LA-4231, "PHENIX, a Two-Dimensional Diffusion-Burnup-Refueling Code," consists of two additions to the original version of the code given in Table I, pp. 9 to 15. These are (1) the capability of performing a series of burnup intervals in one run, and (2) a provision for a buckling correction to be used in X-Y and R-θ calculations. Each addition is discussed briefly below.

The capability of performing a series of burnup intervals allows an entire fuel-cycle analysis to be performed in one run. Thus, if the clean reactor configuration and the appropriate refueling fractions are specified, the equilibrium fuel-cycle parameters can be calculated in a single run. Data dump capabilities are also provided so that the problem can be restarted after any number of burnup intervals. This multi-interval modification requires only two additional input control words, but reduces the maximum allowable storage in the A Common Block from $30{,}000_{10}$ to $27{,}000_{10}$ words.

The buckling correction option is made available by use of the newly added control word BUCK (on control Card 8). If BUCK is input as 0.0 (or left blank), no buckling correction is made. If BUCK > 0.0, and the geometry is X-Y or R-θ, BUCK is used in one of two ways:

a. If 0.0 < BUCK < 1.0, BUCK is used directly as $B^2_{g,I}$, the same for all groups g and regions I.

b. If BUCK > 1.0, it is assumed to be the buckling height of the reactor and the buckling for each group g, and region I is computed as

$$B^2_{g,I} = \left[\frac{3.1416}{\text{BUCK} + 2\left(0.71\ \lambda^{g,I}_{tr}\right)}\right]^2$$

to give the group/region-dependent buckling.

In both cases, the buckling correction consists of adding the quantity $D_{g,I}\ B^2_{g,I}$ to the macroscopic absorption cross section in each region I for each group g. (This quantity is also subtracted from the macroscopic self-scatter cross section to maintain the correct total cross section.) $D_{g,I}$ is computed as $1.0/\ 3\Sigma^{g,I}_{tr}$.

New Input Format

This section specifies the new input required for the additions to the code discussed previously. All references to card numbers are to the original version of the code (Table I).

Card 5 (Now becomes 9I6 format)

IBUMAX	Columns 49-54	The number of burnup intervals to be performed during this run.

Card 8 (Now becomes 3E12.4 format)

DAYST	Columns 13-24	The time in the fuel-cycle analysis when this run begins.
BUCK	Column 25-36	Buckling, CM^{-2} (if BUCK < 1.0), or buckling height, CM (if BUCK > 1.0). If a buckling correction is not desired, BUCK should be set = 0.

If a multiple burnup interval run is being made, i.e., IBUMAX > 1, then before the criticality calculation for the second and any subsequent burnup intervals, new values of the parameters PV, EV, and EVM are read in. This allows changes to be made in the search parameters as the fuel-cycle analysis proceeds to equilibrium. The format for this card is 3E12.4, and for the second burnup interval, this card should follow Card 36, the last refueling data card. A blank card can be inserted if only straight k_{eff} calculations are being performed, i.e., IEVT = 1. There is no additional refueling input required for a multiple-burnup-interval run.

The input sequence for such a run is illustrated by an example:

EXAMPLE: A depletion problem is to be run for three burnup intervals, with one burnup time step per interval (NBSTP = 1) of length 100 days. The calculational sequence is that outlined in Part C, p. 21 of the report, i.e., Search-Burnup-k_{eff} after burnup-Refuel.

The card input format for this run is as follows:

1. Cards 1 through 36 as described in Table I of the report; this takes care of the entire input for the first burnup interval.
2. A PV, EV, EVM card (a new input card) for burnup interval 2.
3. An NCON, DELT card (Card 26) with NCON < 0 and DELT = 100.
4. An NCON, DELT card (Card 26) with NCON < 0 and DELT = 0.
5. A PV, EV, EVM card (a new input card) for burnup interval 3.
6. Repeat Items 3 and 4 from above, i.e., Card 26.
7. FINISH card (Card 37).

This procedure is repeated for up to IBUMAX burnup intervals.

A revised listing of the code is available from the Argonne Code Center, in which all changes or additions to the original version of the source deck are noted with a letter next to the card index number in Columns 73-80.

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PHENIX, a Two-Dimensional Diffusion-Burnup-Refueling Code

by

R. Douglas O'Dell
Thomas J. Hirons

CONTENTS

PHENIX, A TWO-DIMENSIONAL DIFFUSION-BURNUP-REFUELING CODE

by

R. Douglas O'Dell and Thomas J. Hirons

ABSTRACT

PHENIX is a two-dimensional, multigroup, diffusion-burnup-refueling code for use with fast reactors. The code is designed primarily for fuel-cycle analysis of fast reactors and can be used to calculate the detailed burnup and refueling history of fast breeder reactor concepts having any generalized fractional-batch reloading scheme. Either ordinary k_{eff} calculations or searches on material concentrations or on region dimensions can be performed at any time during the burnup history, using the standard source iteration technique. The refueling option of the code accounts for the spatial flux shifts over the reactor lifetime in the calculation of fuel discharge. All programming is in FORTRAN-IV, and the storage requirements are designed so that the code fits in a 64k memory of a CDC-6600 computer.

I. INTRODUCTION

This report describes the two-dimensional diffusion-burnup-refueling code, PHENIX. The mathematical models are described in Sec. II, and users' information is given in Sec. III. A basic code flow chart, the source-deck listing, and a sample problem are presented in Appendices A through C, respectively.

PHENIX is of specific value for analyzing the burnup and refueling history of fast breeder reactors. Much of PHENIX is based on 2DB, a Battelle-Northwest Laboratory code.[1]

Eigenvalues are computed by source-iteration techniques, with group rebalancing, successive line overrelaxation, and fission-source overrelaxation used to accelerate convergence. Variable dimensioning is used to make maximum use of the fast memory available in the computer. In addition, only one energy group is treated at any given time, so that the storage requirements are relatively insensitive to the number of energy groups being treated.

The code searches on material concentrations and region dimensions to achieve a desired value of k_{eff}. Concentration searches can also be performed during the burnup, if desired, to account for fuel depletion. Following burnup, any or all regions of the reactor can be refueled using any desired refueling fraction. The refueling option accounts for the spatial flux shifts over the reactor lifetime.

The format of the input data blocks (e.g., microscopic cross sections, geometry specifications, and material compositions) is, for the most part, similar to the Los Alamos S_n codes[2,3] DTF-IV and 2DF, as well as to 2DB.

II. PROGRAM DESCRIPTION

A. Formulation and Solution of Difference Equations

1. Neutron Balance Equations. The time-independent multigroup diffusion equations can be written

$$D_g \nabla^2 \phi_g - \Sigma^r_g \phi_g + S_g = 0 ,$$

$$g = 1, \ldots, G , \tag{1}$$

where

G = the number of energy groups,

g = energy group index (g = 1 denotes highest energy group),

ϕ_g = group flux,

D_g = diffusion coefficient ($= \lambda^{tr}_g/3$),

$$\Sigma_g^r = \text{removal cross section,}$$

$$= \Sigma_g^a + \sum_{g'=g+1}^{G} \Sigma(g \to g') \ ,$$

Σ_g^a = absorption cross section,

$\Sigma(g \to g')$ = down-scatter cross section from group g to g',

S_g = neutron source rate.

The neutron source term, S_g, for group g consists of two terms, a fission source term and an inscatter source term from higher energy groups,

$$S_g = \frac{\chi_g}{k_{eff}} \sum_{g'=1}^{G} (\nu\Sigma^f)_{g'} \phi_{g'} + \sum_{g''=1}^{g-1} \Sigma(g'' \to g) \phi_{g''} \ , \tag{2}$$

where

χ_g = fission fraction,

k_{eff} = effective multiplication factor,

$(\nu\Sigma^f)_g \phi_g$ = fission source rate from neutrons in group g.

Equation 1 can be recast into a set of spatially coupled difference equations suitable for iterative solution by digital computer. These difference equations are formed by overlaying a mesh grid on the reactor to produce a grid of incremental mesh subvolumes. The mesh spacing is the same for all energy groups. Associated with each mesh subvolume is a mesh point at which the diffusion equation is to be discretely evaluated. In this code, the mesh point is located at the geometric center of its mesh subvolume (instead of at the intersection of mesh grid lines). In this manner, each mesh point has associated with it the mesh subvolume established by the mesh grid.

The spatial difference equations for each mesh point are formed by integrating Eqs. 1 and 2 over the mesh subvolume associated with the mesh point. The group flux at each mesh point is assumed to be the average group flux in the associated mesh subvolume, and the group constants at each mesh point are constant over its mesh subvolume. If we consider the (i,j) mesh point shown in Fig. 1, the integration of the removal and source terms of Eq. 1 yields

$$\int_{V_{i,j}} \Sigma_g^r \phi_g(i,j) \, dV = (\Sigma_g^r \phi_g V)_{i,j} \ , \tag{3}$$

and

$$\int_{V_{i,j}} S_g(i,j) \, dV = (S_g V)_{i,j} \ , \tag{4}$$

where $V_{i,j}$ is the mesh subvolume associated with the (i,j)th mesh point. In performing the subvolume integration on the leakage term, $D_g \nabla^2 \phi_g$, we can apply Green's theorem:

$$\int_V D \nabla^2 \phi \, dV = \int_A D \nabla\vec{\phi} \cdot d\vec{A} \ . \tag{5}$$

The flux gradient at the mesh boundary is approximated, in the usual manner, by the forward (or backward) difference technique. Applying Eq. 5, together with Eqs. 3 and 4, to the diffusion equation at point (i,j) yields the basic difference equation (dropping the group index for simplicity):

$$(\overline{D}A/\ell)_{i,i-1} (\phi_{i-1,j} - \phi_{i,j}) + (\overline{D}A/\ell)_{i,i+1}$$

$$\cdot (\phi_{i+1,j} - \phi_{i,j}) + (\overline{D}A/\ell)_{j,j-1} (\phi_{i,j-1} - \phi_{i,j})$$

$$+ (\overline{D}A/\ell)_{j,j+1} (\phi_{i,j+1} - \phi_{i,j}) - (\Sigma^r \phi V)_{i,j}$$

$$+ (SV)_{i,j} = 0 \ , \tag{6}$$

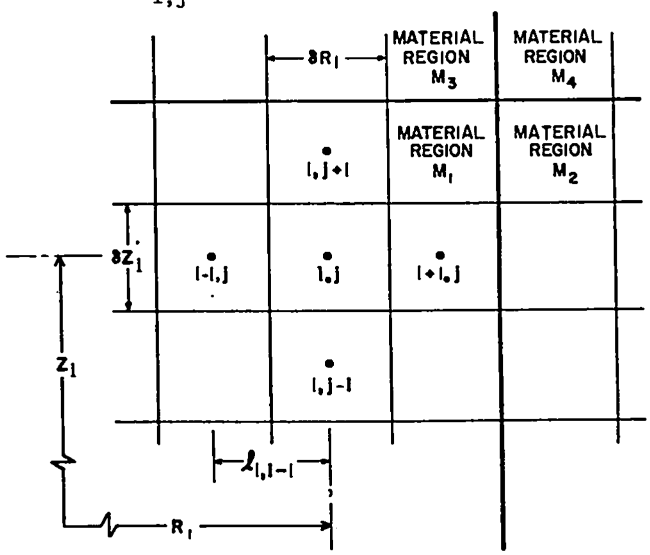

Fig. 1. Mesh grid and mesh point configuration.

where, referring to Fig. 1,

ℓ = distance between mesh point (i,j) and the adjacent mesh point indicated by the subscripts in Eq. 6, e.g., $\ell_{i,i-1} = R_i - R_{i-1}$,

A = area of common boundary between mesh subvolume (i,j) and the subvolume indicated by the subscripts in Eq. 6,

$\overline{D}$ = effective diffusion coefficient between mesh point (i,j) and the mesh point indicated by the subscripts in Eq. 6, e.g., between points (i,j) and (i-1,j),

$$\overline{D} = \frac{D_{i,j}\, D_{i-1,j}\, (\delta R_i + \delta R_{i-1})}{D_{i,j}\, \delta R_{i-1} + D_{i-1,j}\, \delta R_i} ,$$

chosen to ensure continuity of current between mesh subvolumes.

If the point (i,j) does not lie on an exterior boundary, Eq. 6 can be rearranged into the form

$$\phi_{i,j} = \frac{(SV)_{i,j} + \sum_{k=1}^{4} C_k^{i,j}\, \phi_k}{\Gamma_{i,j}} , \qquad (7)$$

where

ϕ_k = the flux at one of the four mesh points adjacent to the point (i,j),

$$C_k^{i,j} = \overline{D}A/\ell , \qquad (8)$$

$$\Gamma_{i,j} = (\Sigma^r V)_{i,j} + \sum_{k=1}^{4} C_k . \qquad (9)$$

It should be remembered that an equation of the form of Eq. 7 exists for each group g at every interior mesh point. Thus, there is a system of equations of the form of Eq. 7 that is amenable to iterative solution.

2. Boundary Conditions. Two boundary conditions are available for use in PHENIX, zero flux gradient and flux vanishing. These are shown graphically in Fig. 2.

If we consider the *zero flux gradient* condition and refer to the left boundary of the model shown in Fig. 2, we see that we can place, in principle, an effective mesh interval, e.g., interval 0, outside the left boundary. Since zero flux gradient at the left boundary implies symmetry, the pseudo mesh interval is the mirror image of interval 1.

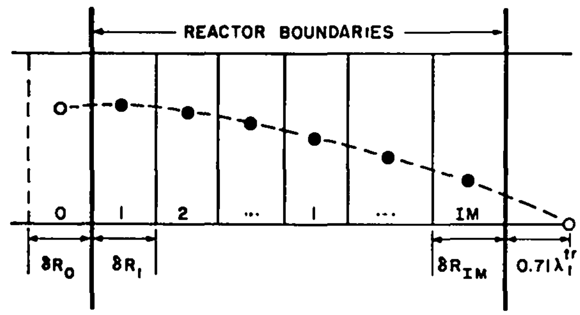

Fig. 2. One-dimensional schematic diagram of reactor boundary conditions.

For difference Eq. 6 applied at the point with i = 1, the first term represents the left leakage from the mesh subvolume on the left boundary. Because of symmetry, however, there is no net leakage and the first term of Eq. 6 must vanish. This is accomplished in the code by setting the coefficient $\overline{D}A/\ell$ equal to zero. (The setting of the flux difference $\phi_{0,j} - \phi_{1,j} = 0$ is not possible in the code because $\phi_{0,j}$ does not exist.) In the simplified form of Eq. 7, therefore, a zero flux gradient boundary condition is treated by setting the appropriate $C_k = 0$.

To consider the basic handling of the *flux vanishing* boundary condition, refer to the right reactor boundary in Fig. 2. Let the right-most mesh subvolume in the reactor be called the (IM,j)th. The flux vanishing condition requires that we effectively place an additional mesh point (IM + 1,j) a distance of 0.71 λ_g^{tr} to the right of the reactor boundary and require that the flux $\phi_{IM+1,j}$ at that point be zero. From the second term of Eq. 6 (with i = IM), the flux difference is merely $-\phi_{IM,j}$, and, further, the distance ℓ between the IMth and (IM+1)st mesh interval is 0.5 δR_{IM} + 0.71 λ_g^{tr}. In the simplified form of Eq. 7, then, the flux vanishing condition is treated by eliminating the zero flux term in the four-term sum of the numerator and by setting the appropriate C_k in the denominator equal to

$$\frac{\overline{D}A}{0.5\ \delta R + 0.71\ \lambda^{tr}} .$$

3. Method of Solution. The group flux distributions and the eigenvalue are computed by the source-iteration technique. This technique consists of the following process: A guess is made of the initial flux distribution for all groups, and an initial fission source distribution, FSD_0, is

calculated. For group 1, the source term $(S_1V)_{i,j}$ is computed for each mesh point, and a set of coupled, inhomogeneous algebraic equations of the form of Eq. 7 is produced. The set of equations is solved iteratively by systematically proceeding through the mesh. Each use of the entire set of equations is called an *inner iteration* (or mesh sweep). Several inner iterations are usually performed until the flux distribution (for group 1) that conforms to the initial source distribution is found. Once this is done, FSD_0 is used to calculate the fission source for group 2, and the group 1 fluxes just calculated are used to calculate the inscatter source for group 2. These two terms are combined to produce the source term $(S_2V)_{i,j}$ for group 2. The group 2 equations are then iteratively solved for the group 2 fluxes that conform to the source distribution. This sequence is repeated through all groups. The determination of all group flux distributions that result from the initial fission source distribution, FSD_0, constitutes an *outer iteration.*

After an outer iteration, a new fission source distribution (FSD) is computed from the new flux distributions. The multiplication ratio, λ, is then obtained as the ratio of the new total fission source rate to the previous total fission source rate where the total fission source rate is merely the volume-weighted sum of the fission source distributions.

Before beginning a new outer iteration, the FSD is effectively multiplied by 1/λ (in the code the fission fractions χ_g are multiplied by 1/λ) in order to maintain the steady-state condition that total reactor neutron production equals total reactor neutron losses.

With the new FSD, a second outer iteration is performed to give a second set of group fluxes and a second value of λ. From these, another FSD is computed and another outer iteration performed. As this procedure continues, the value of λ approaches unity, and the problem is converged when $|1 - \lambda| <$ EPS, where EPS is the eigenvalue convergence criterion, an input parameter. The value of k_{eff} for the reactor is simply the product of the successive λ's.

Several features are incorporated in PHENIX to accelerate the convergence. These are line inversion with successive line overrelaxation, fission source overrelaxation, and group rebalancing.

The iterative technique is improved by the use of line inversion with successive line overrelaxation. In this method, the entire set of equations of the form of Eq. 7 for a row or column are solved simultaneously, yielding the group fluxes a row or a column at a time. The fluxes are then overrelaxed using the extrapolated Liebmann scheme,

$$\phi^{\nu+1} = \phi^{\nu} + \mathrm{ORF} \cdot \left(\phi_{br}^{\nu+1} - \phi^{\nu}\right) , \qquad (10)$$

where

ϕ^{ν} = the group flux calculated in the νth inner iteration,

$\phi_{br}^{\nu+1}$ = the group flux just calculated in the (ν+1) inner iteration before overrelaxation,

ORF = overrelaxation factor,

$\phi^{\nu+1}$ = overrelaxed group flux.

The overrelaxation factor is an input parameter that is somewhat problem dependent. An ORF of 1 produces no overrelaxation, an ORF < 1 constitutes underrelaxation. For most problems, an ORF of 1.5 or 1.6 is best.

The line inversion can be performed by rows (radially), by columns (axially), or by alternating the direction from one mesh sweep to the next. On the basis of experiments with different core geometries and different combinations of boundary conditions, the code will determine the best direction by considering the boundary conditions together with the average axial and radial mesh spacing. Specifically, in R-θ geometry, inversion is done axially; for problems with an even number of reflective boundary conditions, inversion is done in the direction of least average mesh spacing; and for problems with an odd number of reflective boundary conditions, the mesh is swept in alternating directions.

Fission-source overrelaxation is also used to accelerate convergence. The extrapolated Liebmann method is applied to the FSD by comparing the FSD from the outer iteration just completed with the FSD from the previous outer iteration. Specifically,

$$\mathrm{FSD}^{n+1} = \mathrm{FSD}^{n} + \mathrm{ORFF} \cdot \left(\mathrm{FSD}_{br}^{n+1} - \mathrm{FSD}^{n}\right) , \qquad (11)$$

where the notation is similar to that used in Eq. 10. The fission source overrelaxation factor ORFF is computed internally as

$$\text{ORFF} = 1.0 + 0.6 \cdot (\text{ORF} - 1) . \qquad (12)$$

Group rebalancing is also used to improve the convergence rate. In group rebalancing, the flux in each group is normalized by balancing the total reactor loss rate for the group with total reactor source for the group. The latter quantity is merely the sum of $(S_g V)_{i,j}$ over all mesh points. This rebalancing is performed immediately before the series of inner iterations for the group is begun. With group rebalancing, a one-region reactor problem with zero flux gradient boundary conditions would be solved in one outer iteration.

B. Search Options

1. General Operation of the Search Routine. It is possible in PHENIX to adjust material concentration or reactor dimensions to achieve a desired value of k_{eff}. (The desired value of k_{eff} is input as PV, and the code is also instructed to use this value by setting the input quantity, IPVT, to 2.)

Regardless of the parameter being adjusted, the search is conducted by performing a sequence of k_{eff}-type calculations, each for a different value of the desired parameter, to find the value of the desired parameter which makes λ (described in Sec. A.3) equal to unity.

For the initial system, the sequence of outer iterations continues until two successive values of λ differ by less than the parametric eigenvalue convergence criterion EPSA. After the first converged λ is obtained, the initial value of the eigenvalue* (the input quantity EV) is altered by the eigenvalue modifier EVM, an input number. If $\lambda > 1$, the new eigenvalue is equal to EV + EVM; if $\lambda < 1$, the new value is EV - EVM. With a new eigenvalue and hence a new value of the parameter being searched on, a second converged value of λ is computed. Basically, then, after two values of λ (or k_{eff}) are obtained for two different system parameter values, the program attempts to fit a curve through the most recent values of λ to extrapolate or interpolate to a value of unity. Depending on the amount of information available and the magnitude of $|1 - \lambda|$, this curve fit proceeds in different ways. A parabolic curve fit cannot be made until three converged values of λ are available and is not attempted, even then, unless $|1 - \lambda|$ is between input limits XLAL and XLAH. If the parabolic fit is tried and the roots are imaginary, the root closest to the previous EV is used as the new value of EV. Once a bracket is obtained (change of sign of $\lambda - 1$), the fit procedure is not allowed to move out of the range of this bracket. Should the parabolic fit select an eigenvalue outside the bracket region, this value is rejected, and the new value is taken as the average of the two previous values.

Whenever the parabolic fit is not used, a linear fit is incorporated from which the new eigenvalue is

$$EV_{new} = EV_{old} + \text{POD} \cdot \text{EQ} \cdot (1 - \lambda) , \qquad (13)$$

where POD is an input parameter oscillation damper designed to restrict the amount of change in the eigenvalue, and EQ is a measure of the slope of the curve. When $|1 - \lambda| >$ XLAH, $(1 - \lambda)$ in Eq. 13 is replaced by XLAH with the sign of $(1 - \lambda)$ to prevent too large a change in EV. After $|1 - \lambda| <$ XLAL, the value of EQ is fixed and kept constant to prevent numerical difficulty in approximating the derivative when λ is close to unity.

Because parametric search problems involve a series of k_{eff} calculations, it is to the user's advantage to study his particular problem in order to optimize his calculations and to assure himself that a solution is possible. Ideally, the user will have some reasonable estimate of the critical parameter before beginning the search calculation.

2. Material Concentration Search. The general search procedure just described can be applied to the problem of selectively determining material concentrations (atom densities) to produce the desired value of k_{eff}. The concentration search can

*It should be noted that the term *eigenvalue* assumes a different meaning in the search mode than in the ordinary k_{eff} calculation described in Sec. A.3. In the latter calculation, *eigenvalue* simply refers to the product of the λ's, so that the *eigenvalue* approaches k_{eff} as λ approaches unity. In the search calculation, however, *eigenvalue* is a quantity that is used directly to alter the parameter being searched on.

be performed on any of the materials in any or all of the reactor zones. The eigenvalue EV is applied to the input atom density for a particular material in a given zone to yield an adjusted material atom density

$$N^i = N^i_{input} \cdot (1.0 + EV \cdot I4^i) \quad . \tag{14}$$

The superscript i denotes both the material and the reactor zone, and I4 is an input quantity, the search material modifier. The use of material modifiers permits a high degree of flexibility in the search. All materials whose modifiers are zero are unaltered by the search. On the other hand, if a particular region contains, for example, ^{235}U and ^{238}U, the proper enrichment can be determined by giving ^{235}U and ^{238}U modifiers that differ in sign. In this manner, when the ^{235}U concentration is increased, the ^{238}U concentration will be decreased. In a similar manner, control rods with fueled followers can be properly treated in the search.

3. Dimensional Search (Delta Calculation). In applying the search option to the reactor dimensions, the reactor zone boundaries are selectively modified. Because each radial and axial zone is subdivided into its particular radial and axial mesh, the dimension changes are determined by adjusting the mesh widths δr^i and δz^j for the ith radial and jth axial zone by means of the algorithms

$$\delta r^i = \delta r^i_0 (1 + R3^i \cdot EV) \tag{15}$$

and

$$\delta z^j = \delta z^j_0 (1 + Z3^j \cdot EV) \quad . \tag{16}$$

In Eqs. 15 and 16, the subscript 0 refers to the initial (input) widths. $R3^i$ is an input quantity, the mesh modifier for the ith radial zone, while $Z3^j$, also an input quantity, is the mesh modifier for the jth axial zone. If one of the R3 or Z3 values is zero, the associated mesh width is unchanged, whereas if all the mesh modifiers are unity, all reactor dimensions are uniformly expanded or contracted. The proper selection of the mesh modifiers can produce a wide variety of dimensional change combinations. For example, an interface between two zones can be moved while the rest of the system is left unchanged.

C. Burnup Method

Burnup is performed by PHENIX using the point burnup equation applied separately to each burnable isotope in each zone. The point burnup equation can be written

$$\frac{dN_i}{dt} \doteq -\lambda_i N_i - \bar{\sigma}_{a,i} N_i \bar{\phi} + \lambda_k N_k + \sum_j \left(\bar{\sigma}_{c,j} N_j \bar{\phi}\right) + \sum_m \left(\bar{\sigma}_{f,m} N_m \bar{\phi}\right) , \tag{17}$$

where

N_i = atom density of burnable nuclide i,

$\lambda_i \doteq$ decay constant for nuclide i,

$\bar{\sigma}_{a,i}$ = zone- and group-averaged absorption cross section for nuclide i,

$\bar{\sigma}_{f,i}$ = zone- and group-averaged fission cross section for nuclide i,

$\bar{\sigma}_{c,i} \doteq$ zone- and group-averaged capture cross section for nuclide i,

$\bar{\phi}$ = zone-averaged total flux for the zone.

The last two sums in Eq. 17 provide for two capture and seven fission sources of N_i, respectively. The fission sources are necessary if fission product buildup is to be considered.

The burnup time is an input quantity, DELT, and is arbitrarily subdivided into ten smaller substeps. The point burnup equation is then solved iteratively as a marchout problem using the substeps. The zone-averaged fluxes and cross sections used in Eq. 17 are computed before each burnup time. The total reactor power from the burnable isotopes, and the relative flux distributions (both spectral and spatial), are assumed constant throughout the burnup calculation. The iterative marchout algorithm is best seen if Eq. 17 is rewritten in the form

$$\frac{d\vec{N}}{dt} \doteq \vec{G}(\vec{N},t) \quad . \tag{18}$$

The basic marchout difference equation is then

$$\vec{N}(t_j) = \vec{N}(t_{j-1}) + \frac{\delta t}{2}\left(\vec{G}_{j-1} + \vec{G}_j\right) \quad , \tag{19}$$

where j is the index on time (j = 1, 2, ..., 10), and δt is the length of the substep. Equation 19 is transcendental in that $\vec{N}(t_j)$ must be known in order for $\vec{G}_j$ to be known. The code, therefore, iterates on the $\vec{N}$ at each substep, using the iteration algorithm,

$$\vec{N}^{\nu}(t_j) = \vec{N}(t_{j-1}) + \frac{\delta t}{2}\left(\vec{G}_{j-1} + \vec{G}_j^{\nu-1}\right), \qquad (20)$$

where ν is the iteration index. Because the length of the substep is usually short, only a few iterations are necessary. Rather than complicate the marchout procedure with convergence tests on the $\vec{N}^{\nu}(t_j)$, therefore, the code automatically performs five iterations at each substep. Because of this, together with the assumption that relative flux profiles are unchanged during burnup, relatively short substeps should be employed if rapid burnup is expected or if large spatial or spectral flux shifts are anticipated.

D. The Refueling Option

1. The Refueling Method. Since the burnup analysis of large fast reactors is frequently performed in conjunction with fuel-cycle analyses (especially for fast breeder reactors), a flexible and comprehensive refueling option has been included in PHENIX. For total reactor refueling following a specified length of burnup, the refueling problem is simple. For mixed-batch fractional refueling, however, the problem is considerably more difficult. For example, if one-fourth of the core fuel is to be discharged and replaced with clean fuel at the end of each burnup interval (the total time a reactor is operated between refuelings), it is necessary to distinguish this fuel fraction from that which remains in the reactor. In this type of refueling scheme, the core fuel at the end of a burnup interval consists of four distinct constituents: fuel that has resided in the reactor for four successive burnup intervals and is ready to be discharged, fuel that has burned for three burnup intervals, fuel that has burned for two burnup intervals, and fuel that has been burned for one interval. (In this example, we assume that the reactor has been operated for a time equal to at least four burnup intervals.)

Since PHENIX deals with homogenized atom densities, the analysis could, of course, be done by explicitly tagging the elements (or isotopes) of each constituent. For example, for the fractional refueling described above, the core could be assigned four separate ^{239}Pu constituents, each characterized by an atom density and each corresponding to one of the resident constituents of the core. The sum of these constituent atom densities would be the total ^{239}Pu atom density in the core. Note that, although this method is conceptually straightforward, it poses a severe bookkeeping problem. The code will treat each tagged constituent isotope or element separately and will require both a cross-section table and an atom density specification for each. This considerably increases the required input data and storage requirements for the code.

An alternative to the explicit tagging method that eliminates this bookkeeping problem has been employed in PHENIX. The method used in PHENIX requires that all fuel discharged from a given zone begin its life as clean fuel with the same relative isotopic content, i.e., the isotopic content of the fuel charge is invariant from one burnup interval to the next for a given zone.

The method of calculation is best described by an example. Suppose that the i burnup interval has just been completed and that the discharge from a given region is to be computed. Let the refueling fraction for this region be 1/4 and assume that $i \geq 4$. Thus, the fuel to be discharged consists of the constituent fuel that has been burned over the four burnup intervals (i - 3) through i. Using the clean fuel charge atom densities for the region, the basic burnup equation, Eq. 17, is applied using the zone-averaged total flux and zone- and group-averaged cross sections for the region during the (i-3) burnup interval. The resulting atom densities are then used as input to burnup over the (i-2) burnup interval using the average flux and cross sections for that burnup interval. This procedure is continued through the i burnup interval. The atom densities determined in this manner are those that resulted from the successive burnup of clean fuel over the last four burnup intervals. Because the charge for the (i-3) burnup interval was only one-fourth of the clean fuel atom density, the discharge atom densities are merely one-fourth of the atom densities obtained by successive burnup.

With the discharge thus determined for the i burnup interval, the homogenized initial atom densities for the (i+1) burnup interval can be directly computed. This is possible since the burnup portion of PHENIX has calculated the homogenized atom densities, N_i, at the end of the i burnup interval, as well as the discharge, D_i, following the i burnup interval, and the charge, C_0, for all burnup intervals is known. The homogenized input atom density for the (i+1) burnup interval, N^0_{i+1}, for the particular zone and isotope is then

$$N^0_{i+1} = N_i - D_i + C_0 \; . \qquad (21)$$

Note that the successive burnup calculations account for both the spectral and spatial flux shifts from one burnup interval to the next.

2. Specific Features of the Refueling Option. The refueling option is designed for use in the detailed analysis of a reactor over its operational lifetime, with refueling occurring periodically. Accordingly, the analysis must begin with the initial burnup interval and proceed through successive burnup intervals in order. Information such as zone-averaged total fluxes and zone- and group-averaged cross sections from previous burnup intervals must be supplied as input for the refueling subroutines. Either a card or a tape dump can be used for input. Because of the cumulative requirements for data as the burnup analysis progresses, it is recommended that magnetic tape be used for data storage for the refueling.

Refueling can be performed using any refueling fraction and with any frequency, with each zone being treated independently. For example, zone 1 can have two-thirds of its fuel replaced every third refueling, while zone 2 can have one-half of its fuel replaced at each refueling.

After the detailed refueling (zone by zone) has been computed, any combination of zones can be collapsed one or more times, if desired, to provide mass summary subtotals for the burnable isotopes. This is useful, for example, for collapsing a many-region fast breeder reactor into the three basic regions of core, radial blanket, and axial blanket. A further option provides for the charge-discharge masses for the first NECOP (see Input Instructions) collapses to be punched on cards. These punched data can be used as input for economic analysis, if desired.

III. USERS' INFORMATION

A. Input Instructions

This section describes the input format and deck setup for PHENIX. Several of the data blocks (RO, ZO, MO, K7, IO, I1, I2, R2, R3, Z2, Z3, and I4) are read by the two generalized input subroutines, REARL (for floating point data), or REAFXP (for fixed point data). These routines streamline the input block and allow for the ganging of input in the case of repeated identical entries. When REARL and REAFXP are used, all cards contain six data fields of 12 columns each. The last nine columns of each field contain the data associated with the particular field; columns 2-3 contain an integer N from 0 to 99. The first column of each field must contain

- 0 or blank - no effect ($N \nearrow 0$),
- 1 - repeat associated entry N times,
- 2 - do N linear interpolations between associated data entry and succeeding data entry,
- 3 - terminate reading of this array with previous data entry.

The data blocks mentioned above (except K7) contain information concerning the materials and geometric composition of the reactor and can be conveniently calculated and punched by a data preparation code[4] such as DPC. This sequence of data blocks is also compatible as input to the transport theory codes DTF-IV and 2DF which were developed at LASL.

An additional subroutine, TRIG, is used in PHENIX to read trigger data for burnup and refueling problems. This routine uses a dense format, 24I3 per card, which is useful in condensing the size of the input deck for a large number of mixture specifications.

The input blocks required when the refueling option is used are all read by the subroutine INPR. This isolation of the refueling input streamlines the flow of the code and helps to conserve storage requirements. The input card format is given in Table I.

TABLE I

INPUT CARD FORMAT FOR PHENIX

Variable	Columns	Description
Card 1 (12A6 format)		To run a series of problems, repeat data input starting with this card.
ID(12)	1-72	Identification Card 1
Card 2 (11A6, F6.1 format)		
ID(11)	1-66	Identification Card 2
TMAX	67-72	Maximum running time in minutes; this allows a final dump to be obtained if convergence is forced; if zero, not used.
Card 3 (12I6 format)		
IGE	1-6	Geometry specification = 0, X-Y = 1, R-Z = 2, R-θ
IZM	7-12	Number of material zones
IBL	13-18	Left boundary condition = 0, vacuum = 1, reflective
IBR	19-24	Right boundary condition (same conditions as for IBL)
IBT	25-30	Top boundary condition (same conditions as for IBL)
IBB	31-36	Bottom boundary condition (same conditions as for IBL)
IEVT	37-42	Eigenvalue type = 1, k_{eff} = 2, concentration search = 3, dimensional (delta) search
IPVT	43-48	Parametric value type = 1, none = 2, k_{eff}
IM	49-54	Number of radial mesh intervals ($\geq$3)
JM	55-60	Number of axial mesh intervals ($\geq$3)
IZ	61-66	Number of radial zones (delta option only)
JZ	67-72	Number of axial zones (delta option only)
Card 4 (12I6 format)		
IGM	1-6	Number of energy groups ($\leq$50)
ML	7-12	Number of input materials
ICST	13-18	Cross-section type. For a detailed discussion of these types, see Cards 10 and 11. = 1, Type 1 = 2, Type 2
IHT	19-24	Position of sigma total in cross-section table
IHS	25-30	Position of sigma self-scatter in cross-section table
ITL	31-36	Cross-section table length
IXSEC	37-42	Read cross sections = 0, from cards = 1, from tape
MO1	43-48	Total number of mixture specifications (see cards 17-19)
OITM	49-54	Maximum number of outer iterations allowed
IITM	55-60	Maximum number of inner iterations per group per outer iteration. Recommended value is 5.

TABLE I (continued)

Variable	Columns	Description
Card 4 (12I6 format) continued		
MSHSWP	61-66	Direction of line inversion in solution for the group fluxes = 1, alternating direction = 2, radial = 3, axial = 4, code decides
ISTART	67-72	Initial flux guess = 0, none (code assumes a flat flux in all groups) = 1, $\phi(r)*\phi(z)$ from cards (same for all groups) = 2, $\phi(r,z,E)$ from cards = 3, $\phi(r,z,E)$ from tape = 4, $\phi(r)*\phi(z)$, sinusoids (calculated by code, same for all groups)
Card 5 (8I6 format)		
IREF	1-6	Burnup-refuel control parameter = 0, no burnup = 1, burnup only = 2, burnup and refuel
NBSTP	7-12	Number of burnup time steps in a burnup interval
IFS	13-18	Perform a concentration search after the final burnup time step = 0, no = 1, yes
NPOIS	19-24	Material number of control poison
MWDT	25-30	Calculate burnup in MWd/T = 0, no = 1, yes (used only in burnup calculations) Must be set = 1 then.
IPFLX	31-36	Control for punching flux dump = 0, no punching = 1, punch fluxes before burnup = 2, punch fluxes after burnup
IPRIN	37-42	Print control = 1, full print always = 2, full print for DAY = 0 only = 3, partial print always (In a partial print, the cross sections, group fluxes, and fission source rate are omitted.)
IDMTPS	43-48	Prepare data dump tape = 0, no = 1, yes
Card 6 (6E12.4 format)		
EPS	1-12	Eigenvalue convergence criterion, i.e., criterion applied to the total fission source rate. Typical value is 10^{-5} to 10^{-6} for straight k_{eff} calculations and 10^{-4} for search calculations.
SRCRT	13-24	Neutron source rate for normalization (not used if POWR is used)
POWR	25-36	Reactor power in MWT for normalization (must be set to zero if SRCRT is used)
ORF	37-48	Overrelaxation factor used in inner iteration flux calculation. The optimum value of this parameter is somewhat problem dependent, but a value of 1.4 to 1.6 is satisfactory for most cases.
FLXTST	49-60	Inner iteration flux test = EP, check convergence of all fluxes using the criterion EP = 0., code uses EPS as convergence criterion for all fluxes
PV	61-72	Desired parametric value (used only for search problems, i.e., IPVT = 2)

TABLE I (continued)

Variable	Columns	Description
Card 7 (6E12.4 format)		
EPSA	1-12	Parametric value convergence criterion (used only in search calculations). Recommended value is ≈10 EPS.
EV	13-24	Initial eigenvalue guess (used only in search calculations)
EVM	25-36	Initial eigenvalue modifier (search only). This value should decrease reactivity; i.e., EV + EVM should produce a lower reactivity than EV. This parameter is extremely problem dependent.
EV2	37-48	Eigenvalue guess for second and succeeding searches
XLAL	49-60	Lower limit on $\|\lambda - 1\|$. Recommended value is ≈0.001 (search only).
XLAH	61-72	Upper limit on $\|\lambda - 1\|$. Recommended value is ≈0.5 (search only).
Card 8 (E12.4 format)		
POD	1-12	Parameter oscillation damper. Ratio of the computed eigenvalue change to the predicted eigenvalue change. It can be used to accelerate convergence or damp out oscillations. The appropriate value is problem dependent but should be near 1.0. (A POD of exactly 1.0 produces no damping.)
Card 9 (A6, 2E6.2 format) (used only if IXSEC ≠ 0)		
HOLN(ML)	1-6	Identification (name) of first material
ATW(ML)	7-12	Atomic weight of first material
ALAM(ML)	13-18	Decay constant for first material in days^{-1}. Used only in burnup calculations.
Card 10 (6E12.5 format) (used only if IXSEC ≠ 0) (Begins cross-section data for first group for first material.)		
C(1,IGM,ML)	1-12	σ_c
C(2,IGM,ML)	13-24	σ_f
C(3,IGM,ML)	25-36	$\sigma_{s_{total}}$
C(4,IGM,ML)	37-48	σ_a
C(5,IGM,ML)	49-60	$\nu\sigma_f$
C(6,IGM,ML)	61-72	σ_{tr} ($\approx \sigma_{total}$)
Card 11 (6E12.5 format)		
C(7,IGM,ML)	1-12	$\sigma_s(g \rightarrow g)$, self-scatter
C(8,IGM,ML)	13-24	$\sigma_s(g - 1 \rightarrow g)$
C(9,IGM,ML)	25-36	$\sigma_s(g - 2 \rightarrow g)$

Continue for the remaining downscatter terms, and then repeat for the remaining groups for material 1. Then repeat Cards 9 through 11 for all groups in all remaining materials.

The format given above is for the Type 2 cross sections (ICST = 2), which is the punched output format for the MC^2 code.[5] In this format, the data for each material are punched continuously, i.e., no new card is started for each group. Also, σ_c and $\sigma_{s_{total}}$ are not used, and these positions in the table length (1 and 3) are deleted by the code.

In the Type 1 cross section format, σ_c and $\sigma_{s_{total}}$ do not appear, and all other cross sections are appropriately adjusted in the table length. In addition, the data for each new energy group must begin on a new card.

TABLE I (continued)

For both cross-section types, the code checks the input data to ensure that $\sigma_{tr} = \sigma_a + \sum_{g'} \sigma(g \rightarrow g')$ within a certain error criterion.

If IXSEC = 1, all data on Cards 9 through 11 will be on tape, and these cards will be omitted. Note that, if the cross-section data are on tape, the order in which the materials are read and numbered must be consistent with the material numbering in the I1 block (see Card 18).

Variable	Columns	Description
Card 12a (6E12.6 format) (used only if ISTART = 1)		
RF(IM)	1-12	Initial flux guess for first radial interval
RF(IM)	13-24	Initial flux guess for second radial interval
Continue for all radial intervals. This flux profile is used for all energy groups.		
Card 12b (6E12.6 format) (used only if ISTART = 1)		
ZF(JM)	1-12	Initial flux guess for first axial interval
ZF(JM)	13-24	Initial flux guess for second axial interval
Continue for all axial intervals. This flux profile is used for all energy groups.		
Card 12c (6E12.6 format) (used only if ISTART = 2)		
NO(IMJM)	1-12	Initial flux guess for first mesh point in first group
NO(IMJM)	13-24	Initial flux guess for second mesh point in first group
Continue for all mesh points and all energy groups.		
Card 13 [6(I1,I2,E9) format]		
RO(IM+1)	1-12	Radial position of first mesh boundary (0.0)
RO(IM+1)	13-24	Radial position of second mesh boundary (cm)
Continue for IM+1 radial boundary positions.		
Card 14 [6(I1,I2,E9) format]		
ZO(JM+1)	1-12	Axial position of first mesh boundary (0.0)
ZO(JM+1)	13-24	Axial position of second mesh boundary (cm)
Continue for JM+1 axial boundary positions. For an R-θ calculation, the θ increments should be in fractions of 360°, e.g., 180° = 0.5.		
Card 15 [6(I1,I2,I9) format]		
MO(IMJM)	1-12	Zone (mix) number for first mesh interval
MO(IMJM)	13-24	Zone (mix) number for second mesh interval
Continue for all mesh intervals. The mesh intervals are numbered beginning at the lower left and then proceeding through each row in order.		
Card 16 [6(I1,I2,E9) format]		
K7(IGM)	1-12	Fission fraction (spectrum) for first energy group
K7(IGM)	13-24	Fission fraction for second energy group
Continue for all energy groups.		
Card 17 [6(I1,I2,I9) format]		
IO(MO1)	1-12	Material number assigned to Zone (mix) 1
Repeat same entry for a total of N + 1 times where N is the number of materials in Mix 1. Then repeat the same procedure for all remaining zones (mixes).		

TABLE I (continued)

Variable	Columns	Description
Card 18 [6(I1,I2,I9) format]		
I1(MO1)	1-12	= 0 (to trigger storage area for Mix 1)
I1(MO1)	13-24	Number of first material in Mix 1
I1(MO1)	25-36	Number of second material in Mix 1

Continue for all materials in Mix 1. Then repeat the same procedure for all remaining mixes.

Card 19 [6(I1,I2,E9) format]		
I2(MO1)	1-12	= 0
I2(MO1)	13-24	Concentration of first material in Mix 1 (atoms/b-cm)
I2(MO1)	25-36	Concentration of second material in Mix 1

Continue for all materials in Mix 1. Then repeat the same procedure for all remaining mixes. Note that the length of the I0, I1, and I2 blocks is the same (= MO1).

Card 20 [6(I1,I2,I9) format] (used only if IEVT = 3)		
R2(IM)	1-12	Dimensional search zone number for first radial interval
R2(IM)	13-24	Dimensional search zone number for second radial interval

Continue for all radial mesh intervals.

Card 21 [6(I1,I2,E9) format] (used only if IEVT = 3)		
R3(IZ)	1-12	Dimensional modifier for first radial zone
R3(IZ)	13-24	Dimensional modifier for second radial zone

Continue for all radial zones.

Card 22 [6(I1,I2,I9) format] (used only if IEVT = 3)		
Z2(JM)	1-12	Dimensional search zone number for first axial interval
Z2(JM)	13-24	Dimensional search zone number for second axial interval

Continue for all axial mesh intervals.

Card 23 [6(I1,I2,E9) format] (used only if IEVT = 3)		
Z3(JZ)	1-12	Dimensional modifier for first axial zone
Z3(JZ)	13-24	Dimensional modifier for second axial zone

Continue for all axial zones.

Card 24 [6(I1,I2,E9) format] (used only if IEVT = 2)		
I4(MO1)	1-12	Search material modifier for first position in the MO1 block
I4(MO1)	13-24	Search material modifier for second position in the MO1 block

Continue for all positions in the MO1 block.

Card 25 (24I3 format) (used only if MWDT = 1)		
NTRIG(MO1)	1-3	Trigger for total fuel mass calculation for first position in MO1 block = 0, not a fuel isotope = 1, a fuel isotope
NTRIG(MO1)	4-6	Same conditions as above for the second position in MO1 block

Continue for all positions in the MO1 block.

TABLE I (continued)

Variable	Columns	Description
Card 26 (I6,E12.0 format) (burnup control card)		
NCON	1-6	Burnup control = 0, end of problem, read input data for next case = N, read burnup parameters for N isotopes and take time step of DELT < 0, take time step of DELT
DELT	7-18	Length of time step in days

Card 27 (12I6 format) (used only if NCON > 0). This card contains all burnup parameters for the first burnable isotope.

