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FUMBLE: AN APPROACH TO FAST POWER REACTOR FUEL MANAGEMENT AND BURNUP CALCULATIONS

P. GREEBLER
C. L. COWAN

PREPARED FOR THE
UNITED STATES ATOMIC ENERGY COMMISSION
UNDER CONTRACT No. AT(04-3)-189
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Development Report

FUMBLE: AN APPROACH TO FAST POWER REACTOR
FUEL MANAGEMENT AND BURNUP CALCULATIONS

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ABSTRACT

1. Name: FUMBLE
2. Computer: GE 635
3. Problem Solved: FUMBLE computes the fuel burnup in reactor operations. This includes the evaluation of reactivity effects, breeding (or depletion) and inventories of fuel, and fuel costs for changing economic conditions and supplied fuel compositions throughout the reactor lifetime (or for as many refueling operating intervals as desired). Fuel cost components associated with fabrication and reprocessing are computed by treating these operations in a "black box" manner, using input data parameters such as reprocessing time, fissile material losses, unit fabrication costs, etc. Considerable flexibility is allowed in the specifications of reactor refueling, including fuel compositions for the startup reactor, recycle schemes and fissile makeup compositions for subsequent core loadings, amounts of fuel to be replaced in different positions of the reactor at any refueling, and shuffling of fuel from one part of the reactor to another or temporarily storing fuel discharged from the reactor for later additional burnup. The refueling specifications may be changed from one refueling operating interval to another, as well as operating interval time, power rating, and load factor. Fuel costs may be evaluated for several different sets of cost input data (different economic assumptions) and may be based on net costs accrued and energy produced by spent fuel batches and/or on net costs incurred for all fuel held and energy produced by the entire reactor for each operating interval.
4. Method of Solution: Fuel burnup calculations are carried out in each reactor region (e.g., core region 1, core region 2, axial blanket region 1, etc.) using a region dependent one group flux, and region and material dependent one group capture and fission cross sections which are supplied as input

from a separate multigroup diffusion (transport) calculation. Two sets of data from related multigroup calculations may be input to FUMBLE and used as end point cases for interpolation of the fluxes, volumes and cross sections. Region and material dependent reactivity worths are used in FUMBLE to calculate the combinations of recycle and make up materials for reload fuel that satisfies both required reactivity and a specified power distribution in going from one operating interval to another.

5. Restrictions on the Complexity of the Problem: Variable dimensioned arrays are used exclusively within the program. Hence the only problem size restriction is dictated by the amount of available computer memory.
6. Typical Running Time: A detailed problem consisting of 30 reactor regions, 10 operating intervals, 8 fuel materials and requesting all output options required 2 minutes of central processor time on the GE635 computer.
7. Unusual Features of the Program: None.
8. Related and Auxiliary Programs: FUMBLE and the two-dimensional synthesis diffusion code BISYN are linked. Punched cards from a BISYN case give fluxes, volumes, cross sections and reactivity worths in the FUMBLE format. Punched cards from a FUMBLE case give fuel material concentration in the BISYN format.
9. Status: In use, with detailed checkout status given in Section 6.3.
10. References: P. Greebler, C.L. Cowan, "FUMBLE, An Approach to Fast Power Reactor Fuel Management and Burnup Calculations", General Electric Company, GEAP-13599, April, 1970.
11. Machine Requirements: Minimum Computer Memory is 48K on the GE 635. Two tapes and one auxiliary may be required for some cases.

12. Programming Languages Used: FUMBLE is written almost entirely in FORTRAN-IV. Only those routines used in the GE compressed binary input and output options are presently written in RWSBT language and FORTRAN versions of these routines are also provided.
13. Operating Systems: GECOS-III with FORTRAN-IV Compiler.
14. Other Programming or Operating Information: None.

SECTION I

SUMMARY1.1 Introduction

Development of a versatile fuel management and burnup code is recognized as one of the most important LMFBR Physics needs for the commitment of demonstration plants and for the design and the operational planning of demonstration and large LMFBR plants.⁽¹⁾

Early burnup codes which utilized a zero-dimensional reactor model have now evolved to the point where limited burnup studies for fast reactors can now be made on a two-dimensional reactor model. Two-dimensional burnup capability was especially important for fast power reactors in order to accurately and efficiently treat multi-zone-enriched cores with axial and radial blankets. Development of two-dimensional burnup codes was held up to a large extent because computation costs appeared so large as to make such codes uneconomical for general use in reactor design and evaluation. The RAPFU code⁽²⁾ developed by General Electric adopted a simplified approach to bypass the very expensive reactivity calculations and, thereby, made two-dimensional burnup computation a very powerful tool that has been used extensively and successfully for fast reactor design studies. The BICYCL code⁽³⁾ which uses perturbation theory and direct multigroup diffusion theory as alternate options for the reactivity calculations allows greater accuracy than RAPFU for special situations that may require it and extends certain capabilities such as allowing fuel shuffling from one zone of the reactor to another during refueling.