Variable	Columns	Description
MATN(NCON)	1-6	Material sequence number (I1 number) of first burnable isotope
NBR(NCON)	7-12	Control for breeding ratio calculation = 0, no effect = 1, fertile isotope = 2, fissile isotope
LD(NCON)	13-18	= 0, no decay source = N, decay source from burnable isotope N
LCN(NCON,2)	19-24	= 0, no capture source = N, capture source from burnable isotope N
LCN(NCON,2)	25-30	= 0, no capture source = N, capture source from burnable isotope N
LFN(NCON,7)	31-36	= 0, no fission source = N, fission source from burnable isotope N
LFN(NCON,7)	37-42	= 0, no fission source = N, fission source from burnable isotope N

Continue for other five possible fission sources. Repeat Card 27 for all burnable isotopes. Then repeat Card 26 for additional time steps. For these additional time steps, NCON should be <0. After all time steps have been calculated, a final Card 26 should be used with NCON < 0 and DELT = 0. This allows the final values of the zone-averaged total fluxes and cross sections and the final breeding ratio to be calculated and printed before the problem is ended.

Note: This section begins the input for the refueling option of the code. All succeeding data (except for the final Card 37) should be input only if IREF = 2.

Card 28 (6I6 format)

Variable	Columns	Description
KNT	1-6	The burnup interval just completed in the fuel-cycle history
NREG	7-12	The maximum number of regions requiring refueling during the burnup history
NREPO	13-18	Refuel control rods during refueling = 0, no = 1, yes
KLAPS	19-24	Region collapse option = 0, no collapse = N, number of collapses to be performed
INTMAX	25-30	Maximum number of burnup intervals to be analyzed in the total fuel-cycle history
NECOP	31-36	Punch option for input to economics code = 0, no punched output = N, data from the first N collapses will be punched

TABLE I (continued)

Variable	Columns	Description
Card 29 (I6,F12.5,I6 format)		
K(NREG)	1-6	Zone number of first region to be refueled
XO(NREG)	7-18	Fraction of fuel in Zone K which is to be replaced
NFRE(NREG)	19-24	Number of burnup intervals between refueling for Zone K, i.e., the refueling frequency

Repeat Card 29 for NREG zones that are to be refueled.

Variable	Columns	Description
Card 30 (24I3 format)		
TRG(NCON)	1-3	Trigger to refuel first burnable isotope = 0, no = 1, yes
TRG(NCON)	3-6	Same conditions for second burnable isotope

Continue for all burnable isotopes.

Variable	Columns	Description
Card 31 (6F12.7 format) [omit if using tape dump (IDMTPS = 1) and KNT > 1]		
HNO(MO1)	1-12	Clean atom density (no burnup) of material in the first position of the MO1 block
HNO(MO1)	13-24	Same conditions for material in the second position of the MO1 block

Continue for all positions in the MO1 block. (Note: The HNO block is identical to the I2 block at the reactor beginning-of-life.)

Variable	Columns	Description
Card 32 (6E12.5 format) [omit if using tape dump (IDMTPS = 1)]		
PHI(IZM,KLNT)	1-12	Zone-averaged total flux used to burn the constituent material in REFUEL for the first zone in the first burnup interval
PHI(IZM,KLNT)	13-24	Same conditions for second zone in the first burnup interval

Continue for all zones in the first burnup interval. Then repeat Card 32 for all burnup intervals up to KLNT.

Variable	Columns	Description
Card 33 (6E12.5 format) [omit if using tape dump (IDMTPS = 1)]		
ABXS(NCON,IZM,KLNT)	1-12	Zone-group-averaged absorption cross section used to burn the constituent material in REFUEL for the first burnable isotope in the first zone in the first burnup interval
ABXS(NCON,IZM,KLNT)	13-24	Same conditions for second burnable isotope in the first zone in the first burnup interval

Continue for all burnable isotopes in the first zone. Then repeat Card 33 for all zones in the first burnup interval. Then repeat this entire sequence for all burnup intervals up to KLNT.

Variable	Columns	Description
Card 34 (6E12.5 format) [omit if using tape dump (IDMTPS = 1)]		
FIXS(NCON,IZM,KLNT)	1-12	Zone-group-averaged fission cross section used to burn the constituent material in REFUEL for the first burnable isotope in the first zone in the first burnup interval

Continue same format as with the ABXS values (Card 33).

Variable	Columns	Description
Card 35 (I6 format) (omit if KLAPS = 0)		
KZNS(KLAPS)	1-6	The number of regions involved in the first collapse
Card 36 (24I3 format) (omit if KLAPS = 0)		
IZON(KLAPS,KZNS(1))	1-3	Region number of the first region in the first collapse
IZON(KLAPS,KZNS(1))	3-6	Region number of the second region in the first collapse

Continue for KZNS(1) regions in the first collapse. Then repeat Cards 35 and 36 for KLAPS collapses.

Variable	Columns	Description
Card 37 (A6 format)		
6H FINISH	1-6	Card to terminate the entire run. This is the final data card for all problems and is used only once, even if a series of problems are run.

B. Output Information

In this section, a brief description of the complete PHENIX printed output is given. The only portions of this output list which are not always given are the cross sections, group fluxes, and fission-source rate, which may be deleted by use of the IPRIN control word. All output arrays are clearly defined by headings that designate the particular quantity or variable. For a description of quantities that can be output on cards or tape, refer to the Input Instructions (Sec. A).

1. Problem Identification and Input Control Words: The information on Cards 1-8, along with a description of each parameter, is listed in tabular form.

2. Variable Storage Requirements: The amount of storage required to store the data arrays in the A Common Block is printed as the variable LAST. This is followed by the amount of temporary storage required to rearrange the microscopic cross sections and write this disk file. If either of these values exceeds the maximum allowable storage (presently $30{,}000_{10}$ words), the problem will abort.

3. Input Materials: The input materials (total of ML) are listed by number and name.

4. Microscopic Cross-Section Check: All microscopic cross sections (see Input Instructions) are checked for consistency by the code, and those found to be in error by >1.0% or >0.01% are flagged, and the corresponding material and group numbers are printed.

5. Flux Guess: If fluxes of the form $\phi = \phi(r) * \phi(z)$ are input using cards or the subroutine SINUS (ISTART = 1 or 4), the respective radial and axial profiles are printed. When the sinusoidal guess is used, the flux profiles are printed after the radial and axial mesh blocks, since these r and z values are needed to generate the sinusoid. When fluxes of the form $\phi(r,z,E)$ are input (ISTART = 2 or 3), these values are not printed in order to conserve space.

6. Mesh Boundaries: The RO and ZO mesh boundary blocks are printed directly from the input.

7. Zone Numbers by Mesh Point: The MO block (zone numbers by mesh point) is printed directly from the input.

8. Material Numbers by Zone (Mix Number): These values (M2 block) are calculated by assigning zone 1 material number ML + 1, zone 2 material number ML + 2, etc., and are used as indices for the macroscopic cross sections for each zone. The total cross-section array for any group (microscopic + macroscopic) then has dimensions (ITL,MT) where MT = ML + IZM.

9. Fission Spectrum: The K7 block (fission fractions) are printed directly from the input.

10. Mixture Specifications: The IO/I1/I2 blocks (mix number/material number for mix/material atom density) are printed directly from the input.

11. Picture Plot of Reactor: The subroutine MAPR prints a picture plot of the reactor, mesh point by mesh point. This plot appears twice, the first time by zone number (MO number), and the second time by material number (M2 number). After the second plot, the direction of line inversion to be used in the solution of the flux equations is printed. This is particularly useful if the code has selected this option, since the picture of the reactor is available on the same page.

12. Mixture Specifications: The IO/I1/I2 blocks are printed in tabular form, along with the NTRIG block (trigger for MWd/T calculation if MWDT = 1). The time (in days) for the burnup interval is printed at the beginning of this output block, and this value is incremented by the time step DELT as the specified burnup steps are performed. This output of the mixture specifications is particularly useful for times other than zero, since the change in atom density of the burnable isotopes from their previous values can be observed.

13. Cross-Section Edit: A complete listing by group of both the microscopic and macroscopic cross sections is given. The first ML materials are the microscopic values, while the remaining IZM are the macroscopic. In the printing of the table length, position 1 is σ_f; 2 is σ_a; 3 is $\nu\sigma_f$; 4 is $\sigma_{tr}(= \sigma_{total})$; 5 is $\sigma(g \rightarrow g)$, self-scatter; and 6 and all succeeding positions contain the inscatter cross sections, e.g., $\sigma(g - 1 \rightarrow g)$, $\sigma(g - 2 \rightarrow g)$, etc. The entire cross-section edit may be omitted, depending on the value of IPRIN (see Card 5 in the Input Instructions).

14. Eigenvalue Print: After each outer iteration, the running time, outer iteration number, inner iteration total for that outer iteration, eigenvalue slope, eigenvalue, and λ are printed. The eigenvalue slope has meaning only in a search calculation and will be printed as zero in a regular k_{eff} calculation (IEVT = 1).

15. Searched Atom Densities: In a concentration search (IEVT = 2), the atom densities that have been changed to produce the desired parametric eigenvalue are printed by zone and material number.

16. Final Neutron Balance Table: The final values of fission rate, inscatter and outscatter, absorption, and leakage are printed for each group, along with the sum over all groups. For the sum over groups, inscatter should equal outscatter, and absorption plus total leakage should equal fission source.

17. Mesh Coordinates and Spacing: The mesh boundaries (RO and ZO blocks) are printed along with the actual coordinates of the mesh points (R4 and Z4 blocks). Note that R4(I) = [RO(I + 1) + RO(I)]/2, same for Z4. This output block is printed only the first time through the code, i.e., for DAY = 0.

18. Group Fluxes. The final normalized group fluxes are printed for each mesh point with the entire axial profile appearing in column form for each radial mesh point. The vertical mesh coordinates (Z4 block) are also included at the right-hand side of the page after every fifth radial flux value. The entire group flux output may be omitted, depending on the value of IPRIN (see Card 5 in the Input Instructions).

19. Total Flux: The sum of the group fluxes at each mesh point is printed in the same format used for the group fluxes. This output block is printed after each criticality calculation.

20. Power Density: The normalized power density (MWt/ℓ) at each mesh point is printed, again using the group-flux format. These values are calculated by summing the product, $\phi * \Sigma_f$, at each mesh point over all groups. This output block is printed after each criticality calculation.

21. Power Fraction: The fraction of the total power produced by each zone is listed. This calculation is performed only if the normalization is made on thermal power rather than neutron source rate.

22. Fuel Burnup: In burnup calculations, the fuel burnup for each zone in MWd/T, along with the total zone fuel mass, is printed following each burnup step. The calculation is performed using the fuel mass at the beginning of the burnup step along with a linearly averaged power fraction.

23. Fission Source Rate: The normalized fission neutron source rate (n/cm^3-sec) at each mesh point is printed, again using the group-flux format. These values are calculated by summing the product, $\phi * \nu\Sigma_f$, at each mesh point over all groups. This output block may be omitted, depending on the value of IPRIN (see Card 5 in the Input Instructions).

24. Material Inventory: For each zone, the volume and mass of each material in the zone (in kg) are printed. This output block is printed after each criticality calculation.

25. Burnup Parameters: For burnup calculations, the names and material numbers of each of the burnable isotopes are printed, along with all the information contained on Card 27 in the Input Instructions.

26. Burnup Edit: For each region in the reactor, the zone-averaged total flux and zone volume are printed, along with the following quantities for each burnable isotope: atom density, total fission and absorption rates, and the zone-spectrum-averaged fission and absorption microscopic cross sections used in the actual burnup. At the end of the burnup edit, the contribution to the breeding ratio from each zone is given along with the total breeding ratio for the reactor. In this code, breeding ratio is an instantaneous quantity and is defined as the sum over all fertile isotopes of absorption minus fission divided by the sum over all fissile isotopes of absorption. Both sums are, of course, taken over the entire reactor.

NOTE: ALL SUBSEQUENT OUTPUT BLOCKS ARE OBTAINED ONLY IF THE REFUELING OPTION OF THE CODE IS USED (IREF = 2).

27. Zone-Averaged Total Fluxes: For each zone, the zone-averaged total flux from the previous burnup interval to be used in the flux shift correction for calculating discharge is printed. These values are based on a linear average of the fluxes at the beginning and end of the burnup steps in the previous burnup interval.

28. REFUEL Input Control Words: The control parameters for REFUEL (see Card 28 in the Input Instructions) are printed in tabular form along with the length of the previous burnup interval. The amount of storage for REFUEL required for the various data arrays in the A Common Block is also printed as LAST (not to exceed $30{,}000_{10}$ as mentioned previously). In the A Common Block for REFUEL, all quantities contained previously in A which are not needed in REFUEL are destroyed, and the storage space is used for the new variables that are introduced in REFUEL (see statement INP 53 in Appendix B).

29. Clean Fuel Atom Densities: The clean atom density (beginning of burnup life) for each position in the MO1 block is printed, along with the corresponding IO and I1 numbers.

30. Refueling Fractions and Frequencies: For each region to be refueled after the particular burnup interval, the refueling fraction and frequency are printed. A list of the burnable isotopes to be refueled in these regions is also given.

31. Microscopic Absorption Cross Sections: For each burnable isotope in each reactor zone, the zone- and group-averaged microscopic absorption cross section used to burn materials in REFUEL is printed for the two previous burnup intervals, i.e., for KLNT and KNT burnup intervals.

32. Microscopic Fission Cross Sections: Same as output block number 31, except absorption is replaced by fission.

33. Zone-Averaged Total Fluxes: For each zone, the zone-averaged total fluxes from previous burnup intervals (up to a maximum of 8) used in burning materials in REFUEL are printed. The final column of fluxes (for burnup interval KNT) is identical to that given in output block number 27.

34. Burnable Isotopes in Each Zone: All burnable isotopes in all regions are listed according to their positions in the MO1 block.

35. Zone Summary of Charge and Discharge: For each zone and for all materials in that zone, the following quantities are printed.

a. Discharge atom density and mass (in kg) from burnup interval KNT,

b. Charge atom density and mass (in kg) for burnup interval INT(= KNT + 1),

c. Initial composition (atom density and mass) for burnup interval INT.

36. Refueled Atom Densities: The input atom densities, after refueling, for the next burnup interval INT are printed in order of their appearance in the MO1 block. These are the same atom densities (given in a different format) as those listed in Part c of the previous output block.

37. Region Collapse Data: For each of the region collapses performed (total of KLAPS), the regions involved in the given collapse are listed along with the total volume of these regions. Then, for each burnable isotope, the following collapsed masses (in kg) are printed.

a. Composition at end of burnup interval KNT,

b. Discharge from burnup interval KNT,

c. Charge for burnup interval INT,

d. Composition for beginning of burnup interval INT.

38. Total Reactor Summary: For each material in the reactor (total of ML), the following masses (in kg) are printed.

a. Total reactor discharge from burnup interval KNT,

b. Total reactor charge for burnup interval INT,

c. Total mass in reactor at beginning of burnup interval INT.

C. Data Storage Requirements

The variable dimensioned arrays used in the code require LMX storage locations where

LMX = MAX(L1,L2,L3),

and

L1 = storage required for criticality and burnup (if desired) calculations,

L2 = temporary storage required for cross-section rearrangement,

L3 = storage required if the refueling option of the code is used.

Storage locations L1 and L2 are required for all problems, whereas L3 is needed only for refueling. If any of these three parameters exceeds the $30{,}000_{10}$ word maximum, the problem will abort. In terms of input quantities, the three storage parameters are defined as follows.

L1 = 5 + ITL*MT + 2*IGM + 4*MO1 + 5*JM + 7*IM
+ 7*IZM + 10*IMJM + 15*ML + 6*IZM*ML
+ 2*MAX(IM,JM)

if delta search calculation,

+ (IM + JM + IZ + JZ)

if concentration search calculation,

+ (MO1)

if burnup (MWd/T) calculation,

+ (MO1 + 3*IZM).

L2 = 3*ML + ITL*MT*(IGM + 1).

L3 = NREG + KLAPS + IMJM + ITL*MT + 5*MO1 + 16*ML

+ NCON*(1 + 2*NECOP) + IZM*[5 + INTMAX

+ KLAPS * 2*ML + NCON*(4 + 2*INTMAX)].

For nearly all practical problems, L1 is greater than both L2 and L3. L2 may be unusually large if a fine energy group structure with a large table length is used.

Note that the $30{,}000_{10}$ word maximum mentioned above can easily be raised or lowered by changing that number on the following cards of the source deck:

1. MAIN 421
2. INP 33
3. " 35
4. " 93
5. " 412

(see Appendix B).

D. Representative Running Times on the CDC-6600 Computer

PHENIX running times for k_{eff} calculations for various fast reactor compositions are shown in Table II. The running times listed are actual execution times and do not include system-dependent

TABLE II

RUNNING TIMES FOR k_{eff} CALCULATIONS

Geometry	No. of Reflective Boundary Conditions	No. of Groups	No. of Mesh Points	Execution Time (min)
R-Z	1	2	306	0.10
R-Z	1	8	1462	1.42
R-Z	1	16	1462	3.10
R-Z	2	8	900	0.64
R-Z	2	8	1224	1.33
X-Y	0	8	1064	0.57
R-θ	3	8	600	0.58

operation times, such as compiling time. All problems listed in Table II used the sinusoidal flux guess (ISTART = 4) and an eigenvalue convergence criterion, EPS, of 10^{-5}.

REFERENCES

1. W. W. Little, Jr., and R. W. Hardie, "2DB User's Manual," BNWL-831 Rev. 1, Battelle Northwest Laboratory (1969).

2. K. D. Lathrop, "DTF-IV, A FORTRAN-IV Program for Solving the Multigroup Transport Equation with Anisotropic Scattering," LA-3373, Los Alamos Scientific Laboratory (1965).

3. Unpublished data. 2DF, A Two-Dimensional Transport Theory Code from the Los Alamos Scientific Laboratory.

4. W. H. Hannum and B. M. Carmichael, "DPC, A Two-Dimensional Data Preparation Code," LA-3427-MS, Los Alamos Scientific Laboratory (1966).

5. B. J. Toppel, A. L. Rago, and D. M. O'Shea, "MC^2, A Code to Calculate Multigroup Cross Sections," ANL-7318, Argonne National Laboratory (1967).

APPENDIX A

LOGICAL FLOW OF PHENIX

The basic logical flow of PHENIX is shown by Fig. A.1. The subroutine blocks referred to in the figure are listed below with a brief description of each subroutine. Additional information concerning the logical flow is included.

Subroutine Block 1

INP	Controls the reading and printing of input data and computes variable dimension pointers and various program constants.
ERRO2	Prints an error message.
XSECT	Reads cross sections from cards or tape and writes the cross-section file, NCR1.
INPFLX	Reads input fluxes (if any) and writes the flux file, NFLUX1.
SINUS	Calculates sinusoidal flux guess both radially and axially, for any combination of vacuum and reflective boundary conditions, and writes the flux file, NFLUX1.
REARL	Reads real (floating-point) data.
REAFXP	Reads fixed-point (integer) data.
TRIG	Reads trigger data used in burnup and refueling calculations.
MAPR	Produces picture plot of reactor by zone and material.

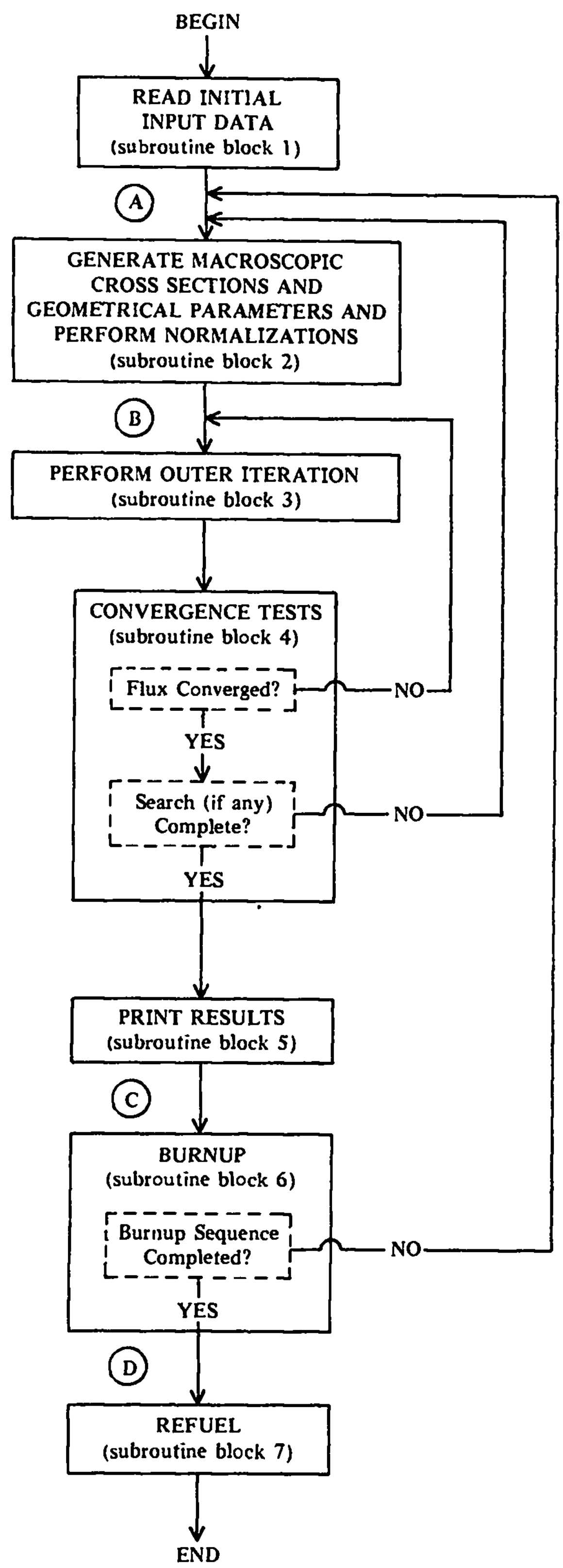

Fig. A.1. Simplified logical flow chart for PHENIX.

Subroutine Block 2

INIT	Mixes cross sections, modifies geometry (if delta search), calculates mesh areas and volumes, and calculates initial fission distributions.
ERRO2	Prints an error message.
FISCAL	Calculates fission sums and performs normalization.

Subroutine Block 3

EVPRT	Prints and monitors the eigenvalue calculation. It prints time, eigenvalue, lambda, etc., after each outer iteration.
OUTER	Performs and controls a complete outer iteration.
ICOEF	Calculates the coefficients for the pointwise flux equations.
INNER	Calculates the fluxes in a specified group using line inversion.
REBAL	Performs group rebalancing and flux normalization before each group calculation.

Subroutine Block 4

CONVRG	Performs convergence tests and computes new eigenvalue in search problems.
ERRO2	Prints an error message.

Subroutine Block 5

SUMMRY	Prints the final totals, including group fluxes, total flux, power density, power fraction, and fission source rate. Also calculates and prints burnup rates (MWd/T) in burnup calculations.
GRPTOT	Computes and prints group totals.
PRT	Prints any IM*JM array.
EVPRT	See Subroutine Block 3.
ERRO2	Prints an error message.
GRAM	Calculates and prints the mass of each material in each zone, and the zone volume.

Note: If no burnup is to be performed, the program terminates at this point (C on Fig. A.1).

Subroutine Block 6

INPB	Reads and prints the input burnup data.
AVERAG	Calculates the zone-averaged total fluxes, zone- and group-averaged fission and absorption cross sections, and breeding ratio.

EIGTRG Controls the flow of the eigenvalue type in search calculations.

MARCH Calculates the time-dependent isotopic concentrations, i.e., performs the burnup.

With regard to the flow of the code in burnup calculations, it should be noted that the flow is controlled by both the initial type of calculation (k_{eff}, concentration search, or delta search) and the number of burnup steps to be performed.

a. If the initial type of calculation is k_{eff} (IEVT = 1), the code returns to point A after each and every burnup step and does a "k_{eff} after burnup" calculation.

b. If the initial type of calculation is a delta search (IEVT = 3), only the initial calculation is a delta search. Following completion of the initial search, the code becomes a k_{eff}-type and all subsequent operations are performed as such.

c. If the initial type of calculation is a concentration search (IEVT = 2), the code flows as "search-burnup-k_{eff} after burnup." This cycle is repeated for each burnup step. Following completion of the last such sequence, the code proceeds directly to refueling (if desired) or performs a final search before refueling. If the concentration searches have been on the control poison, the final search can be of value in determining whether or not enough poison remains to ensure the desired degree of criticality at the end of the burnup interval.

Note: If no refueling is to be performed, the program terminates at this point (D in Fig. A.1).

<u>Subroutine Block 7</u>

REFUEL Calculates atom densities of constituents with greatest burnup, to compute the actual discharge, the charge, and the initial composition for the next burnup interval.

INPR Reads, writes, and punches data to be used in REFUEL.

TRIG Reads trigger data used in burnup and refueling calculations.