The above burnup codes, and others now in use, have limited applicability because they are equilibrium cycle codes. At the end of an operating interval, a spent fuel batch is removed from each of the various reactor zones and is replaced by a fresh fuel batch in accordance with fissile recycle and makeup instructions that are identical for all refuelings. The relative simplicity of equilibrium cycle calculations made it attractive to use this approach to

develop fuel cycle computational capability on a timely basis for the purpose of scoping the long-term economic potentials and the design problems related to fuel composition of fast power reactors. However, the equilibrium fuel cycle does not represent the operation of a real reactor and, hence, does not provide adequate information upon which to establish a firm core design. Since LMFBR demonstration plant commitments and detailed designs are expected to be underway in the next few years, an acute need exists for a fuel management and burnup code with sufficient flexibility to enable computation of realistic fuel cycles and thereby to define the requirements on the reactor design imposed by such fuel cycles. This report gives the specifications of a computer code which will go a long way toward fulfilling this need.

1.2 Specific Requirements for a Fuel Management Code

Problem areas that will be made amenable to accurate and efficient calculation with the new code are indicated by the following examples:

1. Fuel management of the startup core -

- a) Accept low burnup of the first several discharged fuel batches versus storage of such fuel for later additional burnup in the reactor. Sensitivity of these alternatives to uncertainties in early fabrication and plutonium inventory costs. Design provisions to allow for reactivity coefficients, power peaking, and control requirements of the different alternatives.
- b) Startup core isotopics (e.g., economics and design problems in control and power distribution associated with a U-235 startup core instead of one loaded with plutonium discharged by water reactors).

2. Impact of potential technological developments -

- a) Start with an oxide core and switch to an advanced fuel (e.g., carbide) later in plant lifetime. Extent to which core design can anticipate and accommodate such a change. Projected power costs over plant lifetime for reasonable assumptions on the timing of advanced fuel development.
- b) Same as (a) for developments in clad material that will allow higher fuel densities or higher burnups, or in design of fuel rod spacers and subassembly structure.
- c) Advancements in fuel fabrication and reprocessing with resultant decreasing fuel cost with time. Similar effects on cost of increasing throughput with time. Optimum fuel management for time-varying costs and requirements imposed on control and other design areas.

3. Maximum utilization of fuel resources. Incentives and problems associated with incorporation of thorium into core or blanket regions during reactor lifetime.

4. Optimum blanket refueling (e.g., replacement of a small batch of the radial blanket fuel at each refueling versus replacement of a larger fraction of the blanket at every second or third shutdown for core refueling). Effect on power distribution in relationship to design of flow orificing.

5. Fuel warranty services -

- a) Calculate isotopic concentration changes in each fuel batch from fabrication to reprocessing.

5. b) Maintain record of fissile weight inventory in each fuel batch, including out-of-pile storage between successive reactor exposures if such fuel management procedure is used.
- c) Maintain record of energy produced and of fuel cost components accrued in each fuel batch from fabrication to reprocessing, allowing for time-varying processing costs, interest rates, and values of the various fissile isotopes during the lifetime of any given fuel batch.

General features of the code that have been specified in order to permit adequate treatment of problems of the type indicated above are summarized in Section 1.4.

1.3 Computational Model and Procedures

In order to obtain a versatile fuel management code that runs quickly enough on the computer to be economically practical as a general tool in support of design and operational planning, a synthesis approach was adopted for calculation of the time-varying, composition-dependent reaction rate cross sections, material reactivity worths, reference multiplication factor and corresponding reference isotopic concentrations, and regional fluxes and volumes. This synthesis approach utilizes output from precalculated, two-dimensional multigroup diffusion theory cases, and interpolates the above parameters using these precalculated data as interpolation end points and fuel composition parameters specified by input data as an interpolation index. The precalculated multigroup diffusion cases (and the present version of the code calls for two such cases to be run) must be run using reactor fuel compositions that give a reasonable approximation of the flux spectra of the first operating interval and of the last operating interval, respectively, to the extent that perturbation theory is a valid approximation for treatment of the differences in composition between the actual reactor and the precalculated multigroup cases run. The two-dimensional, multigroup diffusion synthesis code BISYN⁽⁴⁾ will be adapted so that it can be requested to output the required interpolation end point data for punched cards or tape in format directly usable as input to the fuel management code.

*Only one multigroup case need be run if the cross sections and other above-mentioned data are to be held constant for all operating intervals.

Figure 1 shows a simplified flow chart of the calculations performed. After an initial data checking routine (box 1 of Figure 1) and another module that sets up the first core conditions (box 2), the code proceeds in a loop that carries out a complete sequence of calculations for each operating interval. (An operating interval is the time between successive refueling shutdowns.) Box 3 enters the loop at the point where a first estimate has been made of the fuel isotopic concentrations at the beginning of the operating interval and indicates that burnup calculations are then performed to obtain the isotopic concentrations at the end of the operating interval and the incremental energy produced in each fuel batch during the operating interval. The beginning-of-interval isotopic concentrations are first estimates only for newly-loaded fuel batches; isotopics are established for those batches that are carried over from previous operating intervals. The burnup is determined by the operating interval time and load factor, supplied as input data for each interval, and by neutron fluxes which have been normalized to give the reactor rated thermal power (also supplied as input data).

Box 4 indicates that a reactivity test (reactor multiplication factor) is performed at end-of-interval conditions to determine whether the estimated beginning-of-interval concentrations were adequate. If not, these concentrations are adjusted (box 8) in accordance with previously established parameters that execute fissile recycle and makeup instructions; and the burnup and reactivity testing are repeated in an iterative process that continues until the reactivity requirement is satisfied or the number of iterations exceeds a limit specified in the input data.

If the reactivity requirement is satisfied, a burnup test on the spent fuel to be discharged from specified zones is made (box 5) if requested by input data. If the burnup requirement is not satisfied, the code will check if a change in the operating interval time may be made (as indicated by input data) sufficient to allow the burnup requirement to be satisfied. If such time adjustment is permitted, the code will make the change in operating time for that interval, adjust the estimated beginning-of-interval isotopic concentrations in the freshly loaded fuel in accordance with the adjustment made in the

FIGURE 1

SIMPLIFIED FLOW CHART

FIGURE 1

SIMPLIFIED FLOW CHART (Cont'd)

FIGURE 1

SIMPLIFIED FLOW CHART (Cont'd)

12. Set up fissile recycle and fuel makeup control parameters to satisfy estimated reactivity requirement for next operating interval and to approximately satisfy desired power distribution.

13. Compare fissile recycle requirements with availability of recycle material. Readjust recycle and makeup control parameters accordingly. Calculate isotopic concentrations for beginning of operating interval for zones with variable isotopic content. Update recycle repository material inventories.

Go to Burnup Calculations (box 3 of preceding pages).

operating interval time, and will then proceed with the burnup calculation of end-of-interval isotopic concentrations and reactivity test following the iterative process described above.

If reactivity and burnup requirements are both satisfied, the code will test to determine if limits on power peaking and reactivity control required for burnup are exceeded (box 6). If these limits are exceeded, the code will just stop the calculation.

If all the tests are satisfied, the beginning and the end-of-interval isotopics are established and the code executes instructions provided by input data on disposition of the fuel to be discharged at the end of the operating interval (box 7). Fuel being discharged from specified zones may be stored for later exposure in the reactor after a specified holdup time expressed as an integral multiple of operating intervals. Fuel may also be shuffled from one zone to another - corresponding to zero holdup time in storage. Plutonium in the fuel discharged from any zone of the reactor may be allocated to one of the designated plutonium recycle repositories, to be made available for recycle after a specified holdup time that allows for reprocessing and fabrication. Similarly, uranium discharged from any zone may be allocated to one of the designated uranium recycle repositories.

Figure 2 shows the reactor computational model broken down into zones and regions and defines what is meant by these subdivisions. Figure 3 is a schematic representation of the fuel storage, recycle, and makeup process, including some description of the repository concept used.

After updating the repository material inventories, the code proceeds to the output routine where neutronics and economics data for the operating interval just completed are processed as indicated in box 9 of Figure 1.

FIGURE 2

EXAMPLE OF REACTOR COMPUTATIONAL MODEL

1. Reactor is broken down into zones and regions.
2. Each zone consists of one or more regions. Fuel loaded into a given zone must have the same initial isotopic concentrations for all regions of that zone. Fuel batches are loaded into and discharged from the reactor zones in accordance with input data instructions - uniformly for all regions of a given zone.
3. Each region has a distinct neutron flux level and spectrum, with corresponding reaction rate cross sections and material (isotopic) reactivity worths which change with varying composition from one operating interval to another.
4. Isotopic concentrations of a given fuel batch freshly loaded into a given zone are the same for all regions of that zone, as noted in 2 above. However, as burnup proceeds, the batch isotopic concentrations will differ from one region to another within the zone.
5. In the example below there are 7 zones and 16 regions. In general, this will vary with the requirements of the reactor case being calculated.

FIGURE 3

MODEL FOR TREATMENT OF FUEL STORAGE, RECYCLE, AND MAKEUP

(Number of storage repositories, recycle repositories of each kind, fissile and makeup sources specified by input data)

I-11

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* A recycle repository is an abstract entity used to keep track of the excess fissile material sent to reprocessing over that returned to the reactor from fabrication facilities.

If the last operating interval (input data) has not been reached, the code proceeds to set up the beginning-of-interval conditions for the next operating interval. A first step is the interpolation routine based on the synthesis approach mentioned in the first paragraph of this section (1.3) and outlined in box 10. This is followed by execution of the reactor reload instructions for those reactor zones that tend to have a fixed input isotopic composition from one operating interval to another - this is usually the case for blanket zones - and for those zones that are receiving previously irradiated fuel that has been held up in storage repositories or is being shuffled from another zone (box 11).

Core zones that do not receive previously irradiated and stored fuel will generally be designated as variable isotopic content zones and are reloaded in accordance with recycle and makeup instructions provided as input data. For each such zone, a first choice recycle repository is specified (including hold-up time on the availability of recycled material). Also specified for each variable isotopic zone is a second choice recycle repository (this is optional input), a fissile makeup source to be used if sufficient recycle material is not available in the selected repositories, and a source that makes up the bulk of fertile material required to provide the total fuel atom density specified by input data (see Figure 3). The code sets up parameters, in accordance with the input data instructions, which are used for the calculation of the recycle and fissile makeup reload requirements of each variable fissile zone (box 12). The calculated fissile and fertile inputs summed over all the variable fissile zones are forced to provide the excess burnup reactivity needed for the next operating interval and, in addition, to give a power split between the various variable isotopic content zones that is at least close to a specified (by input data) power distribution.