APPENDIX B

FORTRAN LISTING OF SOURCE DECK

```
      PROGRAM PHENIX(INPUT,TAPE10=INPUT,OUTPUT,TAPE9=OUTPUT,NCR1,TAPE3=   MAIN
     1NCR1,ISCRAT,TAPE4=NSCRAT,ISCRAT,TAPE5=ISCRAT,NFLUX1,TAPE8=NFLUX1,   MAIN
     2TAPE11,TAPE12,PUNCH)                                                MAIN
C                                                                         MAIN
C     * * * * *  DESCRIPTION OF SUBROUTINES  * * * * *                    MAIN
C                                                                         MAIN
C     PHENIX     MAIN PROGRAM - SETS UP TAPE UNITS AND DISK FILES AND     MAIN
C                CALLS THE FOLLOWING SUBROUTINES.. INP,INIT,FISCAL,EVPRT, MAIN
C                ERRO2,OUTER,CONVRG,SUMMRY,GRAN,INPB,AVERAG,EIGTRG,MARCH. MAIN
C                                                                         MAIN
C     INP        SUBROUTINE TO CONTROL THE READING AND PRINTING OF INPUT  MAIN
C                DATA, COMPUTE VARIABLE DIMENSION POINTERS AND VARIOUS    MAIN
C                PROGRAM CONSTANTS. INP IS CALLED BY PHENIX AND CALLS     MAIN
C                XSECT,INPFLX,REARL,REAFXP,MAPR,ERRO2,TRIG,AND REFUEL.    MAIN
C                                                                         MAIN
C     ERRO2      SUBROUTINE TO PRINT AN ERROR MESSAGE. IT IS CALLED BY    MAIN
C                PHENIX,INP,REARL,REAFXP,INIT,CONVRG, AND SUMMRY.         MAIN
C                                                                         MAIN
C     XSECT      SUBROUTINE TO READ CROSS SECTIONS FROM CARDS OR TAPE,    MAIN
C                AND WRITE THE CROSS SECTION FILE NCR1.  IT IS CALLED     MAIN
C                BY INP.                                                  MAIN
C                                                                         MAIN
C     INPFLX     SUBROUTINE TO READ INPUT FLUXES AND WRITE THE FLUX FILE  MAIN
C                NFLUX1. IT IS CALLED BY INP.                             MAIN
C                                                                         MAIN
C     SINUS      SUBROUTINE TO CALCULATE SINUSOIDAL FLUX INPUT GUESS BOTH MAIN
C                RADIALLY AND AXIALLY, FOR ANY COMBINATION OF  VACUUM AND MAIN
C                REFLECTIVE BOUNDARY CONDITIONS. IT IS CALLED BY INP.     MAIN
C                                                                         MAIN
C     REARL      SUBROUTINE TO READ FLOATING POINT DATA. IT IS CALLED BY  MAIN
C                INP AND CALLS ERRO2.                                     MAIN
C                                                                         MAIN
C     REAFXP     SUBROUTINE TO READ INTEGER DATA.  IT IS CALLED BY INP ANDMAIN
C                CALLS ERRO2.                                             MAIN
C                                                                         MAIN
C     TRIG       SUBROUTINE TO READ TRIGGER DATA USED IN BURNUP AND       MAIN
C                REFUELING CALCULATIONS. IT IS CALLED BY INP AND INPB.    MAIN
C                                                                         MAIN
C     MAPR       SUBROUTINE TO PRODUCE A PICTURE PLOT BY ZONE AND MATERIALMAIN
C                IT IS CALLED BY INP.                                     MAIN
C                                                                         MAIN
C     INIT       SUBROUTINE TO MIX CROSS SECTIONS, MODIFY GEOMETRY,       MAIN
C                CALCULATE MESH AREAS AND VOLUMES, AND CALCULATE INITIAL  MAIN
C                FISSION DISTRIBUTIONS.  IT IT CALLED BY PHENIX AND CALLS MAIN
C                ERRO2.                                                   MAIN
C                                                                         MAIN
C     FISCAL     SUBROUTINE TO CALCULATE FISSION SUMS AND PERFORM         MAIN
C                NORMALIZATION. IT IS CALLED BY PHENIX.                   MAIN
C                                                                         MAIN
C     EVPRT      SUBROUTINE TO PRINT AND MONITOR THE EIGENVALUE           MAIN
C                CALCULATICN. IT  PRINTS TIME, EIGENVALUE, LAMBDA, ETC.   MAIN
C                AFTER EACH OUTER ITERATION.  IT IS CALLED BY PHENIX AND  MAIN
C                SUMMRY.                                                  MAIN
C                                                                         MAIN
C     OUTER      SUBROUTINE TO PERFORM AND CONTROL A COMPLETE OUTER       MAIN
C                ITERATION.  IT IS CALLED BY PHENIX AND CALLS ICHEF,      MAIN
C                AND INNER,                                               MAIN
C                                                                         MAIN
```

```
C     ICOEF     SUBROUTINE TO CALCULATE COEFFICIENTS FOR THE FLUX
C               EQUATION. IT IS CALLED BY OUTER.
C
C     INNER     SUBROUTINE TO CALCULATE THE FLUXES IN A SPECIFIED GROUP
C               USING LINE INVERSION. IT IS CALLED BY OUTER AND CALLS
C               REBAL.
C
C     REBAL     SUBROUTINE TO PERFORM GROUP REBALANCING AND FLUX
C               NORMALIZATION BEFORE EACH GROUP FLUX CALCULATION. IT IS
C               CALLED BY INNER.
C
C     CONVRG    SUBROUTINE TO PERFORM CONVRG TESTS AND COMPUTE NEW EIGVAL
C               IN SRCH PROBLEMS.IT IS CALLED BY PHENIX AND CALLS ERRO2.
C
C     SUMMRY    SUBROUTINE TO PRINT THE FINAL TOTALS, INCLUDING GROUP
C               FLUXES,TOTAL FLUX,POWER DENSITY,POWER FRACTION, AND
C               FISSION SOURCE RATE. ALSO CALCULATES AND PRINTS MWD/T
C               BURNUP RATES IN BURNUP CALCULATIONS. IT IS CALLED BY
C               PHENIX AND CALLS EVPRT,PRT, GRPTOT, AND ERRO2.
C
C     GRPTOT    SUBROUTINE TO COMPUTE AND PRINT GROUP TOTALS. IT IS
C               CALLED BY SUMMRY.
C
C     PRT       SUBROUTINE TO PRINT ANY IM*JM ARRAY. IT IS CALLED
C               BY SUMMRY.
C
C     GRAM      SUBROUTINE TO CALCULATE AND PRINT THE MASS OF EACH
C               MATERIAL IN EACH ZONE,AND THE ZONE VOLUME. IT IS CALLED
C               BY PHENIX.
C
C     INPB      SUBROUTINE TO READ AND PRINT THE INPUT BURNUP DATA.
C               IT IS CALLED BY PHENIX.
C
C     AVERAG    SUBROUTINE TO CALCULATE ZONE-AVERAGED TOTAL FLUXES,ZONE-
C               AND GROUP-AVERAGED FISSION AND ABSORPTION CROSS SECTIONS,
C               AND BREEDING RATIO. IT IS CALLED BY PHENIX.
C
C     EIGTRG    SUBROUTINE TO CONTROL THE FLOW OF THE EIGENVALUE TYPE
C               IN SEARCH CALCULATIONS. IT IS CALLED BY PHENIX.
C
C     MARCH     SUBROUTINE TO CALCULATE THE TIME-DEPENDENT ISOTOPIC
C               CONCENTRATIONS. IT IS CALLED BY PHENIX.
C
C     REFUEL    SUBROUTINE TO CALCULATE ATOM DENSITIES OF CONSTITUENTS
C               WITH GREATEST BURNUP, TO COMPUTE THE ACTUAL DISCHARGE,
C               THE CHARGE, AND THE INITIAL COMPOSITION FOR THE NEXT
C               BURNUP INTERVAL. IT IS CALLED BY INP AND CALLS INPR.
C
C     INPR      SUBROUTINE TO READ, WRITE, AND PUNCH DATA TO BE USED IN
C               REFUEL.  IT IS CALLED BY REFUEL AND CALLS TRIG.
C
C      * * * * *   INPUT CONTROL WORDS  * * * * *
C
C      DELT          LENGTH OF BURNUP TIME STEP (DAYS)
C      EPS           EIGENVALUE CONVERGENCE CRITERION
C      EPSA          PARAMETRIC EIGENVALUE CONVERGENCE CRITERION (SEARCH)
C      EV            INITIAL EIGENVALUE GUESS (SEARCH ONLY)
C      EVM           EIGENVALUE MODIFIER (SEARCH ONLY)
```

```
C       EV2          EIGENVALUE GUESS FOR THE 2ND AND ALL OTHER SEARCHES MAIN 117
C       FLXTST       INNER ITERATION FLUX TEST                           MAIN 118
C                       (0/EP = TEST WITH EPS/TEST WITH FP)              MAIN 119
C       IBB          BOTTOM BOUNDARY CONDITION (0/1=VACUUM/REFLECTIVE)   MAIN 120
C       IBL          LEFT   BOUNDARY CONDITION (0/1=VACUUM/REFLECTIVE)   MAIN 121
C       IBR          RIGHT  BOUNDARY CONDITION (0/1=VACUUM/REFLECTIVE)   MAIN 122
C       IBT          TOP    BOUNDARY CONDITION (0/1=VACUUM/REFLECTIVE)   MAIN 123
C       ICST         CROSS SECTION TYPE (1/2=TYPE1/TYPE2)                MAIN 124
C       ID(23)       IDENTIFICATION (COL 1-72,CARD 1, COL 1-66,CARD 2)   MAIN 125
C       IDMTPG       PREPARE DATA DUMP TAPE (0/1 = NO/YES)               MAIN 126
C       IEVT         EIGENVALUE TYPE (1/2/3=KEFF/CONCENTRATION/DELTA)    MAIN 127
C       IFS          PERFORM FINAL SEARCH (0/1 = NO/YES)                 MAIN 128
C       IGE          GEOMETRY (0/1/2 = X-Y/R-Z/R-THETA)                  MAIN 129
C       IGM          NUMBER OF GROUPS                                    MAIN 130
C       IHS          POSITION OF SIGMA SELF-SCATTER IN X-SECT TABLE      MAIN 131
C       IHT          POSITION OF SIGMA-TOTAL IN CROSS SECTION TABLE      MAIN 132
C       IITM         MAX NO. OF INNER ITERATIONS PER GRP PER OUTER ITER. MAIN 133
C       IM           NUMBER OF RADIAL MESH INTERVALS                     MAIN 134
C       INTMAX       MAX. NO. OF BURNUP INTERVALS TO BE ANALYZED         MAIN 135
C       IPFLX        PUNCH FLUX DUMP (0/1/2=NO/FLUX BEFORE BURNUP/FLUX   MAIN 136
C                       AFTER BURNUP)                                    MAIN 137
C       IPRIN        PRINT CONTROL (1/2/3=FULL PRINT ALWAYS/FULL PRINT   MAIN 138
C                       ONLY FOR DAY=0./PARTIAL PRINT ALWAYS)            MAIN 139
C       IPVT         PARAMETRIC EIGENVALUE TYPE (1/2 = NONE/KEFF)        MAIN 140
C       IREF         BURNUP/REFUEL CONTROL (0/1/2=NO BURNUP/BURNUP ONLY/ MAIN 141
C                       BURNUP AND REFUEL)                               MAIN 142
C       ISTART       INPUT FLUX GUESS (0/1/2/3/4=NONE/CARDS/CARDS/TAPE/  MAIN 143
C                       SINUSOID,  1=X(R)*X(Z), 2=X(R,Z,E), 3=X(R,Z,E)   MAIN 144
C                       FROM TAPE, 4=X(R)*X(Z),SINUSOIDS)                MAIN 145
C       ITL          CROSS SECTION TABLE LENGTH                          MAIN 146
C       IXSEC        READ CROSS SECTIONS FROM TAPE (0/1 = NO/YES)        MAIN 147
C       IZ           NO. OF RADIAL ZONES (DELTA OPTION ONLY)             MAIN 148
C       IZM          NUMBER OF MATERIAL ZONES                            MAIN 149
C       JM           NUMBER OF AXIAL MESH INTERVALS                      MAIN 150
C       JZ           NO. OF AXIAL ZONES  (DELTA OPTION ONLY)             MAIN 151
C       KLAPS        REGION COLLAPSE OPTION IN REFUEL (0=NO/N=NO. OF     MAIN 152
C                       COLLAPSES                                        MAIN 153
C       KNT          BURNUP INTERVAL BEING ANALYZED                      MAIN 154
C       ML           NUMBER OF INPUT MATERIALS                           MAIN 155
C       MSHSWP       CONTROL FOR LINE INVERSION DIRECTION (1/2/3/4 = ALT MAIN 156
C                       DIR/RAD/AXIAL/LET CODE DECIDE)                   MAIN 157
C       MWDT         CALCULATE BURNUP IN MWD/T (0/1 = NO/YES)            MAIN 158
C       M01          TOTAL NUMBER OF MIXTURE SPECIFICATIONS              MAIN 159
C       NBSTP        NO. OF BURNUP TIME STEPS IN THE BURNUP INTERVAL     MAIN 160
C       NCON         NEG/ZERO/POS=TAKE TIME STEP OF DELT/END OF PROBLEM/ MAIN 161
C                       TAKE TIME STEP OF DELT AND READ BURNUP DATA      MAIN 162
C       NECOP        PUNCH OPTION FOR CHARGE/DISCHARGE DATA (DATA FROM   MAIN 163
C                       FIRST NECOP COLLAPSES WILL BE PUNCHED)           MAIN 164
C       NPOIS        MATERIAL NO. OF CONTROL POISON                      MAIN 165
C       NREG         NO. OF REGIONS(ZONES) REQUIRING REFUELING           MAIN 166
C       NREPO        REFUEL CONTROL POISON DURING REFUELING (0/1=NO/YES) MAIN 167
C       OITM         MAX NO. OF OUTER ITERATIONS ALLOWED                 MAIN 168
C       ORF          OVER-RELAXATION FACTOR                              MAIN 169
C       POD          PARAMETER OSCILLATION DAMPER (SEARCH ONLY)          MAIN 170
C       POWR         REACTOR POWER (MWT)                                 MAIN 171
C       PV           DESIRED VALUE OF PARAMETRIC EIGENVALUE (SEARCH ONLY)MAIN 172
C       SRCRT        NEUTRON SOURCE RATE                                 MAIN 173
C       TMAX         MAX ALLOWABLE RUNNING TIME IN MINUTES               MAIN 174
```

```
C       XLAH          LAMBDA-1 UPPER LIMIT (SEARCH ONLY)
C       XLAL          LAMBDA-1 LOWER LIMIT (SEARCH ONLY)
C
C       * * * * *   INTERNAL VARIABLES  * * * * *
C
C       NINP          INPUT TAPE (DISK FILE)
C       NOUT          OUTPUT TAPE (DISK FILE)
C       NCR1          CROSS SECTION TAPE (DISK FILE)
C       NFLUX1        FLUX TAPE (DISK FILE)
C       NSCRAT        SCRATCH TAPE (DISK FILE)
C       ISCRAT        DISK FILE FOR FLUX COEFF. AND TEMPORARY FLUX DUMP
C       NDUMP         TAPE FOR INPUT AND OUTPUT FLUXES AND ATOM DENSITIES
C       NMICR         MICROSCOPIC CROSS SECTION TAPE
C       ALA           LAMBDA
C       B07           USED FOR INTERNAL COMPUTATION IN FISCAL AND INIT
C       CNT           CONVERGENCE TRIGGER FOR LAMBDA
C       CVT           CONVERGENCE TRIGGER
C       DAY           BURNUP TIME IN DAYS
C       EPF           (MW-SEC)/(FISSION)    (BASED ON 215 MEV/FISSION)
C       E01           TEMPORARY
C       E02           TEMPORARY
C       E03           TEMPORARY
C       EQ            TEMPORARY FOR CONVRG
C       EVP           PREVIOUS EIGENVALUE
C       EVPP          EIGENVALUE FOR TWO ITERATIONS BACK
C       GBAR          GROUP INDICATOR FOR TAPE MOTION IN OUTER
C       IBPTRG        TEMPORARY TRIGGER FOR DETERMINING WHETHER AN
C                        NON-DELT CARD IS TO BE READ
C       IBUR          RUNNING COUNT OF THE NUMBER OF BURNUP STEPS
C       IGEP          IGE + 1
C       IGP           IGM + 1
C       IGV           GROUP INDICATOR FOR INNER AND OUTER
C       II            INNER ITERATION COUNT FOR A SINGLE GROUP
C       IMJM          IM*JM
C       INT           NO. OF NEXT BURNUP INTERVAL (= KNT+1) (IN REFUEL)
C       IP            IM + 1
C       ITEMS         TEMPORARY
C       ITEMP         TEMPORARY
C       ITEMP1        TEMPORARY
C       ITEMP2        TEMPORARY
C       IZP           IZM + 1
C       JP            JM + 1
C       KLNT          NO. OF PREVIOUS BURNUP INTERVAL (=KNT-1) (IN REFUEL)
C       K07           TEMPORARY
C       KPAGE         PAGE COUNTER FOR MONITOR PRINT
C       LAP           LAMBDA FOR PREVIOUS EIGENVALUE
C       LAPP          LAMBDA FOR TWO ITERATIONS BACK
C       LAR           LAMBDA FOR PREVIOUS ITERATION
C       LC            LOOP COUNT  (TOTAL II IN A SINGLE OUTER ITERATION)
C       MT            TOTAL NUMBER OF MATERIALS INCLUDING MIXES (ML+IZM)
C       NCOEF         TRIGGER FOR A NEW CALCULATION OF FLUX
C                        COEFFICIENTS.(SEARCH ONLY)
C       NGO           TEMPORARY FOR FLOW OF EIGENVALUE TYPE
C       NGOTO         TEMPORARY
C       NSWEEP        INTERNAL CONTROL FOR DIRECTION OF LINE INVERSION
C       P02           OUTER ITERATION COUNT
C       PBAR          TEMPORARY
C       SBAR          TEMPORARY
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C       SK7             SUM OF K7 OVER ALL GROUPS
C       TOC             0/1=NOT DELTA/DELTA CALCULATION
C       T11             PREVIOUS FISSION TOTAL
C       TEMF            TEMPORARY
C       TEMI            TEMPORARY
C       TEMP            TEMPORARY
C       TEMP1           TEMPORARY
C       TEMP2           TEMPORARY
C       TEMP3           TEMPORARY
C       TEMP4           TEMPORARY
C       TI              TIME
C       V11             TOTAL SOURCE FOR THE GROUP
C
C       * * * * *  SUBSCRIPTED VARIABLES  * * * * *
C
C       ABXS(NCON,IZM,INTMAX)
C                       ZONE- GROUP-AVG ABSORPTION X-SECT USED TO BURN MTLS
C                         IN REFUEL
C       ALAM(ML)        DECAY CONSTANT  (DAYS-1)
C       ATW(ML)         MATERIAL ATOMIC WEIGHT
C       AXS(ML,IZM)     SPECTRUM AVERAGED ABSORPTION CROSS SECTION
C       A0(IP)          RADIAL AREA ELEMENT
C       A1(IM)          AXIAL  AREA ELEMENT
C       BREDRT(IZM)     CONTRIBUTION TO BREEDING RATIO FROM ZONE IZM
C       BURNUP(IZM)     AVERAGE BURNUP RATE IN MWD/T FOR ZONE IZM
C       CG(NECOP,NCON)
C                       CHARGE MASSES TO BE PUNCHED (IN REFUEL)
C       CHARGE(ML)      TOTAL CHARGE MASSES FOR EACH MATERIAL (IN REFUEL)
C       CN(IZM,NCON)    CHARGE ATOM DENSITIES (IN REFUEL)
C       CNP(IZM,NCON)   TEMPORARY ATOM DENSITY STORAGE (IN REFUEL)
C       C0(ITL,MT)      CROSS SECTION ARRAY FOR CURRENT GROUP
C       CXR(JM)         CONSTANTS FOR RIGHT BOUNDARY
C       CXS(IM,JM,3)    CONSTANTS INVOLVING CROSS SECTIONS FOR FLUX CALC.
C       CXT(IM)         CONSTANTS FOR TOP BOUNDARY
C       DG(NECOP,NCON)
C                       DISCHARGE MASSES TO BE PUNCHED (IN REFUEL)
C       DISCHG(ML)      TOTAL DISCHARGE MASSES FOR EACH MTL
C       DN(IZM,NCON)    DISCHARGE ATOM DENSITIES (IN REFUEL)
C       E0(IGP)         FISSION RATE
C       E1(IGP)         FISSION SOURCE
C       E2(IGP)         IN-SCATTER
C       E3(IGP)         OUT-SCATTER
C       E4(IGP)         ABSORPTIONS
C       E5(IGP)         LEFT LEAKAGE
C       E6(IGP)         RIGHT LEAKAGE
C       E7(IGP)         TOP LEAKAGE
C       E8(IGP)         BOTTOM LEAKAGE
C       E9(IGP)         TOTAL LEAKAGE
C       FIXS(NCON,IZM,INTMAX)
C                       ZONE- GROUP-AVG FISSION X-SECT USED TO BURN MTLS
C                         IN REFUEL
C       FUTOT(IZM)      TOTAL FUEL MASS IN TONS FOR ZONE IZM
C       FXS(ML,IZM)     SPECTRUM AVERAGED FISSION CROSS SECTION
C       F0(IM,JM)       FISSIONS  (OLD)
C       F2(IM,JM)       FISSIONS  (NEW)
C       HA(IM OR JM)    TEMPORARY STORAGE FOR LINE INVERSION
C       HN0(M,1)        CLEAN (NO BURNUP) ATOM DENSITIES OF MTLS IN EACH MIX
C       HNI(M,1)        INITIAL ATOM DENSITY OF EACH MTL IN EACH MIX FOR
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C                    INPUT TO NEXT BURNUP (I2 BLOCK FOR NEXT INTERVAL)
C      HOLN(ML)      MATERIAL NAME
C      IZON(KLAPS,IZM)
C                    ACTUAL REGION NUMBERS OF REGIONS TO BE COLLAPSED IN
C                       EACH COLLAPSE (IN REFUEL)
C      I0(M01)       MIX NUMBER
C      I1(M01)       MATERIAL NUMBER FOR MIX
C      I2(M01)       MATERIAL DENSITY
C      I3(M01)       MATERIAL DENSITIES FOR GRAM CALCULATION
C      I4(M01)       SEARCH MATERIAL MODIFIER (CONC SEARCH ONLY)
C      K6(IGM)       FISSION SPECTRUM  (EFFECTIVE)
C      K7(IGM)       FISSION SPECTRUM  (INPUT)
C      KZNS(KLAPS)   NO. OF REGIONS TO BE COLLAPSED IN EACH COLLAPSE IN
C                       REFUEL
C      LCN(ML,2)     SOURCE ISOTOPES FOR CAPTURE
C      LD(ML)        SOURCE ISOTOPE FOR DECAY
C      LFN(ML,7)     SOURCE ISOTOPES FOR FISSION
C      MASS(ML,IZM)  MATERIAL INVENTORY IN EACH ZONE
C      MASSP(ML,IZM) MATERIAL INVENTORY IN EACH ZONE (PREVIOUS)
C      MATN(ML)      MATERIAL NUMBER FOR BURNABLE ISOTOPES
C      M0(IM,JM)     ZONE NUMBERS
C      M2(IZM)       MATERIAL NUMBERS BY ZONE
C      NBIFLG(IZM,NCON)
C                    VALUES IN M01 ARRAY THAT ARE BURNABLE ISOTOPES
C                       (IN REFUEL)
C      NBF(ML)       0/1/2=NO EFFECT/FERTILE/FISSILE ISOTOPE
C      NFRE(IZM)     NO. OF BURNUP INTERVALS BETWEEN REFUELING FOR EACH
C                       REGION TO BE REFUELED
C      NTRIG(M01)    TRIGGER FOR TOTAL FUEL MASS CALCULATION
C      N0(IM,JM)     TOTAL FLUX  (OLD)
C      N2(IM,JM)     TOTAL FLUX  (NEW)
C      PA(IM OR JM)  TEMPORARY STORAGE FOR LINE INVERSION
C      PFRAC(IZM)    FRACTION OF TOTAL POWER PRODUCED BY ZONE IZM
C      PFPREV(IZM)   PREVIOUS POWER FRACTION FOR ZONE IZM
C      PHI(INTMAX,IZM)
C                    ZONE- AVG TOTAL FLUX USED TO BURN THE CONSTITUENT
C                       MTLS IN REFUEL
C      PHIB(IZM)     ZONE AVERAGED FLUX
C      R0(IP)        INITIAL RADII
C      R1(IP)        CURRENT RADII
C      R2(IM)        RADIAL ZONE NUMBERS  (DELTA CALCULATION ONLY)
C      R3(IZ)        RADIAL ZONE MODIFIERS  (DELTA CALCULATION ONLY)
C      R4(IM)        AVERAGE RADII
C      R5(IM)        DELTA-R
C      S2(IM,JM)     FIXED SOURCE
C      TRG(NCON)     TRIGGER TO REFUEL EACH BURNABLE ISOTOPE(0/1=NO/YES)
C      VOL(IZM)      ZONE VOLUME (LITERS)
C      V0(IM,JM)     VOLUME ELEMENTS
C      X0(IZM)       REFUELING FRACTION FOR REGIONS TO BE REFUELED
C      Z0(JP)        INITIAL AXII
C      Z1(JP)        CURRENT AXII
C      Z2(JM)        AXIAL ZONE NUMBERS  (DELTA CALCULATION ONLY)
C      Z3(JZ)        AXIAL ZONE MODIFIERS  (DELTA CALCULATION ONLY)
C      Z4(JM)        AVERAGE AXII
C      Z5(JM)        DELTA-Z
C
C      * * * * *  INPUT DATA BLOCKS  * * * * *
C
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C     DATA BLOCK 1      CROSS SECTION DATA
C           (OMIT IF IXSEC = 1)
C
C     DATA BLOCK 2      INPUT FLUX GUESS DATA
C           (OMIT IF ISTART = 0 OR 4)
C
C     DATA BLOCK 3      RADIAL MESH BOUNDARIES (P0 BLOCK)
C
C     DATA BLOCK 4      AXUAL  MESH BOUNDARIES (Z0 BLOCK)
C
C     DATA BLOCK 5      ZONE NUMBERS AT EACH MESH POINT (M0 BLOCK)
C
C     DATA BLOCK 6      FISSION FRACTION FOR EACH GROUP (K7 BLOCK)
C
C     DATA BLOCK 7      MIXTURE NUMBERS (I0 BLOCK)
C
C     DATA BLOCK 8      MATERIALS IN EACH MTX (I1 BLOCK)
C
C     DATA BLOCK 9      ATOM DENSITIES OF MATERIALS IN EACH MTX (I2 BLOCK)
C
C     DATA BLOCK 10     ZONE NUMBERS FOR RADIAL INTERVALS (R2 BLOCK)
C           (OMIT IF IEVT.NE.3)
C
C     DATA BLOCK 11     RADIAL DIMENSIONAL MODIFIERS (R3 BLOCK)
C           (OMIT IF IEVT.NE.3)
C
C     DATA BLOCK 12     ZONE NUMBERS FOR AXIAL INTERVALS (Z2 BLOCK)
C           (OMIT IF IEVT.NE.3)
C
C     DATA BLOCK 13     AXIAL DIMENSIONAL MODIFIERS (Z3 BLOCK)
C           (OMIT IF IEVT.NE.3)
C
C     DATA BLOCK 14     SEARCH MATERIAL MODIFIERS.(I4 BLOCK)
C           (OMIT IF IEVT.NE.2)
C
C     DATA BLOCK 15     TRIGGER FOR MTLS THAT ARE FUEL (NTRIG BLOCK)
C           (OMIT IF MWDT = 0)
C
C
C       * * * * *  MAIN PROGRAM  * * * * *
C
      COMMON   NINP,    NOUT,    NCR1, NFLUX1, NSCRAT, ISCRAT,  NDUMP,
     1       NMICR,     ALA,     B07,    CNT,    CVT,    DAY, E0(51),
     2     E1(51), E2(51), E3(51), E4(51), E5(51), E6(51), E7(51),
     3     E8(51), E9(51),     E01,    E02,    E03
      COMMON     EQ,     EVP,   EVPP,    EPF,   GBAR,   IGEP,    IGP,
     1         IGV,      II,   IMJM,     IP,  ITEMP, ITEMP1, ITEMP2,
     2         IZP,      JP,    K07, KPAGE,    LAP,   LAPP,    LAR,
     3          LC,  NGOTO,   ORFP,    P02,   PBAR,
     4        SBAR,     SK7,    T06,    T11,   TEMP,  TEMP1,  TEMP2,
     5       TEMP3,   TEMP4,     TI,    V11,   NXCM
      COMMON IO(23),   IMAX,    IGE,    IZM,     IM,     JM,    IBL,
     1         IBR,     IBT,    IBB,    IGM,   IEVT,   IPVT, ISTART,
     2          ML,      MT,    M01,   ICST,    IHT,    IHS,    ITL,
     3          IZ,      JZ,   OITM,   IITM,   MWDT,  IPFLX,  IPRIN,
     4      IDMTPS,    IREF,  IXSEC,  NPOIS,   NCON
      COMMON    EPS,   SRCRT,   POWR,    ORF, FLXTST,     PV,   EPSA,
     1          EV,     EVM,   XLAL,   XLAH,    POD,   DELT,    IFS,
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     2         NRSTP,     IBUR,      EV2,      NGO,  IBRTRG,  NCOEF,  NSWEEP
      COMMON    LATW,    LHOLN,    LALAM,      LC0,     LI0,     LI1,     LI2,
     2         LPHIP,     LVOL,      LN0,     LAXX,    LFXX,   LMATN,     LLD,
     3          LLCN,     LLFN,      LN2,      LA0,     LA1,     LF0,     LF2,
     4           LI3,      LK6,      LK7,      LM0,     LM2,     LR0,     LR1,
     5           LR2,      LR3,      LR4,      LR5,     LS2,     LV0,     LZ0,
     6           LZ1,      LZ2,      LZ3,      LZ4,     LZ5,    LCXS,   LMASS,
     7          LNBR,    LPHIB,     LAXS,     LFXS,  LMASSP,    LCXR,    LCXT,
     8           LHA,      LPA,   LPFRAC,  LNTRIG,  LPFPRV,  LBURUP,  LFUTOT,
     9        LBRDRT,   LPHIPP,      LI4
      INTEGER    B07,      CNT,      CVT,      P02,     T06,      R2,      Z2
      INTEGER   DITM
      REAL        I2,       I3,       K6,       K7,     LAP,    LAPP,     LAR,
     1            N0,       N2,     MASS,    MASSP,      I4
      COMMON A(30000)
      DAY=0.
 1    CONTINUE
      REWIND 3
      REWIND 4
      REWIND 5
      REWIND 8
      CALL INP
 10   CALL INIT(A(LK6), A(LK7), A(LI0), A(LI1), A(LI2), A(LM0), A(LM2),
     1          A(LN0), A(LR0), A(LR1), A(LR2), A(LR3), A(LR4), A(LR5),
     2          A(LZ0), A(LZ1), A(LZ2), A(LZ3), A(LZ4), A(LZ5), A(LA0),
     3          A(LA1), A(LF0), A(LC0), A(LV0),    ITL,      TM,
     4          JM,MT,A(LNTRIG),A(LI4))
      CALL FISCAL (A(LN0),A(LF0) ,A(LV0) ,A(LC0) ,A(LK6) ,
     2             A(LM0) ,A(LM2),ITL,MT)
C     CALL MONITOR PRINT
 20   CALL EVPRT
      GO TO (50, 30, 30, 40), NGOTO
 30   CALL ERR02(6H*MONPR, 30,1)
C     PERFORM AN OUTER ITERATION
 40   CALL OUTER( A(LA0), A(LA1), A(LC0), A(LF0), A(LK6),
     1            A(LM0), A(LM2), A(LN0), A(LN2), A(LS2), A(LV0),A(LZ5),
     2            A(LF2), ITL, MT, A(LCXS), IM, JM, A(LR5), A(LR4),
     3            A(LZ4), A(LCXR), A(LCXT), A(LHA), A(LPA))
C     PERFORM FISSION CALCULATION
      CALL FISCAL (A(LN0),A(LF0) ,A(LV0) ,A(LC0) ,A(LK6) ,
     2             A(LM0) ,A(LM2),ITL,MT)
C     PERFORM CONVERGENCE AND NEW PARAMETER CALCULATIONS
      CALL CONVRG (A(LF2), A(LK6))
      GO TO (50,20,10), NGOTO
C     50/20/10=FINAL PRINT/MONITOR PRINT/SEARCH CALCULATION
 50   CALL SUMMRY (A(LF2), A(LN2), A(LR1), A(LZ1), A(LR4), A(LZ4),
     1          IM,JM,A(LN2),A(LC0),A(LN0),A(LM0),A(LM2),A(LF0),ITL,MT,
     2             A(LV0),A(LFUTOT),A(LI0),A(LI1),A(LI2),A(LPFRAC),
     3             A(LPFPRV),A(LBURUP),A(LI4))
      CALL GRAM(A(LMASS), A(LVOL),  A(LATW), A(LHOLN), IM, JM,
     1          A(LM0), A(LM2), A(LV0), A(LI0), A(LI1), A(LI2), ML,
     2          A(LI3),A(LFUTOT),A(LNTRIG),A(LI4))
      CALL INPB(A(LMATN),A(LNBR),A(LLD),A(LLCN),A(LLFN),A(LALAM),
     1          A(LHOLN),ML,A(LI2))
      IF(NCOM)   60,1,60
 60   CALL AVERAG(A(LPHIB),A(LAXS),A(LFXS),A(LMATN),A(LMASS),A(LATW),
     1            A(LVOL),A(LC0),A(LN2),A(LN0),A(LV0),A(LHOLN),ML,ITL,
     2            A(LNBR), A(LAXX), A(LFXX),A(LBRDRT))
      CALL EIGTRG(IEVT,K07,IBUR,EV,EV2,NGO,EQ,IPVT)
      IF(NGO.EQ.1) GO TO 65
      IF(DELT) 10,1,10
 65   IF(DELT) 70,1,70
 70   CALL MARCH(A(LPHIB),A(LMATN),A(LFXS),A(LAXS),A(LVOL),A(LMASS),
     1           A(LMASSP),A(LALAM),A(LLD),A(LLCN),A(LLFN),ML,
     2           A(LI0),A(LI1),A(LI2),A(LM2),A(LPHIP),A(LPHIPP),IZM)
      GO TO 10
      END
```

```
      SUBROUTINE INP
      COMMON  NINP,    NOUT,    NCR1,  NFLUXT,  NSCRAT,  ISCRAT,   NDUMP,
     1        NMICR,    ALA,     B07,     CNT,     CVT,     DAY,  E0(51),
     2       E1(51),  E2(51),  E3(51),  E4(51),  E5(51),  E6(51),  E7(51),
     3       E8(51),  E9(51),     E01,     E02,     E03
      COMMON    EQ,     EVP,    EVPP,     EPF,    GBAR,    IGEP,     IGP,
     1         IGV,      II,    IMJM,      IP,   ITEMP,  ITEMP1,  ITEMP2,
     2         IZP,      JP,     K07,   KPAGE,     LAP,    LAPP,     LAR,
     3          LC,   NGOTO,    ORFP,     P02,    PBAR,
     4        SBAR,     SK7,     T06,     T11,    TEMP,   TEMP1,   TEMP2,
     5       TEMP3,   TEMP4,      TI,     V1),    MXCM
      COMMON ID(23),   IMAX,     IGE,     IZM,      IM,      JM,     IBL,
     1         IBR,     IBT,     IN8,     IGM,    IEVT,    IPVT,  ISTART,
     2          ML,      MT,     M01,    ICST,     IHT,     IHS,     ITL,
     3          IZ,      JZ,    OITM,    IITM,    MWDT,   IPFLX,   IPRIN,
     4       IOUTPS,   IREF,   IXSEC,  NPOIS,    NCON
      COMMON     EPS,   SRCRT,    POWR,     DRF,  FLXTST,      PV,    EPSA,
     1          EV,     EVM,    XLAL,    XLAH,     POU,    DELT,     IFS,
     2       NBSTP,    IBUR,     EV2,     NGO,  IBRTRG,   NCOLF,  NSWEEP
      COMMON    LATW,   LHCLN,   LALAM,     LCN,     LI0,     LI1,     LI2,
     2       LPHIP,    LVOL,     LN0,    LAXX,    LFXX,   LMATN,     LLD,
     3        LLCN,    LLFN,     LN2,     LA0,     LA1,     LF0,     LF2,
     4         LI3,     LK6,     LK7,     LM0,     LM2,     LR0,     LR1,
     5         LR2,     LR3,     LR4,     LR5,     LS2,     LV0,     LZ0,
     6         LZ1,     LZ2,     LZ3,     LZ4,     LZ5,    LCXS,   LMASS,
     7        LMIR,   LPFIB,    LAXS,    LFXS,  LMASSP,    LCXR,    LCXT,
     8         LHA,     LPA,  LPFRAC,  LNTRIG,  LPFPRV,  LBURUP,  LFUTOT,
     9      LBRDRT,  LPFIPP,     LI4
      INTEGER  B07,     CNT,     CVT,     P02,     T06,      R2,      Z2
      INTEGER  OITM
      REAL      I2,      I3,      K6,      K7,     LAP,    LAPP,     LAR,
     1          N0,      N2,    MASS,   MASSP,      I4
      COMMON A(30000)
      EQUIVALENCE (A,INTT),(A,AA)
       DIMENSION  INTT(30000),AA(30000)
C     THIS SUBROUTINE CONTROLS THE READING OF ALL INPUT DATA
      NCR1 = 3
      NSCRAT = 4
      ISCRAT=5
      NINP=10
      NOUT=?
      NFLUX1 = 8
      NDUMP = 11
      NMICR = 12
      PRINT 5
    5 FORMAT(1H1)
      IF(DAY.EQ.0.) GO TO 45
      IF (IREF.NE.2) GO TO 45
      READ (NINP,10)  KNT, NREG, NREPO, KLAPS, INTMAX, NECOP
   10 FORMAT (6I6)
      INT = KNT+1
      KLNT = KNT-1
      LX0=LI2
      LNFRE = LX0 + IZM
      LTRG = LNFRE + IZM
      LHN0 = LTRG + NCON
      LPHI = LHN0 + M01
      LAMXS = LPHI + IZM*INTMAX
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      LFIXS = LABXS + NCCN*IZM*INTMAX
      LKZNS = LFIXS + NCCN*IZM*INTMAX
      LIZON = LKZNS + KLAPS
      LNZN = LIZON + KLAPS*IZM
      LDN = LNZN + NREG
      LCN = LDN + IZM*NCON
      LCNP = LCN + IZM*NCON
      LHNI = LCNP + IZM*NCON
      LDG = LHNI + M01
      LCG = LDG + NECOP*NCON
      LDIS= LCG + NECOP*NCON
      LCHG = LDIS + ML
      LNBI = LCHG + ML
      LAST = LNBI + IZM*NCON
      PRINT 15, KNT,INT
15    FORMAT(1H1,//10X,42H * * * * * REFUEL BETWEEN BURNUP INTERVALS,
     1       I3,4H AND,I3,10H * * * * *////)
      PRINT 20, KNT, NREG, NREPO, KLAPS, INTMAX, NECOP
20    FORMAT (//
     180H  KNT      BURNUP INTERVAL JUST COMPLETED
     A                                                  I2/
     280H  NREG     NO. OF REGIONS REQUIRING REFUELING
     A                                                  I2/
     380H  NREPO    REFUEL CONTROL RODS DURING REFUELING (0/1=NO/YES)
     A                                                  I2/
     480H  KLAPS    REGION COLLAPSE OPTION (0=NO / N=NO.OF COLLAPSES)
     A                                                  I2/
     580H  INTMAX   MAX. NO. OF BURNUP INTERVALS TO BE ANALYZED
     A                                                  I2/
     680H  NECOP    PUNCH OPTION FOR INPUT TO ECONOMICS CODE
     A                                                  I2/
     B60H           (DATA FROM FIRST NECOP COLLAPSES WILL BE PUNCHED)  )
      PRINT 25, LAST
25    FORMAT (////5X,7H LAST =  I6)
      IF (LAST - 30000) 35,35,30
30    STOP
35    DO 40 I=LN2,LAST
40    A(I) = 0.
      CALL REFUEL (KNT,NREG,NREPO,NPOIS,KLAPS,INTMAX,NECOP, A(LX0),
     1       A(LNFRE), A(LTRG), A(LIINO), A(LPHI), A(LABXS), A(LFIXS),
     2       A(LKZNS),A(LIZON),IZM,I101,ML,DAY,IGM,IMJM,ISTART,NCON,
     3       IDMTPS, A(LI0), A(LI1), A(LI2), A(LPHIP), A(LN0), A(LVOL),
     4       A(LAXX), A(LFXX), A(LMATN), A(LALAM), A(LLD), A(LLCN),
     5       A(LLFN), A(LHCLN), A(LATW), A(LNZN), A(LDN), A(LCN), A(LCNP),
     6       A(LHNI), A(LDG), A(LCG), A(LDIS), A(LCHG), A(LCNP), A(LNBI))
45    CONTINUE
      PRINT 50
50    FORMAT(30X,40H  *   *   *   *    P H E N I X   *   *   *   * ///)
      READ(IINP,55)  (ID(I),I=1,12)
55    FORMAT (12A6)
      IF(ID(1).EQ.6HFINISH) 320,56
56    READ( IINP,57)   (ID(I),I=13,23), TMAX
57    FORMAT (11A6,F6.1)
      IF(ID(13).EQ.6HFINISH) 320,60
60    CONTINUE
      PRINT 63
63    FORMAT(/5X,29H CARDS 1 AND 2  (ID AND TMAX)/)
      PRINT 65, (ID(I),I=1,23), TMAX
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65    FORMAT(10X,12A6/10X,11A6/10X, 8H  TMAX = F6.1, 5H MIN. //)
      READ (MINP, 70) IGE,IZM,IBL,IBR,IBT,IBB,IEVT,IPVT,IM,JM,IZ,JZ,
     1   IGM,ML,ICST,IHT,IHS,ITL,IXSEC,M01,OITM,IITM,MSHSWP,ISTART,
     2   IRFF,NUSTP,IFS,NPOIS,MWDT,IPFLX,IPRIN,IDMTPS,
     3   EPS,SRCRT,POWR,CRF,FLXTST,PV,
     4   EPSA,EV,EVM,LV2,XLAL,XLAH,POD
70    FORMAT (12I6 / 12I6 / 8I6 / 6E12.4 / 6E12.4 / E12.4)
      PRINT 72
72    FORMAT (/5X,26H CARD 3 DATA    12I6 FORMAT     /)
      PRINT 75, IGE, IZM, IBL, IBR, IBT, IBB
75    FORMAT (
     180H  IGE     GEOMETRY (0/1/2 = X-Y/R-Z/R-THETA)
     A                       I12/
     280H  IZM     NUMBER OF MATERIAL ZONES(REGIONS)
     A                       I12/
     380H  IBL     LEFT BOUNDARY CONDITION (0/1=VACUUM/REFLECTIVE)
     A                       I12/
     480H  IBR     RIGHT BOUNDARY CONDITION (SAME AS IBL)
     A                       I12/
     580H  IBT     TOP BOUNDARY CONDITION (SAME AS IBL)
     A                       I12/
     680H  IBB     BOTTOM BOUNDARY COND. (SAME AS IBL)
     A                       I12)
      PRINT 80, IEVT, IPVT, IM, JM, IZ, JZ
80    FORMAT (
     180H  IEVT    EIGENVALUE TYPE (1/2/3=KEFF/CONC/DELTA)
     A                       I12/
     280H  IPVT    PARAMETRIC EIGENVALUE TYPE (1/2=NONE/KEFF)
     A                       I12/
     380H  IM      NUMBER OF RADIAL MESH INTERVALS
     A                       I12/
     480H  JM      NUMBER OF AXIAL MESH INTERVALS
     A                       I12/
     580H  IZ      NO. OF RADIAL ZONES (DELTA OPTION ONLY)
     A                       I12/
     680H  JZ      NO. OF AXIAL  ZONES (DELTA OPTION ONLY)
     A                       I12)
      PRINT 85
85    FORMAT (/5X,26H CARD 4 DATA    12I6 FORMAT  /)
      PRINT 90, IGM, ML, ICST, IHT, IHS, ITL
90    FORMAT (
     180H  IGM     NUMBER OF GROUPS
     A                       I12/
     280H  ML      NUMBER OF INPUT MATERIALS
     A                       I12/
     380H  ICST    CROSS SECTION TYPE (1/2=TYPE1/TYPE2)
     A                       I12/
     480H  IHT     POSITION OF SIGMA TOTAL IN X-SECT TABLE
     A                       I12/
     580H  IHS     POSITION OF SIGMA SELF-SCATTER IN X-SECT TABLE
     A                       I12/
     680H  ITL     CROSS SECTION TABLE LENGTH
     A                       I12)
      PRINT 95, IXSEC, M01, OITM, IITM, MSHSWP, ISTART
95    FORMAT (
     180H  IXSEC   READ X-SECTS FROM TAPE (0/1=NO/YES)
     A                       I12/
     280H  M01     TOTAL NO. OF MIXTURE SPECIFICATIONS
```

```
     A                           I12/
     380H  OITM     MAX NO. OF OUTER ITERATIONS ALLOWED
     A                           I12/
     480H  IITM     MAX NO. OF INNER ITERATIONS ALLOWED PER OUTER ITER.
     A                           I12/
     580H  ISHSWP LINE INVERSION DIRECTION (1/2/3/4=ALT DIR/RAD/AX/CODE
     ADECIDES                    I12/
     680H  ISTART FLUX GUESS (0/1/2/3/4=NONE/CARDS/CARDS/TAPE/SINUSOID)
     A                           I12)
      PRINT 100
 100  FORMAT (/5X,26H CARD 5 DATA    8I6 FORMAT  /)
      PRINT 105, IREF, NBSTP, IFS, NPOIS, MWDT
 105  FORMAT (
     180H  IREF     BURNUP/REFUEL CONTROL (0/1/2=NO BURNUP/BURNUP ONLY/BUR
     ANUP AND REFUEL)            I12/
     280H  NBSTP    NUMBER OF BURNUP TIME STEPS IN A BURNUP INTERVAL
     A                           I12/
     380H  IFS      PERFORM FINAL SEARCH (0/1 = NO/YES)
     A                           I12/
     480H  NPOIS    MATERIAL NO. OF CONTROL POISON
     A                           I12/
     580H  MWDT     CALCULATE BURNUP IN MWD/T (0/1=NO/YES)
     A                           I12)
      PRINT 107, IPFLX, IPRIN, IDHTPS
 107  FORMAT (
     180H  IPFLX    PUNCH FLUX DUMP (0/1/2=NO/FLUX BEFORE BURNUP/FLUX AFTE
     AR BURNUP)                  I12/
     280H  IPRIN    PRINT CONTROL(1/2/3=FULL PRINT/FULL PRINT FOR DAY=0 ON
     ALY/PARTIAL PRINT)          I12/
     380H  IDHTPS PREPARE DATA DUMP TAPE (0/1=NO/YES)
     A                           I12)
      PRINT 110
 110  FORMAT (/5X,28H CARD 6 DATA    6E12.4 FORMAT  /)
      PRINT 115, EPS, SRCRT, POWR, ORF, FLXTST, PV
 115  FORMAT (
     180H  EPS      EIGENVALUE CONVERGENCE CRITERION
     A                           1PE12.4/
     280H  SRCRT    NEUTRON SOURCE RATE (FOR NORMALIZATION)
     A                           1PE12.4/
     380H  POWR     REACTOR POWER (MWT) (FOR NORMALIZATION)
     A                           1PE12.4/
     480H  ORF      OVERRELAXATION FACTOR
     A                           1PE12.4/
     580H  FLXTST INNER ITERATION FLUX TEST (0/EP=EPS/EP FOR TEST)
     A                           1PE12.4/
     680H  PV       DESIRED VALUE OF PARAMETRIC EIGENVALUE (SEARCH ONLY)
     A                           1PE12.4)
      PRINT 120
 120  FORMAT (/5X,28H CARD 7 DATA    6E12.4 FORMAT  /)
      PRINT 125, EPSA, EV, EVM, EV2, XLAL, XLAH
 125  FORMAT (
     180H  EPSA     PARAMETRIC EIGNVALUE CONVERGENCE CRITERION(SEARCH ONLY
     A                           1PE12.4/
     280H  EV       INITIAL EIGENVALUE GUESS (SEARCH ONLY)
     A                           1PE12.4/
     380H  EVM      EIGENVALUE MODIFIER (SEARCH ONLY)
     A                           1PE12.4/
     480H  EV2      EIGENVALUE GUESS FOR 2ND AND ALL OTHER SEARCHES
```

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     A                    1PE12.4/
     580H  XLAL    LAMBDA-1 LOWER LIMIT (SEARCH ONLY)
     A                    1PE12.4/
     680H  XLAM    LAMBDA-1 UPPER LIMIT (SEARCH ONLY)
     A                    1PE12.4)
      PRINT 130
 130  FORMAT (/5X,28H CARD 8 DATA    E12.4 FORMAT  /)
      PRINT 135, POD
 135  FORMAT(
     180H  POD     PARAMETER OSCILLATION DAMPER (SEARCH ONLY)
     A                    1PE12.4//)
      NXCM = TTL - IHS
      IF (POWR.EQ.0 ) GO TO 145
      SRCRT = POWR
 145  CONTINUE
      FPF = 215.*1.602*10.**(-19)
      TMAX = TMAX*60.
      KPAGE = 58
      IZP = IZM + 1
      IP  = IM + 1
      JP  = JM + 1
      IGP = IGM + 1
      IGEP = IGE + 1
      IMJM = IM*JM
      MT=ML + IZM
      EQ = .0
      LAP = .0
      LAPP = .0
      LAR = 0.0
      ALA = .0
      LC = 0
      P02 = 0
      CVT = 0
      CNT = 0
      NCON = 0
      T06 = 0
      IBUR=0
      IF (FLXTST.EQ.0.) FLXTST = EPS
      TEMF= 0.
      IF (IEVT.EQ.2) TEMF= 1.
      K07=IEVT
      IF (IEVT.NE.3) GO TO 155
      T06 = 1
 155  CONTINUE
      IF(ISTART.NE.3) GO TO 165
      REWIND NDUMP
 165  CONTINUE
C     COMPUTE DIMENSION POINTERS
      LATW = 1
      LHOLN = LATW + ML
      LALAM = LHOLN + ML
      LCN = LALAM + ML
      LI0 = LCN + ITL*MT
      LI1 = LI0 + M01
      LI2 = LI1 + M01
      LPHIP = LI2 + M01
      LPHIPP = LPHIP + IZM
      LVOL = LPHIPP + IZM
```

```
      LN0 = LVOL + IZM
      LAXX = LN0 + IMJM
      LFXX = LAXX + ML*IZM
      LMATN = LFXX + ML*IZM
      LLD = LMATN + ML
      LLCN = LLD + ML
      LLFN = LLCN + ML*2
      LN2 = LLFN + ML*7
      LA0 = LN2 + IMJM
      LA1 = LA0 + IP
      LF0 = LA1 + IM
      LF2 = LF0 + IMJM
      LI3 = LF2 + IMJM
      LI4 = LI3 + M01
      LK6 = LI4 + M01*ITEMF
      LK7 = LK6 + IGM
      LM0 = LK7 + IGM
      LM2 = LM0 + IMJM
      LR0 = LM2 + IZM
      LR1 = LR0 + IP
      LR2 = LR1 + IP
      LR3 = LR2 + IM*T06
      LR4 = LR3 + IZ*T06
      LR5 = LR4 + IM
      LS2 = LR5 + IM
      LV0 = LS2 + IMJM
      LZ0 = LV0 + IMJM
      LZ1 = LZ0 + JP
      LZ2 = LZ1 + JP
      LZ3 = LZ2 + JM*T06
      LZ4 = LZ3 + JZ*T06
      LZ5 = LZ4 + JM
      LCXS  = LZ5 + JM
      LMASS = LCXS + IMJM*3
      LNBR = LMASS + ML*IZM
      LPHIB = LNBR + ML
      LAXS = LPHIB + IZM
      LFXS = LAXS + ML*IZM
      LMASSP = LFXS + ML*IZM
      LCXR = LMASSP + ML*IZM
      LCXT = LCXR + JM
      LHA = LCXT + IM
      LPA=LHA + MAX0(IM,JM)
      LPFRAC = LPA + MAX0(IM,JM)
      LNTRIG = LPFRAC + IZM
      LPFPRV = LNTRIG + M01*MWDT
      LBURUP = LPFPRV + IZM*MWDT
      LFUTOT = LBURUP + IZM*MWDT
      LBRDRT = LFUTOT + IZM*MWDT
      LAST = LBRDRT + IZM
  175 ITEMP = 1 + 3*ML + IGP*ITL*MT
      PRINT 180, LAST,ITEMP
  180 FORMAT(/2X,5HLAST=I6/,2X,50HTEMPORARY STORAGE FOR CROSS SECTION RE
     2ARRANGEMENT=,I6)
      IF(LAST - ITEMP) 185,190,190
  185 LAST=ITEMP
  190 CONTINUE
C     READ CROSS SECTIONS AND WRITE CROSS SECTION TAPE
```

```
      CALL XSECT( A(LNO),A(LCO),ITL,IGM,MT,A(LATW),A(LHOLN),A(LALAM))
      DO 195  I=LCO, LAST
  195 A(I)=0.
C     READ FLUXES AND WRITE FLUX TAPE
      IF (ISTART.EQ.4) GO TO 199
      CALL INPFLX ( A(LNO), A(LRO), A(LZO))
  199 PRINT 200
  200 FORMAT(51H0MESH BOUNDARIES (R0/Z0=RADIAL POINTS/AXIAL POINTS))
C     READ RADIAL INTERVALS
      CALL REARL(6H     R0,A(LRO),IP)
C     READ AXIAL INTERVALS
      CALL REARL(6H     Z0,A(LZO),JP)
      IF (ISTART.NE.4) GO TO 210
C     DETERMINE SINUSOIDAL FLUX GUESS AND PREPARE FLUX TAPE
      CALL SINUS(A(LNO),A(LRO),A(LR1),A(LZO),A(LZ1),IP,JP,IBL,IBR,IBT,
     1           IBB,IGM)
  210 CONTINUE
C     READ ZONE NUMBERS
      PRINT 215
  215 FORMAT(30H0ZONE NUMBERS BY MESH INTERVAL)
      CALL REAFXP(6H     M0,A(LMO),IPJM)
C     SET MATERIAL NUMBERS FOR REGIONS
      PRINT 220
  220 FORMAT(25H0MATERIAL NUMBERS BY ZONE)
      LM3=LM2 + IZM - 1
      K=1
      DO 221 I=LM2,LM3
      INTT(I)=K + ML
  221 K=K + 1
      PRINT 222, IZM, (INTT(I),I=LM2,LM3)
  222 FORMAT(10X,2HM2,I6/(10I12))
C     READ FISSION FRACTIONS
      PRINT 225
  225 FORMAT(17H0FISSION SPECTRUM)
      CALL REARL(6H     K7,A(LK7),IGM)
      IF(M01) 250,250,230
  230 PRINT 240
  240 FORMAT(82H0MIXTURE SPECIFICATIONS (I0/I1/I2=MIX NUMBER/MAT. NUMBER
     1 FOR MIX/MATERIAL DENSITY))
      CALL REAFXP (6H     I0, A(LI0), M01)
      CALL REAFXP (6H     I1, A(LI1), M01)
      CALL REARL  (6H     I2, A(LI2), M01)
      GO TO 255
  250 CALL ERRO2(6H** INP,250,1)
C     CHECK FOR DELTA CALCULATION
  255 IF (IEVT.NE.3) GO TO 280
      PRINT 270
  270 FORMAT(85H0DELTA OPTION DATA    (R2/Z2/R3/Z3=RADIAL/AXIAL ZONE NOS.
     1/RADIAL/AXIAL ZONE MODIFIERS))
      CALL REAFXP(6H     R2, A(LR2), IM)
      CALL REARL(6H     R3,A(LR3),IZ)
      CALL REAFXP(6H     Z2, A(LZ2), JM)
      CALL REARL(6H     Z3,A(LZ3),JZ)
C     CHECK FOR SEARCH CALCULATION
  280 IF(IEVT.NE.2) GO TO 285
      CALL REARL(6H     I4,A(LI4),M01)
C     CHECK FOR BURNUP CALCULATION
  285 IF (MUDT.EQ.0) GO TO 290
```

```
C       READ IN THE NTRIG ARRAY
        CALL TRIG(A(LNTRIG),M01)
C       END OF INPUT DATA
C
 290    CALL MAPR(A(LM0),A(LM2),IM,JM,A(LC0))
        IF(LAST - 30000) 330, 330,300
 300    PRINT 310
 310    FORMAT(26H PROGRAM CAPACITY EXCEEDED)
 320    STOP
 330    CONTINUE
C
C       DETERMINE DIRECTION OF LINE INVERSION
C
        IF (ISE.EQ.2) GO TO 370
        GO TO (350, 360, 370, 340) MSHSWP
 340    IBSUM = IBL + IBR + IBT + IBB
        IF (IBSUM.EQ.1) GO TO 350
        RM = AA(LR1 - 1)
        ZM = AA(LZ1 - 1)
        IF ((RM*JM/(ZM*IM)) - 1.) 360,370,370
 350    NSWEEP = 0
        GO TO 380
 360    NSWEEP = -1
        GO TO 380
 370    NSWEEP = 1
 380    PRINT 385
 385    FORMAT(////5X, 12H * * * * * * /)
        ITEMP = NSWEEP + 2
        GO TO (390,400,410) ITEMP
 390    PRINT 395
 395    FORMAT (5X,38H DIRECTION OF LINE INVERSION = RADIAL   )
        GO TO 420
 400    PRINT 405
 405    FORMAT(5X,52HDIRECTION OF LINE INVERSION = ALTERNATING DIRECTION )
        GO TO 420
 410    PRINT 415
 415    FORMAT (5X, 36H DIRECTION OF LINE INVERSION = AXIAL   )
 420    RETURN
        END
```

```
        SUBROUTINE ERR02( HOL,JSUBR,I)
        COMMON    NINP   ,NOUT   ,NCR1   ,NFLUX1,NSCRAT
        PRINT 5 ,   HOL, JSUBR
 5      FORMAT(2H */9H ERROR IN,A6,3H AT,I6/2H */2H *)
        GO TO (10,15) I
 10     STOP
 15     RETURN
        END
```

```
      SUBROUTINE XSECT (C, CO, JTL, JGM, JMT, ATW, HOLN, ALAM)
      COMMON   NINP,    NCUT,    NCR1, NFLUX1, NSCRAT, ISCRAT,  NDUMP,
     1        NMICR,    ALA,     B07,     CNT,     CVT,    DAY, E0(51),
     2  E1(51), E2(51), E3(51), E4(51), E5(51), E6(51), E7(51),
     3  E8(51), E9(51),      E01,     E02,     E03
      COMMON     E0,     EVP,    EVPP,     EPF,    GBAR,   IGEP,    IGP,
     1         IGV,      II,    IMJM,      IP,   ITEMP, ITEMP1, ITEMP2,
     2         IZP,      JP,     K07,  KPAGE,    LAP,    LAPP,    LAR,
     3          LC,   NGCTO,    ORFP,     P02,    PBAR,
     4        SBAR,     SK7,     T06,     T11,    TEMP,  TEMP1,  TEMP2,
     5       TEMP3,   TEMP4,      TI,     V11,    NXCM
      COMMON ID(23),    IMAX,     IGE,     IZM,      IM,     JM,    IBL,
     1         IBR,     IBT,     IBB,     IGM,    IEVT,   IPVT, ISTART,
     2          ML,      MT,     MOL,    ICST,     IHT,    IHS,    ITL,
     3          IZ,      JZ,    OITM,    IITM,    MWDT,  IPFLX,  IPRIN,
     4      NMTPS,    IREF,   IXSEC,   MPOIS,    NCON
      COMMON    EPS,   SRCRT,    POUR,     ORF,  FLXTST,     PV,   EPSA,
     1          FV,     EVM,    XLAL,    XLAH,    POD,    NELT,    IFS,
     2      NNSTP,    IBUR,     EV2,     NGO,  IBRTRG,  NCOEF, NSWEEP
      INTEGER   B07,     CNT,     CVT,     P02,    T06,      R2,     Z2
      INTEGER  OITM
      REAL       I2,      I3,      K6,      K7,     LAP,   LAPP,    LAR,
     1           N0,      N2,    MASS,   MASSP,     I4
      DIMENSION C(JTL,JGM,JMT), CO(JTL,JMT), ATW(1), HOLN(1), ALAM(1)
C
C     THIS SUBROUTINE READS CROSS SECTIONS FROM CARDS OR TAPE AND WRITES
C     CROSS SECTION TAPE (DISK FILE)
C
      PRINT 5, (ID(I),I=1,23)
    5 FORMAT (1H1,12A6/11A6///)
      IF(IXSEC.EQ.1) REWIND NMICR
      DO 150 I=1,ML
      IF(IXSEC.EQ.1) GO TO 15
      READ(NINP,10) HOLN(I),ATW(I),ALAM(I)
   10 FORMAT(A6,2E6.2)
      GO TO 20
   15 READ(NMICR) HOLN(I),ATW(I),ALAM(I)
      READ(NMICR) ((C(L,IIG,I),L=1,ITL),IIG=1,IGM)
   20 ALAM(I)=ALAM(I)/(24.*3600.)
      PRINT 25, I,HOLN(I)
   25 FORMAT(I3,6X,A6)
      IF(IXSEC.EQ.1) GO TO 150
C     DETERMINE TYPE OF XSECT CARDS,ICST=1/2=TYPE1/TYPE2
      IF (ICST.EQ. 2) GO TO 70
      DO 30 IIG=1,IGM
   30 READ(NINP,35) (C(L,IIG,I),L=1,ITL)
   35 FORMAT(6E12.5)
      GO TO 150
   70 READ(NINP,35) ((C(L,IIG,I),L=1,ITL),IIG=1,IGM)
  150 CONTINUE
      IF(IXSEC.EQ.1) REWIND NMICR
      IF (ICST.EQ.1) GO TO 190
C     SECTION TO DELETE POSITIONS ONE AND THREE FROM CROSS SECTIONS
      ITL = ITL - 2
      INDL = 0
      DO 180 M=1,ML
      DO 180 J=1,IGM
      DO 170 I = 1, ITL
```

```
      IF ( I .GE. 2 ) GO TO 160
      L = I + 1 +INDL
      TEMPX = C ( L, J, M )
      C ( I, J, M ) = TEMPX
      GO TO 170
  160 IF ( I .GT.ITL) GO TO 170
      L = I + 2     +INDL
      TEMPX = C ( L, J, M )
      C ( I, J, M ) = TEMPX
  170 CONTINUE
      INDL = INDL + 2
  180 CONTINUE
      IHS = IHS - 2
      IHT = IHT - 2
  190 CONTINUE
C     CHECK ON CROSS SECTION CONSISTENCY AND ORDER
      TEMP1=1.0
      TEMP2=0.01
      DO 260 J=1,ML
      DO 260  I=1,IGM
      G = C (IHT-2, I,J ) + C ( IHS, I, J)
      DO 210  K = 1, NXCM
      KK = I + K
      M = IHS + K
      IF(KK - IGM)  200, 200, 210
  200 G = G + C(M,KK,J)
  210 CONTINUE
      IF ( ABS((G-C(IHT,I,J))/C(IHT,I,J))-.01) 240,220,220
  220 PRINT 265, J,I,TEMP1
      GO TO 260
  240 IF (ABS((G-C(IHT,I,J))/C(IHT,I,J))-.0001) 260,250,250
  250 PRINT 265, J,I,TEMP2
  260 CONTINUE
  265 FORMAT(1H /,16H CHECK MATERIAL I2,5X, 7H GROUP I2,2X,36HCROSS SECT
     2ION IMBALANCE IN EXCESS OF,F5.2,8H PERCENT)
C     WRITE CROSS SECTION TAPE
      DO 280 IIG=1,IGM
      DO 270  M=1,MT
      DO 270  L=1,ITL
  270 CO(L,M)=C(L,IIG,M)
  280 WRITE (NCR1)     ((CO(L,M),L=1,ITL),M=1,MT)
      REWIND NCR1
      RETURN
      END
```

```
      SUBROUTINE INPFLX (NO, RF, ZF)
      COMMON   NINP,    NCUT,    NCR1, NFLUX1, NSCRAT, ISCRAT,  NDUMP,
     1         NMICR,    ALA,     B07,    CNT,    CVT,    DAY, E8(51),
     2      E1(51), E2(51), E3(51), E4(51), E5(51), E6(51), E7(51),
     3      E8(51), E9(51),     E01,    E02,    E03
      COMMON     ED,     EVP,    EVPP,    EPF,   GBAR,   IGEP,    IGP,
     1          IGV,      II,   IMJM,     IP,  ITEMP, ITEMP1, ITEMP2,
     2          IZP,      JP,     K07,  KPAGE,    LAP,   LAPP,    LAR,
     3           LC,   NGCTO,    ORFP,    P02,   PBAR,
     4         SBAR,     SK7,     T06,    T11,   TEMP,  TEMP1,  TEMP2,
     5        TEMP3,   TEMP4,      TI,    V1),   MXCM
      COMMON ID(23),    IMAX,     IGE,    IZM,     IM,     JM,    IBL,
     1          IBR,     IBT,     IBB,    IGM,   IEVT,   IPVT, ISTART,
     2           ML,      MT,     M01,   ICST,    IHT,    IHS,    ITL,
     3           IZ,      JZ,    OITM,   IITM,   IWDT,  IPFLX,  IPRIN,
     4       IDMTPS,    IREF,   IXSEC,  MPOIS,   NCON
      COMMON    EPS,   SRCRT,    POWR,    DRF, FLXTST,     PV,   EPSA,
     1           EV,     EVM,    XLAL,   XLAH,    POD,   DELT,    IFS,
     2        MISTP,    IBUR,     EV2,    NGO, IBRTRG,  NCOEF, NSWEEP
      INTEGER   B07,     CNT,     CVT,    P02,    T06,     R2,     Z2
      INTEGER  OITM
      REAL       I2,      I3,      K6,     K7,    LAP,   LAPP,    LAR,
     1           NO,      N2,    MASS,  MASSP,     I4
      DIMENSION  NO(1), RF(1), ZF(1)
C     THIS SUBROUTINE READS INPUT FLUXES AND PREPARES FLUX TAPE (DISK)
      PRINT 5
    5 FORMAT(1H1)
C     ISTART = 0/1/2/3/4=NO FLUX/CARDS/CARDS/TAPE/SINUSOID
      KK = ISTART + 1
      DO 120   IIG = 1, IGM
      GO TO (110,30,80,100,120) KK
   10 DO 20  I=1, IM
      DO 20   J = 1, JM
      ITEMP = (J - 1)*IM + I
   20 NO(ITEMP) = 1.0
      GO TO 110
   30 IF(IIG - 1)  40,40,60
   40 PRINT 50
   50 FORMAT(55H0FLUX GUESS  (RF/ZF=TOTAL RADIAL FLUX/TOTAL AXIAL FLUX))
      READ(NINP,90)  (RF(I),I=1,IM)
      READ(NINP,90)  (ZF(J),J=1,JM)
      PRINT 52, IM, (RF(I),I=1,IM)
   52 FORMAT (6X,3H RF,I6/(10E12.5))
      PRINT 54, JM, (ZF(J),J=1,JM)
   54 FORMAT (6X,3H ZF,I6/(10E12.5))
   60 DO 70   I = 1, IM
      DO 70   J = 1, JM
      ITEMP = (J - 1)*IM + I
   70 NO(ITEMP) = RF(I)*ZF(J)
      GO TO 110
   80 READ(NINP,90)    (NO(I), I=1, IMJM)
   90 FORMAT(6E12.6)
      GO TO 110
  100 READ (NDUMP)  (NO(I), I=1,IMJM)
  110 WRITE(NFLUX1)   (NO(I), I=1, IMJM)
  120 CONTINUE
      REWIND NFLUX1
      REWIND NDUMP
      RETURN
      END
```