After fissile and fertile material requirements of the variable fissile zones have been calculated, the code compares recycle material requirements with the availability of such material in the various recycle repositories (box 13). Adjustments in the reload isotopics are then made for those core

zones where insufficient recycle material is available, these adjustments involving substitutions of second choice recycle material (if available) for the first choice recycle material, or of makeup fissile material in place of the recycle material, conducted in such a manner as to maintain the initially established reactivity and the specified fuel atom densities. Recycle repository inventories are again updated. The core converts the material weights of the reload fuel batches to regional and batch atom densities corresponding to the beginning-of-interval condition for the next operating period, and thereby returns to our starting point (box 3) in the loop.

1.4 General Features and User Options

1.4.1 Time Dependence of Input Data Parameters

Extensive input data options are provided to make the code a highly flexible tool. Time variation of most of the input-control data, in the sense that this input may be changed at the beginning of any operating interval as specified, is one feature that contributes to the flexibility. Following are input data parameters that may be varied with time:

1. Operating interval time, load factor, power
2. Criteria for burnup test and for power peaking and burnup reactivity tests.
3. Refueling instructions - including number of fuel batches replaced in each zone at each refueling shutdown, disposition of discharged fuel to storage or recycle repositories, reload fuel composition in fixed isotopic zones, replacement with previously irradiated fuel held up in storage or shuffled between zones, and recycle and fissile makeup for variable isotopic content zones.
4. Fuel cost parameters - including unit fabrication and reprocessing costs (\$/kg) for the different fuels in the various zones, fabrication and reprocessing times and fissile losses, plant heat

rate, interest rates for fissile inventory and for fabrication inventory, and the values of fissile materials (or parameters in the formula used to derive such values in the case of natural, depleted, or enriched uranium).

5. Controls that determine the kind and detail of output data to be printed.

1.4.2 Isotopes and Burnup Chains

Fuel isotopes that may be included are:

1. The U^{238} -Pu chain.
2. The Th^{232} -U chain, or just the U-235 and U-236 portion of it.
3. One aggregate fission product; two permitted if both chains (or portions of both chains) are present.
4. A non-fuel burnable poison.

Radioactive decay of Pu-241 and Pa-233 is treated both in-pile and out-of-pile.

1.4.3 Refueling Options (Including Recycle)

Refueling options include the following:

1. At any given refueling shutdown, replace any integral number of the fuel batches in any given zone (from zero to all of the fuel batches in that zone).
2. Discharged fuel may be shuffled to another zone or may be stored for further irradiation after a hold-up time of a specified number of operating intervals.
3. Discharged fissile material may be inventoried, with separate records maintained for materials of different isotopic content, and made available for recycle after a hold-up time of a specified number of operating intervals. The holdup time may be either 0,1,2 or 3 intervals (except zero is not permitted for discharged fuel if Pa-233

is present to allow all of the Pa-233 to decay to U-233); or all of the fissile material that has accrued in a given repository for a time period in excess of a specified minimum number of operating intervals may be made available for recycle.

4. The amount of fissile material discharged from a reactor zone and allocated to a recycle repository may be multiplied by an input constant. A constant of unity is the usual self-recycle situation in which the reactor can be refueled only with as much recycle material as it has discharged from earlier operation. A constant greater than or less than unity represents a situation in which other reactors of similar type and operating history are also contributing to the available recycle material inventory, and the reactor under calculation is given either more than its contributed share of the available recycle material (constant greater than unity) or less than its share. (In a later version of the code, this constant may be used to treat fuel cycle coupling between different reactors of similar type.)
5. A preferred recycle material is listed for each variable fissile zone, and a backup (second choice) recycle material may be listed to be used if the preferred material is not available in sufficient quantity to satisfy reload requirements. (These materials may be, for example, fissile uranium and plutonium if both the U-238 and the Th-232 isotopic chains are included; or they may be "dirty" Pu discharged from the core zones and "clean" Pu discharged from the blanket zones if only the U-238 chain is used.)
6. Fissile makeup or fertile makeup sources, may be made available with the isotopic composition of each specified by input data. One such fissile source may be, for example, a plutonium isotopic composition characteristic of Pu discharged by water reactors. Another (if desired) might be fully, or partially, enriched uranium. (In a later version of the code, fuel cycles of different reactor types - such as water reactors and LMFBR's - may

be coupled by treating the fissile makeup sources as repositories similar to the recycle repositories.) Examples of fertile makeup sources are depleted or natural uranium or thorium.