```
      SUBROUTINE SINUS(N0,R0,R1,Z0,Z1,IP,JP,IBL,IBR,IBT,IBB,IGM)
      COMMON NINP,NOUT,NCR1,NFLUX1
      REAL N0
      DIMENSION N0(1), R0(1), R1(1),Z0(1), Z1(1)
C     RADIAL SINUSOID CALCULATION
      KRAD = 2*IBL + IBR + 1
      MIM = IP-1
      GO TO (10,20,30,40), KRAD
 10   RTOT = 5. + R0(IP) -R0(1) + 5.
      DO 11 I=1,MIM
      R1(I) = ((R0(I) + R0(I+1))*0.5 + 5.)*3.14159/RTOT
 11   R1(I) = SIN(R1(I))
      GO TO 50
 20   RTOT = 5. + R0(IP) - R0(1)
      DO 21 I=1,MIM
      R1(I) = ((R0(I)+R0(I+1)) *0.5 + 5.0)*3.14159/(2.0*RTOT)
 21   R1(I) = SIN(R1(I))
      GO TO 50
 30   RTOT = 5.0 + R0(IP)-R0(1)
      DO 31 I=1,MIM
      R1(I) = ((R0(I)+R0(I+1))*0.5)*3.14159/(2.0*RTOT)
 31   R1(I)= COS(R1(I))
      GO TO 50
 40   DO 41 I=1,MIM
 41   R1(I) = 1.0
C     AXIAL SINUSOID CALCULATION
 50   KVERT = 2*IBB + IBT + 1
      MJM = JP-1
      GO TO (60,70,80,90), KVERT
 60   ZTOT = 5.0 + Z0(JP) - Z0(1) + 5.0
      DO 61 J=1,MJM
      Z1(J) = ((Z0(J)+Z0(J+1))*0.5 + 5.0)*3.14159/ZTOT
 61   Z1(J) = SIN(Z1(J))
      GO TO 100
 70   ZTOT = 5.0 + Z0(JP) -Z0(1)
      DO 71 J=1,MJM
      Z1(J) = ((Z0(J) + Z0(J+1))*0.5 + 5.0)*3.14159/(2.0*ZTOT)
 71   Z1(J) = SIN(Z1(J))
      GO TO 100
 80   ZTOT = 5.0 + Z0(JP) - Z0(1)
      DO 81 J=1,MJM
      Z1(J) = ((Z0(J)+Z0(J+1))*0.5 )*3.14159/(2.0*ZTOT)
 81   Z1(J)= COS(Z1(J))
      GO TO 100
 90   DO 91 J = 1,MJM
 91   Z1(J) = 1.0
 100  PRINT 101
 101  FORMAT (55H0FLUX SHAPE  (RF/ZF=TOTAL RADIAL FLUX/TOTAL AXIAL FLUX)
     1)
      PRINT 102 ,      MIM,( R1(I),I=1,MIM)
 102  FORMAT (6X,3H RF,I6/(10E12.5))
      PRINT 103,       MJM,(Z1(J),J=1,MJM)
 103  FORMAT (6X,3H ZF,I6/(10E12.5))
      DO 104 I=1,MIM
      DO 104 J=1,MJM
      ITEMP = (J-1)*MIM + I
 104  N0(ITEMP) = R1(I)*Z1(J)
      MIMJM = MIM*MJM
      DO 105 II=1,IGM
 105  WRITE(NFLUX1) (N0(I),I=1,MIMJM)
      REWIND NFLUX1
      RETURN
      END
```

```
      SUBROUTINE REARL (HOLL,ARRAY,NCOUNT)
      DIMENSION ARRAY(1),V(12),K(12),IN(12)
      COMMON   NINP   ,NOUT   ,NCR1   ,NFLUX1,NSCRAT
      JFLAG=0
      J=1
 10   IF(JFLAG)20,40,20
 20   DO 30 JJ=1,6
      K(JJ)=K(JJ+6)
      IN(JJ)=IN(JJ+6)
 30   V(JJ)=V(JJ+6)
      JFLAG=0
      GO TO 60
 40   READ (NINP,50)        (K(I),IN(I),V(I),I=1,6)
 50   FORMAT(6(I1,I2,E9.4))
 60   DO 140 I=1,6
      L=K(I)+1
      GO TO (70,80,100,150),L
C     NO MODIFICATION
 70   ARRAY(J)=V(I)
      J=J+1
      GO TO 140
C     REPEAT
 80   L=IN(I)
      DO 90 M=1,L
      ARRAY(J)=V(I)
      J=J+1
 90   CONTINUE
      GO TO 140
C     INTERPOLATE
 100  IF(I-5) 120,110,110
 110  READ (NINP,50)        (K(JJ),IN(JJ),V(JJ),JJ=7,12)
      JFLAG=1
 120  L=IN(I)+1
      DEL=(V(I+1)-V(I))/FLOAT (L)
      DO 130 M=1,L
      ARRAY(J)=V(I)+DEL*FLOAT (M-1)
      J=J+1
 130  CONTINUE
 140  CONTINUE
      GO TO 10
C     TERMINATE
 150  J=J-1
      PRINT 160,             HOLL,J      ,( ARRAY(I),I=1,J)
 160  FORMAT(6X,A6,I6/(10E12.5))
      IF(J   -NCOUNT)170,180,170
 170  CALL ERRO2( 6H*REARL,170,1)
 180  RETURN
      END
```

```
      SUBROUTINE REAFXP (HOLL, IARRAY, NCOUNT)
      DIMENSION IARRAY(1),IV(6),K(6),IN(6)
      COMMON    NINP   ,NOUT   ,NCR1   ,NFLUX1,NSCRAT
      J=1
 10   READ(NINP,20)          (K(I),IN(I),IV(I),I=1,6)
 20   FORMAT(6(I1,I2,I9))
      DO 70 I=1,6
      L=K(I)+1
      GO TO (30,40,60,80 ),L
C     NO MODIFICATION
 30   IARRAY(J)=IV(I)
      J=J+1
      GO TO 70
C     REPEAT
 40   L=IN(I)
      DO 50 M=1,L
      IARRAY(J)=IV(I)
      J=J+1
 50   CONTINUE
      GO TO 70
C     INTERPOLATE
 60   CALL ERR02(6H*REAFX,60,1)
 70   CONTINUE
      GO TO 10
C     TERMINATE
 80   J=J-1
      PRINT 90,            HOLL,J        ,(IARRAY(I),I=1,J)
      IF(J   -NCOUNT)100,110,100
 90   FORMAT(6X,A6,I6/(10I12))
 100  CALL ERR02( 6H*REAFX,100,1)
 110  RETURN
      END
```

```
      SUBROUTINE TRIG (NDUM,MM)
      COMMON    NINP,NOUT
      DIMENSION   NDUM(1)
      READ(NINP,10)  (NDUM(I) ,  I=1,MM)
 10   FORMAT(24I3)
      RETURN
      END
```

```
      SUBROUTINE MAPR (M0,M2, JIM,JJM, K)
      COMMON    MINP,    NCUT,    NCR1, NFLUX1, NSCRAT, ISCRAT,  NDUMP,
     1        NMICR,     ALA,     B07,     CNT,     CVT,    DAY, E0(51),
     2       E1(51), E2(51), E3(51), E4(51), E5(51), E6(51), E7(51),
     3       E8(51), E9(51),     E01,     E02,     E03
      COMMON       EQ,     EVP,    EVPP,     EPF,    GBAR,   IGEP,    IGP,
     1            IGV,      II,    IMJM,      IP,   ITEMP, ITEMP1, ITEMP2,
     2            IZP,      JP,     K07,   KPAGE,     LAP,   LAPP,    LAR,
     3             LC,   NGCTO,    ORFP,     P02,    PBAR,
     4           SBAR,     SK7,     T06,     T11,    TEMP,  TEMP1,  TEMP2,
     5          TEMP3,   TEMP4,      TI,     V11,    MXCM
      COMMON  ID(23),    IMAX,     IGE,     IZM,      IM,     JM,    IBL,
     1            IFR,     IBT,     IBB,     IGM,    IEVT,   IPVT, ISTART,
     2             ML,      MT,     M01,    ICST,     IHT,    IHS,    ITL,
     3             IZ,      JZ,    OITM,    IITM,    MWDT,  IPFLX,  IPRIN,
     4         IDMTPS,    IREF,  IXSEC,    MPOIS,    NCON
      COMMON      EPS,   SHCRT,    POWR,     ORF,  FLXTST,     PV,   EPSA,
     1             EV,     EVM,    XLAL,    XLAH,     POD,   HELT,    IFS,
     2          NUSTP,    IBUR,     EV2,     NGO,  IBRTRG,  HCOEF, NSWEEP
      INTEGER     B07,     CNT,     CVT,     P02,     T06,     R2,     Z2
      INTEGER    OITM
      REAL         I2,      I3,      K6,      K7,     LAP,   LAPP,    LAR,
     1             N0,      N2,    MASS,   MASSP,      I4
      DIMENSION M0(JIM*JJM), M2(1), K(1)
C     PRODUCE A PICTURE PRINT BY ZONE AND MATERIAL
      PRINT 10, (ID(I), I=1,23)
   10 FORMAT (1H1,12A6/11A6///)
      DO 20  JJ=1,JM
      J=JM-JJ+1
   20 PRINT 30,              (M0(I,J),I=1,IM)
   30 FORMAT( 5H      ,55I2)
      PRINT 40
   40 FORMAT(2H A/2H X/2H I/2H A/2H L//8H  RADIAL)
      PRINT 10, (ID(I),I=1,23)
      DO 60 JJ=1,JM
      J=JM-JJ+1
      DO  50 L=1,IM
      N=M0(L,J)
   50 K(L)=IABS (M2(N))
   60 PRINT 30,          (K(L),L=1,IM)
      PRINT 40
      RETURN
      END
```

```
      SUBROUTINE INIT (K6, K7, I0, I1, I2, M0, M2, N0, R0, R1, R2,
     1                  R3, R4, R5, Z0, Z1, Z2, Z3, Z4, Z5, A0, A1,
     2          F0, C0, V0, JTL, JIM, JJM, JMT, NTRIG, I4)
      COMMON   NINP,    NCUT,    NCR1, NFLUX1, NSCRAT, ISCRAT,  NDUMP,
     1        NMICR,     ALA,     B07,    CNT,    CVT,    DAY, E0(51),
     2       E1(51), E2(51), E3(51), E4(51), E5(51), E6(51), E7(51),
     3       E8(51), E9(51),     E01,    E02,    E03
      COMMON     EQ,     EVP,    EVPP,    EPF,   GBAR,   IGEP,    IGP,
     1          IGV,      II,    IMJM,     IP,  ITEMP, ITEMP1, ITEMP2,
     2          IZP,      JP,     K07, KPAGE,    LAP,   LAPP,    LAR,
     3           LC,   NGOTO,    ORFP,    P02,   PBAR,
     4         SBAR,     SK7,     T06,    T11,   TEMP,  TEMP1,  TEMP2,
     5        TEMP3,   TEMP4,      TI,    V11,   UXCM
      COMMON ID(23),    IMAX,     IGE,    IZM,     IM,     JM,    IBL,
     1          IBR,     IBT,     IRB,    IGM,   IEVT,   IPVT, ISTART,
     2           ML,      MT,     M01,   ICST,    IHT,    IHS,    ITL,
     3           IZ,      JZ,    OITM,   IITM,   MWDT,  IPFLX,  IPRIN,
     4       IDMTPS,    IREF,   IXSEC,  NPOIS,   NCON
      COMMON    EPS,   SRCRT,    POWR,    ORF, FLXTST,     PV,   EPSA,
     1           EV,     EVM,    XLAL,   XLAH,    POD,   DELT,    IFS,
     2        NBSTP,    IBUR,     EV2,    NGO, IHRTRG,  NCOEF, NSWEEP
      INTEGER   B07,     CNT,     CVT,    P02,    T06,     R2,     Z2
      INTEGER  OITM
      REAL       I2,      I3,      K6,     K7,    LAP,   LAPP,    LAR,
     1           N0,      N2,    MASS,  MASSP,     I4
      DIMENSION  K6(1), K7(1), I0(1), I1(1), I2(1), R0(1), R1(1),
     1           R2(1), R3(1), R4(1), R5(1), Z0(1), Z1(1), Z2(1),
     2           Z3(1), Z4(1), Z5(1), A0(1), A1(1), C0(JTL,JMT),
     3           V0(JIM,JJM), M0(1), M2(1), N0(1), F0(1),
     4           NTRIG(1) , I4(1)
      IF(P02) 15,5,15
    5 PRINT 10, DAY
   10 FORMAT(1H1,30X,11H T I M E  =F8,3,8H D A Y S///)
   15 B07=1
C     PRINT ATOM DENSITIES IF P02=0
      IF(P02) 65,20,65
   20 IF(MWDT,FQ.1) GO TO 35
      PRINT 25,        (J, I0(J), I1(J), I2(J) , J=1,M01)
   25 FORMAT(1H0,3X,16H MIXTURE NUMBER ,18H   MIX COMMAND     ,24H MATERI
     2AL ATOMIC DENSITY//(I4,1X,I8,8X,I8,8X,E20.8))
      GO TO 45
   35 PRINT 40,        (J, I0(J), I1(J), I2(J), NTRIG(J),  J=1,M01)
   40 FORMAT(1H0,3X, 16H MIXTURE NUMBER ,18H   MIX COMMAND         ,
     224H MATERIAL ATOMIC DENSITY,12H        NTRIG//(I4,1X,I8,8X,I8,8X,E2
     30.8,9X,I6))
   45 IF(IPRIN.EQ.3) GO TO 70
      IF(DAY.NE.0.) GO TO 60
   50 PRINT 55
   55 FORMAT(/19H1CROSS-SECTION EDIT)
      GO TO 70
   60 IF(IPRIN.EQ.1) GO TO 50
      GO TO 70
   65 IF(IEVT.NE.2) GO TO 175
C     CALCULATE MACROSCOPIC CROSS SECTIONS
   70 REWIND NCR1
      DO 170 IIG=1,IGM
      READ (NCR1)     ((C0(I,J),I=1,ITL),J=1,MT)
      DO 120 M=1,M01
```

```
      IF(I0(M) - MT) 80,80,75
75    CALL ERRO2(6H* INIT,75,1)
80    IF(I1(M) -MT) 85,75,75
85    N=I0(M)
      L=I1(M)
      TEMP=0.
      IF(IEVT.EQ.2) TEMP=I4(M)
      E01 = I2(M)*(1. + EV*TEMP)
105   DO 120 I=1,ITL
      IF(L) 110,115,110
110   C0(I,N)=C0(I,N)+C0(I,L)*E01
      GO TO 120
115   C0(I,N)=C0(I,N)*E01
120   CONTINUE
      IF(P02) 165,125,165
125   IF(IPRIN.EQ.3) GO TO 165
      IF(DAY.NE.0.) GO TO 150
130   PRINT 135, IIG
135   FORMAT(7H GROUP I3,15H CROSS-SECTIONS)
      DO 140 N=1,MT
140   PRINT 145, N, (C0(I,N),I=1,ITL)
145   FORMAT(4H MAT,I3,(10E11.3))
      GO TO 165
150   IF(IPRIN.EQ.1) GO TO 130
165   WRITE (NSCRAT)    ((C0(I,J),I=1,ITL),J=1,MT)
170   CONTINUE
      REWIND NCR1
      REWIND NSCRAT
C     SWITCH TAPE DESIGNATIONS
      ITEMP=NSCRAT
      NSCRAT=NCR1
      NCR1=ITEMP
175   CONTINUE
      NCOEF=1
C     MODIFY GEOMETRY
      IF(P02) 200,180,200
180   IF(NCON) 300,185,300
185   DO 190 I=1,IP
190   R1(I)=R0(I)
      DO 195 J=1,JP
195   Z1(J)=Z0(J)
200   IF(IEVT.NE.3) GO TO 230
      DO 205 I=1,IM
      K=R2(I)
205   R1(I+1)=R1(I)+(R0(I+1)-R0(I))*(1.0+ EV*R3(K))
      DO 210 J=1,JM
      K=Z2(J)
210   Z1(J+1)=Z1(J)+(Z0(J+1)-Z0(J))*(1.0+ EV*Z3(K))
      IF(IGE - 2) 230,215,230
215   IF(ABS (Z1(JP)-1.0)-1.0E-04)230,230,220
220   CALL ERRO2(6H* INIT,220,1)
230   CONTINUE
C     CALCULATE AREAS AND VOLUMES
      PI2=6.28318
      IF(P02) 235,240,235
235   IF(IEVT.NE.3) GO TO 300
240   DO 275 I=1,IM
      R4(I)=(R1(I+1)+R1(I))*0.5
```

```
      R5(I)=R1(I+1)-R1(I)
      IF( R5(I) ) 245,245,250
245   CALL ERRO2(6H* INIT,245,1)
250   GO TO (255,260,265) , IGEP
255   A0(I)=1.
      A0(IP)=1.
      A1(I)=R5(I)
      GO TO 270
260   A0(I)=PI2*R1(I)
      A0(IP)=PI2*R1(IP)
      A1(I)=PI2*R5(I)*R4(I)
      GO TO 270
265   A0(I)=PI2*R1(I)
      A0(IP)=PI2*R1(IP)
      A1(I)=R5(I)
270   CONTINUE
      DO 295 J=1,JM
      Z4(J)=(Z1(J+1)+Z1(J))*0.5
      Z5(J)=Z1(J+1)-Z1(J)
      IF( Z5(J) ) 275,275,280
275   CALL ERRO2(6H* INIT,275,1)
280   DO 295 I=1,IM
      GO TO (285,290,290) , IGEP
285   V0(I,J)=R5(I)*Z5(J)
      GO TO 295
290   V0(I,J)=PI2*R5(I)*Z5(J)*R4(I)
295   CONTINUE
300   CONTINUE
C     CHECK PARAMETRIC EIGENVALUE
      IF(P02) 330,305,330
305   SK7=0.
      DO 320 IIG=1,IGM
      IF(IPVT.EQ.1) GO TO 310
      K6(IIG)=K7(IIG)/PV
      GO TO 320
310   K6(IIG)=K7(IIG)
320   SK7=SK7+K7(IIG)
330   CONTINUE
C
C     CALCULATE INITIAL (OR NEW) FISSION NEUTRON SOURCES
      T11=E1(IGP)
      DO 350 I=1,IMJM
350   F0(I)=0.
      DO 360 IIG=1,IGM
      E0(IIG) = .0
      READ (NFLUX1)      (N0(I),I=1,IMJM)
      READ (NCR1)     ((C0(I,J),I=1,11L),J=1,NT)
      DO 360 J=1,JM
      DO 360 K=1,IM
      I = K + (J-1)*IM
      ITEMP=M0(I)
      ITEMP=M2(ITEMP)
      E0(IIG) = E0(IIG) + V0(K,J)*N0(I)*C0(1,ITEMP)
      F0(I)=F0(I) + C0(3,ITEMP)*N0(I)
360   CONTINUE
      REWIND NFLUX1
      REWIND NCR1
      RETURN
      END
```

```
      SUBROUTINE FISCAL   (N0, F0, V0, C0, K6, M0, M2, JTL,JMT)
      COMMON    NINP,    NCUT,    NCR1, NFLUX1, NSCRAT, ISCRAT,   NDUMP,
     1          NMICR,    ALA,     B07,    CNT,    CVT,    DAY, E0(51),
     2        E1(51), E2(51), E3(51), E4(51), E5(51), E6(51), E7(51),
     3        E8(51), E9(51),    E01,    E02,    E03
      COMMON       EQ,    EVP,    EVPP,    EPF,   GBAR,   IGEP,     IGP,
     1            IGV,     II,    IMJM,     IP,  ITEMP, ITEMP1,  ITEMP2,
     2            IZP,     JP,     K07,  KPAGE,    LAP,   LAPP,     LAR,
     3             LC,  NGCTO,    ORFP,    P02,   PBAR,
     4           SBAR,    SK7,     T06,    T11,   TEMP,  TEMP1,   TEMP2,
     5          TEMP3,  TEMP4,      TI,    V11,   NXCM
      COMMON ID(23),     IMAX,     IGE,    IZM,     IM,     JM,     IBL,
     1            IBR,    IBT,     IBB,    IGM,   IEVT,   IPVT,  ISTART,
     2             ML,     MT,     M01,   ICST,    IHT,    IHS,     ITL,
     3             IZ,     JZ,    OITM,   IITM,   NWDT,  IPFLX,   IPRIN,
     4         IDMTPS,   IREF,   IXSEC,  NPOIS,   NCON
      COMMON      EPS,  SRCRT,    POWR,    ORF, FLXTST,     PV,    EPSA,
     1             EV,    EVM,    XLAL,   XLAH,    POD,   DELT,     IFS,
     2          NUSTP,   IBUR,     EV2,    NGO, IBRTRG,  NCOEF,  NSWEEP
      INTEGER     B07,    CNT,     CVT,    P02,    T06,     R2,      Z2
      INTEGER    OITM
      REAL         I2,     I3,      K6,     K7,    LAP,   LAPP,     LAR,
     1             N0,     N2,    MASS,  MASSP,     I4
      DIMENSION  N0(1), F0(1), V0(1), C0(JTL,JMT),K6(1), M0(1), M2(1)
      LAR = ALA
C
C     FISSION SUMS
C
      IF(B07.EQ.0) GO TO 40
      E01=0.
      DO 10  I=1,IMJM
   10 E01=E01+V0(I)*F0(I)
      DO 20  IIG=1,IGM
   20 E1(IIG)=K6(IIG)*E01
      E0(IGP)=0.
      E1(IGP)=0.
      DO 30  IIG=1,IGM
      E0(IGP)=E0(IGP)+E0(IIG)
   30 E1(IGP)=E1(IGP)+E1(IIG)
      IF(B07) 70, 40, 70
   40 ALA = E1(IGP)/T11
      TEMP=1.0/ALA
      IF (IEVT-1) 70,50,70
   50 DO 60  IIG=1,IGM
      E1(IIG)=E1(IIG)*TEMP
   60 K6(IIG)=K6(IIG)*TEMP
      E1(IGP)=E1(IGP)*TEMP
   70 CONTINUE
C
C     NORMALIZATION
C
      B07=0
      IF (POWR) 140,100,90
   90 E01 = SRCRT/(E0(IGP)*EPF)
      GO TO 110
  100 E01 = SRCRT/E1(IGP)
  110 DO 120 IIG=1,IGP
  120 E1(IIG)=E01*E1(IIG)
      DO 130 I=1,IMJM
  130 F0(I)=E01*F0(I)
  140 RETURN
      END
```

```
      SUBROUTINE EVPRT
      COMMON    MINP,      NCUT,      NCR1, NFLUX1, NSCRAT, ISCRAT,   NDUMP,
     1         NMICR,       ALA,       B07,      CNT,     CVT,      DAY, E0(51),
     2        E1(51), E2(51), E3(51), E4(51), E5(51), E6(51), E7(51),
     3        E8(51), E9(51),        E01,      E02,     E03
      COMMON        EQ,       EVP,      EVPP,      EPF,    GBAR,     IGEP,     IGP,
     1             IGV,        II,      IMJM,       IP,   ITEMP,  ITEMP1, ITEMP2,
     2             IZP,        JP,       K07,   KPAGE,     LAP,     LAPP,     LAR,
     3              LC,     NGOTO,      OHFP,      P02,    PBAR,
     4            SBAR,       SK7,       T06,      T11,    TEMP,    TEMP1,   TEMP2,
     5           TEMP3,     TEMP4,        TI,      V11,    NXCM
      COMMON  ID(23),      IMAX,       IGE,      IZM,      IM,       JM,     IBL,
     1             IBR,       IBT,       IBB,      IGM,    IEVT,     IPVT, ISTART,
     2              ML,        MT,       M01,     ICST,     IHT,      IHS,     ITL,
     3              IZ,        JZ,      OITM,     IITM,    MWDT,    IPFLX,   IPRIN,
     4          IOUTPS,      IREF,    IXSEC,    NPOIS,    NCON
      COMMON       EPS,     SHCRT,      POWR,      OHF, FLXTST,       PV,    EPSA,
     1              EV,       EVM,      XLAL,     XLAH,     POD,     DELT,     IFS,
     2          NUSTP,      IBUR,       EV2,      NGO, IHRTRG,    NCOEF,  NSWEEP
      INTEGER     B07,       CNT,       CVT,      P02,     T06,       R2,      Z2
      INTEGER    OITM
      REAL         I2,        I3,        K6,       K7,     LAP,     LAPP,     LAR,
     1              N0,        N2,      MASS,    MASSP,      I4
C     MONITOR PRINT
      CALL SECOND(TI)
      TI = TI/60.
      KPAGE = KPAGE + 1
      IF(KPAGE - 40) 40,10,10
   10 KPAGE=0
      PRINT 20
   20 FORMAT(105H1      TIME              OUTER            IN. IT.       EIGENVAL
     1UE        EIGENVALUE         LAMBDA                          )
      PRINT 30
   30 FORMAT(105H     (MINUTES)       ITERATIONS        PER LOOP           SLOPE
     1                                                          /)
   40 PRINT 50, TI,P02, LC,EQ,EV, ALA
   50 FORMAT(4X,F6.3,10X,I4,11X,I4,6X,E15.8,E15.8,E15.8)
      P02=P02 + 1
      LC=0
      IF(P02 - OITM) 70,70,60
   60 NGOTO=1
      GO TO 80
   70 NGOTO=4
   80 RETURN
      END
```

```
      SUBROUTINE OUTER( A0, A1, C0, F0, K6, M0, M2, N0, N2,
     1                  S2, V0, Z5, F2, JTL, JMT, CXS,
     2                  JIM, JJM, R5, R4, Z4, CXR, CXT, HA, PA)
      COMMON   NINP,    NOUT,    NCR1, NFLUX1, NSCRAT, ISCRAT,  NDUMP,
     1         NUICR,    ALA,     B07,    CNT,    CVT,    DAY, E0(51),
     2        E1(51), E2(51), E3(51), E4(51), E5(51), E6(51), E7(51),
     3        E8(51), E9(51),     E01,    E02,    E03
      COMMON     EQ,     EVP,    EVPP,    EPF,   GBAR,   IGEP,    IGP,
     1          IGV,      II,    IMJM,     IP,  ITEMP, ITEMP1, ITEMP2,
     2          IZP,      JP,     K07,  KPAGE,    LAP,   LAPP,    LAR,
     3           LC,   NGCTO,    ORFP,    P02,   PBAR,
     4         SBAR,     SK7,     T06,    T11,   TEMP,  TEMP1,  TEMP2,
     5        TEMP3,   TEMP4,      TI,    V11,   HXCM
      COMMON ID(23),    IMAX,     IGE,    IZM,     IM,     JM,    IBL,
     1          IBR,     IBT,     IBB,    IGM,   IEVT,   IPVT, ISTAR1,
     2           ML,      MT,     M01,   ICST,    IHT,    IHS,    ITL,
     3           IZ,      JZ,    OITM,   IITM,   MWDT,  IPFLX,  IPRIN,
     4       IDMTPS,    IREF,   IXSEC,  NPOIS,   NCON
      COMMON    EPS,   SRCRT,    POWR,    ORF, FLXTST,     PV,   EPSA,
     1           EV,     EVM,    XLAL,   XLAH,    POD,   DELT,    IFS,
     2       NUSTP,     IBUR,     EV2,    NGO, IHRTRG,  NCDEF, NSWEEP
      INTEGER   B07,     CNT,     CVT,    P02,    T06,     R2,     Z2
      INTEGER  OITM
      REAL       I2,      I3,      K6,     K7,    LAP,   LAPP,    LAR,
     1           N0,      N2,    MASS,  MASSP,     I4
      DIMENSION  A0(1), A1(1), F0(1), K6(1), M0(1), M2(1),N0(1),N2(1),
     2       V0(1), V7(1), Z5(1), F2(1), C0(JTL,JMT),   HA(1), PA(1),
     3       CXS(JIM,JJM,3), R5(1), R4(1), Z4(1), CXR(1), CXT(1),S2(1)
      INTEGER       GBAR, PBAR, SBAR
      IGV=1
   10 READ(NCR1)     ((C0(I,M),I=1,ITL),M=1,MT)
C     CALCULATION OF FISSION SOURCE FOR GROUP IGV AT EACH MESH POINT
      DO 20 I=1,IMJM
   20 S2(I)=K6(IGV)*F0(I)
C     CALCULATION OF IN-SCATTERING SOURCE FOR GROUP IGV AT EACH MESH PT.
      GBAR=IGV+IHS-ITL
      IF(GBAR - 1) 40,50,50
   40 GBAR=1
   50 PBAR = IHS + IGV - 1
      IF(PBAR - ITL) 70,70,60
   60 PBAR = ITL
   70 IF(GBAR - IGV) 80,100,100
   80 READ (NSCRAT)  (N2(I),I=1,IMJM)
      DO 90 I=1,IMJM
      ITEMP=M0(I)
      ITEMP=M2(ITEMP)
      TEMP=C0(PBAR,ITEMP)
   90 S2(I)=S2(I)+N2(I)*TEMP
      GO TO 110
  100 READ (NFLUX1)  (N2(I),I=1,IMJM)
  110 GBAR=GBAR+1
      PBAR=PBAR-1
      IF(GBAR - IGV) 80,100,120
  120 IF(IGV - IGM) 140,130,140
  130 REWIND NCR1
  140 V11=0.
C     CALCULATION OF TOTAL SOURCE FOR GROUP IGV
      DO 150 I=1,IMJM
```

```
      S2(I)=S2(I)*V0(I)
  150 V11=V11+S2(I)
      IF(IGV.EQ.1) GO TO 160
      E2(IGV) = V11 - E1(IGV)
      GO TO 170
  160 E2(1)=0.
  170 CONTINUE
C     GROUP FLUX CALCULATION
      II=0
      IF(P02.NE.1) GO TO 200
  190 CALL ICOEF(M0,M2,CXS,V0,C0,A0,Z5,R5,R4,Z4,A1,IM,JM,ITL,CXR,CXT)
      GO TO 220
  200 IF(IEVT.EQ.1) GO TO 210
      IF(NCOEF.EQ.1) GO TO 190
  210 READ (ISCRAT) (((CXS(KI,KJ,KF),KI=1,IM),KJ=1,JM),KF=1,3)
      READ (ISCRAT) (CXR(KJ),KJ=1,JM), (CXT(KI),KI=1,IM)
  220 CALL INNER(N0,N2,CXS,S2,M0,M2,V0,C0,IM,JM,ITL,CXR,CXT,HA,PA)
  240 WRITE (NSCRAT) (N2(I),I=1,IMJM)
C     REPOSITION FLUX FILE FOR NEXT INSCATTERING CALCULATION(IF NEEDED)
      SBAR=ITL-INS
      IF(SBAR) 260,260,250
  250 DO 255 IS=1,SBAR
  255 BACKSPACE NSCRAT
  260 CONTINUE
C     CALCULATE NEW FISSION SOURCES
      E0(IGV)=0.
      DO 270 I=1,IMJM
      ITEMP=M0(I)
      ITEMP=M2(ITEMP)
      E0(IGV)=E0(IGV) + C0(1,ITEMP)*N2(I)*V0(I)
  270 F2(I)=F2(I) + C0(3,ITEMP)*N2(I)
      IGV=IGV+1
      IF(IGV - IGM) 10,10,280
  280 T11 = E1(IGP)
C     SWITCH TAPE DESIGNATIONS
      REWIND ISCRAT
      NCOEF=0
      REWIND NCR1
      REWIND NSCRAT
      REWIND NFLUX1
      ITEMP = NSCRAT
      NSCRAT = NFLUX1
      NFLUX1 = ITEMP
C     OVER-RELAX FISSION SOURCE
      ORFF= 1. + .6*(ORF-1.)
      E01=0.
      E02=0.
      DO 290 I=1,IMJM
      E01=E01+V0(I)*F2(I)
      F2(I)=F0(I)+ORFF*(F2(I)-F0(I))
  290 E02=E02+V0(I)*F2(I)
      TEMP1=E01/E02
      DO 300 I=1,IMJM
  300 F0(I)=TEMP1*F2(I)
C     CALCULATE NEW GROUP FISSION SOURCES
      DO 310 IIG=1,IGM
  310 E1(IIG)=K6(IIG)*E01
      E0(IGP)=0.
      E1(IGP)=0.
      DO 320 IIG=1,IGM
      E0(IGP)=E0(IGP)+E0(IIG)
  320 E1(IGP)=E1(IGP)+E1(IIG)
      RETURN
      END
```

```
      SUBROUTINE ICOEF (M0, M2, CXS, V0, C0, A0, Z5, R5, R4, Z4, A1,      ICOEF
     2                 JIM,JJM,JTL,CXR,CXT)                                ICOEF
      COMMON  NIMP,    NCUT,    NCR1, NFLUX1, NSCRAT, ISCRAT,  NDUMP,     ICOEF
     1       NMICR,    ALA,     B07,     CNT,     CVT,    DAY, E0(51),    ICOEF
     2      E1(51), E2(51), E3(51), E4(51), E5(51), E6(51), E7(51),      ICOEF
     3      E8(51), E9(51),     E01,     E02,     E03                     ICOEF
      COMMON    E0,     EVP,    EVPP,     EPF,    GBAR,   IGEP,    IGP,   ICOEF
     1         IGV,      II,    IMJM,      IP,   ITEMP, ITEMP1, ITEMP2,   ICOEF
     2         IZP,      JP,     K07,  KPAGE,     LAP,   LAPP,    LAR,    ICOEF
     3          LC,  NGCT0,    ORIP,     P02,    PBAR,                    ICOEF
     4        SBAR,     SK7,     T06,     T11,    TEMP,  TEMP1,  TEMP2,   ICOEF
     5       TEMP3,   TEMP4,      TI,     V11,    IXCM                    ICOEF
      COMMON ID(23),   TMAX,     IGE,     IZM,      IM,     JM,    IBL,   ICOEF
     1         IBR,     IBT,     IBB,     IGM,    IEVT,   IPVT, ISTART,   ICOEF
     2          ML,      MT,     M01,    ICST,     IHT,    IHS,    ITL,   ICOEF
     3          TZ,      JZ,    OITM,    IITM,    NWDT,  IPFLX,  IPRIN,   ICOEF
     4      IDMTPS,    IREF,  IXSEC,   NPOIS,    NCON                     ICOEF
      COMMON   EPS,   SRCRT,    POWR,     URF, FLXTST,     PV,   EPSA,   ICOEF
     1          EV,     EVM,    XLAL,    XLAH,     POD,   DELT,    IFS,   ICOEF
     2       NISTP,    IBUR,     EV2,     NGO, IBRTRG,  NCOEF, NSWEEP     ICOEF
      INTEGER  B07,     CNT,     CVT,     P02,     T06,     R2,     Z2    ICOEF
      INTEGER  OITM                                                       ICOEF
      REAL      I2,      I3,      K6,      K7,     LAP,   LAPP,    LAR,   ICOEF
     1          M0,      N2,    MASS,   MASSP,      I4                    ICOEF
      DIMENSION  M0(1), M2(1),CXS(JIM,JJM,3),V0(1), C0(JTL,1),            ICOEF
     1          A0(1), Z5(1), R5(1), R4(1), Z4(1), A1(1),CXR(1), CXT(1)ICOEF
C     THIS SUBROUTINE CALCULATES COEFFICIENTS FOR THE FLUX EQUATION       ICOEF
      PI2 = 6.28318                                                       ICOEF
C                                                                         ICOEF
C     FIRST MASTER LOOP CALCULATES THE FOLLOWING QUANTTTIES               ICOEF
C        1. REMOVAL X-SECT(I)*V0(I) FOR ALL MESH POINTS                   ICOEF
C        2. CXS(KI,KJ,1) FOR ALL MESH POINTS EXCEPT KI=1                  ICOEF
C        3. CXS(KI,KJ,2) FOR ALL MESH POINTS EXCEPT KJ=1                  ICOEF
C                                                                         ICOEF
      DO 60 KJ=1,JM                                                       ICOEF
      DO 60 KI=1,IM                                                       ICOEF
      GO TO (10,10, 5), IGEP                                              ICOEF
    5 TEMP = PI2*(Z4(KJ) - Z4(KJ-1))*R4(KI)                               ICOEF
      GO TO 15                                                            ICOEF
   10 TEMP = Z4(KJ) - Z4(KJ-1)                                            ICOEF
   15 I = KI + (KJ-1)*IM                                                  ICOEF
      ITEMP = M0(I)                                                       ICOEF
      ITEMP = M2(ITEMP)                                                   ICOEF
      CXS(KI,KJ,3)=V0(I)*(C0(4,ITEMP) - C0(5,ITEMP))                      ICOEF
      IF(KI - 1) 35,35,20                                                 ICOEF
   20 ITEMP1 = M0(I-1)                                                    ICOEF
      ITEMP1 = M2(ITEMP1)                                                 ICOEF
      IF (ITEMP - ITEMP1) 30,25,30                                        ICOEF
   25 CXS(KI,KJ,1)=A0(KI   )*Z5(KJ)/(3.*C0(4   ,ITEMP)*(R4(KI)-R4(KI-1))) ICOEF
      GO TO 35                                                            ICOEF
   30 CXS(KI,KJ,1) = A0(KI)*Z5(KJ)*(R5(KI-1)+R5(KI))/((R4(KI)-R4(KI-1))*ICOEF
     1 (3.*(R5(KI-1)*C0(4   ,ITEMP1) + R5(KI)*C0(4   ,ITEMP))))           ICOEF
   35 IF(KJ - 1) 60,60,40                                                 ICOEF
   40 ITEMP3 = M0(I - IM)                                                 ICOEF
      ITEMP3 = M2(ITEMP3)                                                 ICOEF
      IF (ITEMP - ITEMP3) 50,45,50                                        ICOEF
   45 CXS(KI,KJ,2) = A1(KI)/(3.*C0(4   ,ITEMP)*TEMP)                      ICOEF
      GO TO 60                                                            ICOEF
```

```
 50   CXS(KI,KJ,2) = A1(KI)*(Z5(KJ-1) + Z5(KJ))/(TEMP*
     1 (3.*(Z5(KJ-1)*C0(4   ,ITEMP3) + Z5(KJ)*C0(4   ,ITEMP))))
 60   CONTINUE
C
C     SECOND MASTER LOOP CALCULATES FLUX COEFFICIENTS ALL AROUND THE
C     REACTOR PERIMETER,AND SUMS THE COEFFICIENTS AT EACH MESH POINT.
C
      DO 190 KJ=1,JM
      DO 190 KI=1,IM
      GO TO (70,70,65) , IGEP
 65   TEMP = .5*PI2*Z5(KJ)*R4(KI)
      GO TO 75
 70   TEMP = .5*Z5(KJ)
 75   I = KI + (KJ-1)*IM
      ITEMP = M0(I)
      ITEMP = M2(ITEMP)
      TEMP1 = CXS(KI+1,KJ,1)
      TEMP2 = CXS(KI,KJ+1,2)
C     CHECK FOR BOTTOM ROW CALCULATION
      IF(KJ - 1) 80,80,110
 80   IF(IBB.EQ.1) GO TO 85
      CXS(KI,KJ,2) = A1(KI)/(3.*C0(4   ,ITEMP)*( TEMP     +.71/
     1 C0(4   ,ITEMP)))
      GO TO 140
 85   CXS(KI,KJ,2)=0.
      GO TO 140
C     CHECK FOR TOP ROW CALCULATION
 110  IF(KJ - JM) 140,115,115
 115  IF(IBT.EQ.1) GO TO 120
      TEMP2         = A1(KI)/(3.*C0(4   ,ITEMP)*( TEMP     +.71/
     1 C0(4   ,ITEMP)))
      CXT(KI) = TEMP2
      GO TO 140
 120  TEMP2=0.
      CXT(KI)=0.
C     CHECK FOR LEFT HAND COLUMN CALCULATION
 140  IF(KI - 1) 145,145,160
 145  IF(IBL.EQ.1) GO TO 150
      CXS(KI,KJ,1) = A0(KI   )*Z5(KJ)/(3.*C0(4   ,ITEMP)*
     1 (.5*R5(KI) + .71/C0(4   ,ITEMP)))
      GO TO 180
 150  CXS(KI,KJ,1)=0.
      GO TO 180
C     CHECK FOR RIGHT HAND COLUMN CALCULATION
 160  IF(KI - IM) 180,165,165
 165  IF(IBR.EQ.1) GO TO 175
      TEMP1         = A0(KI+1)*Z5(KJ)/(3.*C0(4   ,ITEMP)*
     1 (.5*R5(KI) + .71/C0(4   ,ITEMP)))
      CXR(KJ) = TEMP1
      GO TO 180
 175  TEMP1=0.
      CXR(KJ)=0.
 180  CXS(KI,KJ,3) = CXS(KI,KJ,3) + CXS(KI,KJ,1) + CXS(KI,KJ,2)
     1   + TEMP1 + TEMP2
 190  CONTINUE
      WRITE(ISCRAT) (((CXS(KI,KJ,KF),KI=1,IM),KJ=1,JM),KF=1,3)
      WRITE(ISCRAT) (CXR(KJ),KJ=1,JM), (CXT(KI),KI=1,IM)
      RETURN
      END
```

```
      SUBROUTINE INNER(N0, N2, CXS, S2, M0, M2, V0, C0,JIM,JJM, JTL,
     1                 CXR,CXT, HA, PA)
      COMMON   NINP,    NCUT,    NCR1, NFLUX1, NSCRAT, ISCRAT,  NDUMP,
     1        NMICR,     ALA,     B07,    CNT,    CVT,    DAY, E0(51),
     2       E1(51), E2(51), E3(51), E4(51), E5(51), E6(51), E7(51),
     3       E8(51), E9(51),      E01,    E02,    E03
      COMMON     EQ,     EVP,    EVPP,    EPF,   GBAR,   IGEP,    IGP,
     1          IGV,      II,    IMJM,     IP,  ITEMP, ITEMP1, ITEMP2,
     2          IZP,      JP,     K07,  KPAGE,    LAP,   LAPP,    LAR,
     3           LC,   NGCTO,    ORFP,    P02,   PBAR,
     4         SBAR,     SK7,     T06,    T11,   TEMP,  TEMP1,  TEMP2,
     5        TEMP3,   TEMP4,      TI,    V11,   NXCM
      COMMON ID(23),    IMAX,     IGE,    IZM,     IM,     JM,    IBL,
     1          IBR,     IBT,     IBB,    IGM,   IEVT,   IPVT, ISTART,
     2           ML,      MT,     M01,   ICST,    IHT,    IHS,    ITL,
     3           IZ,      JZ,    OITM,   IITM,   MWOT,  IPFLX,  IPRIN,
     4       IHMTPS,    IREF,  IXSEC,   MPOIS,   NCON
      COMMON    EPS,   SHCRT,    POWR,    ORF, FLXTST,     PV,   EPSA,
     1           EV,     EVM,    XLAL,   XLAH,    POD,   DELT,    IFS,
     2       NBSTP,    IBUR,     EV2,    NGO, IBRTRG,  NCOEF, NSWEEP
      INTEGER   B07,     CNT,     CVT,    P02,    T06,     R2,     Z2
      INTEGER  OITM
      REAL       I2,      I3,      K6,     K7,    LAP,   LAPP,    LAR,
     1           N0,      N2,    MASS,  MASSP,     I4
      DIMENSION  N0(1), N2(1),CXS(JIM,JJM,3),S2(1), M0(1), M2(1),
     1           V0(1), C0(JTL,1), CXR(1), CXT(1), HA(1), PA(1)
      CALL REBAL  (N2, C0, V0, CXS, M0, M2, ITL, IM, JM, CXR, CXT)
      IKB = IM - 1
      JKB = JM - 1
      IF (NSWEEP) 5, 5, 205
    5 DO 10 I=1,IMJM
   10 N0(I) = N2(I)
C     FLUX CALCULATION USING SOR WITH LINE INVERSION
C
C     CALCULATION OF BOTTOM BOUNDARY FLUX
      KI = 1
      KJ = 1
      I = KI + (KJ - 1)*IM
      HA(KI)= CXS(KI+1,KJ,1)/CXS(KI,KJ,3)
      PA(KI)= (S2(I) + CXS(KI,KJ+1,2)*N2(1+IM))/CXS(KI,KJ,3)
      DO 15 KI = 2,IKB
      I = KI + (KJ - 1)*IM
      HA(KI) = CXS(KI+1,KJ,1)/(CXS(KI,KJ,3)- CXS(KI,KJ,1)*HA(KI-1))
   15 PA(KI) = (S2(I) + CXS(KI,KJ+1,2)*N2(I+IM)+ CXS(KI,KJ,1)*PA(KI-1))/
     1  (CXS(KI,KJ,3) - CXS(KI,KJ,1)*HA(KI-1))
      KI = IM
      I = KI + (KJ - 1)*IM
      N2(I)  = (S2(I) + CXS(KI,KJ+1,2)*N2(I+IM)+ CXS(KI,KJ,1)*PA(KI-1))/
     1  (CXS(KI,KJ,3) - CXS(KI,KJ,1)*HA(KI-1))
      DO 20 KII = 2,IM
      KI = IM - KII + 1
      I = KI + (KJ - 1)*IM
   20 N2(I) = PA(KI) + HA(KI) * N2(I+1)
      DO 25 KI = 1,IM
      I = KI + (KJ - 1)*IM
   25 N2(I) = N0(I) + ORF*(N2(I) - N0(I))
C     PRINCIPAL FLUX LOOP
      DO 45 KJ = 2,JKB
```

```
      KI = 1
      I = KI + (KJ - 1)*IM
      HA(KI)= CXS(KI+1,KJ,1)/CXS(KI,KJ,3)
      PA(KI)= (S2(I) + CXS(KI,KJ,2)*N2(I-IM)+ CXS(KI,KJ+1,2)*N2(I+IM))/
     1  CXS(KI,KJ,3)
      DO 30 KI = 2,IKB
      I = KI + (KJ - 1)*IM
      HA(KI) = CXS(KI+1,KJ,1)/(CXS(KI,KJ,3)- CXS(KI,KJ,1)*HA(KI-1))
   30 PA(KI) = (S2(I) + CXS(KI,KJ,2)*N2(I-IM)+ CXS(KI,KJ+1,2)*N2(I+IM)+
     1 CXS(KI,KJ,1)*PA(KI-1))/(CXS(KI,KJ,3) - CXS(KI,KJ,1)*HA(KI-1))
      KI = IM
      I = KI + (KJ - 1)*IM
      N2(I)  = (S2(I) + CXS(KI,KJ,2)*N2(I-IM)+ CXS(KI,KJ+1,2)*N2(I+IM)+
     1 CXS(KI,KJ,1)*PA(KI-1))/(CXS(KI,KJ,3) - CXS(KI,KJ,1)*HA(KI-1))
      DO 35 KII = 2,IM
      KI = IM - KII + 1
      I = KI + (KJ - 1)*IM
   35 N2(I) = PA(KI) + HA(KI) * N2(I+1)
      DO 40 KI = 1,IM
      I = KI + (KJ - 1)*IM
   40 N2(I) = N0(I) + ORF*(N2(I) - N0(I))
   45 CONTINUE
C     CALCULATION OF TOP BOUNDARY FLUX
      KJ = JM
      KI = 1
      I = KI + (KJ - 1)*IM
      HA(KI)= CXS(KI+1,KJ,1)/CXS(KI,KJ,3)
      PA(KI) = (S2(I) + CXS(KI,KJ,2)*N2(I-IM))/CXS(KI,KJ,3)
      DO 50 KI = 2,IKB
      I = KI + (KJ - 1)*IM
      HA(KI) = CXS(KI+1,KJ,1)/(CXS(KI,KJ,3)- CXS(KI,KJ,1)*HA(KI-1))
   50 PA(KI) = (S2(I) + CXS(KI,KJ,2)*N2(I-IM)+ CXS(KI,KJ,1)*PA(KI-1))/
     1   (CXS(KI,KJ,3) - CXS(KI,KJ,1)*HA(KI-1))
      KI = IM
      I = KI + (KJ - 1)*IM
      N2(I)  = (S2(I) + CXS(KI,KJ,2)*N2(I-IM)+ CXS(KI,KJ,1)*PA(KI-1))/
     1   (CXS(KI,KJ,3) - CXS(KI,KJ,1)*HA(KI-1))
      DO 55 KII = 2,IM
      KI = IM - KII + 1
      I = KI + (KJ - 1)*IM
   55 N2(I) = PA(KI) + HA(KI) * N2(I+1)
      DO 60 KI = 1,IM
      I = KI + (KJ - 1)*IM
   60 N2(I) = N0(I) + ORF*(N2(I) - N0(I))
C
C     INNER ITERATION CONTROL
C
      LC = LC + 1
      II = II + 1
      IF(II - IITM) 80,95,95
   80 TEMP1=0.
      DO 90 I=1,IMJM
      TEMP2=ABS (1.0-N0(I)/N2(I))
      IF(TEMP1-TEMP2)85,90,90
   85 TEMP1=TEMP2
   90 CONTINUE
      IF(TEMP1 - FLXTSI) 95,95,92
   92 IF (NSWEEP) 5, 205, 205
```

```
 95   CONTINUE
      RETURN
205   DO 210 I=1,IMJM
210   NO(I) = N2(I)
C     FLUX CALCULATION USING SOR WITH LINE INVERSION
C
C     CALCULATION OF LEFT BOUNDARY FLUX
      KI = 1
      KJ = 1
      I = KI + (KJ - 1)*IM
      HA(KJ)= CXS(KI,KJ+1,2)/CXS(KI,KJ,3)
      PA(KJ)= (S2(I) + CXS(KI+1,KJ,1)*N2(I+1))/CXS(KI,KJ,3)
      DO 215  KJ=2,JKB
      I = KI + (KJ - 1)*IM
      HA(KJ) = CXS(KI,KJ+1,2)/(CXS(KI,KJ,3)- CXS(KI,KJ,2)*HA(KJ-1))
215   PA(KJ) = (S2(I) + CXS(KI+1,KJ,1)*N2(I+1) + CXS(KI,KJ,2)*PA(KJ-1))/
     1   (CXS(KI,KJ,3) - CXS(KI,KJ,2)*HA(KJ-1))
      KJ = JM
      I = KI + (KJ - 1)*IM
      N2(I)  = (S2(I) + CXS(KI+1,KJ,1)*N2(I+1) + CXS(KI,KJ,2)*PA(KJ-1))/
     1   (CXS(KI,KJ,3) - CXS(KI,KJ,2)*HA(KJ-1))
      DO 220  KJJ=2,JM
      KJ = JM - KJJ + 1
      I = KI + (KJ - 1)*IM
220   N2(I) = PA(KJ) + HA(KJ) * N2(I+IM)
      DO 225  KJ = 1,JM
      I = KI + (KJ - 1)*IM
225   N2(I) = NO(I) + ORF*(N2(I) - NO(I))
C     PRINCIPAL FLUX LOOP
      DO 245  KI = 2,IKB
      KJ = 1
      I = KI + (KJ - 1)*IM
      HA(KJ)= CXS(KI,KJ+1,2)/CXS(KI,KJ,3)
      PA(KJ)= (S2(I) + CXS(KI,KJ,1)*N2(I-1) + CXS(KI+1,KJ,1)*N2(I+1))/
     1   CXS(KI,KJ,3)
      DO 230  KJ = 2,JKB
      I = KI + (KJ - 1)*IM
      HA(KJ) = CXS(KI,KJ+1,2)/(CXS(KI,KJ,3)- CXS(KI,KJ,2)*HA(KJ-1))
230   PA(KJ) = (S2(I) + CXS(KI,KJ,1)*N2(I-1) + CXS(KI+1,KJ,1)*N2(I+1) +
     1 CXS(KI,KJ,2)*PA(KJ-1))/(CXS(KI,KJ,3) - CXS(KI,KJ,2)*HA(KJ-1))
      KJ = JM
      I = KI + (KJ - 1)*IM
      N2(I)  = (S2(I) + CXS(KI,KJ,1)*N2(I-1) + CXS(KI+1,KJ,1)*N2(I+1) +
     1 CXS(KI,KJ,2)*PA(KJ-1))/(CXS(KI,KJ,3) - CXS(KI,KJ,2)*HA(KJ-1))
      DO 235  KJJ = 2,JM
      KJ = JM - KJJ + 1
      I = KI + (KJ - 1)*IM
235   N2(I) = PA(KJ) + HA(KJ) * N2(I+IM)
      DO 240  KJ = 1,JM
      I = KI + (KJ - 1)*IM
240   N2(I) = NO(I) + ORF*(N2(I) - NO(I))
245   CONTINUE
C     CALCULATION OF RIGHT BOUNDARY FLUX
      KI = IM
      KJ = 1
      I = KI + (KJ - 1)*IM
      HA(KJ)= CXS(KI,KJ+1,2)/CXS(KI,KJ,3)
      PA(KJ)= (S2(I) + CXS(KI,KJ,1)*N2(I-1))/CXS(KI,KJ,3)
```

```
      DO 250  KJ= 2,JKB
      I = KI + (KJ - 1)*IM
      HA(KJ) = CXS(KI,KJ+1,2)/(CXS(KI,KJ,3)- CXS(KI,KJ,2)*HA(KJ-1))
  250 PA(KJ) = (S2(I) + CXS(KI,KJ,1)*N2(I-1) + CXS(KI,KJ,2)*PA(KJ-1))/
     1  (CXS(KI,KJ,3) - CXS(KI,KJ,2)*HA(KJ-1))
      KJ = JM
      I = KI + (KJ - 1)*IM
      N2(I)  = (S2(I) + CXS(KI,KJ,1)*N2(I-1) + CXS(KI,KJ,2)*PA(KJ-1))/
     1  (CXS(KI,KJ,3) - CXS(KI,KJ,2)*HA(KJ-1))
      DO 255  KJJ = 2,JM
      KJ = JM - KJJ + 1
      I = KI + (KJ - 1)*IM
  255 N2(I) = PA(KJ) + HA(KJ) * N2(I+IM)
      DO 260  KJ = 1,JM
      I = KI + (KJ - 1)*IM
  260 N2(I) = N0(I) + OMF*(N2(I) - N0(I))
C
C     INNER ITERATION CONTROL
      LC = LC + 1
      II = II + 1
      IF(II - IITM) 280, 295,295
  280 TEMP1=0.
      DO 290  I=1,IMJM
      TEMP2=ABS (1.0-N0(I)/N2(I))
      IF(TEMP1-TEMP2) 285, 290, 290
  285 TEMP1=TEMP2
  290 CONTINUE
      IF(TEMP1 - FLXTSI) 295, 295, 292
  292 IF (NSWEEP) 5, 5, 205
  295 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE REBAL  (N2, CO, VO, CXS, MO, M2, JTL,JIM,JJM, CXR, CXT)
      COMMON   MINP,    NCUT,    NCR1, NFLUX1, NSCRAT, ISCRAT,  NDUMP,
     1        NMICR,     ALA,     B07,    CNT,    CVT,    DAY, E0(51),
     2       E1(51), E2(51), E3(51), E4(51), E5(51), E6(51), E7(51),
     3       E8(51), E9(51),     E01,    E02,    E03
      COMMON     EQ,     EVP,    EVPP,    EPF,   GBAR,   IGEP,    IGP,
     1          IGV,      II,    IMJM,     IP,  ITEMP, ITEMP1, ITEMP2,
     2          IZP,      JP,     K07,  KPAGE,    LAP,   LAPP,    LAR,
     3           LC,   NGCTO,    ORFP,    P02,   PBAR,
     4         SBAR,     SK7,     T06,    T11,   TEMP,  TEMP1,  TEMP2,
     5        TEMP3,   TEMP4,      TI,    V1T,   NXCM
      COMMON IO(23),    IMAX,     IGE,    IZM,     IM,     JM,    IBL,
     1          IBR,     IBT,     IBB,    IGM,   IEVT,   IPVT, ISTART,
     2           ML,      MT,     M01,   ICST,    IHT,    IHS,    ITL,
     3           IZ,      JZ,    OITM,   IITM,   HWDT,  IPFLX,  IPRIN,
     4       IDMTPS,    IREF,   IXSEC,  NPOIS,   NCON
      COMMON    EPS,   SRCRT,    POWR,    ORF, FLXTST,     PV,   EPSA,
     1           EV,     EVM,    XLAL,   XLAH,    POD,   DELT,    IFS,
     2       NBSTP,     IBUR,     EV2,    NGO, IBRTRG,  NCOEF, NSWEEP
      INTEGER   B07,     CNT,     CVT,    P02,    T06,     R2,     Z2
      INTEGER  OITM
      REAL       I2,      I3,      K6,     K7,    LAP,   LAPP,    LAR,
     1           M0,      N2,    MASS,  MASSP,     I4
      DIMENSION  N2(1), CO(JTL,1), VO(1),CXS(JIM,JJM,3),MO(1), M2(1),
     1           CXR(I), CXT(1)
C     THIS SUBROUTINE NORMALIZES FLUXES BEFORE EACH GROUP CALCULATION
C     CALCULATE ABSORPTION AND OUT-SCATTER
      E3(IGV)=0.
      E4(IGV)=0.
      DO 10  I=1, IMJM
      TEMP = VO(I)*N2(I)
      ITEMP = MO(I)
      ITEMP = M2(ITEMP)
      E3(IGV) = E3(IGV) + (CO(4,ITEMP) - CO(5,ITEMP) - CO(2,ITEMP))*TEMP
   10 E4(IGV) = E4(IGV) + CO(2,ITEMP)*TEMP
C     CALCULATE LEFT LEAKAGE
      E5(IGV)=0.
      IF(IBL) 15,15,25
   15 DO 20 KJ=1,JM
      I = (KJ - 1)*IM + 1
   20 E5(IGV) = E5(IGV) + CXS(1,KJ,1)*N2(I)
C     CALCULATE RIGHT LEAKAGE
   25 E6(IGV)=0.
      IF(IBR) 30,30,40
   30 DO 35 KJ=1,JM
      I = KJ*IM
   35 E6(IGV) = E6(IGV) + CXR(KJ)*N2(I)
C     CALCULATE TOP LEAKAGE
   40 E7(IGV)=0.
      IF(IBT) 45,45,55
   45 DO 50 KI=1,IM
      I = IMJM - IM + KI
   50 E7(IGV) = E7(IGV) + CXT(KI)*N2(I)
C     CALCULATE BOTTOM LEAKAGE
   55 E8(IGV)=0.
      IF(IBB) 60,60,70
   60 DO 65 KI=1,IM
   65 E8(IGV) = E8(IGV) + CXS(KI,1,2)*N2(KI)
```

```
70    E9(IGV) = E5(IGV) + E6(IGV) + E7(IGV) + E8(IGV)
      TEMP = (E1(IGV) + E2(IGV))/(E3(IGV) + E4(IGV) + E9(IGV))
      DO 75 I=1,IMJM
75    N2(I) = TEMP*N2(I)
      E3(IGV) = TEMP*E3(IGV)
      E4(IGV) = TEMP*E4(IGV)
      E5(IGV) = TEMP*E5(IGV)
      E6(IGV) = TEMP*E6(IGV)
      E7(IGV) = TEMP*E7(IGV)
      E8(IGV) = TEMP*E8(IGV)
      E9(IGV) = TEMP*E9(IGV)
      RETURN
      END
```

```
      SUBROUTINE CONVRG(F2,K6)
      COMMON   AIRP,    NCUT,    NCR1, NFLUX1, NSCRAT, ISCRAT,  NDUMP,
     1        NNICR,     ALA,     B07,    CNT,    CVT,    DAY, F0(51),
     2       E1(51), E2(51), E3(51), E4(51), E5(51), E6(51), E7(51),
     3       E8(51), E9(51),     E01,    E02,    E03
      COMMON     EQ,     EVP,    EVPP,    EPF,   GBAR,   IGEP,    IGP,
     1          IGV,      II,    IMJM,     IP,  ITEMP, ITEMP1, ITEMP2,
     2          IZP,      JP,     K07,  KPAGE,    LAP,   LAPP,    LAR,
     3           LC,   NGOTO,    ORFP,    P02,   PBAR,
     4         SHAR,     SK7,     T06,    T11,   TEMP,  TEMP1,  TEMP2,
     5        TEMP3,   TEMP4,      TI,    V11,   NXCM
      COMMON ID(23),    TMAX,     IGE,    IZM,     IM,     JM,    IBL,
     1          IBR,     IBT,     IBB,    IGM,   IEVT,   IPVT, ISTART,
     2           ML,      MT,     M01,   ICST,    IHT,    IHS,    ITL,
     3           IZ,      JZ,    OITM,   IITM,   MWOT,  IPFLX, IPRIN,
     4       IDMTPS,    IREF,   IXSEC,  NPOIS,   NCON
      COMMON    EPS,   SRCRT,    POWR,    ORF, FLXTST,     PV,   EPSA,
     1           EV,     EVM,    XLAL,   XLAH,    POD,   DELT,    IFS,
     2       NBSTP,    IBUR,     EV2,    NGO, IBRTRG,  NCOEF, NSWEEP
      INTEGER   B07,     CNT,     CVT,    P02,    T06,     R2,     Z2
      INTEGER  OITM
      REAL       I2,      I3,      K6,     K7,    LAP,   LAPP,    LAR,
     1           N0,      N2,    MASS,  MASSP,     I4
      DIMENSION F2(1), K6(1)
C     CHECK TIME LIMIT
      IF(TMAX) 25,25,10
   10 CALL SECOND(TEMP)
      IF(TEMP - TMAX) 25,15,15
   15 NGOTO=1
      PRINT 20
   20 FORMAT(53H1 * *  RUNNING TIME EXCEEDED--FORCED CONVERGENCE  * *//)
      RETURN
C     CHECK EIGENVALUE CONVERGENCE
   25 E01=1. - ALA
      E02=ABS(E01)
      IF(E1(IGP)) 30,30,35
   30 CALL ERRO2(6HCONVRG,30,1)
   35 IF(E02 - EPS) 40,40,45
   40 CVT=1
      IF(P02.LE.3) CVT=0
C     INITIALIZE FISSION NEUTRON SOURCE RATES FOR NEXT ITERATION
   45 DO 50 I=1,IMJM
   50 F2(I)=0.
      IF(CVT.NE.1) GO TO 80
C     FINAL EIGENVALUE CALCULATION
      NGOTO=1
      IF(IEVT.NE.1) GO TO 75
   55 EV=0.
      DO 60 I=1,IGM
   60 EV=EV + K6(I)
      EV=SK7/EV
   65 RETURN
   75 EV=EV+POD*EQ*E01
      GO TO 65
C     EIGENVALUE CALCULATION IF NOT CONVERGED
   80 IF(IEVT.NE.1) GO TO 85
      NGOTO=2
      GO TO 55
```

```
C       CHECK FOR CALCULATION OF NEW EV IN SEARCH PROBLEM(IEVT=2 OR 3)
 85     E03=ABS (ALA-LAR)
        IF(LAPP) 250,95,250
 95     IF(LAP) 170,105,170
 105    IF(EQ)  225,115,225
 115    IF(E03 - EPSA) 145,145,125
C       RETURN TO MAIN PROGRAM WITH EV STILL = TO THE PREVIOUS(SAME) VALUE
 125    NGOTO=2
        RETURN
C       FIRST CHANGE IN EV. IT IS NOW SET TO EV + OR - EVM. PROGRAM
C       RETURNS TO INIT FOR RECALCULATION OF X-SECT OR ZONE THICKNESSES
 145    LAP=ALA
        EVP=EV
        IF(E01) 155,155,150
 150    EV=EV - EVM
        GO TO 160
 155    EV=EV + EVM
 160    NGOTO=3
        RETURN
C       SECOND CHANGE IN EV.(IF E03.LE.EPSA). TRIGGERED BY LAP GT. 0
 170    IF(E03 - EPSA) 175,175,125
 175    EQ=(EVP-EV)/(LAP-ALA)
        IF(CNT) 210,185,210
 185    IF(E02 - XLAL) 215,215,190
 190    IF(E02 - XLAH) 210,210,195
 195    E01=SIGN (XLAH,E01)
 210    LAPP=LAP
        LAP=ALA
        EVPP=EVP
        EVP=EV
        GO TO 225
 215    CNT=1
        LAP=0.
        LAPP=0.
 225    EV=EV+PUD*EQ*E01
 230    IF ((LAPP-1.0)/(LAP-1.0)) 235,160,160
 235    TEMP1=AMIN1(EVP,EVPP)
        IF (EV-TEMP1) 240,245,245
 240    EV=(EVPP+EVP)/2.
        GO TO 160
 245    TEMP1=AMAX1(EVP,EVPP)
        IF (EV-TEMP1) 160,240,240
C       THIRD(AND SUCCEEDING) CHANGE IN EV(IF E03.LE.EPSA). TRIGGERED
C       BY LAPP GT. 0
 250    IF(E03 - EPSA) 260,260,125
C       CALCULATE QUADRATIC COEFFICIENTS.
 260    TEMP1=EVP-EV
        TEMP2=EVPP-EV
        TEMP3=EVPP-EVP
        TEMP4=TEMP1*(EVP+EV)
        TEMP5=-TEMP2*(EV+EVPP)
        TEMP6=TEMP3*(EVPP+EVP)
        DENOM=TEMP3*TEMP2*TEMP1
        EQA=((LAPP-1.0)*TEMP1*EVP*EV-(LAP-1.0)*TEMP2
       1*EV*EVPP+(ALA-1.0)*TEMP3*EVPP*EVP)/DENOM
        EQB=-(LAPP*TEMP4+LAP*TEMP5+ALA*TEMP6)/DENOM
        EQC=(LAPP*TEMP1-LAP*TEMP2+ALA*TEMP3)/DENOM
        DISCR=EQB*EQB-4.*EQA*EQC
```

```
      IF(DISCR) 175,270,270                                            CONV 117
  270 IF(EQ2 - XLAL) 215,215,280                                       CONV 118
  280 TEMP1=EQC+EQC                                                    CONV 119
      TEMP=SQRT (DISCR)                                                CONV 120
      EQ=1.0/(EQB+EV*TEMP1)                                            CONV 121
      LAPP=LAP                                                         CONV 122
      LAP=ALA                                                          CONV 123
      EVPP=EVP                                                         CONV 124
      EVP=EV                                                           CONV 125
      EV1=(TEMP-EQB)/TEMP1                                             CONV 126
      EV2=-(TEMP+EQB)/TEMP1                                            CONV 127
      EVA=ABS (EV-EV1)                                                 CONV 128
      EVB=ABS (EV-EV2)                                                 CONV 129
      IF (EVA-EVB) 290,290,300                                         CONV 130
  290 EV=EV1                                                           CONV 131
      GO TO 230                                                        CONV 132
  300 EV=EV2                                                           CONV 133
      GO TO 230                                                        CONV 134
      END                                                              CONV 135
```

```
      SUBROUTINE SUMMRY(F2,N2,R1,Z1,R4,Z4,JIM,JJM,FN2,
     2           C0,N0,M0,M2,F0,JTL,JMT,V0,FUTOT,I0,I1,I2,
     3           PFRAC,PFPREV,BURNUP,I4)
      COMMON   NINP,     NCUT,     NCR1,  NFLUX1,  NSCRAT,  ISCRAT,   NDUMP,
     1         NMICR,     ALA,      B07,     CNT,     CVT,     DAY,  E0(51),
     2        E1(51), E2(51), E3(51), E4(51), E5(51), E6(51), E7(51),
     3        E8(51), E9(51),      E01,     E02,     E03
      COMMON      EQ,      EVP,    EVPP,     EPF,    GBAR,    IGEP,     IGP,
     1           IGV,       II,    IMJM,      IP,   ITEMP,  ITEMP1,  ITEMP2,
     2           IZP,       JP,     K07,   KPAGE,     LAP,    LAPP,     LAR,
     3            LC,    NGOTO,    ORFP,     P02,    PBAR,
     4          SBAR,      SK7,     T06,     T11,    TEMP,   TEMP1,   TEMP2,
     5         TEMP3,    TEMP4,      TI,     V11,    NXCM
      COMMON  ID(23),     IMAX,     IGE,     IZM,      IM,      JM,     IBL,
     1           IBR,      IBT,     IBB,     IGM,    IEVT,    IPVT,  ISTART,
     2            ML,       MT,     M01,    ICST,     IHT,     IHS,     ITL,
     3            IZ,       JZ,    OITM,    IITM,    MWDT,   IPFLX,   IPRIN,
     4         IDMTPS,    IREF,   IXSEC,   NPOIS,    NCON
      COMMON     EPS,    SHCRT,    POWR,     OHF,  FLXTST,      PV,    EPSA,
     1            EV,      EVM,    XLAL,    XLAH,     POD,    DELT,     IFS,
     2         NHSTP,     IBUR,     EV2,     NGO,  IBRTRG,   NCOEF,  NSWEEP
      INTEGER    B07,      CNT,     CVT,     P02,     T06,      R2,      Z2
      INTEGER   OITM
      REAL        I2,       I3,      K6,      K7,     LAP,    LAPP,     LAR,
     1            N0,       N2,    MASS,   MASSP,      I4
      DIMENSION F2(JIM,JJM), N2(JIM,JJM), R1(1), Z1(1), R4(1), Z4(1),
     1          FLUX(6), FN2(1), C0(JTL,JMT), N0(JIM,JJM), M0(JIM,JJM),
     2          M2(1), F0(JIM,JJM)
      DIMENSION  V0(JIM,JJM),FUTOT(1),I0(1),I1(1),I2(1),PFRAC(1),
     2          PFPREV(1),BURNUP(1),I4(1)
C     FINAL PRINT
      ICARD=1
C     PRINT FINAL EIGENVALUE AND OTHER FINAL OUTER ITERATION PARAMETERS
      CALL EVPRT
C     PRINT ATOM DENSITIES FROM SEARCH CALCULATION (IF IEVT=2)
      IF(IEVT.NE.2) GO TO 60
      PRINT 10, PV
 10   FORMAT(1H1///,2X,100HTHESE ARE THE DESIRED ATOM DENSITIES OBTAINED
     1 FROM THE CONC SEARCH TO GIVE A PARAMETRIC VALUE OF PV=  F9.6///)
      DO 30 M=1,M01
      IF (I4(M).EQ.0.) GO TO 30
      TEMF = I2(M)*(1.0 + EV*I4(M))
      K = I0(M) - ML
      PRINT 20, K, I1(M), TEMF
 20   FORMAT(10X,7HREGION=I2,5X,9HMATERIAL=I2,5X,15HMATL ATOM DENS=F10.7
     1 )
 30   CONTINUE
 50   CONTINUE
C     PRINT FINAL GROUP TOTALS
 60   CALL GRPTOT
      IF(DAY.NE.0.) GO TO 105
C     PRINT MESH INTERVALS AND COORDINATES
      J=IP
      IF(IP - JP) 70,70,65
 65   J=JP
 70   PRINT 80,            (I,R1(I),R4(I),Z1(I),Z4(I),I=1,J)
 80   FORMAT(      84H                RADII                   AVG RADII
     1           AXII                AVG AXII//(I4,4F20.4))
```

```
      J=J + 1
      IF(IP - JP) 85,115,95
 85   PRINT 90,          (I,Z1(I),Z4(I),I=J,JP)
 90   FORMAT(I4,40X,2F20.4)
      GO TO 105
 95   PRINT 100,         (I,R1(I),R4(I),I=J,IP)
 100  FORMAT(I4,2F20.4)
 105  CONTINUE
C     INITIALIZE TOTAL FLUX AND POWER DENSITY ARRAYS
      DO 110 I=1,IM
      DO 110 J=1,JM
      N0(I,J)=0.
 110  F2(I,J)=0.
C     MASTER LOOP FOR OUTPUTTING OF FLUXES (PRINT/TAPE/PUNCH OPTIONS)
      DO 350 IIG=1,IGM
      READ (NFLUX1)((N2(I,J),I=1,IM),J=1,JM)
      READ(NCR1)((CO(II,J), II = 1, ITL), J = 1, MT)
C     CALCULATE TOTAL FLUX AND POWER DENSITY
      DO 120 I=1,IM
      DO 120 J=1,JM
      N0(I,J) = N0(I,J) + N2(I,J)
      ITEMP = M0(I,J)
      ITEMP = M2(ITEMP)
 120  F2(I,J)= F2(I,J) + CO(1,ITEMP)*N2(I,J)*1000.*EPF
C     PRINT GROUP FLUXES (IF DESIRED)
      IF(IPRIN.EQ.3) GO TO 160
      IF(DAY.NE.0.) GO TC 140
 125  PRINT 130,IIG
 130  FORMAT(1H1, 20X,14HFLUX FOR GROUP,I2)
      CALL PRT(IM,JM,N2,Z4)
      GO TO 160
 140  IF(IPRIN.EQ.1) GO TO 125
C     WRITE FLUXES ON TAPE(FOR IREF=0 OR 1),OR DISK(FOR IREF=2),IF DESRD
 160  IF(IDMTPS) 230,230,170
 170  IF(DAY.NE.0.) GO TC 200
      IF(IREF.NE.0) GO TC 230
 180  WRITE(NDUMP)  ((N2(I,J),I=1,IM),J=1,JM)
      GO TO 230
 200  IF(IREF.EQ.1) GO TC 180
      IF(IREF.EQ.0) GO TC 220
      WRITE(ISCRAT)  ((N2(I,J),I=1,IM),J=1,JM)
      GO TO 230
 220  CALL ERRO2(6HSUMMRY,220,1)
C     PUNCH FLUXES (IF DESIRED)
 230  IF(IPFLX.EQ.0) GO TO 350
      IF(DAY.NE.0.) GO TC 245
      IF(IPFLX.EQ.1) GO TO 255
      GO TO 350
 245  IF(IPFLX.NE.2) GO TO 350
 255  DO 300 I=1,IMJM,6
      DO 280 J=1,6
 280  FLUX(J) = 0.
      II = MIN0(I+5,IMJM)
      JI = 1
      DO 290 J=I,II
      FLUX(JI) = FN2(J)
 290  JI = JI + 1
      PUNCH 310, (FLUX(J),J=1,6),ICARD
```

```
  300 ICARD = ICARD + 1
  310 FORMAT(1P6E12.6,4HFLUX,I4)
  350 CONTINUE
C     PRINT TOTAL FLUX AND POWER DENSITY
      PRINT 355
  355 FORMAT(1H1//, 19X,11H TOTAL FLUX//)
      CALL PRT(IM,JM,N0,Z4)
      PRINT 360
  360 FORMAT(1H1//, 19X, 26HPOWER DENSITY   (MWT/LITER))
      CALL PRT(IM,JM,F2,Z4)
C     CALCULATE AND PRINT REGIONAL POWER FRACTIONS
      IF(POWR.LE.0.) GO TO 475
      DO 365 I=1,IZM
  365 PFRAC(I)=0.
      DO 370 I=1,IM
      DO 370 J=1,JM
      ITEMP=M0(I,J)
      ITEMP=M2(ITEMP) - ML
  370 PFRAC(ITEMP)=PFRAC(ITEMP) + F2(I,J)*V0(I,J)*.001
      PRINT 375
  375 FORMAT(1H1,///10X,39HPOWER PRODUCTION FRACTION FOR EACH ZONE///)
      DO 380 I=1,IZM
      PFRAC(I)=PFRAC(I)/POWR
  380 PRINT 385, I,PFRAC(I)
  385 FORMAT(/20X,2HI=I2,2X,6HPFRAC=F9.6)
C     CALCULATE AND PRINT BURNUP RATES FOR EACH ZONE
      IF(MWDT.EQ.0) GO TO 475
      IF(DAY.EQ.0.) GO TO 460
      IF(IBRTRG.EQ.0) GO TO 460
      PRINT 400
  400 FORMAT(1H1,///10X,83HTHESE ARE THE AVERAGE BURNUP RATES,IN MWD/TON
     2,FOR EACH ZONE OVER THE PREVIOUS CYCLE///)
      PRINT 405, DELT
  405 FORMAT(//10X,5HDELT=F8.2,7H    DAYS////)
      DO 425 I=1,IZM
      IF(FUTOT(I).EQ.0.) GO TO 415
      BURNUP(I)= (PFRAC(I) + PFPREV(I))*POWR*DELT/(2.*FUTOT(I))
      BRNMET=BURNUP(I)*1.10
      GO TO 425
  415 BURNUP(I)=0.
      BRNMET=0.
  425 PRINT 430,       I,FUTOT(I),BURNUP(I),BRNMET
  430 FORMAT(/5X,2HI=I2,4X,24HFUEL MASS IN SHORT TONS=F7.3,4X,29HAVG. BU
     2RNUP IN MWD/SHORT TON=F9.2,5X,30HAVG. BURNUP IN MWD/METRIC TON=F9.
     32)
  460 DO 470 II=1,IZM
  470 PFPREV(II)=PFRAC(II)
  475 IF(IPRIN.EQ.3) GO TO 500
      IF(DAY.NE.0.) GO TO 490
  480 PRINT 485
  485 FORMAT(1H1,20X,19HFISSION SOURCE RATE)
      CALL PRT(IM,JM,F0,Z4)
      GO TO 500
  490 IF(IPRIN.EQ.1) GO TO 480
  500 REWIND NCR1
      REWIND NFLUX1
      REWIND NDDMP
      RETURN
      END
```

```
      SUBROUTINE GRPTOT
      COMMON   MINP,    NCUT,     NCR1, NFLUX1, NSCRAT, ISCRAT,   NDUMP,
     1        NMICR,     ALA,     B07,     CNT,     CVT,    DAY, E0(51),
     2     E1(51), E2(51), E3(51), E4(51), E5(51), E6(51), E7(51),
     3     E8(51), E9(51),     E01,     E02,     E03
      COMMON     EQ,     EVP,    EVPP,     EPF,    GBAR,    IGEP,     IGP,
     1         IGV,      I1,    IMJM,      IP,   ITEMP,  ITEMP1,  ITEMP2,
     2         IZP,      JP,     K07,   KPAGE,     LAP,    LAPP,     LAR,
     3          LC,   NGCTO,    OHFP,     P02,    PBAR,
     4        SBAR,     SK7,     T06,     T11,    TEMP,   TEMP1,   TEMP2,
     5       TEMP3,   TEMP4,      TI,     V11,    NXCM
      COMMON ID(23),    IMAX,     IGE,     IZM,      IM,      JM,     IBL,
     1         IBR,     IBT,     IBB,     IGM,    IEVT,    IPVT,  ISTART,
     2          ML,      MT,     M01,    ICST,     IHT,     IHS,     ITL,
     3          IZ,      JZ,    OITM,    IITM,    MWDT,   IPFLX,   IPRIN,
     4      INITPS,    IREF,   IXSEC,  NPOIS,    NCON
      COMMON    EPS,   SRCRT,    POWR,     DRF,  FLXTST,      PV,    EPSA,
     1          EV,     EVM,    XLAL,    XLAH,     POD,    DELT,     IFS,
     2       NHSTP,    IBUR,     EV2,     NGO,  IBRTRG,   NCOEF,  NSWEEP
      INTEGER   B07,     CNT,     CVT,     P02,     T06,      R2,      Z2
      INTEGER  OITM
      REAL       I2,      I3,      K6,      K7,     LAP,    LAPP,     LAR,
     1           N0,      N2,    MASS,   MASSP,      I4
      E2(IGP) = .0
      E3(IGP) = .0
      E4(IGP) = .0
      E5(IGP) = .0
      E6(IGP) = .0
      E7(IGP) = .0
      E8(IGP) = .0
      E9(IGP) = .0
      DO 10 I = 1,IGM
      E2(IGP) = E2(IGP) + E2(I)
      E3(IGP) = E3(IGP) + E3(I)
      E4(IGP) = E4(IGP) + E4(I)
      E5(IGP) = E5(IGP) + E5(I)
      E6(IGP) = E6(IGP) + E6(I)
      E7(IGP) = E7(IGP) + E7(I)
      E8(IGP) = E8(IGP) + E8(I)
   10 E9(IGP) = E9(IGP) + E9(I)
      PRINT 20
   20 FORMAT (1H1, 28H FINAL NEUTRON BALANCE TABLE///
     159H GROUP  FISSION SOURCE  IN-SCATTER  OUT-SCATTER  ABSORPTION,1X,
     265H     L. L.         H. L.         T. L.         B. L.    TOTAL LEAKA
     3GE//)
      DO 30 I = 1,IGM
   25 FORMAT (I6, 1P9E13.3)
   30 PRINT 25,      I,E1(I),E2(I),E3(I),E4(I),E5(I),E6(I),E7(I),
     1 E8(I),E9(I)
      PRINT 35
   35 FORMAT (1H )
      I = IGM + 1
      PRINT 25,      I,E1(I),E2(I),E3(I),E4(I),E5(I),E6(I),E7(I),
     1 E8(I),E9(I)
      RETURN
      END
```

```
      SUBROUTINE PRT (JIM,JJM, N2, Z4)
      DIMENSION N2(JIM,JJM), Z4(1)
      REAL N2
      IM = JIM
      JM = JJM
      DO  50 I=1,IM,5
      I1=I
      I2=I+4
      IF(I2-IM) 20, 20, 10
   10 I2=IM
   20 PRINT 30,            ( JJ,JJ=I1,I2)
   30 FORMAT( 5I20)
      DO  50 JJ=1,JM
      J=JJ
   40 FORMAT(I5,E15.7,5E20.7)
   50 PRINT 40,         J,(N2(K,J),K=I1,I2),Z4(J)
      RETURN
      END
```

```
      SUBROUTINE GRAM(MASS, VOL,  ATW, HOLN,JIM,JJM, M0, M2, V0,
     2                I0, I1, I2, JML, I3,FUTOT, NTRIG, I4)
      COMMON   NTIM,    NCUT,    NCR1, NFLUX1, NSCRAT, ISCRAT,  NDUMP,
     1        NMICR,     ALA,     B07,    CNT,    CVT,    DAY, E0(51),
     2       E1(51), E2(51), E3(51), E4(51), E5(51), E6(51), E7(51),
     3       E8(51), E9(51),     E01,    E02,    E03
      COMMON     EQ,     EVP,    EVPP,    LPF,   GBAR,   IGEP,    IGP,
     1          IGV,      II,    IMJM,     IP,  ITEMP, ITEMP1, ITEMP2,
     2          IZP,      JP,     K07,  KPAGE,    LAP,   LAPP,    LAR,
     3           LC,   NGCTO,    ORFP,    P02,   PBAR,
     4         SBAR,     SK7,     T06,    T11,   TEMP,  TEMP1,  TEMP2,
     5        TEMP3,   TEMP4,      TI,    V11,   NXCM
      COMMON ID(23),    IMAX,     IGE,    IZM,     IM,     JM,    IBL,
     1          IBR,     IBT,     IBB,    IGM,   IEVT,   IPVT, ISTART,
     2           ML,      MT,     M01,   ICST,    IHT,    IHS,    ITL,
     3           IZ,      JZ,    OITM,   TITM,   MWDT,  IPFLX,  IPRIN,
     4       IDMTPS,    IREF,  IXSEC,   IPOIS,   NCON
      COMMON    EPS,   SRCRI,    POWR,    ORF, FLXTST,     PV,   EPSA,
     1           EV,     EVM,    XLAL,   XLAH,    POD,   DELT,    IFS,
     2        NISTP,    IBUR,     EV2,    NGO, IBRTRG,  NCOEF, NSWEEP
      INTEGER   B07,     CNT,     CVT,    P02,    T06,     R2,     Z2
      INTEGER OITM
      REAL       I2,      I3,      K6,     K7,    LAP,   LAPP,    LAR,
     1           N0,      N2,    MASS,  MASSP,     I4
      DIMENSION MASS(JML,1), VOL(1), ATW(1), HOLN(1), M0(JIM,JJM),
     1          M2(1), V0(JIM,JJM), I0(1), I1(1), I2(1), I3(1),
     2          FUTOT(1),NTRIG(1),I4(1)
C     THIS SUBROUTINE CALCULATES THE MASS OF THE VARIOUS MATERIALS
      IF(MWDT.EQ.0) GO TO 6
      DO 5 N=1,IZM
    5 FUTOT(N)=0.
    6 CONTINUE
      PRINT 10, (ID(I),I=1,23)
   10 FORMAT (1H1, 12A6/11A6///)
      PRINT 20
   20 FORMAT(45H MATERIAL INVENTORY (KILOGRAMS) FOR EACH ZONE /  )
      DO 25 I=1,IZM
   25 VOL(I) = 0.0
      DO 30 I=1,ML
      DO 30 J=1,IZM
   30 MASS(I,J) = 0.0
      DO 40  J = 1, JM
      DO 40  I = 1, IM
      K = M0(I,J)
   40 VOL(K) = VOL(K) + V0(I, J)*.001
      DO 50  M=1,M01
      I3(M) = I2(M)
      IF (IEVT.NE.2) GO TO 50
      I3(M) = I2(M)*(1.0 + EV*I4(M))
   50 CONTINUE
      DO  90 N =1, IZM
      NN = M2(N)
      DO  90 M = 1,M01
      IF(I0(M) - NN)  90,60,90
   60 L = I1(M)
   70 IF (L) 90,90,80
   80 E01 = I3(M)
      MASS(L,N) = ((E01*ATW(L)*VOL(N))/.6023) + MASS(L,N)
```

```
      IF (MWDT.EQ.0) GO TO 90                                      GRAM  59
      IF(NTMIG(M).EQ.0) GO TO 90                                   GRAM  60
      FUTOT(N)=FUTOT(N) + MASS(L,M)*0.0011                         GRAM  61
90    CONTINUE                                                     GRAM  62
      DATA   ZONE/6H ZONE /                                        GRAM  63
      DO 160 L = 1, IZM, 5                                         GRAM  64
      LL = L + 4                                                   GRAM  65
      IF(LL - IZM) 110, 110, 100                                   GRAM  66
100   LL = IZM                                                     GRAM  67
110   PRINT 120,        ((ZONE, K), K=L, LL)                       GRAM  68
120   FORMAT(//26H   MATERIAL   ATOMIC WT.   ,3X, 5(A6,I2,12X))    GRAM  69
      PRINT 130,        (VOL(K), K = L, LL)                        GRAM  70
130   FORMAT(25X, 5(E8.3, 7H LITERS, 5X))                          GRAM  71
      DO 140 K = 1, ML                                             GRAM  72
140   PRINT 150,       K, HOLN(K), ATW(K), (MASS(K, I), I = L, LL) GRAM  73
150   FORMAT( I3,1X, A6, F13.3, 1X, 1PE13.3, 1P4E20.3)             GRAM  74
      IF(LL - IZM)  160, 170, 170                                  GRAM  75
160   CONTINUE                                                     GRAM  76
170   RETURN                                                       GRAM  77
      END                                                          GRAM  78
```

```
      SUBROUTINE INPB(MATN,NBR,LD,LCN,LFN,ALAM,HOLN,JML,I2)
      COMMON   MINP,     NCUT,    NCR1,  NFLUX1,  NSCRAT,  ISCRAT,   NDUMP,
     1        NMICR,      ALA,     B07,     CNT,     CVT,     DAY,  E0(51),
     2      E1(51),  E2(51),  E3(51),  E4(51),  E5(51),  E6(51),  E7(51),
     3      E8(51),  E9(51),     E01,     E02,     E03
      COMMON     EN,      EVP,    EVPP,     EPF,    GBAR,    IGEP,     IGP,
     1          IGV,       II,    IMJM,      IP,   ITEMP,  ITEMP1,  ITEMP2,
     2          IZP,       JP,     K07,   KPAGE,     LAP,    LAPP,     LAR,
     3           LC,    NGCTO,    ORFP,     P02,    PBAR,
     4         SBAR,      SK7,     T06,     T11,    TEMP,   TEMP1,   TEMP2,
     5        TEMP3,    TEMP4,      TI,     V11,    NXCM
      COMMON ID(23),     IMAX,     IGE,     IZM,      IM,      JM,     IBL,
     1          IBR,      IBT,     IBB,     IGM,    IEVT,    IPVT,  ISTART,
     2           ML,       MT,     M01,    ICST,     IHT,     IHS,     ITL,
     3           IZ,       JZ,    OITM,    IITM,    MWDT,   IPFLX,   IPRIN,
     4       IDNTPS,     IREF,   IXSEC,   NPDIS,    NCON
      COMMON    EPS,    SRCRT,    POWR,     ORF,  FLXTST,      PV,    EPSA,
     1           EV,      EVM,    XLAL,    XLAH,     POD,    DELT,     IFS,
     2       NBSTP,     IBUR,     EV2,     NGO,  IBRTRG,   NCOEF,  NSWEEP
      INTEGER   B07,      CNT,     CVT,     P02,     T06,      R2,      Z2
      INTEGER OTTM
      REAL       I2,       I3,      K6,      K7,     LAP,    LAPP,     LAR,
     1           N0,       N2,    MASS,   MASSP,      I4
      DIMENSION  MATN(1), NBR(1), LD(1),LCN(JML,1),LFN(JML,1), ALAM(1),
     1 HOLN(1), I2(1)
C
C     * * * * *  BURNUP DATA  * * * * *
C
C    CARD 1            NCON, DELT (BURNUP CONTROL WORDS)
C
C    CARD BLOCK 2     MATN, NBR, LD, LCN, LFN    (NCON CARDS)
C           (OMIT IF NCON.LE.0)
C
C    REPEAT ABOVE CARDS FOR MULTIPLE BURNUP STEPS AS PER INSTRUCTIONS
C
C    FINAL CARD IN BURNUP DATA DECK SHOULD BE A CARD 1
C
C     THIS SUBROUTINE READS AND PRINTS THE BURNUP DATA
      IF(DAY.EQ.0.) GO TO 5
      IF(K07.NE.2) GO TO 5
      IF(IEVT.NE.2) GO TO 12
    5 READ(MINP,10) ITEMP,DELT
   10 FORMAT(I6,E12.0)
      DAY=DAY + DELT
      IBRTRG=1
      IBUR=IBUR + 1
      GO TO 14
   12 IBRTRG=0
      IF(IBUR.NE.NBSTP) GO TO 14
      IF(IFS) 13,13,14
   13 READ(MINP,10) ITEMP,DELT
   14 CVT=0
      CNT = 0
      P02 = 0
      ALA = 0.0
      LAP = 0.0
      LAPP = 0.0
      LAR = 0.0
```

```
      KPAGE=50
      IF(IBURNG.EQ.0) GO TO 100
      IF(ITEMP) 100,15,20
15    NCON = ITEMP
      GO TO 100
20    NCON = ITEMP
      DO 40  N = 1, NCON
30    FORMAT(12I6)
40    READ(IINP,30)  MATN(N),NBR(N),LD(N),(LCN(N,K),K=1,2),(LFN(N,K),
     1 K=1,7)
      PRINT 60
60    FORMAT(12H1BURNUP DATA///)
      PRINT 70
70    FORMAT(130H BURNABLE          MATERIAL          NAME          LAMBDA
     1       NBR              *  *  *  *  8  *  SOURCE ISOTOPE FOR  *  *  *  *
     2  *  *    /
     3          130H  ISOTOPE              NO.                     (DAYS-1)
     4                         DECAY                  CAPTURE                  FISS
     5ION       /9H       NC.   )
      DO 90  N=1, NCON
      ITEMP = MATN(N)
      ALAM(ITEMP) = 24.*3600.*ALAM(ITEMP)
      PRINT 80,         N, MATN(N), HOLN(ITEMP), ALAM(ITEMP), NBR(N),
     1LD(N),     (LCN(N,K),K=1,2),  (LFN(N,K),K=1,7)
80    FORMAT(3X, I3, 12X, I3, 10X, A6, 7X, E9.3, I9, 15X, I3, 13X, 2I3,
     1       10X, 7I3)
90    ALAM(ITEMP) = ALAM(ITEMP)/(3600.*24.)
100   RETURN
      END
```