1.4.4 Fuel Cost Options

Fuel cost options include the following:

1. Unit of cost may be \$/MBtu or mill/kwh (the latter permitted if the heat rate is held constant).
2. Fuel costs computed in the output routine at the end of a calculated operating interval may be based on either or both of the following:
 - a) Costs (or credits) accrued and total energy produced in only those fuel batches that are discharged from the reactor and reprocessed at the end of the operating interval. This is probably the most meaningful fuel cost as a measure of fuel economical performance.
 - b) Power cost associated with each operating interval, taking into account fabrication cost of reload fuel at beginning-of-interval, reprocessing cost of spent fuel at end of interval, and all inventory costs throughout the interval and the fabrication and reprocessing periods of the reload and spent fuel, respectively. (The cost components considered are the same for (a) and (b). The difference is that all the batches are costed simultaneously at a given period in time for (b), whereas for (a) cost data is accrued on each individual batch from fabrication through reprocessing, generally involving a time period of several operating intervals.)
3. Costs may be broken down and printed for each zonal contribution and further, for each batch contribution.

4. Printout may be held to total cost only, or show a breakdown into the following six cost components:
 - a) Credit for fissile breeding (or cost for fissile depletion).
 - b) Fabrication cost
 - c) Reprocessing cost
 - d) Fissile inventory charges - including out-of-pile contributions in fabrication, reprocessing, and storage of fuel batches between reactor exposures (if any).
 - e) Fabrication inventory charges.
 - f) Reprocessing negative inventory credits.
5. Alternate sets of input cost data may be specified, and the code will calculate requested fuel cost output for each set. (For example, one set may be based on pessimistic assumptions on fabrication and reprocessing costs, interest rates, and/or fissile material value; and another on optimistic economic assumptions; etc.) Each set of cost data may be time-varying (i.e., may be changed at the beginning of any specified operating interval).
6. A levelized fuel cost⁽⁵⁾ may be requested for each set of cost input data. This is a weighted fuel cost over all operating intervals since startup and takes into account the reduced value of fixed dollar expenditures and revenues of the future relative to those of the present. The percent reduction factor per annum is given by input data.

1.4.5 Interpolation of Multigroup Nuclear Data

The interpolation routine (see first paragraph of Section 1.3 and box 10 of Figure 1) allows the following user options:

1. Linear interpolation (or extrapolation) between the sets of end point data provided by the two multigroup diffusion theory cases, based on a composition-dependent interpolation index. The interpolation may be between operating intervals or between different times during the operating cycle.

2. Discontinuous switch from one set of end point data to the other at beginning of an operating interval when the interpolation index based on the preceding end-of-interval composition reaches some designated value.
3. Discontinuous switch from one set of end point data to the other at the beginning of a designated operating interval (without consideration of the value of the composition-dependent index).
4. Large flexibility in the selection of parameters that determine the nature of the composition-dependent interpolation index.
(For example, if the user is studying a reactor that starts up with U-235 and switches to plutonium as self-recycle material becomes available, the interpolation index may be a simple function of the Pu-239 content or of the Pu-239/U-235 ratio averaged over specified reactor zones; if the reactor under study starts with oxide fuel and switches later to carbide, the interpolation index may be selected to be proportional to the total fuel atom density in selected zones; etc.)

1.4.6 First Core Options

The first core (beginning of first operating interval) may be selected from one of the following eight options:

1. All fuel batches in a given zone have the same isotopic composition (characteristic of a startup core) and that composition is obtained from the regional compositions of the first multigroup diffusion theory case (case A) associated with the interpolation routine end point data.
2. Same as 1 above, except that the multigroup diffusion case compositions correspond to the average of the first operating interval; and beginning-of-interval isotopic concentrations for the various batches are computed by doing a reverse (in time) burnup calculation.

3. Same as 1 above, except that the multigroup diffusion case compositions correspond to the end of the first operating interval; and beginning-of-interval isotopic concentrations for the various batches are computed by doing a reverse (in time) burnup calculation.
4. Fuel batches at the beginning of an equilibrium refueling interval are determined from the regional compositions of the first multigroup diffusion theory case (case A) associated with the interpolation routine end point data.
5. Same as 4 except that the multigroup diffusion case compositions correspond to the average of the equilibrium operating interval; and beginning-of-interval isotopic concentrations for the different batches are computed by doing a reverse (in time) burnup calculation.
6. Same as 5 except that the multigroup diffusion case compositions correspond to the end of the equilibrium operating interval; and beginning-of-interval isotopic concentrations for the different batches are computed by doing a reverse (in time) burnup calculation.
7. Isotopic concentrations for each fuel batch in each zone provided directly as input data - this option will generally require a lot of number writing by the user who prepares the input.
8. A restart of a burnup problem that has already been carried through some number of operating intervals. (For example, user may want to stop the problem after one or more operating intervals, examine the output data obtained, and then restart the problem with a new operating strategy - input data - based on the information obtained from the first few operating intervals. For calculations related to fuel warranty services, users would want to restart the problem for each operating interval.) The output routine includes a restart option which provides the data required (on tape or punched on cards) for such a restart case.

SECTION IIFLOW CHARTS AND GENERAL INTRODUCTIONTO DETAILED SPECIFICATIONS

The simplified flow chart of Figure 1 gives an outline of the computations performed by the code. In this section somewhat more detailed flow charts are given, key elements, and basic assumptions for several of the computational routines are discussed, and limitations imposed on the input data are described. This is done to make it easier to follow the detailed specifications which are given as a sequence of statements (instructions and equations) in Section 3.