```
      SUBROUTINE AVERAG(PHIB,AXS,FXS,MATN,MASS,ATW,VOL,CO,N2,M0,V0,
     1                  HOLN, JML, JTL, NBR, AXX, FXX,BREDRT)
      COMMON  MINP,    NCUT,    NCR1,  NFLUX1,  NSCRAT,  ISCRAT,   NDUMP,
     1       NMICR,     ALA,     B07,     CNT,     CVT,     DAY,  E0(51),
     2      E1(51),  E2(51),  E3(51),  E4(51),  E5(51),  E6(51),  E7(51),
     3      E8(51),  E9(51),     E01,     E02,     E03
      COMMON     EP,     EVP,    EVPP,     EPF,    GBAR,    IGEP,     IGP,
     1          IGV,      II,    IMJM,      IP,   ITEMP,  ITEMP1,  ITEMP2,
     2          IZP,      JP,     K07,   KPAGE,     LAP,    LAPP,     LAR,
     3           LC,   NGOTO,    ORFP,     P02,    PBAR,
     4         SBAR,     SK7,     T06,     T11,    TEMP,   TEMP1,   TEMP2,
     5        TEMP3,   TEMP4,      TI,     V11,    HXCM
      COMMON I0(23),    IMAX,     IGE,     IZM,      IM,      JM,     IBL,
     1          IBR,     IBT,     IBB,     IGM,    IEVT,    IPVT,  ISTART,
     2           ML,      MT,     M01,    ICST,     IHT,     IHS,     ITL,
     3           IZ,      JZ,    OITM,    IITM,    MWDT,   IPFLX,   IPRIN,
     4       IDMTPS,    IREF,   IXSEC,   MPDIS,    NCON
      COMMON    EPS,   SRCRT,    POWR,     ORF,  FLXTST,      PV,    EPSA,
     1           EV,     EVM,    XLAL,    XLAH,     POD,    DELT,     IFS,
     2        NUSTP,    IBUR,     EV2,     NGO,  IBRTRG,   NCOEF,  NSWEEP
      INTEGER   B07,     CNT,     CVT,     P02,     T06,      R2,      Z2
      INTEGER OITM
      REAL       I2,      I3,      K6,      K7,     LAP,    LAPP,     LAR,
     1           N0,      N2,    MASS,   MASSP,      I4
      DIMENSION PHIB(1), AXS(JML,1), FXS(JML,1), MATN(1), MASS(JML,1),
     1          ATW(1), VOL(1), CO(JTL,1), N2(1), M0(1), V0(I), HOLN(1)
     2          ,NBR(1), AXX(JML,1), FXX(JML,1), BREDRT(1)
C
C     THIS SUBROUTINE CALCULATES ZONE AVERAGED FLUXES, FISSION CROSS
C     SECTIONS, AND ABSORPTION CROSS SECTIONS.
C
      PRINT 5
    5 FORMAT(1H1)
      RL = 0.0
      RC = 0.0
      DO 10  KZ=1,IZM
      PHIB(KZ) = 0.0
      DO 10  KN =1,NCON
      AXS(KN,KZ) = 0.0
      FXS(KN,KZ) = 0.0
      LN = MATN(KN)
   10 MASS(LN,KZ) = (MASS(LN,KZ)*.6023)/(ATW(LN)*VOL(KZ))
      DO 20    IIG=1,IGM
      READ(NCR1)   ((CO(II,J), II=1,ITL),J=1,MT)
      READ(NFLUX1)   (N2(I), I=1,IMJM)
      DO 20    I=1,IMJM
      KZ = M0(I)
      PHIB(KZ) = PHIB(KZ) + N2(I)*V0(I)
      DO 20    KN=1,NCON
      LN = MATN(KN)
      AXS(KN,KZ) = AXS(KN,KZ) + CO(2,LN)*N2(I)*V0(I)
   20 FXS(KN,KZ) = FXS(KN,KZ) + CO(1,LN)*N2(I)*V0(I)
      DO 80    KZ=1,IZM
      BREDRT(KZ)=0.
      TEMP3 = PHIB(KZ)
      PHIB(KZ) = PHIB(KZ)/(VOL(KZ)*1000.)
      PRINT 30,          KZ, PHIB(KZ), VOL(KZ)
   30 FORMAT(/////,30X,9H Z O N E ,I3,7X,7H FLUX =,1PE10.4,7X,9H VOLUME
```

```
     1=,1PE10.4,7H LITERS/)
      PRINT 40
 40   FORMAT(115H BURNABLE       MATERIAL          NAME              ATOM
     1         FISSION      ABSORPTION          SIGMA           SIGMA   /
     2         115H  ISOTOPE              NO.                          DENSITY
     3           RATE            RATE              FISSION         ABSORPTION/
     4           7H      NO./)
      DO 80   KN=1,NCON
      LN = MATN(KN)
      TEMP1 = AXS(KN,KZ)*MASS(LN,KZ)
      TEMP2 = FXS(KN,KZ)*MASS(LN,KZ)
      AXS(KN,KZ) = AXS(KN,KZ)/TEMP3
      FXS(KN,KZ) = FXS(KN,KZ)/TEMP3
      IF (IBRCH6.EQ.0) GO TO 45
      IF (DELT.NE.0.) AXX(KN,KZ) = AXS(KN,KZ)/NBSTP + AXX(KN,KZ)
      IF (DELT.NE.0.) FXX(KN,KZ) = FXS(KN,KZ)/NBSTP + FXX(KN,KZ)
 45   CONTINUE
 50   FORMAT(4X,I3,11X,I3,10X,A6,2X,1P5E15.3)
      PRINT 50,          KN, LN, HOLN(LN), MASS(LN,KZ), TEMP2, TEMP1,
     1 FXS(KN,KZ), AXS(KN,KZ)
      ITEMP = NBR(KN)
      IF(ITEMP - 1)  80, 60, 70
 60   RC = RC + TEMP1 - TEMP2
      BREDRT(KZ)=BREDRT(KZ) + TEMP1 - TEMP2
      GO TO 80
 70   RL = RL + TEMP1
 80   CONTINUE
      DO 90  KZ = 1,IZM
      BREDRT(KZ)=BREDRT(KZ)/RL
 90   PRINT 100, KZ, BREDRT(KZ)
 100  FORMAT(30X,3HKZ=I2,2X,11HBREDRT(KZ)=F7.4)
      TEMP = RC/RL
      PRINT 110, TEMP
 110  FORMAT(1H ///18H  BREEDING RATIO =F7.4)
      REWIND NCR1
      REWIND NFLUX1
      RETURN
      END
```

```
      SUBROUTINE EIGTR6(IEVT,K07,IBUR,EV,EV2,NGO,EQ,IPVT)
      IF(IEVT.NE.1) GO TO 100
      IF(K07.NE.2) GO TO 200
      IEVT=2
      EV=EV2
      IPVT=2
      NGO=2
      RETURN
 100  IEVT=1
      IPVT=1
      EV=0.
      EQ=0.
 200  NGO=1
      RETURN
      END
```

```
      SUBROUTINE MARCH(PHIB,MATN,FXS,AXS,VOL,MASS,MASSP,ALAM,LD,LCN,      MAR
     1                 LFH,JML,I0,I1,I2,M2,PHIP,PHIPP,JZM)                MAR
      COMMON  NINP,    NCUT,    NCR1,  NFLUX1,  NSCRAT,  ISCRAT,  NDUMP,  MAR
     1        NMICR,    ACA,     B07,     CNT,     CVT,     DAY,  E0(51), MAR
     2     E1(51), E2(51), E3(51), E4(51), E5(51), E6(51), E7(51),        MAR
     3     E8(51), E9(51),      E01,     E02,     E03                     MAR
      COMMON      EN,     EVP,    EVPP,     EPF,    GBAR,    IGEP,    IGP, MAR
     1           IGV,      II,    IMJM,      IP,   ITEMP,  ITEMP1, ITEMP2, MAR
     2           IZP,      JP,     K07,   KPAGE,     LAP,    LAPP,    LAR, MAR
     3            LC,   NGCTO,    ORFP,     P02,    PBAR,                  MAR
     4          SBAR,     SK7,     T06,     T11,    TEMP,   TEMP1,  TEMP2, MAR
     5         TEMP3,   TEMP4,      TI,     V11,    UXCM                   MAR
      COMMON  ID(23),    IMAX,     IGE,     IZM,      IM,      JM,    IBL, MAR
     1           IBR,     IBT,     IBB,     IGM,    IEVT,    IPVT, ISTART, MAR
     2            ML,      MT,     M01,    ICST,     IHT,     IHS,    ITL, MAR
     3            IZ,      JZ,    OITM,    I1TM,    MWDT,   IPFLX,  IPRIN, MAR
     4       IDUMPS,    IREF,   IXSEC,   NPOIS,    NCON                   MAR
      COMMON     EPS,   SRCR1,    POWR,     ORF,  FLXTST,      PV,   EPSA, MAR
     1            EV,     EVM,    XLAL,    XLAH,     POD,    DELT,    IFS, MAR
     2        NBSTP,    IBUR,     EV2,     NGO,  IBRTRG,   NCOEF,  NSWEEP  MAR
      INTEGER    B07,     CNT,     CVT,     P02,     T06,      R2,     Z2  MAR
      INTEGER OITM                                                        MAR
      REAL        I2,      I3,      K6,      K7,     LAP,    LAPP,    LAR, MAR
     1            N0,      N2,    MASS,   MASSP,     I4                    MAR
      DIMENSION  PHIB(1), MATN(1), FXS(JML,1),AXS(JML,1),VOL(1),          MAR
     1           MASS(JML,1),MASSP(JML,1),ALAM(1), LD(1), LCN(JML,1),     MAR
     2           LFH(JML,1),I0(1),I1(1),I2(1),M2(1),PHIP(1),PHIPP(1)      MAR
C                                                                         MAR
C     THIS SUBROUTINE COMPUTES THE TIME DEPENDENT ISOTOPIC CONCENTRATIONMAR
C                                                                         MAR
      TEMP = DELT * 24. * 3600. / 10.                                     MAR
      TEMP1 = .0                                                          MAR
      DO 5 KZ = 1,IZM                                                     MAR
      PHIPP(KZ) = PHIB(KZ)                                                MAR
      PHIB(KZ) = PHIB(KZ) * 10.**(-24)                                    MAR
      DO 5 KN = 1,NCON                                                    MAR
      LN = MATN(KN)                                                       MAR
    5 TEMP1 = TEMP1 + FXS(KN,KZ)*PHIB(KZ)*MASS(LN,KZ)*VOL(KZ)             MAR
      DO 120 KT = 1,10                                                    MAR
      TEMP3 = .0                                                          MAR
      DO 10 KZ = 1,IZM                                                    MAR
      DO 10 KN = 1,NCON                                                   MAR
      LN = MATN(KN)                                                       MAR
   10 MASSP(LN,KZ) = MASS(LN,KZ)                                          MAR
      DO 90  KZ = 1,IZM                                                   MAR
      DO 80 KKK = 1,5                                                     MAR
      DO 80 KN = 1,NCON                                                   MAR
      LN = MATN(KN)                                                       MAR
      TEMP2=-(MASS(LN,KZ)+MASSP(LN,KZ))*(ALAM(LN)+AXS(KN,KZ)*PHIB(KZ))    MAR
      IF (LD(KN)) 30, 30, 20                                              MAR
   20 KK = LD(KN)                                                         MAR
      KK = MATN(KK)                                                       MAR
      TEMP2 = TEMP2 + ALAM(KK)*(MASS(KK,KZ) + MASSP(KK,KZ))               MAR
   30 DO 50 K = 1,2                                                       MAR
      KK = LCN(KN,K)                                                      MAR
      KL = MATN(KK)                                                       MAR
      IF (KK) 50, 50, 40                                                  MAR
   40 TEMP2 = TEMP2 + (AXS(KK,KZ) - FXS(KK,KZ))*PHIB(KZ)*                 MAR
```

```
     1 (MASS(KL,KZ) + MASSP(KL,KZ))
50    CONTINUE
      DO 70 K = 1,7
      KK = LFN(KN,K)
      KL = MATN(KK)
      IF (KK) 70, 70, 60
60    TEMP2 = TEMP2 + FXS(KK,KZ)*PHIB(KZ)*(MASS(KL,KZ)+MASSP(KL,KZ))
70    CONTINUE
80    MASS(LN,KZ) = MASSP(LN,KZ) + .5*TEMP*TEMP2
      DO 90  KN = 1,NCON
      LN = MATN(KN)
90    TEMP3 = TEMP3 + FXS(KN,KZ)*PHIB(KZ)*MASS(LN,KZ)*VOL(KZ)
      IF(TEMP3)  120, 120, 100
100   DO 110 KZ = 1,IZM
110   PHIB(KZ) = PHIB(KZ) * TEMP1/TEMP3
120   CONTINUE
      DO 130 KZ = 1,IZM
130   PHIB(KZ) = PHIB(KZ)*10.**(24)
      IF(IREF.NE.2) GO TO 165
      IF (IBUR.LT.NBSTP) GO TO 145
      PRINT 140
140   FORMAT(1H1///,8X,105H THESE ARE THE ZONE-AVERAGED TOTAL FLUXES TO
     2BE USED IN THE FLUX SHIFT CORRECTION FOR SUBROUTINE REFUEL     ///)
145   DO 150 KZ=1,IZM
      PHIP(KZ) =(PHIPP(KZ) + PHIB(KZ))*.5/NBSTP + PHIP(KZ)
      IF (IBUR.LT.NBSTP) GO TO 150
      PRINT 160,  KZ, PHIP(KZ)
150   CONTINUE
160   FORMAT (20X,7H ZONE =,I2,4X,11H AVG FLUX =,1PE10.4/)
165   DO 200  KZ=1,IZM
      DO 200  M=1,N01
      IF(T1(M) - N2(KZ))  200, 170, 200
170   DO 190  KN=1,NCON
      LN = MATN(KN)
      IF(LN - I1(M))  190, 180, 190
180   T2(M) = MASS(LN,KZ)
190   CONTINUE
200   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE REFUEL( KNT,NREG,NREP2,NPOIS,KLAPS,INTMAX,NECOP,XO,
     1      NFRE, TRG, HNO, PHI, ABXS, FIXS, KZNS, IZON, IZM, M01, ML,
     2      DAY, IGM, IMJM,ISTART,NCON,IDMTPS, I0, I1, I2, PHIP, PSI,
     3      V, AXS, FXS, MATN, ALAM, LD, LCN, LFN, HOLN, ATW, NZN, DN,
     4      CN , CNP, HNI, DG, CG, DISCHG, CHARGE, COMPO, NBIFLG)
      DIMENSION X0(1), NFRE(1), TRG(1), HNO(1), PHI(INTMAX,IZM),
     1      ABXS(NCON,IZM,INTMAX), FIXS(NCON,IZM,INTMAX), KZNS(1),
     2      IZON(KLAPS,IZM), I0(1), I1(1), I2(1), PHIP(1), PSI(1),V(1),
     3      AXS(ML,IZM), FXS(ML,IZM), MATN(1), ALAM(1), LD(1), LCN(ML,2),
     4      LFN(ML,7), HOLN(1), ATW(1), NZN(1), DN(IZM,NCON),
     5      CN(IZM,NCON), CNP(IZM,NCON), HNI(1), DG(NECOP,NCON),
     6      CG(NECOP,NCON), DISCHG(1), CHARGE(1), COMPO(1),
     7      NBIFLG(IZM,NCON)
      COMMON NINP, NOUT,  NCR1,  NFLUX1,  NSCRAT.  ISCRAT,  NDUMP
      INTEGER TRG
      REAL I2
C
C     CARD BLOCK 1      K,X0(K), NFRE(K)  K=1,NREG             I6,F12.5,I6
C
C     CARD BLOCK 2      TRG(N)        N=1,NCON  (1 CARD)               24I3
C
C     CARD BLOCK 3      HNO(I)        I=1,M01                         6F12.7
C       (OMIT IF USING TAPE NDUMP AND KNT GT. 1)
C
C     CARD BLOCK 4      PHI(I,J)      I=1,IZM J=1,KLNT                6E12.5
C       (OMIT IF USING TAPE NDUMP)
C
C     CARD BLOCK 5      ABXS(I,J,K) I=1,NCON J=1,IZM K=1,KLNT   6E12.5
C       (OMIT IF USING TAPE NDUMP)
C
C     CARD BLOCK 6      FIXS(I,J,K) I=1,NCON J=1,IZM K=1,KLNT   6E12.5
C       (OMIT IF USING TAPE NDUMP)
C
C     CARD BLOCK 7      KZNS(I)       (KLAPS PAIRS OF CARDS)              I6
C                       IZON(I,J)     J=1,KZNS(I)                       24I3
C
C
C     READ IN THE INPUT DATA
C
      INT = KNT + 1
      KLNT = KNT - 1
      CALL INPR (KNT, NREG, KLAPS, INTMAX, X0, NFRE,  TRG, HNO, PHI,
     1         ABXS, FIXS, KZNS, IZON, IZM. M01, ML, DAY, IGM, IMJM,
     2           ISTART, NCON, IDMTPS, I0, I1, I2, PHIP, PSI, AXS, FXS.
     3           MATN, HOLN, NZN, NBIFLG )
C
C  MAIN LOOP (CALC OF ATOM DENS OF CONSTITUENTS HAVING THE MOST BURNUP
C
      DAYP = DAY*24.*3600./10.
      DO 505 N=1,NREG
      KZ = IZN(N)
      X = KNT/NFRE(KZ)
      IF (X.EQ.1.0.OR.X0(KZ).EQ.1.0) GO TO 485
      DIFF = 1.0 - X*X0(KZ)
      IF(ABS(DIFF).LE..005) DIFF=0.0
      IF (DIFF) 375,375,390
  375 KK=1
  380 DIFF = DIFF + X0(KZ)
```

```
      IF (ABS(DIFF).LE..005) DIFF=0.0
      DIFP = ABS(DIFF - X0(KZ))
      IF (DIFP.LE..005) DIFF = X0(KZ)
      IF (DIFF.GT.0.) GO TO 385
      KK = KK + NFRE(KZ)
      GO TO 380
385   ISTRT = KK
      COEF = DIFF
      DIFP = X0(KZ) - COEF
      GO TO 395
390   ISTRT = 1
      COEF = X0(KZ)
      DIFP = X0(KZ) - COEF
395   ITEMS = ISTRT
400   DO 415 I=1,NCON
      II = NBIFLG(KZ,I)
      IF (II) 405,405,410
405   CN(KZ,I) = 0.
      GO TO 415
410   CN(KZ,I) = HNO(II)
415   CONTINUE
420   PHY = PHI(ITEMS,KZ)*10.**(-24)
      DO 470 KT=1,10
      DO 425 KN=1,NCON
425   CNP(KZ,KN) = CN(KZ,KN)
      DO 465 KKK=1,5
      DO 460 KN=1,NCON
      IF (NBIFLG(KZ,KN).EQ.0) GO TO 460
      LN = MATN(KN)
      TEMP2=-(CN(KZ,KN)+CNP(KZ,KN))*(ALAM(LN)+ABXS(KN,KZ,ITEMS)*PHY)
      IF (LD(KN)) 435,435,430
430   KK = LD(KN)
      KLN = MATN(KK)
      TEMP2 = TEMP2 + ALAM(KLN)*(CN(KZ,KK)+CNP(KZ,KK))
435   DO 445 K=1,2
      KK = LCN(KN,K)
      IF(KK) 445,445,440
440   TEMP2 =TEMP2 + (ABXS(KK,KZ,ITEMS)-FIXS(KK,KZ,ITEMS))*PHY*(CN(KZ,
     1KK) + CNP(KZ,KK))
445   CONTINUE
      DO 455 K=1,7
      KK = LFN(KN,K)
      IF(KK) 455,455,450
450   TEMP2 = TEMP2 + FIXS(KK,KZ,ITEMS)*PHY*(CN(KZ,KK)+CNP(KZ,KK))
455   CONTINUE
      CN(KZ,KN) = CNP(KZ,KN) + 0.5*DAYP*TEMP2
460   CONTINUE
465   CONTINUE
470   CONTINUE
      ITEMS = ITEMS + 1
      IF (ITEMS.GT.KNT) GO TO 475
      GO TO 420
475   DO 480 KN=1,NCON
      DN(KZ,KN) = DN(KZ,KN) + CN(KZ,KN)*COEF
      IF (TAG(KN).EQ.0) CN(KZ,KN)=0.
480   CONTINUE
      IF(DIFP.LE.0.) GO TO 505
      COEF = DIFP
```

```
      NFRE = 0.                                                         REF  117
      ISTRT = ISTRT + NFRE(KZ)                                          REF  118
      GO TO 395                                                         REF  119
  485 DO 500 KN=1,NCON                                                  REF  120
      II = NB1FLG(KZ,KN)                                                REF  121
      IF (II) 490,490,495                                               REF  122
  490 DN(KZ,KN) = 0.                                                    REF  123
      GO TO 500                                                         REF  124
  495 DN(KZ,KN) = X0(KZ)*I2(II)                                         REF  125
      IF (TRG(KN).EQ.0) DN(KZ,KN) = 0.                                  REF  126
  500 CONTINUE                                                          REF  127
  505 CONTINUE                                                          REF  128
      DO 510 KZ=1,IZM                                                   REF  129
      DO 510 N=1,NCON                                                   REF  130
  510 CN(KZ,N) = 0.                                                     REF  131
C                                                                       REF  132
C     CALCULATE AND PUNCH THE INPUT ATOM DENSITIES (I2 BLOCK) FOR NEXT  REF  133
C     BURNUP INTERVAL AND PRINT REGION-BY-REGION SUMMARY                REF  134
C                                                                       REF  135
      PRINT 515                                                         REF  136
  515 FORMAT (1H1,/10X,77H REGION DISCHARGE AND CHARGE AND INITIAL COMPOREF  137
     1SITION FOR NEXT BURNUP INTERVAL    //)                            REF  138
      IIK=1                                                             REF  139
      PRINT 520, IIK,V(IIK)                                             REF  140
  520 FORMAT (//3X,7H REGION I3,9H  VOLUME= 1PE10.4,7H LITERS /)        REF  141
      PRINT 525, KNT,INT,INT                                            REF  142
  525 FORMAT (7X,29H ELEMENT     DISCHARGE FROM BI I3,9X, 14H CHARGE FOR REF  143
     1BI I3,8X,23H INITIAL COMPOSITION BI I3)                           REF  144
      PRINT 530                                                         REF  145
  530 FORMAT(16X,10H ATOM DENS,5X,9H MASS(KG),5X,10H ATOM DENS,5X,9H MASREF  146
     1S(KG),5X,24H ATOM DENS        MASS(KG) /)                         REF  147
      DO 560 I=1,M01                                                    REF  148
      HNI(I) = I2(I)                                                    REF  149
      IF (I1(I).EQ.0) GO TO 560                                         REF  150
      IF (I1(I).EQ.NPOIS.AND.NREPO.EQ.1) HNI(I) = HN0(I)                REF  151
      IK = I0(I) - ML                                                   REF  152
      I1FLAG = I1(I)                                                    REF  153
      COEF = ATW(I1FLAG)*V(IK)/.6023                                    REF  154
      IF(IK.EQ.IIK) GO TO 535                                           REF  155
      IIK = IIK + 1                                                     REF  156
      PRINT 520, IIK,V(IIK)                                             REF  157
      PRINT 525,KNT,INT,INT                                             REF  158
      PRINT 530                                                         REF  159
  535 DIS = 0.                                                          REF  160
      CHG = 0.                                                          REF  161
      DO 545 N=1,NREG                                                   REF  162
      KZ = MZN(N)                                                       REF  163
      IF (KZ.LT.IK) GO TO 545                                           REF  164
      IF (KZ.GT.IK) GO TO 550                                           REF  165
      DO 540 L=1,NCON                                                   REF  166
      IF (MATN(L).NE.I1FLAG) GO TO 540                                  REF  167
      IF (TRG(L).EQ.0) GO TO 550                                        REF  168
      DIS = DN(KZ,L)                                                    REF  169
      CHG = X0(KZ)*HN0(I)                                               REF  170
      CN(KZ,L) = CHG                                                    REF  171
      HNI(I) = HNI(I) + CHG - DIS                                       REF  172
      GO TO 550                                                         REF  173
  540 CONTINUE                                                          REF  174
```

```
545   CONTINUE
550   TEMD = DIS*COEF
      TEMC = CHG*COEF
      TEMP = HNI(I)*COEF
      PRINT 555, IIFLAG,DIS,TEMD,CHG,TEMC,HNI(I),TEMP
555   FORMAT(10X,I2,4X,F10.7,5X,1PE10.4,4X,0PF10.7,4X,1PE10.4,5X,
     1      0PF10.7,5X,1PE10.4)
560   CONTINUE
C
C     I2 BLOCK FOR HEAT BURNUP INTERVAL
C
      PUNCH 565, INT,DAY
565   FORMAT (2X,16H I2 BLOCK FOR BI,I3,10H OF LENGTH ,F6.1,5H DAYS )
      PUNCH 570, (HNI(I),I=1,M01)
570   FORMAT (6E12.7)
      PRINT 575, INT
575   FORMAT (1H1,/10X,52H INPUT ATOM DENSITIES (I2 BLOCK) FOR BURNUP IN
     1TERVAL  I3//)
      DO 580 I=1,M01
580   PRINT 585,I,I0(I),I1(I),HNI(I)
585   FORMAT(5X,2HI=,I3,3X,3HI0=,I2,3X,3HI1=,I3,3X,7HI2(I) =,F10.7)
C
C     REGION COLLAPSING (VOLUME AVERAGED)
C
      IF (KLAPS) 665,665,590
590   PRINT 595
595   FORMAT (1H1,10X,57H REGION COLLAPSED INFORMATION FOR ELEMENTS TO B
     1E REFUELED /)
      DO 660 I=1,KLAPS
      TOTV = 0.
      KK = KZNS(I)
      DO 600 K=1,KK
      KZ = IZON(I,K)
600   TOTV = TOTV + V(KZ)
      PRINT 605, I, (IZON(I,K),K=1,KK)
605   FORMAT (//5X,20H REGION COLLAPSE NO. I3,13H FROM REGIONS 24I3)
      PRINT 610, TOTV
610   FORMAT (/ 8X,21H VOL AFTER COLLAPSE = 1PE10.4,8H  LITERS /)
      PRINT 615
615   FORMAT (15X, 84H ELEMENT   COMPOSITION AT END    DISCHARGE FROM
     1 CHARGE FOR    INITIAL COMPOSITION  )
      PRINT 620, KNT, KNT, INT, INT
620   FORMAT(22X, 7H OF BI ,I2,5H, KG., 8X, 4H BI ,I2,5H, KG.,5X,4H BI ,
     1      I2,5H, KG. ,5X,8H FOR BI ,I2,5H, KG. /)
      DO 640 N=1,NCON
      DIS = 0.
      CHG = 0.
      TEMF = 0.
      TEMI = 0.
      LN = MAIN(N)
      DO 625 K=1,KK
      KZ = IZON(I,K)
      DIS = DIS + DH(KZ,N)*V(KZ)/TOTV
      CHG = CHG + CH(KZ,N)*V(KZ)/TOTV
      II = NBIFLG(KZ,N)
      IF (II) 625,625,624
624   TEMI = TEMI + HNI(II)*V(KZ)/TOTV
      TEMF = TEMF + I2(II)*V(KZ)/TOTV
```

```
 625  CONTINUE
      TEMF = TEMF*TOTV*ATW(LN)/.6023
      DIS  = DIS*TOTV*ATW(LN)/.6023
      CHG  = CHG*TOTV*ATW(LN)/.6023
      TEMI = TEMI*TOTV*ATW(LN)/.6023
      PRINT 630, LN, TEMF, DIS, CHG, TEMI
 630  FORMAT (13X,I2,9X,1PE10.4,11X,1PE10.4,6X,1PE10.4,8X,1PE10.4)
C
C     PREPARE AND PUNCH CHARGE AND DISCHARGE MASSES FOR FURTHER
C     ECONOMICS ANALYSIS (IF DESIRED).  FIRST NECOP COLLAPSES WILL
C     BE PUNCHED.
C
      IF (I.GT.NECOP) GO TO 635
      DG(I,N) = DIS
      CG(I,N) = CHG
 635  CONTINUE
 640  CONTINUE
      IF (I.GT.NECOP) GO TO 660
      PUNCH 645, I,KNT
 645  FORMAT (2X,9H COLLAPSE I2,18H DISCHARGE FROM BI I3)
      PUNCH 650, (DG(I,N),N=1,NCOM)
 650  FORMAT (6F12.4)
      PUNCH 655,I,INT
 655  FORMAT (2X,9H COLLAPSE I2,14H CHARGE FOR BI I3)
      PUNCH 650, (CG(I,N),N=1,NCOM)
 660  CONTINUE
 665  CONTINUE
      IF (NECOP.LE.KLAPS) GO TO 675
      PRINT 670
 670  FORMAT(1H1,48H * * * NECOP IS GREATER THAN KLAPS - ERROR * * *///)
C
C     MASS SUMMARY FOR ENTIRE REACTOR
C
 675  DO 680 K=1,ML
      COMPO(K) = 0.
      DISCHG(K) = 0.
 680  CHARGE(K) = 0.
      DO 685 I=1,M01
      IK = I0(I) - ML
      K = I1(I)
 685  COMPO(K) = COMPO(K) + HNI(I)*V(IK)*ATW(K)/.6023
      DO 690 KZ=1,IZM
      DO 690 N=1,NCOM
      LN = MATN(N)
      COEF= V(KZ)*ATW(LN)/.6023
      CHARGE(LN) = CHARGE(LN) + CH(KZ,N)*COEF
 690  DISCHG(LN) = DISCHG(LN) + DH(KZ,N)*COEF
      PRINT 695,KNT,INT,INT
 695  FORMAT(1H1,3X,18H DISCHARGE FROM BI I3,16H,  CHARGE FOR BI I3,
     1       29H  AND INITIAL COMPOS. FOR BI  I3,14H  IN KILOGRAMS //)
      DO 700 I=1,ML
 700  PRINT 705, I,HOLN(I),DISCHG(I),CHARGE(I),COMPO(I)
 705  FORMAT (5X,8H ELEMENT I3,2X,A9,3X,18H TOTAL DISCHARGE = 1PE11.4,
     1       3X,15H TOTAL CHARGE = 1PE11.4,3X,24H TOTAL MASS IN REACTOR =
     2       1PE11.4/)
      RETURN
      END
```

```
      SUBROUTINE INPR (KNT, NREG, KLAPS, INTMAX, X0, NFRE, TRG, HN0,PHI,
     1           ABXS, FIXS, KZNS, IZON, IZM, M01, ML, DAY, IGM, IMJM,
     2             ISTART, NCON, IDMTPS, I0, I1, I2, PHIP, PSI, AXS, FXS,
     3             MATN, HCLN, NZN, NBIFLG )
      DIMENSION  X0(1), NFRE(1), TRG(1), HN0(1), PHI(INTMAX,IZM),
     1     ABXS(NCON,IZM,INTMAX), FIXS(NCON,IZM,INTMAX), KZNS(1),
     2     IZON(KLAPS,IZM), I0(I), I1(1), I2(1), PHIP(1), PSI(1),
     3     AXS(ML,IZM), FXS(ML,IZM), MATN(1), MOLN(1), NZN(1),
     4     NBIFLG(IZM,NCON)
      COMMON  NINP,   NOUT,   NCR1,   NFLUX1,   NSCRAT,   ISCRAT,   NDUMP
      INTEGER TRG
      REAL I2
C
C     THIS SUBROUTINE READS, PRINTS AND PUNCHES INPUT DATA FOR REFUEL
C
      TNT= KNT + 1
      KLNT = KNT - 1
    5 FORMAT (I6,F12.5,I6)
      IN = 0
      DO 15 I=1,NREG
      READ (NINP,5)  K, X0(K), NFRE(K)
      KNF = NFRE(K)
      IF (MOD(KNT,KNF).NE.0) GO TO 10
      IN = IN + 1
      NZN(IN) = K
      GO TO 15
   10 X0(K) = 0.
   15 CONTINUE
      NREG = IN
      CALL TRIG (TRG,NCON)
   20 FORMAT (24I3)
      IF (ISTART.EQ.3) GO TO 30
      READ (NINP,25)  (HN0(J), J=1,M01)
   25 FORMAT (6E12.7)
      GO TO 40
   30 CONTINUE
      DO 35 IIG=1,IGM
   35 READ (NDUMP)
      READ( NDUMP)   (HN0(J)  ,J=1,M01)
   40 CONTINUE
      IF (KLNT.EQ.0) GO TO 65
      IF (IDMTPS.EQ.1) GO TO 55
      DO 45 I=1,KLNT
   45 READ(NINP,50)(PHI(I,J),J=1,IZM)
   50 FORMAT (6E12.5)
      GO TO 65
   55 DO 60 I=1,INTMAX
   60 READ (NDUMP)   (PHI(I,J), J=1,IZM)
   65 CONTINUE
      DO 70 J=1,IZM
   70 PHI(KNT,J) = PHIP(J)
      IF (IDMTPS.EQ.1) GO TO 100
      PUNCH 75, KNT
   75 FORMAT(2X,5H PHI(   I2,3H,J))
      PUNCH 50 , (PHI(KNT,J),J=1,IZM)
      IF (KLNT.EQ.0) GO TO 120
      DO 85 K=1,KLNT
      DO 80 J=1,IZM
```

```
 80     READ (NINP,50)   (ABXS(I,J,K), I=1,NCON)                             INPR  59
 85     CONTINUE                                                             INPR  60
        DO 95 K=1,KLNT                                                       INPR  61
        DO 90 J=1,IZM                                                        INPR  62
 90     READ (NINP,50)   (FIXS(I,J,K), I=1,NCON)                             INPR  63
 95     CONTINUE                                                             INPR  64
        GO TO 120                                                            INPR  65
 100    IF(KLIT.EQ.0) GO TO 120                                              INPR  66
 105    DO 110 K=1,INTMAX                                                    INPR  67
        DO 110 J=1,IZM                                                       INPR  68
 110    READ (NDUMP)   (ABXS(I,J,K),I=1,NCON)                                INPR  69
        DO 115 K=1,INTMAX                                                    INPR  70
        DO 115 J=1,IZM                                                       INPR  71
 115    READ (NDUMP)   (FIXS(I,J,K),I=1,NCON)                                INPR  72
 120    DO 130 J=1,IZM                                                       INPR  73
        DO 125 I=1,NCON                                                      INPR  74
        ABXS(I,J,KNT) = AXS(I,J)                                             INPR  75
 125    FIXS(I,J,KNT) = FXS(I,J)                                             INPR  76
 130    CONTINUE                                                             INPR  77
        IF (IWITPS.EQ.1) GO TO 155                                           INPR  78
        PUNCH 135, KNT                                                       INPR  79
 135    FORMAT(2X,10H ABXS(I,J,  I2,2H) )                                    INPR  80
        DO 140 J=1,IZM                                                       INPR  81
 140    PUNCH 50, (ABXS(I,J,KNT),I=1,NCON)                                   INPR  82
        PUNCH 145, KNT                                                       INPR  83
 145    FORMAT(2X,10H FIXS(I,J,  I2,2H) )                                    INPR  84
        DO 150 J=1,IZM                                                       INPR  85
 150    PUNCH 50, (FIXS(I,J,KNT),I=1,NCON)                                   INPR  86
        GO TO 180                                                            INPR  87
 155    CONTINUE                                                             INPR  88
C                                                                            INPR  89
C       WRITE INFORMATION ON TAPE (NDUMP) IF DESIRED                         INPR  90
C                                                                            INPR  91
        REWIND NDUMP                                                         INPR  92
        DO 160 I=1,IGM                                                       INPR  93
        READ (ISCRAT) (PSI(J),J=1,IMJM)                                      INPR  94
 160    WRITE(NDUMP) (PSI(J),J=1,IMJM)                                       INPR  95
        WRITE (NDUMP)   (HNO(I),I=1,M01)                                     INPR  96
        DO 165 I=1,INTMAX                                                    INPR  97
 165    WRITE(NDUMP)   (PHI(I,J),J=1,IZM)                                    INPR  98
        DO 170 K=1,INTMAX                                                    INPR  99
        DO 170 J=1,IZM                                                       INPR 100
 170    WRITE(NDUMP)   (ABXS(I,J,K),I=1,NCON)                                INPR 101
        DO 175 K=1,INTMAX                                                    INPR 102
        DO 175 J=1,IZM                                                       INPR 103
 175    WRITE(NDUMP)   (FIXS(I,J,K),I=1,NCON)                                INPR 104
        REWIND NDUMP                                                         INPR 105
 180    CONTINUE                                                             INPR 106
C                                                                            INPR 107
C       COMPLETE READING OF INPUT DATA                                       INPR 108
C                                                                            INPR 109
        IF (KLAPS) 200,200,185                                               INPR 110
 185    DO 195 I=1,KLAPS                                                     INPR 111
        READ(NINP,190) KZNS(I)                                               INPR 112
 190    FORMAT (I6)                                                          INPR 113
        KK = KZNS(I)                                                         INPR 114
 195    READ(NINP,20)   (IZCN(I,J),J=1,KK)                                   INPR 115
 200    CONTINUE                                                             INPR 116
```

```
C
C     PRINT THE INPUT DATA
C
      PRINT 210, DAY
  210 FORMAT(////10X,20H LENGTH OF BURNUP INTERVAL,F6.1,6H  DAYS)
      PRINT 215
  215 FORMAT (1H1,//10X,33H CLEAN FUEL ATOM DENSITIES,HNO(I)  ///)
      DO 220 I=1,NN01
  220 PRINT 225,  I, I0(I),  I1(I),  HNO(I)
  225 FORMAT(5X,2HI=,I3,5H  I0=,I2,5H  I1=,I2,16H  CLEAN DENSITY=F10.7)
      PRINT 230,  KNT
  230 FORMAT (1H1,/10X,35H REFUELING DATA FOR BURNUP INTERVAL  I3///)
      PRINT 235
  235 FORMAT (15X,38H REGION   REFUELING    NO.OF INTERVALS /,
     1      24X,  31H FRACTIONS   BETWEEN REFUELINGS  /)
      DO 240 I=1,NREG
      K = NZN(I)
  240 PRINT 245,  K,  X0(K),  NFRE(K)
  245 FORMAT(18X,I2,4X,F9.5,12X,I2)
      PRINT 250
  250 FORMAT (///15X,65H ELEMENTS (BURNABLE ISOTOPES) TO BE REFUELED IN
     1THE ABOVE REGIONS  /)
      DO 260 N=1,NCON
      IF (TRG(N).EQ.0) GO TO 260
      LN = MATN(N)
      PRINT 255, LN,HOLN(LN)
  255 FORMAT (20X,9H ELEMENT ,I2,3X,A9)
  260 CONTINUE
      PRINT 265
  265 FORMAT (1H1,/10X,89H ZONE, GROUP AVERAGED ABSORPTION X-SECTIONS FO
     1R BURNABLE ISOTOPES, ABXS(I,J,K) K=KLNT,KNT  ///)
      N = KLNT
      IF (KLNT.EQ.0) N=1
      NN = KNT
      DO 285 K=N,NN
      PRINT 270, K
  270 FORMAT(/4X,19H BURNUP INTERVAL K=  I3)
      DO 275 J=1,IZM
  275 PRINT 280, J, (ABXS(I,J,K),I=1,NCON)
  280 FORMAT(6X, 8H REGION ,I2/,(10F12.4))
  285 CONTINUE
      PRINT 290
  290 FORMAT (1H1,//10X,83H ZONE, GROUP AVERAGED FISSION X-SECT FOR BURN
     1ABLE ISOTOPES, FIXS(I,J,K), K=KLNT,KNT  ///)
      N = KLNT
      IF (KLNT.EQ.0) N=1
      NN = KNT
      DO 300 K=N,NN
      PRINT 270, K
      DO 295 J=1,IZM
  295 PRINT 280, J, (FIXS(I,J,K),I=1,NCON)
  300 CONTINUE
      PRINT 305
  305 FORMAT (1H1,/10X,59H AVG FLUX USED IN PREVIOUS EIGHT BURNUP INTERV
     1ALS, PHI(I,J)  ///)
      NN = KNT - 7
  310 IF (NN) 315,315,320
  315 NN = NN+1
```

```
      GO TO 310
  320 PRINT 325, (J,J=NN,KNT)
  325 FORMAT(10X,8(6H   PHI(,I2,6H,J)    )/)
      DO 330 J=1,IZM
  330 PRINT 335, J, (PHI(I,J),I=NN,KNT)
  335 FORMAT (2X,2HJ=,I2,4X,8(E12.5,2X))
C
C     TAG THE BURNABLE ISOTOPES IN THE M01 ARRAY
C
      DO 350 I=1,M01
      IK = IG(I) - ML
      IIFLAG = I1(I)
      DO 345 K=1,NREG
      KZ = IZN(K)
      IF (KZ.LT.IK) GO TO 345
      IF (KZ.GT.IK) GO TO 350
      DO 340 N=1,NCOM
      LN = MATN(N)
      IF (LN.NE.IIFLAG) GO TO 340
      NBIFLG(KZ,N) = 1
  340 CONTINUE
  345 CONTINUE
  350 CONTINUE
      PRINT 355
  355 FORMAT(1H1,//10X,49H I VALUES IN M01 ARRAY THAT ARE BURNABLE ISOTO
     1PES  //)
      DO 370 K=1,NREG
      KZ = IZN(K)
      DO 360 N=1,NCOM
  360 PRINT 365, NBIFLG(KZ,N),KZ,N,MATN(N)
  365 FORMAT (5X,2HI=,I3,3X,9H REGION = I2,3X,13H BURN ISO NO.  I2,3X,
     1      12H ELEMENT NO. I2)
  370 CONTINUE
      RETURN
      END
```

APPENDIX C

SAMPLE PROBLEM

In this section, the printed PHENIX output is shown for a Search → Burnup → k_{eff} → Refuel calculation (2 groups, 4 regions).

* * * * P H E N I X * * * *

CARDS 1 AND 2 (ID AND TMAX)

PHENIX EXAMPLE / 2 GROUP / ARGONNE CODE CNTR SAMPLE REACTOR
SEARCH-BURN-KEFF-REFUEL
TMAX = -".0 MIN.

CARD 3 DATA 12I6 FORMAT

IGF	GEOMETRY (0/1/2 = X-Y/R-Z/R-THETA)	1
IZM	NUMBER OF MATERIAL ZONES(REGIONS)	4
IBL	LEFT BOUNDARY CONDITION (0/1=VACUUM/REFLECTIVE)	1
IBR	RIGHT BOUNDARY CONDITION (SAME AS IBL)	0
IBT	TOP BOUNDARY CONDITION (SAME AS IBL)	0
IBB	BOTTOM BOUNDARY COND. (SAME AS IBL)	0
IEVT	EIGENVALUE TYPE (1/2/3=KEFF/CONC/DELTA)	2
IPVT	PARAMETRIC EIGENVALUE TYPE (1/2=NONE/KEFF)	2
IM	NUMBER OF RADIAL MESH INTERVALS	17
JM	NUMBER OF AXIAL MESH INTERVALS	18
IZ	NO. OF RADIAL ZONES (DELTA OPTION ONLY)	0
JZ	NO. OF AXIAL ZONES (DELTA OPTION ONLY)	0

CARD 4 DATA 12I6 FORMAT

IGM	NUMBER OF GROUPS	2
ML	NUMBER OF INPUT MATERIALS	10
ICST	CROSS SECTION TYPE (1/2=TYPE1/TYPE2)	2
IHT	POSITION OF SIGMA TOTAL IN X-SECT TABLE	6
IHS	POSITION OF SIGMA SELF-SCATTER IN X-SECT TABLE	7
ITL	CROSS SECTION TABLE LENGTH	8
IXSEC	READ X-SECTS FROM TAPE (0/1=NO/YES)	0
MO1	TOTAL NO. OF MIXTURE SPECIFICATIONS	36
OITM	MAX NO. OF OUTER ITERATIONS ALLOWED	100
IITM	MAX NO. OF INNER ITERATIONS ALLOWED PER OUTER ITER.	5
MSHSWP	LINE INVERSION DIRECTION (1/2/3/4=ALT DIR/RAD/AX/CODE DECIDES	4
ISTART	FLUX GUESS (0/1/2/3/4=NONE/CARDS/CARDS/TAPE/SINUSOID)	4

CARD 5 DATA 8I6 FORMAT

IREF	BURNUP/REFUEL CONTROL (0/1/2=NO BURNUP/BURNUP ONLY/BURNUP AND REFUEL)	2
NBSTP	NUMBER OF BURNUP TIME STEPS IN A BURNUP INTERVAL	1
IFS	PERFORM FINAL SEARCH (0/1 = NO/YES)	0
NPOIS	MATERIAL NO. OF CONTROL POISON	10
MWDT	CALCULATE BURNUP IN MWD/T (0/1=NO/YES)	1
IPFLX	PUNCH FLUX DUMP (0/1/2=NO/FLUX BEFORE BURNUP/FLUX AFTER BURNUP)	0
IPRIN	PRINT CONTROL(1/2/3=FULL PRINT/FULL PRINT FOR DAY=0 ONLY/PARTIAL PRINT)	2
IDMTPS	PREPARE DATA DUMP TAPE (0/1=NO/YES)	0

CARD 6 DATA 6E12.4 FORMAT

EPS	EIGENVALUE CONVERGENCE CRITERION	1.0000E-04
SRCRT	NEUTRON SOURCE RATE (FOR NORMALIZATION)	0.
POWR	REACTOR POWER (MWT) (FOR NORMALIZATION)	3.0000E+02
ORF	OVERRELAXATION FACTOR	1.5000E+00
FLXTST	INNER ITERATION FLUX TEST (0/EP=EPS/EP FOR TEST)	0.
PV	DESIRED VALUE OF PARAMETRIC EIGENVALUE (SEARCH ONLY)	1.0000E+00

```
    CARD 7 DATA    6E12.4 FORMAT

EPSA    PARAMETRIC EIGNVALUE CONVERGENCE CRITERION(SEARCH ONLY                1.0000E-03
EV      INITIAL EIGENVALUE GUESS (SEARCH ONLY)                               -1.0000E-01
EVM     EIGENVALUE MODIFIER (SEARCH ONLY)                                    -1.0000E-01
EV2     EIGENVALUE GUESS FOR 2ND AND ALL OTHER SEARCHES                       0.
XLAL    LAMBDA-1 LOWER LIMIT (SEARCH ONLY)                                    5.0000E-03
XLAH    LAMBDA-1 UPPER LIMIT (SEARCH ONLY)                                    5.0000E-01

    CARD 8 DATA    E12.4 FORMAT

POD     PARAMETER OSCILLATION DAMPER (SEARCH ONLY)                            1.0000E+00


LAST=  4073
TEMPORARY STORAGE FOR CROSS SECTION REARRANGEMENT=    367
```

PHENIX EXAMPLE / 2 GROUP / ARGONNE CODE CNTR SAMPLE REACTOR
SEARCH-BURN-KEFF-REFUEL

```
 1        IRON
 2        CHROM
 3        NICK
 4        NA
 5        PUA
 6        PUB
 7        U238
 8        OXY
 9        FPH
10        P-10
```

MESH BOUNDARIES (R0/Z0=RADIAL POINTS/AXIAL POINTS)

```
          R0     18
0.        .66667E+01  .13333E+02  .20000E+02  .26667E+02  .33333E+02  .40000E+02  .46667E+02  .53333E+02  .60000E+02
 .66667E+02  .73333E+02  .80000E+02  .86000E+02  .92000E+02  .98000E+02  .10400E+03  .11000E+03
          Z0     19
0.        .40000E+01  .80000E+01  .12000E+02  .16000E+02  .20000E+02  .25000E+02  .30000E+02  .35000E+02  .40000E+02
 .45000E+02  .50000E+02  .55000E+02  .60000E+02  .64000E+02  .68000E+02  .72000E+02  .76000E+02  .80000E+02
```

FLUX GUESS (RF/ZF=TOTAL RADIAL FLUX/TOTAL AXIAL FLUX)

```
       RF     17
 .99896E+00  .99069E+00  .97420E+00  .94964E+00  .91721E+00  .87718E+00  .82989E+00  .77571E+00  .71511E+00  .64858E+00
 .57668E+00  .50000E+00  .42331E+00  .34772E+00  .26980E+00  .19007E+00  .10906E+00
       ZF     18
 .24192E+00  .37461E+00  .50000E+00  .61566E+00  .71934E+00  .81915E+00  .90631E+00  .96593E+00  .99619E+00  .99619E+00
 .96593E+00  .90631E+00  .81915E+00  .71934E+00  .61566E+00  .50000E+00  .37461E+00  .24192E+00
```

ZONE NUMBERS BY MESH INTERVAL

M0 306

2	2	2	2	2	2	2	2	2	2
2	2	4	4	4	4	4	2	2	2
2	2	2	2	2	2	2	2	2	4
4	4	4	4	2	2	2	2	2	2
2	2	2	2	2	2	4	4	4	4
4	2	2	2	2	2	2	2	2	2
2	2	2	4	4	4	4	4	2	2
2	2	2	2	2	2	2	2	2	2
4	4	4	4	4	1	1	1	1	1
1	1	1	1	1	1	1	4	4	4
4	4	1	1	1	1	1	1	1	1
1	1	1	1	4	4	4	4	4	1
1	1	1	1	1	1	1	1	1	1
1	4	4	4	4	4	1	1	1	1
1	1	1	1	1	1	1	1	4	4
4	4	4	1	1	1	1	1	1	1
1	1	1	1	1	4	4	4	4	4
1	1	1	1	1	1	1	1	1	1
1	1	4	4	4	4	4	1	1	1

```
      1           1           1           1           1           1           1           1           1           4
      4           4           4           4           1           1           1           1           1           1
      1           1           1           1           1           1           4           4           4           4
      4           3           3           3           3           3           3           3           3           3
      3           3           3           4           4           4           4           4           3           3
      3           3           3           3           3           3           3           3           3           3
      4           4           4           4           4           3           3           3           3           3
      3           3           3           3           3           3           3           4           4           4
      4           4           3           3           3           3           3           3           3           3
      3           3           3           3           4           4           4           4           4           3
      3           3           3           3           3           3           3           3           3           3
      3           4           4           4           4           4

MATERIAL NUMBERS BY ZONE
         M2      4
         11          12          13          14

FISSION SPECTRUM
         K7      2
 .99234E+00  .76570E-02

MIXTURE SPECIFICATIONS (I0/I1/I2=MIX NUMBER/MAT. NUMBER FOR MIX/MATERIAL DENSITY)
         I0      36
         11          11          11          11          11          11          11          11          11          11
         11          12          12          12          12          12          12          12          12          12
         12          13          13          13          13          13          13          13          13          13
         13          14          14          14          14          14
         I1      36
          0           4           1           2           3           5           6           7           9           8
         10           0           4           1           2           3           5           6           7           9
          8           0           4           1           2           3           5           6           7           9
          8           0           1           2           3           4
         I2      36
0.          .12733E-01  .10033E-01  .25797E-02  .16131E-02  .21241E-02  .30220E-03  .29357E-02 0.          .10730E-01
 .50000E-03 0.          .12733E-01  .10033E-01  .25797E-02  .16131E-02 0.          0.          .53735E-02 0.
 .10730E-01 0.          .12733E-01  .10033E-01  .25797E-02  .16131E-02 0.          0.          .53735E-02 0.
 .10730E-01 0.          .81738E-02  .21016E-02  .13142E-02  .19220E-01
         I4      36
0.          0.          0.          0.          0.          0.          0.          0.          0.          0.
 .10000E+01 0.          0.          0.          0.          0.          0.          0.          0.          0.
0.          0.          0.          0.          0.          0.          0.          0.          0.          0.
0.          0.          0.          0.          0.          0.
```

PHENIX EXAMPLE / 2 GROUP / ARGONNE CODE CNTR SAMPLE REACTOR
SEARCH-BURN-KEFF-REFUEL

```
   3 3 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4
   3 3 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4
   3 3 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4
   3 3 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4
   3 3 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4
   1 1 1 1 1 1 1 1 1 1 1 1 4 4 4 4 4
   1 1 1 1 1 1 1 1 1 1 1 1 4 4 4 4 4
   1 1 1 1 1 1 1 1 1 1 1 1 4 4 4 4 4
   1 1 1 1 1 1 1 1 1 1 1 1 4 4 4 4 4
   1 1 1 1 1 1 1 1 1 1 1 1 4 4 4 4 4
   1 1 1 1 1 1 1 1 1 1 1 1 4 4 4 4 4
   1 1 1 1 1 1 1 1 1 1 1 1 4 4 4 4 4
   1 1 1 1 1 1 1 1 1 1 1 1 4 4 4 4 4
   2 2 2 2 2 2 2 2 2 2 2 2 4 4 4 4 4
   2 2 2 2 2 2 2 2 2 2 2 2 4 4 4 4 4
   2 2 2 2 2 2 2 2 2 2 2 2 4 4 4 4 4
   2 2 2 2 2 2 2 2 2 2 2 2 4 4 4 4 4
   2 2 2 2 2 2 2 2 2 2 2 2 4 4 4 4 4
A
X
I
A
L

 RADIAL
```

```
   1313131313131313131313131414141414
   1313131313131313131313131414141414
   1313131313131313131313131414141414
   1313131313131313131313131414141414
   1313131313131313131313131414141414
   1111111111111111111111111414141414
   1111111111111111111111111414141414
   1111111111111111111111111414141414
   1111111111111111111111111414141414
   1111111111111111111111111414141414
   1111111111111111111111111414141414
   1111111111111111111111111414141414
   1111111111111111111111111414141414
   1212121212121212121212121414141414
   1212121212121212121212121414141414
   1212121212121212121212121414141414
   1212121212121212121212121414141414
   1212121212121212121212121414141414
A
X
I
A
L