The computational routines considered first in this section are those involved in the operating interval loop that starts with box 3 of the simplified flow chart of Figure 1. This will be followed by discussion of the computations done to set up the first core and the input data checking procedures. Flow charts for these routines included in this section will frequently refer to equations or instructions that are listed as statements in Section 3. Mathematical symbols used in these equations and other data (or data blocks) referred to in the flow charts are listed and defined in Section 5.

2.1 Burnup Calculations

The burnup routine calculates isotopic concentrations at the end of each operating interval for all fuel batches in each region, starting with the concentrations at the beginning of the operating interval. Fission product buildups and energy produced in the fuel batches in each zone are also calculated in the burnup routine, as well as the energy produced in the region of peak power. The flow chart of Figure 4 outlines the sequence of these calculations and identifies the pertinent equations (statements) in Section 3.3.

Isotopic concentrations at the end of the operating interval are calculated for each burnup chain in each region using the solution of the burnup equation:

$$\begin{aligned} \frac{dN_m}{dt} = & -(\sigma_{a_m} \phi f + \lambda_m) N_m + (\sigma_{c_{m-1 \rightarrow m}} \phi f + \lambda_{m-1}) N_{m-1} \\ & + \sigma_{c_{m-2 \rightarrow m}} \phi f N_{m-2} \end{aligned} \quad (1)$$

where N_m is the concentration of the m^{th} member of the burnup chain, t is time, f is the load factor, σ_{a_m} the absorption cross section (sum of fission and radiative capture reaction rate cross sections) for the m^{th} member of the chain, λ_m its radioactive decay rate (significant for Pu-241 and Pa-233), $\sigma_{c_{m-1 \rightarrow m}}$ is the radiative capture cross section of chain member $m-1$ resulting in the formation of member m , $\sigma_{c_{m-2 \rightarrow m}}$ the radiative capture cross section of chain member $m-2$ resulting in formation of member m (e.g., neutron capture by Pa-233 forms U-234, bypassing U-233 in the ^{232}Th -U chain), and ϕ is the average neutron flux in the region. State-

ments (3-28) through (3-31) in Section 3.3 give the general solution of the burnup differential equation for region j.

A two-iteration burnup calculation sequence is used - if requested by input data - to make the calculated energy produced by fuel burnup during the operating time interval consistent with the desired rated power. In this two-iteration sequence, the regional fluxes are first normalized to give the desired rated power for the isotopic concentrations present at the beginning of the operating interval. These fluxes are then used in the burnup equations to calculate end-of-interval isotopic concentrations and energy produced during the operating interval and, from the latter, the reactor power (taking into account the load factor). A test is then made to determine whether or not the calculated power level is close enough to the desired power level to bypass the second iteration in the burnup calculation sequence.

If a second iteration is required, it is performed using renormalized regional fluxes. The original flux normalization factor, $R_p^{(1)}$, is changed to a new normalization factor, R_p , by assuming the following exponential variation of power with burnup for a constant flux level:

$$P_e^{(1)} = P_o^{(1)} e^{-a_r R_p^{(1)}} \quad (2)$$

where $P_o^{(1)}$ and $P_e^{(1)}$ are the first iteration calculated power levels for constant flux at respectively the beginning and the end of the operating interval. (Note that $P_o^{(1)}$ was set equal to the desired power level for the first-iteration flux normalization.) The factor a_r is obtained from

equation (2) and then used in equations (3) and (4) below to yield R_p .

$$P_o = \bar{P} \left(\frac{1 - e^{-a_r R_p}}{a_r R_p} \right)^{-1} \quad (3)$$

$$P_o/P_o^{(1)} = R_p/R_p^{(1)} \quad (4)$$

$\bar{P}$ in equation (3) is the average power level for a constant flux, corresponding to the average isotopic concentrations during the operating interval. Equations (2) and (3) are consistent for an exponential power variation with constant flux. $\bar{P}$ is set equal to the desired power level ($\bar{P} = P_o^{(1)}$) specified by input data; and the flux normalization factor, R_p , for the second iteration in the burnup routine obtained from solution of Equations (3) and (4) is given by (same as statement 3-47):

$$R_p = -\frac{1}{a_r} \log_e (1 - a_r R_p^{(1)}) \quad (5)$$

After the second-iteration burnup calculations are completed, the calculated power level is again compared with the desired one; and the problem is terminated if the power criterion is not then satisfied.

FIGURE 4 - FLOW CHART FOR BURNUP CALCULATION

FIGURE 4 - FLOW CHART FOR BURNUP CALCULATION

2.2 Tests on K_{eff} , Burnup, Power Peaking, and Burnup ΔK .

The end-of-interval isotopic concentrations are not established until input data criteria have been satisfied on: (1) K_{eff} at the end of the operating interval; (2) burnup of fuel discharged at the end of the operating interval; (3) relative power density in the region of peak power; and (4) reactivity change due to burnup. Figure 5 shows the flow of calculations for the tests against these criteria and indicates the pertinent equations in Section 3.3.