 RADIAL
```

* * * * * *

DIRECTION OF LINE INVERSION = ALTERNATING DIRECTION

TIME = 0.000 DAYS

	MIXTURE NUMBER	MIX COMMAND	MATERIAL ATOMIC DENSITY	IITRIG
1	11	0	0.	0
2	11	4	.12733000E-01	0
3	11	1	.10033000E-01	0
4	11	2	.25797000E-02	0
5	11	3	.16131000E-02	0
6	11	5	.21241000E-02	1
7	11	6	.30220000E-03	1
8	11	7	.29357000E-02	1
9	11	9	0.	0
10	11	8	.10730000E-01	0
11	11	10	.50000000E-03	0
12	12	0	0.	0
13	12	4	.12733000E-01	0
14	12	1	.10033000E-01	0
15	12	2	.25797000E-02	0
16	12	3	.16131000E-02	0
17	12	5	0.	1
18	12	6	0.	1
19	12	7	.53735000E-02	1
20	12	9	0.	0
21	12	8	.10730000E-01	0
22	13	0	0.	0
23	13	4	.12733000E-01	0
24	13	1	.10033000E-01	0
25	13	2	.25797000E-02	0
26	13	3	.16131000E-02	0
27	13	5	0.	1
28	13	6	0.	1
29	13	7	.53735000E-02	1
30	13	9	0.	0
31	13	8	.10730000E-01	0
32	14	0	0.	0
33	14	1	.81738000E-02	0
34	14	2	.21016000E-02	0
35	14	3	.13142000E-02	0
36	14	4	.19220000E-01	0

CROSS-SECTION EDIT

GROUP	1 CROSS-SECTIONS					
MAT 1	0.	.473E-02	0.	.267E+01	.261E+01	0.
MAT 2	0.	.440E-02	0.	.235E+01	.233E+01	0.
MAT 3	0.	.217E-01	0.	.336E+01	.326E+01	0.
MAT 4	0.	.807E-03	0.	.301E+01	.291E+01	0.
MAT 5	.160E+01	.174E+01	.473E+01	.735E+01	.557E+01	0.
MAT 6	.492E+00	.679E+00	.151E+01	.756E+01	.680E+01	0.
MAT 7	.653E-01	.217E+00	.183E+00	.744E+01	.710E+01	0.
MAT 8	0.	.117E-02	0.	.305E+01	.291E+01	0.
MAT 9	0.	.300E+01	0.	.300E+01	0.	0.
MAT 10	0.	.143E+01	0.	.369E+01	.222E+01	0.
MAT 11	.373E-02	.529E-02	.110E-01	.151E+00	.142E+00	0.
MAT 12	.351E-03	.128E-02	.986E-03	.149E+00	.144E+00	0.
MAT 13	.351E-03	.128E-02	.986E-03	.149E+00	.144E+00	0.
MAT 14	0.	.919E-04	0.	.891E-01	.865E-01	0.
GROUP	2 CROSS-SECTIONS					
MAT 1	0.	.310E-01	0.	.541E+01	.537E+01	.590E-01
MAT 2	0.	.603E-01	0.	.454E+01	.448E+01	.201E-01
MAT 3	0.	.220E-01	0.	.158E+02	.158E+02	.708E-01
MAT 4	0.	.171E-02	0.	.555E+01	.555E+01	.972E-03
MAT 5	.282E+01	.427E+01	.811E+01	.164E+02	.121E+02	.434E-01
MAT 6	.904E-01	.111E+01	.260E+00	.155E+02	.144E+02	.817E-01
MAT 7	.100E-49	.482E+00	0.	.117E+02	.112E+02	.119E+00
MAT 8	0.	0.	0.	.348E+01	.348E+01	.131E+00
MAT 9	0.	.499E-02	0.	.278E+01	.269E+01	0.
MAT 10	0.	.550E+01	0.	.658E+01	.108E+01	.351E-01
MAT 11	.602E-02	.138E-01	.173E-01	.276E+00	.262E+00	.388E-02
MAT 12	.537E-52	.311E-02	0.	.262E+00	.259E+00	.404E-02
MAT 13	.537E-52	.311E-02	0.	.262E+00	.259E+00	.404E-02
MAT 14	0.	.442E-03	0.	.181E+00	.181E+00	.249E-02

TIME (MINUTES)	OUTER ITERATIONS	IN. IT. PER LOOP	EIGENVALUE SLOPE	EIGENVALUE	LAMBDA
.475	0	0	0.	-.10000000E+00	0.
.484	1	10	0.	-.10000000E+00	.98057572E+00
.490	2	10	0.	-.10000000E+00	.10005892E+01
.495	3	10	0.	-.10000000E+00	.10069641E+01
.501	4	10	0.	-.10000000E+00	.10105221E+01
.507	5	10	0.	-.10000000E+00	.10125627E+01
.513	6	10	0.	-.10000000E+00	.10137181E+01
.520	7	10	0.	-.20000000E+00	.10143945E+01
.528	8	10	0.	-.20000000E+00	.10239155E+01
.535	9	10	-.10153142E+02	.46149150E-01	.10242436E+01
.543	10	10	-.10153142E+02	.46149150E-01	.10019617E+01
.550	11	10	-.10153142E+02	.66932114E-01	.10021469E+01
.559	12	10	-.10153142E+02	.69774132E-01	.10002799E+01
.567	13	10	-.10153142E+02	.70511256E-01	.10000726E+01

THESE ARE THE DESIRED ATOM DENSITIES OBTAINED FROM THE CONC SEARCH TO GIVE A PARAMETRIC VALUE OF PV= 1.000000

REGION= 1 MATERIAL=10 MATL ATOM DENS= .0005353

FINAL NEUTRON BALANCE TABLE

GROUP	FISSION SOURCE	IN-SCATTER	OUT-SCATTER	ABSORPTION	L. L.	R. L.	T. L.	B. L.	TOTAL LEAKAGE
1	2.535E+19	0.	9.328E+18	9.398E+18	0.	1.560E+18	2.531E+18	2.531E+18	6.621E+18
2	1.956E+17	9.328E+18	3.677E+15	6.991E+18	0.	6.056E+17	9.617E+17	9.617E+17	2.529E+18
3	2.554E+19	9.328E+18	9.331E+18	1.639E+19	0.	2.166E+18	3.492E+18	3.493E+18	9.150E+18

	RADII	AVG RADII	AXII	AVG AXII
1	0.0000	3.3333	0.0000	2.0000
2	6.6667	10.0000	4.0000	6.0000
3	13.3333	16.6667	8.0000	10.0000
4	20.0000	23.3333	12.0000	14.0000
5	26.6667	30.0000	16.0000	18.0000
6	33.3333	36.6666	20.0000	22.5000
7	40.0000	43.3333	25.0000	27.5000
8	46.6667	50.0000	30.0000	32.5000
9	53.3333	56.6666	35.0000	37.5000
10	60.0000	63.3334	40.0000	42.5000
11	66.6667	70.0000	45.0000	47.5000
12	73.3333	76.6666	50.0000	52.5000
13	80.0000	83.0000	55.0000	57.5000
14	86.0000	89.0000	60.0000	62.0000
15	92.0000	95.0000	64.0000	66.0000
16	98.0000	101.0000	68.0000	70.0000
17	104.0000	107.0000	72.0000	74.0000
18	110.0000	6.6667	76.0000	78.0000
19			80.0000	4.0000

FLUX FOR GROUP 1

	1	2	3	4	5	
1	.5422699E+15	.5343457E+15	.5186429E+15	.4954960E+15	.4654120E+15	.2000000E+01
2	.8859576E+15	.8730018E+15	.8473403E+15	.8095183E+15	.7603608E+15	.6000000E+01
3	.1266603E+16	.1248069E+16	.1211374E+16	.1157295E+16	.1087006E+16	.1000000E+02
4	.1700074E+16	.1675188E+16	.1625927E+16	.1553334E+16	.1458979E+16	.1400000E+02
5	.2204445E+16	.2172161E+16	.2108277E+16	.2014145E+16	.1891792E+16	.1800000E+02
6	.2879612E+16	.2837424E+16	.2753966E+16	.2631006E+16	.2471185E+16	.2250000E+02
7	.3460358E+16	.3409650E+16	.3309341E+16	.3161561E+16	.2969473E+16	.2750000E+02
8	.3856439E+16	.3799915E+16	.3688103E+16	.3523379E+16	.3309260E+16	.3250000E+02
9	.4057471E+16	.3997992E+16	.3880333E+16	.3707000E+16	.3481587E+16	.3750000E+02
10	.4057500E+16	.3998014E+16	.3880344E+16	.3706999E+16	.3481677E+16	.4250000E+02
11	.3856524E+16	.3799981E+16	.3688135E+16	.3523378E+16	.3309231E+16	.4750000E+02
12	.3460495E+16	.3409757E+16	.3309394E+16	.3161561E+16	.2969431E+16	.5250000E+02
13	.2879783E+16	.2837559E+16	.2754035E+16	.2631011E+16	.2471141E+16	.5750000E+02
14	.2204635E+16	.2172303E+16	.2108348E+16	.2014151E+16	.1891749E+16	.6200000E+02
15	.1700266E+16	.1675326E+16	.1625995E+16	.1553341E+16	.1458941E+16	.6600000E+02
16	.1266786E+16	.1248202E+16	.1211443E+16	.1157309E+16	.1086980E+16	.7000000E+02
17	.8861134E+15	.8731082E+15	.8473917E+15	.8095241E+15	.7603335E+15	.7400000E+02
18	.5423971E+15	.5344386E+15	.5186954E+15	.4955137E+15	.4654533E+15	.7800000E+02

	6	7	8	9	10	
1	.4290574E+15	.3872552E+15	.3409968E+15	.2914909E+15	.2403153E+15	.2000000E+01
2	.7009509E+15	.6326201E+15	.5569584E+15	.4758677E+15	.3917398E+15	.6000000E+01
3	.1002046E+16	.9042931E+15	.7959627E+15	.6796402E+15	.5584299E+15	.1000000E+02
4	.1344912E+16	.1213620E+16	.1068001E+16	.9113475E+15	.7474164E+15	.1400000E+02
5	.1743859E+16	.1573536E+16	.1384498E+16	.1180821E+16	.9669209E+15	.1800000E+02
6	.2277936E+16	.2055391E+16	.1808271E+16	.1541714E+16	.1261032E+16	.2250000E+02
7	.2737176E+16	.2469586E+16	.2172277E+16	.1851216E+16	.1512359E+16	.2750000E+02
8	.3050292E+16	.2751914E+16	.2420256E+16	.2061821E+16	.1682993E+16	.3250000E+02
9	.3209169E+16	.2895142E+16	.2546015E+16	.2168555E+16	.1769368E+16	.3750000E+02
10	.3209153E+16	.2895125E+16	.2545999E+16	.2168542E+16	.1769358E+16	.4250000E+02
11	.3050248E+16	.2751864E+16	.2420209E+16	.2061782E+16	.1682964E+16	.4750000E+02
12	.2737109E+16	.2469510E+16	.2172205E+16	.1851156E+16	.1512314E+16	.5250000E+02
13	.2277861E+16	.2055304E+16	.1808188E+16	.1541646E+16	.1260981E+16	.5750000E+02
14	.1743786E+16	.1573452E+16	.1384419E+16	.1180756E+16	.9668727E+15	.6200000E+02
15	.1344846E+16	.1213544E+16	.1067929E+16	.9112880E+15	.7473726E+15	.6600000E+02
16	.1001994E+16	.9042292E+15	.7959300E+15	.6795873E+15	.5583901E+15	.7000000E+02
17	.7009037E+15	.6325650E+15	.5569054E+15	.4758236E+15	.3917076E+15	.7400000E+02
18	.4290313E+15	.3872202E+15	.3409604E+15	.2914583E+15	.2402897E+15	.7800000E+02

	11	12	13	14	15	
1	.1898504E+15	.1440463E+15	.1235482E+15	.9950273E+14	.7500337E+14	.2000000E+01
2	.3079044E+15	.2295314E+15	.1792238E+15	.1414399E+15	.1056494E+15	.6000000E+01
3	.4363536E+15	.3191623E+15	.2392149E+15	.1851507E+15	.1366983E+15	.1000000E+02
4	.5807214E+15	.4174467E+15	.3028066E+15	.2299418E+15	.1676467E+15	.1400000E+02
5	.7475851E+15	.5285364E+15	.3689741E+15	.2745923E+15	.1976484E+15	.1800000E+02
6	.9712480E+15	.6758482E+15	.4431508E+15	.3223943E+15	.2290015E+15	.2250000E+02
7	.1160883E+16	.7994417E+15	.5120757E+15	.3670673E+15	.2580254E+15	.2750000E+02
8	.1289174E+16	.8831312E+15	.5607680E+15	.3990286E+15	.2787960E+15	.3250000E+02
9	.1354024E+16	.9255255E+15	.5858599E+15	.4156344E+15	.2896103E+15	.3750000E+02
10	.1354018E+16	.9255217E+15	.5858579E+15	.4156334E+15	.2896100E+15	.4250000E+02
11	.1289155E+16	.8831202E+15	.5607623E+15	.3990258E+15	.2787953E+15	.4750000E+02
12	.1160854E+16	.7994257E+15	.5120672E+15	.3670629E+15	.2580241E+15	.5250000E+02
13	.9712147E+15	.6758290E+15	.4431400E+15	.3223884E+15	.2289994E+15	.5750000E+02
14	.7475537E+15	.5285178E+15	.3689628E+15	.2745861E+15	.1976465E+15	.6200000E+02
15	.5806923E+15	.4174283E+15	.3027948E+15	.2299352E+15	.1676446E+15	.6600000E+02
16	.4363260E+15	.3191435E+15	.2392026E+15	.1851436E+15	.1366959E+15	.7000000E+02
17	.3078834E+15	.2295174E+15	.1792148E+15	.1414353E+15	.1056489E+15	.7400000E+02
18	.1898322E+15	.1440324E+15	.1235369E+15	.9949530E+14	.7500008E+14	.7800000E+02

	16	17	
1	.5258362E+14	.3264966E+14	.2000000E+01
2	.7371027E+14	.4565379E+14	.6000000E+01
3	.9471599E+14	.5844897E+14	.1000000E+02
4	.1152589E+15	.7082611E+14	.1400000E+02
5	.1348148E+15	.8248679E+14	.1800000E+02
6	.1549439E+15	.9438457E+14	.2250000E+02
7	.1733808E+15	.1052016E+15	.2750000E+02
8	.1865216E+15	.1128820E+15	.3250000E+02
9	.1933562E+15	.1168702E+15	.3750000E+02
10	.1933562E+15	.1168704E+15	.4250000E+02
11	.1865216E+15	.1128827E+15	.4750000E+02
12	.1733806E+15	.1052030E+15	.5250000E+02
13	.1549434E+15	.9438613E+14	.5750000E+02
14	.1348148E+15	.8248888E+14	.6200000E+02
15	.1152590E+15	.7082826E+14	.6600000E+02
16	.9471638E+14	.5845111E+14	.7000000E+02
17	.7371175E+14	.4565677E+14	.7400000E+02
18	.5258287E+14	.3265239E+14	.7800000E+02

FLUX FOR GROUP 2

	1	2	3	4	5	
1	.2468438E+15	.2432449E+15	.2361227E+15	.2256411E+15	.2120498E+15	.2000000E+01
2	.4412055E+15	.4347687E+15	.4220350E+15	.4032963E+15	.3789972E+15	.6000000E+01
3	.6123979E+15	.6034580E+15	.5857768E+15	.5597577E+15	.5260148E+15	.1000000E+02
4	.7495488E+15	.7385985E+15	.7169467E+15	.6850850E+15	.6437594E+15	.1400000E+02
5	.8374072E+15	.8251638E+15	.8009594E+15	.7653414E+15	.7191368E+15	.1800000E+02
6	.8574062E+15	.8448626E+15	.8200631E+15	.7835663E+15	.7362114E+15	.2250000E+02
7	.9090511E+15	.8957461E+15	.8694371E+15	.8307133E+15	.7804567E+15	.2750000E+02
8	.9577585E+15	.9437364E+15	.9160065E+15	.8751873E+15	.8222025E+15	.3250000E+02
9	.9860101E+15	.9715722E+15	.9430184E+15	.9009842E+15	.8464180E+15	.3750000E+02
10	.9860130E+15	.9715748E+15	.9430199E+15	.9009842E+15	.8464167E+15	.4250000E+02
11	.9577661E+15	.9437426E+15	.9160093E+15	.8751858E+15	.8221971E+15	.4750000E+02
12	.9090632E+15	.8957567E+15	.8694422E+15	.8307113E+15	.7804483E+15	.5250000E+02
13	.8574237E+15	.8448789E+15	.8200719E+15	.7835650E+15	.7362011E+15	.5750000E+02
14	.8374329E+15	.8251854E+15	.8009693E+15	.7653378E+15	.7191220E+15	.6200000E+02
15	.7495834E+15	.7386235E+15	.7169562E+15	.6850793E+15	.6437421E+15	.6600000E+02
16	.6124373E+15	.6034835E+15	.5857856E+15	.5597522E+15	.5259988E+15	.7000000E+02
17	.4412424E+15	.4347896E+15	.4220398E+15	.4032889E+15	.3789816E+15	.7400000E+02
18	.2468739E+15	.2432643E+15	.2361304E+15	.2256395E+15	.2120418E+15	.7800000E+02

	6	7	8	9	10	
1	.1956833E+15	.1769655E+15	.1564184E+15	.1346758E+15	.1125029E+15	.2000000E+01
2	.3497340E+15	.3162615E+15	.2795093E+15	.2406050E+15	.2008986E+15	.6000000E+01
3	.4853712E+15	.4388681E+15	.3877881E+15	.3336898E+15	.2784433E+15	.1000000E+02
4	.5939697E+15	.5369797E+15	.4743473E+15	.4079760E+15	.3401872E+15	.1400000E+02
5	.6634520E+15	.5996841E+15	.5295580E+15	.4551988E+15	.3792708E+15	.1800000E+02
6	.6791172E+15	.6136945E+15	.5416876E+15	.4652694E+15	.3872685E+15	.2250000E+02
7	.7198401E+15	.6503395E+15	.5737827E+15	.4924721E+15	.4094986E+15	.2750000E+02
8	.7582783E+15	.6849564E+15	.6041475E+15	.5182742E+15	.4306390E+15	.3250000E+02
9	.7805776E+15	.7050434E+15	.6217749E+15	.5332632E+15	.4429237E+15	.3750000E+02
10	.7805754E+15	.7050408E+15	.6217723E+15	.5332608E+15	.4429217E+15	.4250000E+02
11	.7582704E+15	.6849475E+15	.6041389E+15	.5182666E+15	.4306327E+15	.4750000E+02
12	.7198274E+15	.6503251E+15	.5737588E+15	.4924601E+15	.4094888E+15	.5250000E+02
13	.6791010E+15	.6136760E+15	.5416697E+15	.4652540E+15	.3872561E+15	.5750000E+02
14	.6634303E+15	.5996601E+15	.5295354E+15	.4551799E+15	.3792561E+15	.6200000E+02
15	.5939457E+15	.5369538E+15	.4743235E+15	.4079566E+15	.3401725E+15	.6600000E+02
16	.4853492E+15	.4388444E+15	.3877664E+15	.3336722E+15	.2784301E+15	.7000000E+02
17	.3497142E+15	.3162411E+15	.2794912E+15	.2405910E+15	.2008887E+15	.7400000E+02
18	.1956718E+15	.1769529E+15	.1564067E+15	.1346663E+15	.1124961E+15	.7800000E+02

	11	12	13	14	15	
1	.9083261E+14	.7098349E+14	.5917706E+14	.4764549E+14	.3589638E+14	.2000000E+01
2	.1619461E+15	.1253353E+15	.9816644E+14	.7833034E+14	.5893587E+14	.6000000E+01
3	.2241841E+15	.1728894E+15	.1338651E+15	.1066505E+15	.8029838E+14	.1000000E+02
4	.2737334E+15	.2113782E+15	.1646142E+15	.1317973E+15	.9954639E+14	.1400000E+02
5	.3051750E+15	.237[illegible]826E+15	.1891937E+15	.1532033E+15	.1163401E+15	.1800000E+02
6	.3116836E+15	.2449867E+15	.2096299E+15	.1729339E+15	.1322641E+15	.2250000E+02
7	.3295017E+15	.2605457E+15	.2274791E+15	.1895766E+15	.1457602E+15	.2750000E+02
8	.3463060E+15	.2741493E+15	.2402537E+15	.2009787E+15	.1549281E+15	.3250000E+02
9	.3560260E+15	.2817898E+15	.2469614E+15	.2068118E+15	.1595788E+15	.3750000E+02
10	.3560245E+15	.2817887E+15	.2469607E+15	.2068114E+15	.1595787E+15	.4250000E+02
11	.3463015E+15	.2741463E+15	.2402517E+15	.2009777E+15	.1549278E+15	.4750000E+02
12	.3294948E+15	.2605411E+15	.2274761E+15	.1895750E+15	.1457597E+15	.5250000E+02
13	.3116749E+15	.2449809E+15	.2096262E+15	.1729319E+15	.1322634E+15	.5750000E+02
14	.3051646E+15	.2370759E+15	.1891896E+15	.1532011E+15	.1163393E+15	.6200000E+02
15	.2737230E+15	.2113715E+15	.1646101E+15	.1317951E+15	.9954563E+14	.6600000E+02
16	.2241749E+15	.1728831E+15	.1338612E+15	.1066485E+15	.8029782E+14	.7000000E+02
17	.1619400E+15	.1253313E+15	.9816413E+14	.7832937E+14	.5893596E+14	.7400000E+02
18	.9082812E+14	.7098028E+14	.5917462E+14	.4764393E+14	.3589576E+14	.7800000E+02

	16	17	
1	.2430454E+14	.1292396E+14	.2000000E+01
2	.3990008E+14	.2121998E+14	.6000000E+01
3	.5440027E+14	.2892276E+14	.1000000E+02
4	.6755370E+14	.3594004E+14	.1400000E+02
5	.7914678E+14	.4215144E+14	.1800000E+02
6	.9025577E+14	.4812987E+14	.2250000E+02
7	.9972524E+14	.5324360E+14	.2750000E+02
8	.1061564E+15	.5672042E+14	.3250000E+02
9	.1094127E+15	.5848078E+14	.3750000E+02
10	.1094127E+15	.5848084E+14	.4250000E+02
11	.1061563E+15	.5672059E+14	.4750000E+02
12	.9972503E+14	.5324381E+14	.5250000E+02
13	.9025550E+14	.4813009E+14	.5750000E+02
14	.7914656E+14	.4215165E+14	.6200000E+02
15	.6755362E+14	.3594036E+14	.6600000E+02
16	.5440035E+14	.2892324E+14	.7000000E+02
17	.3990057E+14	.2121071E+14	.7400000E+02
18	.2430451E+14	.1292459E+14	.7800000E+02

TOTAL FLUX

	1	2	3	4	5	
1	.7891136E+15	.7775905E+15	.7547655E+15	.7211372E+15	.6774618E+15	.2000000E+01
2	.1327163E+16	.1307770E+16	.1269375E+16	.1212815E+16	.1139358E+16	.6000000E+01
3	.1879001E+16	.1851527E+16	.1797151E+16	.1717052E+16	.1613021E+16	.1000000E+02
4	.2449623E+16	.2413787E+16	.2342873E+16	.2238419E+16	.2102738E+16	.1400000E+02
5	.3041852E+16	.2997325E+16	.2909236E+16	.2779486E+16	.2610929E+16	.1800000E+02
6	.3737018E+16	.3682287E+16	.3574029E+16	.3414572E+16	.3207397E+16	.2250000E+02
7	.4369409E+16	.4305396E+16	.4178778E+16	.3992274E+16	.3749930E+16	.2750000E+02
8	.4814197E+16	.4743652E+16	.4604110E+16	.4398567E+16	.4131462E+16	.3250000E+02
9	.5043481E+16	.4969564E+16	.4823352E+16	.4607984E+16	.4328105E+16	.3750000E+02
10	.5043513E+16	.4969589E+16	.4823364E+16	.4607984E+16	.4328094E+16	.4250000E+02
11	.4814290E+16	.4743724E+16	.4604145E+16	.4398563E+16	.4131429E+16	.4750000E+02
12	.4369558E+16	.4305514E+16	.4178837E+16	.3992273E+16	.3749880E+16	.5250000E+02
13	.3737206E+16	.3682438E+16	.3574107E+16	.3414576E+16	.3207342E+16	.5750000E+02
14	.3042068E+16	.2997489E+16	.2909317E+16	.2779488E+16	.2610871E+16	.6200000E+02
15	.2449849E+16	.2413950E+16	.2342951E+16	.2238420E+16	.2102683E+16	.6600000E+02
16	.1879223E+16	.1851685E+16	.1797229E+16	.1717061E+16	.1612978E+16	.7000000E+02
17	.1327356E+16	.1307898E+16	.1269432E+16	.1212813E+16	.1139315E+16	.7400000E+02
18	.7892709E+15	.7777030E+15	.7548258E+15	.7211532E+15	.6774451E+15	.7800000E+02

	6	7	8	9	10	
1	.6247407E+15	.5642207E+15	.4974152E+15	.4261667E+15	.3528183E+15	.2000000E+01
2	.1050685E+16	.9488816E+15	.8364677E+15	.7164727E+15	.5926384E+15	.6000000E+01
3	.1487418E+16	.1343161E+16	.1183751E+16	.1013330E+16	.8368732E+15	.1000000E+02
4	.1936881E+16	.1750599E+16	.1542348E+16	.1319324E+16	.1087604E+16	.1400000E+02
5	.2407311E+16	.2173220E+16	.1914056E+16	.1636020E+16	.1346192E+16	.1800000E+02
6	.2957053E+16	.2669085E+16	.2349958E+16	.2006984E+16	.1648301E+16	.2250000E+02
7	.3457016E+16	.3119926E+16	.2746060E+16	.2343688E+16	.1921857E+16	.2750000E+02
8	.3806571E+16	.3436871E+16	.3024404E+16	.2580096E+16	.2113632E+16	.3250000E+02
9	.3989746E+16	.3600185E+16	.3167790E+16	.2701819E+16	.2212292E+16	.3750000E+02
10	.3989729E+16	.3600165E+16	.3167771E+16	.2701803E+16	.2212280E+16	.4250000E+02
11	.3806518E+16	.3436811E+16	.3024348E+16	.2580049E+16	.2113596E+16	.4750000E+02
12	.3456936E+16	.3119835E+16	.2745974E+16	.2343617E+16	.1921803E+16	.5250000E+02
13	.2956962E+16	.2668980E+16	.2349858E+16	.2006900E+16	.1648237E+16	.5750000E+02
14	.2407216E+16	.2173112E+16	.1913954E+16	.1635936E+16	.1346129E+16	.6200000E+02
15	.1936792E+16	.1750497E+16	.1542252E+16	.1319245E+16	.1087545E+16	.6600000E+02
16	.1487343E+16	.1343074E+16	.1183066E+16	.1013260E+16	.8368202E+15	.7000000E+02
17	.1050618E+16	.9488061E+15	.8363966E+15	.7164146E+15	.5925963E+15	.7400000E+02
18	.6247031E+15	.5641731E+15	.4973671E+15	.4261246E+15	.3527857E+15	.7800000E+02

	11	12	13	14	15	
1	.2806830E+15	.2156297E+15	.1827253E+15	.1471482E+15	.1108997E+15	.2000000E+01
2	.4698505E+15	.3548667E+15	.2773903E+15	.2197702E+15	.1645853E+15	.6000000E+01
3	.6605377E+15	.4920517E+15	.3730800E+15	.2918012E+15	.2169967E+15	.1000000E+02
4	.8544548E+15	.6288249E+15	.4674208E+15	.3617392E+15	.2671931E+15	.1400000E+02
5	.1052760E+16	.7656189E+15	.5581478E+15	.4277956E+15	.3139885E+15	.1800000E+02
6	.1282932E+16	.9208349E+15	.6527807E+15	.4953282E+15	.3612656E+15	.2250000E+02
7	.1490384E+16	.1059987E+16	.7395548E+15	.5566439E+15	.4037856E+15	.2750000E+02
8	.1635480E+16	.1157280E+16	.8010217E+15	.6000073E+15	.4337241E+15	.3250000E+02
9	.1711050E+16	.1207315E+16	.8328213E+15	.6224462E+15	.4491891E+15	.3750000E+02
10	.1710042E+16	.1207310E+16	.8328186E+15	.6224448E+15	.4491887E+15	.4250000E+02
11	.1635456E+16	.1157266E+16	.8010141E+15	.6000035E+15	.4337231E+15	.4750000E+02
12	.1490349E+16	.1059967E+16	.7395433E+15	.5566379E+15	.4037838E+15	.5250000E+02
13	.1282890E+16	.9208099E+15	.6527662E+15	.4953202E+15	.3612628E+15	.5750000E+02
14	.1052718E+16	.7655936E+15	.5581525E+15	.4277872E+15	.3139858E+15	.6200000E+02
15	.8544153E+15	.6287999E+15	.4674049E+15	.3617303E+15	.2671902E+15	.6600000E+02
16	.6605009E+15	.4920266E+15	.3730638E+15	.2917921E+15	.2169937E+15	.7000000E+02
17	.4698234E+15	.3548487E+15	.2773790E+15	.2197647E+15	.1645849E+15	.7400000E+02
18	.2806603E+15	.2156127E+15	.1827115E+15	.1471392E+15	.1108958E+15	.7800000E+02

	16	17	
1	.7688817E+14	.4557362E+14	.2000000E+01
2	.1136103E+15	.6686377E+14	.6000000E+01
3	.1491163E+15	.8737173E+14	.1000000E+02
4	.1828126E+15	.1067661E+15	.1400000E+02
5	.2139616E+15	.1246382E+15	.1800000E+02
6	.2451996E+15	.1425144E+15	.2250000E+02
7	.2731060E+15	.1584452E+15	.2750000E+02
8	.2926780E+15	.1690024E+15	.3250000E+02
9	.3027689E+15	.1753509E+15	.3750000E+02
10	.3027688E+15	.1753512E+15	.4250000E+02
11	.2926779E+15	.1690033E+15	.4750000E+02
12	.2731056E+15	.1584468E+15	.5250000E+02
13	.2451989E+15	.1425162E+15	.5750000E+02
14	.2139614E+15	.1246405E+15	.6200000E+02
15	.1828127E+15	.1067686E+15	.6600000E+02
16	.1491167E+15	.8737435E+14	.7000000E+02
17	.1136123E+15	.6686748E+14	.7400000E+02
18	.7688738E+14	.4557698E+14	.7800000E+02

POWER DENSITY (MWT/LITER)

	1	2	3	4	5	
1	.6551828E-02	.6456086E-02	.6266361E-02	.5986696E-02	.5623214E-02	.2000000E+01
2	.1070434E-01	.1054781E-01	.1023776E-01	.9780785E-02	.9186852E-02	.6000000E+01
3	.1530339E-01	.1507946E-01	.1463609E-01	.1398270E-01	.1313346E-01	.1000000E+02
4	.2054068E-01	.2024001E-01	.1964482E-01	.1876773E-01	.1762772E-01	.1400000E+02
5	.2663460E-01	.2624454E-01	.2547268E-01	.2433536E-01	.2285706E-01	.1800000E+02
6	.5476929E+00	.5396727E+00	.5238095E+00	.5004468E+00	.4700975E+00	.2250000E+02
7	.6329843E+00	.6237120E+00	.6053719E+00	.5783598E+00	.5432649E+00	.2750000E+02
8	.6939530E+00	.6837851E+00	.6636730E+00	.6340502E+00	.5955601E+00	.3250000E+02
9	.7256304E+00	.7149966E+00	.6939628E+00	.6629823E+00	.6227267E+00	.3750000E+02
10	.7256347E+00	.7150000E+00	.6939645E+00	.6629823E+00	.6227252E+00	.4250000E+02
11	.6939655E+00	.6837948E+00	.6636777E+00	.6340497E+00	.5955553E+00	.4750000E+02
12	.6330044E+00	.6237280E+00	.6053798E+00	.5783594E+00	.5432578E+00	.5250000E+02
13	.5477185E+00	.5396934E+00	.5238203E+00	.5004472E+00	.4700897E+00	.5750000E+02
14	.2663691E-01	.2624626E-01	.2547354E-01	.2433543E-01	.2285654E-01	.6200000E+02
15	.2054300E-01	.2024167E-01	.1964564E-01	.1876782E-01	.1762726E-01	.6600000E+02
16	.1530560E-01	.1508106E-01	.1463693E-01	.1398287E-01	.1313314E-01	.7000000E+02
17	.1070622E-01	.1054909E-01	.1023838E-01	.9780854E-02	.9186523E-02	.7400000E+02
18	.6553365E-02	.6457209E-02	.6266996E-02	.5986909E-02	.5623108E-02	.7800000E+02
	6	7	8	9	10	
1	.5183970E-02	.4676905E-02	.4120001E-02	.3521859E-02	.2903545E-02	.2000000E+01
2	.8469048E-02	.7643461E-02	.6729298E-02	.5749542E-02	.4733090E-02	.6000000E+01
3	.1210695E-01	.1092588E-01	.9617003E-02	.8211568E-02	.6747078E-02	.1000000E+02
4	.1624953E-01	.1466323E-01	.1290383E-01	.1101111E-01	.9030456E-02	.1400000E+02
5	.2106970E-01	.1901182E-01	.1672782E-01	.1426695E-01	.1168256E-01	.1800000E+02
6	.4334346E+00	.3912816E+00	.3446066E+00	.2945204E+00	.2422919E+00	.2250000E+02
7	.5008569E+00	.452[illegible]734E+00	.3980094E+00	.3399089E+00	.2791781E+00	.2750000E+02
8	.5490409E+00	.4955109E+00	.4361538E+00	.3723073E+00	.3054764E+00	.3250000E+02
9	.5740698E+00	.5181713E+00	.4559605E+00	.3891235E+00	.3191171E+00	.3750000E+02
10	.5740674E+00	.5180685E+00	.4559579E+00	.3891213E+00	.3191154E+00	.4250000E+02
11	.5490336E+00	.4955026E+00	.4361459E+00	.3723007E+00	.3054713E+00	.4750000E+02
12	.5008456E+00	.4520607E+00	.3979973E+00	.3398988E+00	.2791704E+00	.5250000E+02
13	.4334217E+00	.3912666E+00	.3445923E+00	.2945085E+00	.2422828E+00	.5750000E+02
14	.2106882E-01	.1901081E-01	.1672686E-01	.1426616E-01	.1168198E-01	.6200000E+02
15	.1624873E-01	.1466231E-01	.1290296E-01	.1101039E-01	.9029927E-02	.6600000E+02
16	.1210632E-01	.1092510E-01	.9616245E-02	.8210929E-02	.6746596E-02	.7000000E+02
17	.8468478E-02	.7642794E-02	.6728658E-02	.5749009E-02	.4732700E-02	.7400000E+02
18	.5183654E-02	.4678483E-02	.4119561E-02	.3521466E-02	.2903235E-02	.7800000E+02

	11	12	13	14	15	
1	.2293816E-02	.1747649E-02	0.	0.	0.	.2000000E+01
2	.3720171E-02	.2773250E-02	0.	0.	0.	.6000000E+01
3	.5272123E-02	.3856191E-02	0.	0.	0.	.1000000E+02
4	.7016409E-02	.5043686E-02	0.	0.	0.	.1400000E+02
5	.9032493E-02	.6385897E-02	0.	0.	0.	.1800000E+02
6	.1893958E+00	.1376230E+00	0.	0.	0.	.2250000E+02
7	.2174446E+00	.1567225E+00	0.	0.	0.	.2750000E+02
8	.2374057E+00	.1702920E+00	0.	0.	0.	.3250000E+02
9	.2477502E+00	.1773214E+00	0.	0.	0.	.3750000E+02
10	.2477491E+00	.1773207E+00	0.	0.	0.	.4250000E+02
11	.2374023E+00	.1702900E+00	0.	0.	0.	.4750000E+02
12	.2174395E+00	.1567195E+00	0.	0.	0.	.5250000E+02
13	.1893897E+00	.1376193E+00	0.	0.	0.	.5750000E+02
14	.9032115E-02	.6385672E-02	0.	0.	0.	.6200000E+02
15	.7016056E-02	.5043464E-02	0.	0.	0.	.6600000E+02
16	.5271790E-02	.3855965E-02	0.	0.	0.	.7000000E+02
17	.3719917E-02	.2773082E-02	0.	0.	0.	.7400000E+02
18	.2293595E-02	.1747481E-02	0.	0.	0.	.7800000E+02

	16	17	
1	0.	0.	.2000000E+01
2	0.	0.	.6000000E+01
3	0.	0.	.1000000E+02
4	0.	0.	.1400000E+02
5	0.	0.	.1800000E+02
6	0.	0.	.2250000E+02
7	0.	0.	.2750000E+02
8	0.	0.	.3250000E+02
9	0.	0.	.3750000E+02
10	0.	0.	.4250000E+02
11	0.	0.	.4750000E+02
12	0.	0.	.5250000E+02
13	0.	0.	.5750000E+02
14	0.	0.	.6200000E+02
15	0.	0.	.6600000E+02
16	0.	0.	.7000000E+02
17	0.	0.	.7400000E+02
18	0.	0.	.7800000E+02

POWER PRODUCTION FRACTION FOR EACH ZONE

I= 1 PFRAC= .976125

I= 2 PFRAC= .011973

I= 3 PFRAC= .011973

I= 4 PFRAC= 0.000000

FISSION SOURCE RATE

	1	2	3	4	5	
1	.5346153E+12	.5267958E+12	.5113047E+12	.4884739E+12	.4588042E+12	.2000000E+01
2	.8734486E+12	.8606648E+12	.8353499E+12	.7980445E+12	.7495642E+12	.6000000E+01
3	.1248716E+13	.1230430E+13	.1194231E+13	.1140892E+13	.1071572E+13	.1000000E+02
4	.1676061E+13	.1651510E+13	.1602916E+13	.1531316E+13	.1438261E+13	.1400000E+02
5	.2173304E+13	.2141456E+13	.2078439E+13	.1985594E+13	.1864926E+13	.1800000E+02
6	.4664901E+14	.4596556E+14	.4461377E+14	.4262300E+14	.4003706E+14	.2250000E+02
7	.5395914E+14	.5316832E+14	.5160414E+14	.4930047E+14	.4630766E+14	.2750000E+02
8	.5917810E+14	.5831057E+14	.5659465E+14	.5406743E+14	.5078389E+14	.3250000E+02
9	.6188806E+14	.6098066E+14	.5918586E+14	.5654246E+14	.5310784E+14	.3750000E+02
10	.6188839E+14	.6098092E+14	.5918599E+14	.5654245E+14	.5310772E+14	.4250000E+02
11	.5917907E+14	.5831134E+14	.5659503E+14	.5406740E+14	.5078355E+14	.4750000E+02
12	.5396071E+14	.5316956E+14	.5160476E+14	.4930045E+14	.4630713E+14	.5250000E+02
13	.4665101E+14	.4596716E+14	.4461460E+14	.4262304E+14	.4003647E+14	.5750000E+02
14	.2173458E+13	.2141571E+13	.2078495E+13	.1985596E+13	.1864888E+13	.6200000E+02
15	.1676217E+13	.1651621E+13	.1602969E+13	.1531318E+13	.1438226E+13	.6600000E+02
16	.1248866E+13	.1230538E+13	.1194287E+13	.1140901E+13	.1071547E+13	.7000000E+02
17	.8735765E+12	.8607514E+12	.8353906E+12	.7980471E+12	.7495392E+12	.7400000E+02
18	.5347214E+12	.5268727E+12	.5113473E+12	.4884871E+12	.4587952E+12	.7800000E+02

	6	7	8	9	10	
1	.4229541E+12	.3817358E+12	.3361274E+12	.2873209E+12	.2368715E+12	.2000000E+01
2	.6909788E+12	.6236025E+12	.5490040E+12	.4690589E+12	.3861249E+12	.6000000E+01
3	.9877908E+12	.8914028E+12	.7845943E+12	.6699148E+12	.5504248E+12	.1000000E+02
4	.1325776E+13	.1196317E+13	.1052744E+13	.8983027E+12	.7366986E+12	.1400000E+02
5	.1719044E+13	.1551098E+13	.1364714E+13	.1163913E+13	.9530489E+12	.1800000E+02
6	.3691335E+14	.3332206E+14	.2934560E+14	.2507839E+14	.2062806E+14	.2250000E+02
7	.4269142E+14	.3853176E+14	.3392196E+14	.2896785E+14	.2378875E+14	.2750000E+02
8	.4681565E+14	.4224960E+14	.3718665E+14	.3174064E+14	.2603927E+14	.3250000E+02
9	.4895668E+14	.4417941E+14	.3888085E+14	.3317898E+14	.2720588E+14	.3750000E+02
10	.4895649E+14	.4417920E+14	.3888065E+14	.3317881E+14	.2720575E+14	.4250000E+02
11	.4681511E+14	.4224899E+14	.3718607E+14	.3174015E+14	.2603889E+14	.4750000E+02
12	.4269059E+14	.3853081E+14	.3392105E+14	.2896709E+14	.2378816E+14	.5250000E+02
13	.3691238E+14	.3332094E+14	.2934453E+14	.2507748E+14	.2062736E+14	.5750000E+02
14	.1718981E+13	.1551026E+13	.1364646E+13	.1163858E+13	.9530086E+12	.6200000E+02
15	.1325718E+13	.1196251E+13	.1052681E+13	.8982519E+12	.7366615E+12	.6600000E+02
16	.9877440E+12	.8913469E+12	.7845398E+12	.6698693E+12	.5503910E+12	.7000000E+02
17	.6909372E+12	.6235545E+12	.5489582E+12	.4690211E+12	.3860978E+12	.7400000E+02
18	.4229305E+12	.3817049E+12	.3360955E+12	.2872925E+12	.2368496E+12	.7800000E+02

	11	12	13	14	15	
1	.1871252E+12	.1425666E+12	0.	0.	0.	.2000000E+01
2	.3034839E+12	.2262310E+12	0.	0.	0.	.6000000E+01
3	.4300884E+12	.3145729E+12	0.	0.	0.	.1000000E+02
4	.5723805E+12	.4114420E+12	0.	0.	0.	.1400000E+02
5	.7368417E+12	.5209298E+12	0.	0.	0.	.1800000E+02
6	.1611927E+14	.1170246E+14	0.	0.	0.	.2250000E+02
7	.1852210E+14	.1333669E+14	0.	0.	0.	.2750000E+02
8	.2022984E+14	.1449636E+14	0.	0.	0.	.3250000E+02
9	.2111428E+14	.1509677E+14	0.	0.	0.	.3750000E+02
10	.2111419E+14	.1509671E+14	0.	0.	0.	.4250000E+02
11	.2022957E+14	.1449619E+14	0.	0.	0.	.4750000E+02
12	.1852170E+14	.1333643E+14	0.	0.	0.	.5250000E+02
13	.1611878E+14	.1170214E+14	0.	0.	0.	.5750000E+02
14	.7368158E+12	.5209150E+12	0.	0.	0.	.6200000E+02
15	.5723561E+12	.4114271E+12	0.	0.	0.	.6600000E+02
16	.4300653E+12	.3145573E+12	0.	0.	0.	.7000000E+02
17	.3034669E+12	.2262199E+12	0.	0.	0.	.7400000E+02
18	.1871101E+12	.1425553E+12	0.	0.	0.	.7800000E+02

	16	17	
1	0.	0.	.2000000E+01
2	0.	0.	.6000000E+01
3	0.	0.	.1000000E+02
4	0.	0.	.1400000E+02
5	0.	0.	.1800000E+02
6	0.	0.	.2250000E+02
7	0.	0.	.2750000E+02
8	0.	0.	.3250000E+02
9	0.	0.	.3750000E+02
10	0.	0.	.4250000E+02
11	0.	0.	.4750000E+02
12	0.	0.	.5250000E+02
13	0.	0.	.5750000E+02
14	0.	0.	.6200000E+02
15	0.	0.	.6600000E+02
16	0.	0.	.7000000E+02
17	0.	0.	.7400000E+02
18	0.	0.	.7800000E+02

PHENIX EXAMPLE / 2 GROUP / ARGONNE CODE CNTR SAMPLE REACTOR
SEARCH-BURN-KEFF-REFUEL

MATERIAL INVENTORY (KILOGRAMS) FOR EACH ZONE

	MATERIAL	ATOMIC WT.	ZONE 1 .804E+03 LITERS	ZONE 2 .402E+03 LITERS	ZONE 3 .402E+03 LITERS	ZONE 4 .143E+04 LITERS
1	IRON	55.850	7.482E+02	3.741E+02	3.741E+02	1.086E+03
2	CROM	52.010	1.792E+02	8.958E+01	8.958E+01	2.600E+02
3	NICK	58.710	1.265E+02	6.323E+01	6.323E+01	1.835E+02
4	NA	22.990	3.909E+02	1.954E+02	1.954E+02	1.051E+03
5	PUA	239.130	6.782E+02	0.	0.	0.
6	PUB	240.130	9.690E+01	0.	0.	0.
7	U238	238.120	9.334E+02	8.543E+02	8.543E+02	0.
8	OXY	16.000	2.292E+02	1.146E+02	1.146E+02	0.
9	FPR	119.000	0.	0.	0.	0.
10	B-10	10.010	7.154E+00	0.	0.	0.

BURNUP DATA

BURNABLE ISOTOPE NO.	MATERIAL NO.	NAME	LAMBDA (DAYS-1)	NBR	* * * * * * DECAY	SOURCE ISOTOPE FOR CAPTURE	
1	5	PUA	0.	2	0	3	0
2	6	PUB	0.	1	0	1	0
3	7	U238	0.	1	0	0	0
4	9	FPR	0.	0	0	0	0
5	10	B-10	0.	0	0	0	0

FISSION

0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
1	2	3	0	0	0	0
0	0	0	0	0	0	0

Z O N E 1 FLUX =2.5091E+15 VOLUME =8.0425E+02 LITERS

BURNABLE ISOTOPE NO.	MATERIAL NO.	NAME	ATOM DENSITY	FISSION RATE	ABSORPTION RATE	SIGMA FISSION	SIGMA ABSORPTION
1	5	PUA	2.124E-03	7.949E+18	9.740E+18	1.855E+00	2.272E+00
2	6	PUB	3.022E-04	2.481E+17	4.701E+17	4.068E-01	7.709E-01
3	7	U238	2.936E-03	3.050E+17	1.615E+18	5.149E-02	2.727E-01
4	9	FPR	0.	0.	0.	0.	2.367E+00
5	10	B-10	5.353E-04	0.	2.471E+18	0.	2.288E+00

Z O N E 2 FLUX =1.0700E+15 VOLUME =4.0212E+02 LITERS

BURNABLE ISOTOPE NO.	MATERIAL NO.	NAME	ATOM DENSITY	FISSION RATE	ABSORPTION RATE	SIGMA FISSION	SIGMA ABSORPTION
1	5	PUA	0.	0.	0.	1.975E+00	2.521E+00
2	6	PUB	0.	0.	0.	3.676E-01	8.136E-01
3	7	U238	5.373E-03	1.043E+17	6.906E+17	4.510E-02	2.987E-01
4	9	FPR	0.	0.	0.	0.	2.074E+00
5	10	B-10	0.	0.	0.	0.	2.687E+00

Z O N E 3 FLUX =1.0700E+15 VOLUME =4.0212E+02 LITERS

BURNABLE ISOTOPE NO.	MATERIAL NO.	NAME	ATOM DENSITY	FISSION RATE	ABSORPTION RATE	SIGMA FISSION	SIGMA ABSORPTION
1	5	PUA	0.	0.	0.	1.975E+00	2.521E+00
2	6	PUB	0.	0.	0.	3.676E-01	8.136E-01
3	7	U238	5.373E-03	1.043E+17	6.905E+17	4.510E-02	2.987E-01
4	9	FPR	0.	0.	0.	0.	2.074E+00
5	10	B-10	0.	0.	0.	0.	2.687E+00

ZONE 4 FLUX =3.1482E+14 VOLUME =1.4326E+03 LITERS

BURNABLE ISOTOPE NO.	MATERIAL NO.	NAME	ATOM DENSITY	FISSION RATE	ABSORPTION RATE	SIGMA FISSION	SIGMA ABSORPTION
1	5	PUA	0.	0.	0.	2.015E+00	2.603E+00
2	6	PUB	0.	0.	0.	3.545E-01	8.278E-01
3	7	U238	0.	0.	0.	4.298E-02	3.073E-01
4	9	FPR	0.	0.	0.	0.	1.977E+00
5	10	B-10	0.	0.	0.	0.	2.819E+00

KZ= 1 BREDRT(KZ)= .1573
KZ= 2 BREDRT(KZ)= .0602
KZ= 3 BREDRT(KZ)= .0602
KZ= 4 BREDRT(KZ)= 0.0000

BREEDING RATIO = .2777

THESE ARE THE ZONE-AVERAGED TOTAL FLUXES TO BE USED IN THE FLUX SHIFT CORRECTION FOR SUBROUTINE REFUEL

ZONE = 1 AVG FLUX =2.5547E+15

ZONE = 2 AVG FLUX =1.0895E+15

ZONE = 3 AVG FLUX =1.0894E+15

ZONE = 4 AVG FLUX =3.2054E+14

T I M E = 100.000 D A Y S

	MIXTURE NUMBER	MIX COMMAND	MATERIAL ATOMIC DENSITY	NTRIG
1	11	0	0.	0
2	11	4	.12733000E-01	0
3	11	1	.10033000E-01	0
4	11	2	.25797000E-02	0
5	11	3	.16131000E-02	0
6	11	5	.20342950E-02	1
7	11	6	.31608654E-03	1
8	11	7	.29181180E-02	1
9	11	9	.88672622E-04	0
10	11	8	.10730000E-01	0
11	11	10	.50894427E-03	0
12	12	0	0.	0
13	12	4	.12733000E-01	0
14	12	1	.10033000E-01	0
15	12	2	.25797000E-02	0
16	12	3	.16131000E-02	0
17	12	5	.12632449E-04	1
18	12	6	.32460269E-07	1
19	12	7	.53584436E-02	1
20	12	9	.23686870E-05	0
21	12	8	.10730000E-01	0
22	13	0	0.	0
23	13	4	.12733000E-01	0
24	13	1	.10033000E-01	0
25	13	2	.25797000E-02	0
26	13	3	.16131000E-02	0
27	13	5	.12632003E-04	1
28	13	6	.32457998E-07	1
29	13	7	.53584441E-02	1
30	13	9	.23685917E-05	0
31	13	8	.10730000E-01	0
32	14	0	0.	0
33	14	1	.82738000E-02	0
34	14	2	.21016000E-02	0
35	14	3	.13142000E-02	0
36	14	4	.19220000E-01	0

TIME (MINUTES)	OUTER ITERATIONS	IN. IT. PER LOOP	EIGENVALUE SLOPE	EIGENVALUE	LAMBDA
.590	0	0	0.	0.	0.
.598	1	10	0.	.96601428E+00	.96601428E+00
.604	2	10	0.	.96583630E+00	.99981576E+00
.606	3	2	0.	.96584509E+00	.10000091E+01
.609	4	2	0.	.96584196E+00	.99999676E+00

FINAL NEUTRON BALANCE TABLE

GROUP	FISSION SOURCE	IN-SCATTER	OUT-SCATTER	ABSORPTION	L. L.	R. L.	T. L.	B. L.	TOTAL LEAKAGE
1	2.624E+19	0.	9.590E+18	9.807E+18	0.	1.606E+18	2.618E+18	2.618E+18	6.842E+18
2	2.025E+17	9.590E+18	3.876E+15	7.155E+18	0.	6.314E+17	1.001E+18	1.001E+18	2.634E+18
3	2.644E+19	9.590E+18	9.594E+18	1.696E+19	0.	2.238E+18	3.619E+18	3.619E+18	9.476E+18

TOTAL FLUX

	1	2	3	4	5	
1	.8185213E+15	.8065048E+15	.7827466E+15	.7477849E+15	.7024168E+15	.2000000E+01
2	.1376544E+16	.1356341E+16	.1316342E+16	.1257600E+16	.1181305E+16	.6000000E+01
3	.1948429E+16	.1919832E+16	.1863282E+16	.1780053E+16	.1672035E+16	.1000000E+02
4	.2539244E+16	.2501971E+16	.2428261E+16	.2319769E+16	.2178940E+16	.1400000E+02
5	.3151687E+16	.3105421E+16	.3013917E+16	.2879219E+16	.2704344E+16	.1800000E+02
6	.3868589E+16	.3811790E+16	.3699451E+16	.3534062E+16	.3319301E+16	.2250000E+02
7	.4518396E+16	.4452047E+16	.4320815E+16	.4127593E+16	.3876652E+16	.2750000E+02
8	.4974843E+16	.4901784E+16	.4757278E+16	.4544501E+16	.4268131E+16	.3250000E+02
9	.5209940E+16	.5133428E+16	.4982088E+16	.4759241E+16	.4469774E+16	.3750000E+02
10	.5209868E+16	.5133355E+16	.4982020E+16	.4759183E+16	.4469730E+16	.4250000E+02
11	.4974618E+16	.4901568E+16	.4757079E+16	.4544332E+16	.4268002E+16	.4750000E+02
12	.4517989E+16	.4451655E+16	.4320453E+16	.4127281E+16	.3876402E+16	.5250000E+02
13	.3868086E+16	.3811307E+16	.3699007E+16	.3533678E+16	.3318993E+16	.5750000E+02
14	.3151156E+16	.3104912E+16	.3013453E+16	.2878818E+16	.2704019E+16	.6200000E+02
15	.2538712E+16	.2501462E+16	.2427797E+16	.2319366E+16	.2178610E+16	.6600000E+02
16	.1948017E+16	.1919440E+16	.1862926E+16	.1779748E+16	.1671789E+16	.7000000E+02
17	.1376241E+16	.1356054E+16	.1316134E+16	.1257381E+16	.1181132E+16	.7400000E+02
18	.8183263E+15	.8063225E+15	.7825856E+15	.7476508E+15	.7023136E+15	.7800000E+02

	6	7	8	9	10	
1	.6476910E+15	.5849076E+15	.5156391E+15	.4417905E+15	.3657736E+15	.2000000E+01
2	.1089268E+16	.9830648E+15	.8671141E+15	.7427492E+15	.6144224E+15	.6000000E+01
3	.1541700E+16	.1392098E+16	.1226865E+16	.1050288E+16	.8674902E+15	.1000000E+02
4	.2008972E+16	.1813782E+16	.1598005E+16	.1367019E+16	.1127087E+16	.1400000E+02
5	.2493226E+16	.2250658E+16	.1982260E+16	.1694454E+16	.1394539E+16	.1800000E+02
6	.3059952E+16	.2761811E+16	.2431609E+16	.2076926E+16	.1706160E+16	.2250000E+02
7	.3573528E+16	.3224906E+16	.2838491E+16	.2422858E+16	.1987346E+16	.2750000E+02
8	.3934229E+16	.3550090E+16	.3124087E+16	.2665476E+16	.2184256E+16	.3250000E+02
9	.4120015E+16	.3717567E+16	.3271144E+16	.2790348E+16	.2285525E+16	.3750000E+02
10	.4119986E+16	.3717555E+16	.3271146E+16	.2790361E+16	.2285544E+16	.4250000E+02
11	.3934145E+16	.3550051E+16	.3124088E+16	.2665509E+16	.2184307E+16	.4750000E+02
12	.3573349E+16	.3224797E+16	.2838447E+16	.2422867E+16	.1987387E+16	.5250000E+02
13	.3059726E+16	.2761668E+16	.2431542E+16	.2076921E+16	.1706192E+16	.5750000E+02
14	.2492984E+16	.2250501E+16	.1982181E+16	.1694437E+16	.1394562E+16	.6200000E+02
15	.2008723E+16	.1813616E+16	.1597916E+16	.1366992E+16	.1127100E+16	.6600000E+02
16	.1541521E+16	.1391986E+16	.1226814E+16	.1050286E+16	.8675175E+15	.7000000E+02
17	.1089146E+16	.9835943E+15	.8670901E+15	.7427607E+15	.6144550E+15	.7400000E+02
18	.6476211E+15	.5848708E+15	.5156311E+15	.4418036E+15	.3657991E+15	.7800000E+02

	11	12	13	14	15	
1	.2909915E+15	.2234863E+15	.1892360E+15	.1523244E+15	.1147588E+15	.2000000E+01
2	.4871504E+15	.3678730E+15	.2873751E+15	.2275893E+15	.1703805E+15	.6000000E+01
3	.6847889E+15	.5101966E+15	.3865616E+15	.3022331E+15	.2246771E+15	.1000000E+02
4	.8856571E+15	.6518637E+15	.4843401E+15	.3746983E+15	.2766718E+15	.1400000E+02
5	.1090905E+16	.7936222E+15	.5783866E+15	.4431303E+15	.3251343E+15	.1800000E+02
6	.1328564E+16	.9542666E+15	.6764438E+15	.5130747E+15	.3740841E+15	.2250000E+02
7	.1542025E+16	.1097787E+16	.7662109E+15	.5765292E+15	.4180886E+15	.2750000E+02
8	.1691166E+16	.1198028E+16	.8297317E+15	.6213766E+15	.4490603E+15	.3250000E+02
9	.1767794E+16	.1249564E+16	.8625828E+15	.6445786E+15	.4650573E+15	.3750000E+02
10	.1767812E+16	.1249577E+16	.8625921E+15	.6445849E+15	.4650614E+15	.4250000E+02
11	.1691218E+16	.1198068E+16	.8297579E+15	.6213938E+15	.4490709E+15	.4750000E+02
12	.1542076E+16	.1097830E+16	.7662421E+15	.5765502E+15	.4181019E+15	.5250000E+02
13	.1328610E+16	.9543100E+15	.6764723E+15	.5130939E+15	.3740960E+15	.5750000E+02
14	.1090945E+16	.7936619E+15	.5784124E+15	.4431482E+15	.3251456E+15	.6200000E+02
15	.8856861E+15	.6518932E+15	.4843634E+15	.3747151E+15	.2766824E+15	.6600000E+02
16	.6848261E+15	.5101309E+15	.3865881E+15	.3022527E+15	.2246902E+15	.7000000E+02
17	.4871896E+15	.3679067E+15	.2874020E+15	.2276098E+15	.1703949E+15	.7400000E+02
18	.2910213E+15	.2235136E+15	.1892598E+15	.1523425E+15	.1147714E+15	.7800000E+02

	16	17	
1	.7953542E+14	.4711851E+14	.2000000E+01
2	.1175678E+15	.6915446E+14	.6000000E+01
3	.1543374E+15	.9037884E+14	.1000000E+02
4	.1892284E+15	.1104480E+15	.1400000E+02
5	.2214756E+15	.1289379E+15	.1800000E+02
6	.2538081E+15	.1474272E+15	.2250000E+02
7	.2826829E+15	.1638998E+15	.2750000E+02
8	.3029288E+15	.1754339E+15	.3250000E+02
9	.3133667E+15	.1813765E+15	.3750000E+02
10	.3133692E+15	.1813780E+15	.4250000E+02
11	.3029352E+15	.1754376E+15	.4750000E+02
12	.2826909E+15	.1639045E+15	.5250000E+02
13	.2538148E+15	.1474307E+15	.5750000E+02
14	.2214818E+15	.1289409E+15	.6200000E+02
15	.1892344E+15	.1104513E+15	.6600000E+02
16	.1543456E+15	.9038337E+14	.7000000E+02
17	.1175770E+15	.6916021E+14	.7400000E+02
18	.7954364E+14	.4712321E+14	.7800000E+02

POWER DENSITY (MWT/LITER)

	1	2	3	4	5	
1	.7471976E-02	.7362145E-02	.7144972E-02	.6825285E-02	.6410210E-02	.2000000E+01
2	.1224986E-01	.1200986E-01	.1171385E-01	.1118975E-01	.1050923E-01	.6000000E+01
3	.1747578E-01	.1721900E-01	.1671113E-01	.1596343E-01	.1499247E-01	.1000000E+02
4	.2334085E-01	.2293792E-01	.2231962E-01	.2132093E-01	.2002392E-01	.1400000E+02
5	.3005759E-01	.2961601E-01	.2874257E-01	.2745649E-01	.2578606E-01	.1800000E+02
6	.5463631E+00	.5383433E+00	.5224821E+00	.4991330E+00	.4688183E+00	.2250000E+02
7	.6310000E+00	.6217360E+00	.6034135E+00	.5764380E+00	.5414088E+00	.2750000E+02
8	.6913727E+00	.6812211E+00	.6611426E+00	.6315799E+00	.5931862E+00	.3250000E+02
9	.7227031E+00	.7123912E+00	.6911018E+00	.6601968E+00	.6200573E+00	.3750000E+02
10	.7226931E+00	.7123812E+00	.6910923E+00	.6601887E+00	.6200512E+00	.4250000E+02
11	.6913414E+00	.6811911E+00	.6611148E+00	.6315562E+00	.5931682E+00	.4750000E+02
12	.6309436E+00	.6216818E+00	.6033635E+00	.5763948E+00	.5413743E+00	.5250000E+02
13	.5462927E+00	.5382757E+00	.5224201E+00	.4990792E+00	.4687751E+00	.5750000E+02
14	.3005223E-01	.2961086E-01	.2873785E-01	.2745240E-01	.2578275E-01	.6200000E+02
15	.2333551E-01	.2294279E-01	.2231492E-01	.2131684E-01	.2002056E-01	.6600000E+02
16	.1747174E-01	.1721516E-01	.1670765E-01	.1596042E-01	.1499004E-01	.7000000E+02
17	.1224692E-01	.1200707E-01	.1171135E-01	.1118762E-01	.1050754E-01	.7400000E+02
18	.7470042E-02	.7360340E-02	.7143378E-02	.6823955E-02	.6409184E-02	.7800000E+02

	6	7	8	9	10	
1	.5909067E-02	.5333326E-02	.4696769E-02	.4016100E-02	.3312926E-02	.2000000E+01
2	.9687492E-02	.8743189E-02	.7698535E-02	.6579977E-02	.5420507E-02	.6000000E+01
3	.1381981E-01	.1247173E-01	.1097917E-01	.9378096E-02	.7711491E-02	.1000000E+02
4	.1845718E-01	.1665537E-01	.1465876E-01	.1251306E-01	.1027037E-01	.1400000E+02
5	.2376792E-01	.2144621E-01	.1887167E-01	.1610059E-01	.1319410E-01	.1800000E+02
6	.4322194E+00	.3901657E+00	.3436283E+00	.2937163E+00	.2416902E+00	.2250000E+02
7	.4991051E+00	.4504717E+00	.3966074E+00	.3387552E+00	.2783130E+00	.2750000E+02
8	.5468099E+00	.4934768E+00	.4343750E+00	.3708415E+00	.3043728E+00	.3250000E+02
9	.5715671E+00	.5157935E+00	.4539704E+00	.3874834E+00	.3178804E+00	.3750000E+02
10	.5715631E+00	.5157917E+00	.4539706E+00	.3874851E+00	.3178830E+00	.4250000E+02
11	.5467981E+00	.4934712E+00	.4343750E+00	.3708459E+00	.3043797E+00	.4750000E+02
12	.4990803E+00	.4504567E+00	.3966014E+00	.3387564E+00	.2783187E+00	.5250000E+02
13	.4321877E+00	.3901455E+00	.3436187E+00	.2937152E+00	.2416944E+00	.5750000E+02
14	.2376546E-01	.2144460E-01	.1887085E-01	.1610041E-01	.1319432E-01	.6200000E+02
15	.1845464E-01	.1665365E-01	.1465781E-01	.1251275E-01	.1027047E-01	.6600000E+02
16	.1381802E-01	.1247060E-01	.1097865E-01	.9378060E-02	.7711760E-02	.7000000E+02
17	.9686290E-02	.8742495E-02	.7698301E-02	.6580097E-02	.5420845E-02	.7400000E+02
18	.5908373E-02	.5332965E-02	.4696701E-02	.4016245E-02	.3313202E-02	.7800000E+02

	11	12	13	14	15	
1	.2619476E-02	.1996846E-02	0.	0.	0.	.2000000E+01
2	.4265484E-02	.3184187E-02	0.	0.	0.	.6000000E+01
3	.6034392E-02	.4423865E-02	0.	0.	0.	.1000000E+02
4	.7992830E-02	.5763869E-02	0.	0.	0.	.1400000E+02
5	.1021864E-01	.7253191E-02	0.	0.	0.	.1800000E+02
6	.1890052E+00	.1374107E+00	0.	0.	0.	.2250000E+02
7	.2168867E+00	.1564407E+00	0.	0.	0.	.2750000E+02
8	.2366901E+00	.1699349E+00	0.	0.	0.	.3250000E+02
9	.2469460E+00	.1769207E+00	0.	0.	0.	.3750000E+02
10	.2469486E+00	.1769225E+00	0.	0.	0.	.4250000E+02
11	.2366971E+00	.1699403E+00	0.	0.	0.	.4750000E+02
12	.2168937E+00	.1564467E+00	0.	0.	0.	.5250000E+02
13	.1890115E+00	.1374165E+00	0.	0.	0.	.5750000E+02
14	.1021904E-01	.7253606E-02	0.	0.	0.	.6200000E+02
15	.7993109E-02	.5764173E-02	0.	0.	0.	.6600000E+02
16	.6034768E-02	.4424231E-02	0.	0.	0.	.7000000E+02
17	.4265892E-02	.3184554E-02	0.	0.	0.	.7400000E+02
18	.2619799E-02	.1997150E-02	0.	0.	0.	.7800000E+02

	16	17	
1	0.	0.	.2000000E+01
2	0.	0.	.6000000E+01
3	0.	0.	.1000000E+02
4	0.	0.	.1400000E+02
5	0.	0.	.1800000E+02
6	0.	0.	.2250000E+02
7	0.	0.	.2750000E+02
8	0.	0.	.3250000E+02
9	0.	0.	.3750000E+02
10	0.	0.	.4250000E+02
11	0.	0.	.4750000E+02
12	0.	0.	.5250000E+02
13	0.	0.	.5750000E+02
14	0.	0.	.6200000E+02
15	0.	0.	.6600000E+02
16	0.	0.	.7000000E+02
17	0.	0.	.7400000E+02
18	0.	0.	.7800000E+02

POWER PRODUCTION FRACTION FOR EACH ZONE

I= 1 PFRAC= .972777

I= 2 PFRAC= .013610

I= 3 PFRAC= .013609

I= 4 PFRAC= 0.000000

THESE ARE THE AVERAGE BURNUP RATES, IN MWD/TON, FOR EACH ZONE OVER THE PREVIOUS CYCLE

CELT= 100.00 DAYS

I= 1	FUEL MASS IN SHORT TONS=	1.879	AVG. BURNUP IN MWD/SHORT TON=	15554.42	AVG. BURNUP IN MWD/METRIC TON=	17109.87
I= 2	FUEL MASS IN SHORT TONS=	.940	AVG. BURNUP IN MWD/SHORT TON=	408.37	AVG. BURNUP IN MWD/METRIC TON=	449.21
I= 3	FUEL MASS IN SHORT TONS=	.940	AVG. BURNUP IN MWD/SHORT TON=	408.35	AVG. BURNUP IN MWD/METRIC TON=	449.18
I= 4	FUEL MASS IN SHORT TONS=	0.000	AVG. BURNUP IN MWD/SHORT TON=	0.00	AVG. BURNUP IN MWD/METRIC TON=	0.00

PHENIX EXAMPLE / 2 GROUP / ARGONNE CODE CNTR SAMPLE REACTOR
SEARCH-BURN-KEFF-REFUEL

MATERIAL INVENTORY (KILOGRAMS) FOR EACH ZONE

	MATERIAL	ATOMIC WT.	ZONE 1	ZONE 2	ZONE 3	ZONE 4
			.804E+03 LITERS	.402E+03 LITERS	.402E+03 LITERS	.143E+04 LITERS
1	IRON	55.850	7.482E+02	3.741E+02	3.741E+02	1.086E+03
2	CROM	52.010	1.792E+02	8.958E+01	8.958E+01	2.600E+02
3	NICK	58.710	1.265E+02	6.323E+01	6.323E+01	1.835E+02
4	NA	22.990	3.900E+02	1.954E+02	1.954E+02	1.051E+03
5	PUA	239.130	6.496E+02	2.017E+00	2.017E+00	0.
6	PUB	240.130	1.014E+02	5.204E-03	5.204E-03	0.
7	U238	238.120	9.278E+02	8.519E+02	8.519E+02	0.
8	OXY	16.000	2.292E+02	1.146E+02	1.146E+02	0.
9	FPR	119.000	1.400E+01	1.882E-01	1.882E-01	0.
10	B-10	10.010	6.803E+00	0.	0.	0.

ZONE 1 FLUX =2.5938E+15 VOLUME =8.0425E+02 LITERS

BURNABLE ISOTOPE NO.	MATERIAL NO.	NAME	ATOM DENSITY	FISSION RATE	ABSORPTION RATE	SIGMA FISSION	SIGMA ABSORPTION
1	5	PUA	2.034E-03	7.894E+18	9.694E+18	1.860E+00	2.284E+00
2	6	PUB	3.161E-04	2.670E+17	5.097E+17	4.049E-01	7.730E-01
3	7	U238	2.918E-03	3.116E+17	1.667E+18	5.119E-02	2.739E-01
4	9	FPR	8.867E-05	0.	4.353E+17	0.	2.353E+00
5	10	B-10	5.089E-04	0.	2.449E+18	0.	2.307E+00

ZONE 2 FLUX =1.1089E+15 VOLUME =4.0212E+02 LITERS

BURNABLE ISOTOPE NO.	MATERIAL NO.	NAME	ATOM DENSITY	FISSION RATE	ABSORPTION RATE	SIGMA FISSION	SIGMA ABSORPTION
1	5	PUA	1.263E-05	1.114E+16	1.423E+16	1.978E+00	2.527E+00
2	6	PUB	3.246E-08	5.306E+12	1.179E+13	3.666E-01	8.146E-01
3	7	U238	5.358E-03	1.074E+17	7.151E+17	4.495E-02	2.993E-01
4	9	FPR	2.369E-06	0.	2.183E+15	0.	2.067E+00
5	10	B-10	0.	0.	0.	0.	2.696E+00

ZONE 3 FLUX =1.1088E+15 VOLUME =4.0212E+02 LITERS

BURNABLE ISOTOPE NO.	MATERIAL NO.	NAME	ATOM DENSITY	FISSION RATE	ABSORPTION RATE	SIGMA FISSION	SIGMA ABSORPTION
1	5	PUA	1.263E-05	1.114E+16	1.423E+16	1.978E+00	2.527E+00
2	6	PUB	3.246E-08	5.306E+12	1.179E+13	3.666E-01	8.146E-01
3	7	U238	5.358E-03	1.074E+17	7.151E+17	4.495E-02	2.993E-01
4	9	FPR	2.369E-06	0.	2.183E+15	0.	2.067E+00
5	10	B-10	0.	0.	0.	0.	2.696E+00

ZONE 4 FLUX =3.2600E+14 VOLUME =1.4326E+03 LITERS

BURNABLE ISOTOPE NO.	MATERIAL NO.	NAME	ATOM DENSITY	FISSION RATE	ABSORPTION RATE	SIGMA FISSION	SIGMA ABSORPTION
1	5	PUA	0.	0.	0.	2.019E+00	2.612E+00
2	6	PUB	0.	0.	0.	3.532E-01	8.292E-01
3	7	U238	0.	0.	0.	4.277E-02	3.082E-01
4	9	FPR	0.	0.	0.	0.	1.967E+00
5	10	B-10	0.	0.	0.	0.	2.833E+00

KZ= 1 BREDRT(KZ)= .1644
KZ= 2 BREDRT(KZ)= .0625
KZ= 3 BREDRT(KZ)= .0625
KZ= 4 BREDRT(KZ)= 0.0000

BREEDING RATIO = .2894

* * * * * * REFUEL BETWEEN BURNUP INTERVALS 1 AND 2 * * * * * *

KINT	BURNUP INTERVAL JUST COMPLETED	1
NRFG	NO. OF REGIONS REQUIRING REFUELING	3
NRFPC	REFUEL CONTROL RODS DURING REFUELING (0/1=NO/YES)	1
KLAPS	REGION COLLAPSE OPTION (0=NO / N=NO.OF COLLAPSES)	1
IITMAX	MAX. NO. OF BURNUP INTERVALS TO BE ANALYZED	1
NECOP	PUNCH OPTION FOR INPUT TO ECONOMICS CODE (DATA FROM FIRST NECOP COLLAPSES WILL BE PUNCHED)	0

LAST = 996

LENGTH OF BURNUP INTERVAL 100.0 DAYS

CLEAN FUEL ATOM DENSITIES,HNO(I)

I= 1	I0=11	I1= 0	CLEAN DENSITY= 0.0000000
I= 2	I0=11	I1= 4	CLEAN DENSITY= .0127330
I= 3	I0=11	I1= 1	CLEAN DENSITY= .0100330
I= 4	I0=11	I1= 2	CLEAN DENSITY= .0025797
I= 5	I0=11	I1= 3	CLEAN DENSITY= .0016131
I= 6	I0=11	I1= 5	CLEAN DENSITY= .0021241
I= 7	I0=11	I1= 6	CLEAN DENSITY= .0003022
I= 8	I0=11	I1= 7	CLEAN DENSITY= .0029357
I= 9	I0=11	I1= 9	CLEAN DENSITY= 0.0000000
I= 10	I0=11	I1= 8	CLEAN DENSITY= .0107300
I= 11	I0=11	I1=10	CLEAN DENSITY= .0005000
I= 12	I0=12	I1= 0	CLEAN DENSITY= 0.0000000
I= 13	I0=12	I1= 4	CLEAN DENSITY= .0127330
I= 14	I0=12	I1= 1	CLEAN DENSITY= .0100330
I= 15	I0=12	I1= 2	CLEAN DENSITY= .0025797
I= 16	I0=12	I1= 3	CLEAN DENSITY= .0016131
I= 17	I0=12	I1= 5	CLEAN DENSITY= 0.0000000
I= 18	I0=12	I1= 6	CLEAN DENSITY= 0.0000000
I= 19	I0=12	I1= 7	CLEAN DENSITY= .0053735
I= 20	I0=12	I1= 9	CLEAN DENSITY= 0.0000000
I= 21	I0=12	I1= 8	CLEAN DENSITY= .0107300
I= 22	I0=13	I1= 0	CLEAN DENSITY= 0.0000000
I= 23	I0=13	I1= 4	CLEAN DENSITY= .0127330
I= 24	I0=13	I1= 1	CLEAN DENSITY= .0100330
I= 25	I0=13	I1= 2	CLEAN DENSITY= .0025797
I= 26	I0=13	I1= 3	CLEAN DENSITY= .0016131
I= 27	I0=13	I1= 5	CLEAN DENSITY= 0.0000000
I= 28	I0=13	I1= 6	CLEAN DENSITY= 0.0000000
I= 29	I0=13	I1= 7	CLEAN DENSITY= .0053735
I= 30	I0=13	I1= 9	CLEAN DENSITY= 0.0000000
I= 31	I0=13	I1= 8	CLEAN DENSITY= .0107300
I= 32	I0=14	I1= 0	CLEAN DENSITY= 0.0000000
I= 33	I0=14	I1= 1	CLEAN DENSITY= .0081738
I= 34	I0=14	I1= 2	CLEAN DENSITY= .0021016
I= 35	I0=14	I1= 3	CLEAN DENSITY= .0013142
I= 36	I0=14	I1= 4	CLEAN DENSITY= .0192200

REFUELING DATA FOR BURNUP INTERVAL 1

REGION	REFUELING FRACTIONS	NO.OF INTERVALS BETWEEN REFUELINGS
1	.50000	1
2	.50000	1
3	.50000	1

ELEMENTS (BURNABLE ISOTOPES) TO BE REFUELED IN THE ABOVE REGIONS

ELEMENT	5	PUA
ELEMENT	6	PUB
ELEMENT	7	U238
ELEMENT	9	FPR

I VALUES IN MOI ARRAY THAT ARE BURNABLE ISOTOPES

I= 6	REGION = 1	BURN ISO NO. 1	ELEMENT NO. 5
I= 7	REGION = 1	BURN ISO NO. 2	ELEMENT NO. 6
I= 8	REGION = 1	BURN ISO NO. 3	ELEMENT NO. 7
I= 9	REGION = 1	BURN ISO NO. 4	ELEMENT NO. 9
I= 11	REGION = 1	BURN ISO NO. 5	ELEMENT NO.10
I= 17	REGION = 2	BURN ISO NO. 1	ELEMENT NO. 5
I= 18	REGION = 2	BURN ISO NO. 2	ELEMENT NO. 6
I= 19	REGION = 2	BURN ISO NO. 3	ELEMENT NO. 7
I= 20	REGION = 2	BURN ISO NO. 4	ELEMENT NO. 9
I= 0	REGION = 2	BURN ISO NO. 5	ELEMENT NO.10
I= 27	REGION = 3	BURN ISO NO. 1	ELEMENT NO. 5
I= 28	REGION = 3	BURN ISO NO. 2	ELEMENT NO. 6
I= 29	REGION = 3	BURN ISO NO. 3	ELEMENT NO. 7
I= 30	REGION = 3	BURN ISO NO. 4	ELEMENT NO. 9
I= 0	REGION = 3	BURN ISO NO. 5	ELEMENT NO.10

AVG FLUX USED IN PREVIOUS EIGHT BURNUP INTERVALS, PHI(I,J)

	PHI(1,J)	PHI(
J= 1	.25547E+16	
J= 2	.10895E+15	
J= 3	.10894E+15	
J= 4	.32054E+15	

ZONE. GROUP AVERAGED ABSORPTION X-SECTIONS FOR BURNABLE ISOTOPES, ABXS(I,J,K) K=KLNT,KNT

BURNUP INTERVAL K= 1

REGION 1					
	.2272E+01	.7709E+00	.2727E+00	.2367E+01	.2288E+01
REGION 2					
	.2521E+01	.8136E+00	.2987E+00	.2074E+01	.2687E+01
REGION 3					
	.2521E+01	.8136E+00	.2987E+00	.2074E+01	.2687E+01
REGION 4					
	.2603E+01	.8278E+00	.3073E+00	.1977E+01	.2819E+01

ZONE. GROUP AVERAGED FISSION X-SECT FOR BURNABLE ISOTOPES, FIXS(I,J,K). K=KLNT,KNT

BURNUP INTERVAL K= 1

REGION 1					
	.1855E+01	.4068E+00	.5149E-01	0.	0.
REGION 2					
	.1975E+01	.3676E+00	.4510E-01	0.	0.
REGION 3					
	.1975E+01	.3676E+00	.4510E-01	0.	0.
REGION 4					
	.2015E+01	.3545E+00	.4298E-01	0.	0.

REGION DISCHARGE AND CHARGE AND INITIAL COMPOSITION FOR NEXT BURNUP INTERVAL

REGION 1 VOLUME=8.0425E+02 LITERS

ELEMENT	DISCHARGE FROM BI 1		CHARGE FOR BI 2		INITIAL COMPOSITION BI 2	
	ATOM DENS	MASS(KG)	ATOM DENS	MASS(KG)	ATOM DENS	MASS(KG)
4	0.0000000	0.	0.0000000	0.	.0127330	3.9088E+02
1	0.0000000	0.	0.0000000	0.	.0100330	7.4822E+02
2	0.0000000	0.	0.0000000	0.	.0025797	1.7916E+02
3	0.0000000	0.	0.0000000	0.	.0016131	1.2646E+02
5	.0010171	3.2478E+02	.0010621	3.3912E+02	.0020792	6.6391E+02
6	.0001580	5.0676E+01	.0001511	4.8449E+01	.0003091	9.9125E+01
7	.0014591	4.6392E+02	.0014678	4.6672E+02	.0029269	9.3064E+02
9	.0000443	7.0450E+00	0.0000000	0.	.0000443	7.0450E+00
8	0.0000000	0.	0.0000000	0.	.0107300	2.2924E+02
10	0.0000000	0.	0.0000000	0.	.0005000	6.6831E+00

REGION 2 VOLUME=4.0212E+02 LITERS

ELEMENT	DISCHARGE FROM BI 1		CHARGE FOR BI 2		INITIAL COMPOSITION BI 2	
	ATOM DENS	MASS(KG)	ATOM DENS	MASS(KG)	ATOM DENS	MASS(KG)
4	0.0000000	0.	0.0000000	0.	.0127330	1.9544E+02
1	0.0000000	0.	0.0000000	0.	.0100330	3.7411E+02
2	0.0000000	0.	0.0000000	0.	.0025797	8.9578E+01
3	0.0000000	0.	0.0000000	0.	.0016131	6.3230E+01
5	.0000063	1.0084E+00	0.0000000	0.	.0000063	1.0084E+00
6	.0000000	2.6020E-03	0.0000000	0.	.0000000	2.6020E-03
7	.0026792	4.2594E+02	.0026868	4.2714E+02	.0053660	8.5308E+02
9	.0000012	9.4096E-02	0.0000000	0.	.0000012	9.4096E-02
8	0.0000000	0.	0.0000000	0.	.0107300	1.1462E+02

REGION 3 VOLUME=4.0212E+02 LITERS

ELEMENT	DISCHARGE FROM BI 1		CHARGE FOR BI 2		INITIAL COMPOSITION BI 2	
	ATOM DENS	MASS(KG)	ATOM DENS	MASS(KG)	ATOM DENS	MASS(KG)
4	0.0000000	0.	0.0000000	0.	.0127330	1.9544E+02
1	0.0000000	0.	0.0000000	0.	.0100330	3.7411E+02
2	0.0000000	0.	0.0000000	0.	.0025797	8.9578E+01
3	0.0000000	0.	0.0000000	0.	.0016131	6.3230E+01
5	.0000063	1.0084E+00	0.0000000	0.	.0000063	1.0084E+00
6	.0000000	2.6019E-03	0.0000000	0.	.0000000	2.6019E-03
7	.0026792	4.2594E+02	.0026868	4.2714E+02	.0053660	8.5308E+02
9	.0000012	9.4092E-02	0.0000000	0.	.0000012	9.4092E-02
8	0.0000000	0.	0.0000000	0.	.0107300	1.1462E+02

REGION 4 VOLUME=1.4320E+03 LITERS

ELEMENT	DISCHARGE FROM BI 1 ATOM DENS	DISCHARGE FROM BI 1 MASS(KG)	CHARGE FOR BI 2 ATOM DENS	CHARGE FOR BI 2 MASS(KG)	INITIAL COMPOSITION BI 2 ATOM DENS	INITIAL COMPOSITION BI 2 MASS(KG)
1	0.0000000	0.	0.0000000	0.	.0081738	1.0858E+03
2	0.0000000	0.	0.0000000	0.	.0021016	2.5998E+02
3	0.0000000	0.	0.0000000	0.	.0013142	1.8352E+02
4	0.0000000	0.	0.0000000	0.	.0192200	1.0510E+03

INPUT ATOM DENSITIES (I2 BLOCK) FOR BURNUP INTERVAL 2

I=	I0=	I1=	I2(I) =
1	11	0	0.0000000
2	11	4	.0127330
3	11	1	.0100330
4	11	2	.0025797
5	11	3	.0016131
6	11	5	.0020792
7	11	6	.0003091
8	11	7	.0029269
9	11	9	.0000443
10	11	8	.0107300
11	11	10	.0005000
12	12	0	0.0000000
13	12	4	.0127330
14	12	1	.0100330
15	12	2	.0025797
16	12	3	.0016131
17	12	5	.0000063
18	12	6	.0000000
19	12	7	.0053660
20	12	9	.0000012
21	12	8	.0107300
22	13	0	0.0000000
23	13	4	.0127330
24	13	1	.0100330
25	13	2	.0025797
26	13	3	.0016131
27	13	5	.0000063
28	13	6	.0000000
29	13	7	.0053660
30	13	9	.0000012
31	13	8	.0107300
32	14	0	0.0000000
33	14	1	.0081738
34	14	2	.0021016
35	14	3	.0013142
36	14	4	.0192200

REGION COLLAPSED INFORMATION FOR ELEMENTS TO BE REFUELED

REGION COLLAPSE NO. 1 FROM REGIONS 2 3

VOL AFTER COLLAPSE =8.9425E+02 LITERS

ELEMENT	COMPOSITION AT END OF BI 1, KG.	DISCHARGE FROM BI 1, KG.	CHARGE FOR BI 2, KG.	INITIAL COMPOSITION FOR BI 2, KG.
5	4.0336E+00	2.0168E+00	0.	2.0168E+00
6	1.0408E-02	5.2039E-03	0.	5.2039E-03
7	1.7038E+03	8.5189E+02	8.5428E+02	1.7062E+03
9	3.7638E-01	1.8819E-01	0.	1.8819E-01
10	0.	0.	0.	0.

DISCHARGE FROM BI 1, CHARGE FOR BI 2 AND INITIAL COMPOS. FOR BI 2 IN KILOGRAMS

ELEMENT 1	IRON	TOTAL DISCHARGE = 0.	TOTAL CHARGE = 0.	TOTAL MASS IN REACTOR = 2.5822E+03
ELEMENT 2	CROM	TOTAL DISCHARGE = 0.	TOTAL CHARGE = 0.	TOTAL MASS IN REACTOR = 6.1829E+02
ELEMENT 3	NICK	TOTAL DISCHARGE = 0.	TOTAL CHARGE = 0.	TOTAL MASS IN REACTOR = 4.3643E+02
ELEMENT 4	NA	TOTAL DISCHARGE = 0.	TOTAL CHARGE = 0.	TOTAL MASS IN REACTOR = 1.8327E+03
ELEMENT 5	PUA	TOTAL DISCHARGE = 3.2680E+02	TOTAL CHARGE = 3.3912E+02	TOTAL MASS IN REACTOR = 6.6592E+02
ELEMENT 6	PUB	TOTAL DISCHARGE = 5.0681E+01	TOTAL CHARGE = 4.8449E+01	TOTAL MASS IN REACTOR = 9.9130E+01
ELEMENT 7	U238	TOTAL DISCHARGE = 1.3158E+03	TOTAL CHARGE = 1.3210E+03	TOTAL MASS IN REACTOR = 2.6368E+03
ELEMENT 8	OXY	TOTAL DISCHARGE = 0.	TOTAL CHARGE = 0.	TOTAL MASS IN REACTOR = 4.5849E+02
ELEMENT 9	FPR	TOTAL DISCHARGE = 7.2332E+00	TOTAL CHARGE = 0.	TOTAL MASS IN REACTOR = 7.2332E+00
ELEMENT 10	B-10	TOTAL DISCHARGE = 0.	TOTAL CHARGE = 0.	TOTAL MASS IN REACTOR = 6.6831E+00

* * * * P H E N I X * * * *