If the K_{eff} criterion is not satisfied, the code will adjust the beginning-of-interval isotopic concentrations in the zones of variable isotopic content (see Section 2.3) and repeat the burnup routine. This procedure will be followed in successive iterations until K_{eff} is satisfied or a maximum number of iterations specified by input data is reached (which will stop the problem). In the event that the K_{eff} criterion is not satisfied and there are no zones of variable isotopic content for the current operating interval under calculation, the code will attempt to adjust the operating interval time to satisfy the K_{eff} criterion (to the extent permitted by the time allowance, ΔT , specified as input data) and will then repeat the burnup routine calculations with the adjusted operating interval time.

If the K_{eff} criterion is satisfied, then the test against the burnup criterion is made. If burnup is not satisfied, the code will attempt to adjust the operating interval time to satisfy the burnup criterion (to the extent permitted by the time allowance ΔT). If the time allowance and the burnup criterion appear to be compatible, the code will make the time adjustment,

readjust the beginning-of-interval isotopic concentrations in variable isotopic zones to satisfy the K_{eff} criterion with the estimated new burnup reactivity corresponding to the adjusted operating interval time, and repeat the burnup routine calculations.

Tests against the maximum power density and burnup reactivity criteria are made after the K_{eff} and burnup criteria have been satisfied. Failure to satisfy the limits set on either peak power density or on burnup reactivity stops the problem.

User must exercise caution in setting up the criteria for the various tests. If a burnup test is requested, the specified burnups and the allowed departures from those burnups must be made compatible with the specified operating interval times and the allowances for variations in these times - or else the computation will be stopped on failure to satisfy the burnup criterion. If, for example, a strict time control is specified (i.e., no variation allowed from the specified operating interval times) then the burnup criterion will only serve the purpose of stopping the problem if the burnup does not fall within specified limits. Any of the tests except for K_{eff} can be bypassed for any number or all of the operating intervals by input data selections; and even the K_{eff} test can be made non-restrictive by selection of wide allowances should this be desired for any reason.

FIGURE 5. FLOW CHART FOR TESTS ON K_{eff} , BURNUP,
POWER PEAKING, AND BURNUP REACTIVITY CHANGE

2.3 Isotopic Content Adjustments for Next Iteration

If the K_{eff} criterion is not satisfied or if a time adjustment has been made to satisfy the burnup criterion, and the number of iterations has not reached the maximum allowed, the fissile contents of zones designated by input data as variable-fissile content zones are adjusted in order to attempt to satisfy the K_{eff} criterion in the next iteration. The adjustment for the different variable fissile content zones may change the amounts of preferred recycle material, of backup recycle material, or of fissile makeup - or combinations of all three of these. These changes are compensated in all cases by changes in the fertile source material concentrations made in such a manner as to hold the total fuel atom density fixed at the value specified by input data for each of the zones.

The procedures used to make the isotopic concentration adjustments are fairly straightforward. However, the logic involved is rather tedious because of the many different computational paths that can be followed, depending upon what has been specified by input data for the current operating interval as preferred and backup recycle material for the different zones, the current availability of such recycle material, and whether addition or removal of fissile material is called for. The flow chart of Figure 6 outlines the different computational sequences that can be taken and identifies the pertinent statements, or equations, in Section 3.3.

The detailed specifications of the isotopic content adjustment routine are given near the end of Section 3.3, following the specifications for the initial estimates of the reload fuel requirements in the variable fissile content zones made at the beginning of a new operating interval (see Section 2.8 and Figure 12). This order was followed in the detailed specifications since the recycle and makeup parameters, and the reactivity worths of unit weights of the

various recycle and fissile and fertile makeup materials, used in the fissile content adjustment routine are initially established in the computational routine used to estimate the fuel reload requirements for the first iteration of the new operating interval.

FIGURE 6. FLOW CHART FOR FISSILE CONTENT ADJUSTMENTS

MADE FOR NEXT ITERATION TO SATISFY K_{eff} CRITERION

FIGURE 6. (Continued)

FIGURE 6 (Continued)

FIGURE 6 (continued)

FIGURE 6. (Continued)

2.4 Update of Recycle Repository Records at End of Operating Interval

If criterion on K_{eff} , burnup, power peaking, and burnup reactivity change have been satisfied, the end-of-interval isotopic concentrations are established. The code then updates the fuel recycle repository inventories, mainly to take into account the fuel being discharged at the end of the current operating interval and made available for later recycle. The flow chart of Figure 7 outlines the calculations performed and indicates the pertinent equations (statements) in Section 3.3.

FIGURE 7. FLOW CHART FOR UPDATE OF RECYCLE REPOSITORY RECORDS

2.5 Output Calculations Other Than Fuel Cost

After updating the fuel recycle repositories, the code proceeds to calculate the output data for the current operating interval (the one just completed in the computational sequence). The flow chart of Figure 8 outlines the sequence of output data calculations and indicates the pertinent statements (mostly in Section 3.4). However, the flow chart for the fuel cost calculations is given in Figure 9 and is only referred to in Figure 8.

Output data that can be provided by the code are described in Section 5 under data blocks 51A through 60. The user selects which of these output data he wants printed out for each operating interval through input data selectors described under data blocks 24 through 26 in Section 5.2. As noted in the flow chart of Figure 8, output data may include data that is required for a later restart case, and it may also include a computer core dump in the event of an error stop. Isotopic concentrations in each region at the beginning and at the end of the operating interval, and such concentrations broken down by fuel batch, are included among the output data options, as well as recycle repository material weight records and stored fuel repository weight inventories. Breeding ratio, doubling time, energy, power, and burnup data are also provided.

The bulk of the output calculation routine involves computation of fuel weights and fuel costs. These calculations are done one zone at a time, and the contributions of the various zones are accrued as they are computed to give the total reactor fuel weights and costs (when the

out-of-pile components are added). Reactor fuel weights calculated include discharged fuel at the end of the operating interval, loaded fuel at the beginning of the interval, average inventory during the interval, and inventory at the end of the interval. Any of these weights may be obtained in the printout for the entire reactor and/or for specified zones. The breakdown of weights can be a summary consisting of total fuel, total plutonium, fissile plutonium, total uranium, and fissile uranium; and it may be broken down finer by material, fuel batch, and both material and batch. The fuel cost calculations are described below.

Updating of the stored fuel repository records is included as part of the output calculation routine (see box 36 of Figure 8) because of programming efficiency considerations noted in the detailed specifications. However, the instructions and equations for updating the stored fuel repositories are similar in many ways to those used in the updating of the recycle repository records and, hence, both are described in the same section (Section 3.3.6) of the detailed specifications.

FIGURE 8. FLOW CHART FOR OUTPUT CALCULATIONS
(See Output Data Blocks 51A through 60 in Section 4)

FIGURE 8 (Continued)

FIGURE 8 (continued)

27

If discharge or end-of-interval fuel weight inventory output data is desired for zone group g , calculate fuel burnup for each fuel batch discharged from zone J at end of interval and for the average over all such batches - statements (4-36) and (4-37). Also do set-up calculations for fuel weight calculations as per statements (4-38) through (4-40) if zone J is not a member of a composite zone group or if it is the last member ($w = w_g$) of a composite zone group.

28

If any fuel cost output data, or any discharge or end-of-interval inventory fuel weight output data for zone group g or for the entire reactor are desired, calculate the following: total fuel weight discharged from zone J at end of interval, total plutonium weight, fissile plutonium weight (Pu-239 and Pu-241), total uranium weight, and fissile uranium weight (U-235, U-233 and Pa-233); these weights calculated for each batch discharged from the zone as well as summed over such batches. Also add each of these zonal discharge weights to the accrual of such weights discharged from the entire reactor at the end of the current operating interval. (See statements 4-41 through 4-55.) If requested by input data, also calculate material breakdown of fuel weights discharged from the zone - statement (4-56) and end-of-interval material weight inventories - statement (4-57) - and add zonal material discharged weights and end-of-inventory weight to accruals of such weights for entire reactor - statements (4-58) and (4-59). If end-of-interval inventory fuel weights are desired as output data, for either zone group g or the entire reactor, calculate these weights for zone J , broken down into total fuel weight, total plutonium weight, fissile plutonium weight, total uranium weight, and fissile uranium weight; and also add each of these weights to the accrual of the corresponding end-of-interval fuel weight inventory for the entire reactor - statements (4-60) through (4-69).

29

If any fuel cost output data, or any output data on fuel weights loaded into zones in group g or into the entire reactor at the beginning of the current operating interval (the one just calculated to completion) are desired, calculate the following: total fuel weight loaded into zone J at beginning of interval, total plutonium weight, fissile plutonium weight, total uranium weight, and fissile uranium weight; these weights calculated for each batch loaded into the zone as well as summed over such batches. Also add each of these zonal loaded weights to the accrual of such weights loaded into the entire reactor at the beginning of the current operating interval. If requested by input data, also calculate material breakdown of fuel weights loaded into zone J , and add each such material weight to the accrual of material fuel weights loaded into the entire reactor at the beginning of the interval. (See statements 4-70 through 4-86.)

FIGURE 8. (continued)

30

If any fuel cost output data, or any output data on fuel weight inventory in group g zones or in the entire reactor averaged over the current operating interval are desired, calculate the following: total fuel weight in zone J , averaged over the interval, total plutonium weight, fissile plutonium weight, total uranium weight and fissile uranium weight; these weights calculated for each batch in zone J , as well as summed over such batches. Also add each of these zonal average inventory weights to the accrual of such weights held in the entire reactor for the current operating interval. If requested by input data, also calculate material breakdown of average fuel weight inventories held in zone J , and add each such material weight to the accrual of material inventory held in the entire reactor during the current operating interval. (See statement 4-87 through 4-104).

31

Calculate zone J fuel cost contributions as per boxes 1 through 26 of Figure 9.

32

Write fuel weight and cost output data for zone J , if zone group g is not a composite zone group or if J_w is the last zone ($w = w_g$) of a composite zone group - statement (4-207). This zonal output data is described in Section 5.2, under data blocks 52A through 52W; and write only those data blocks selected for printout by input data provided in data block 25B.

33

Calculate stored fuel fabrication and reprocessing interest costs and update stored fuel repository cost records for next operating interval as per box 27 of Figure 9.

34

If there are any fuel storage repositories ($N_{\max}^{\text{stor}} > 0$), update hold-up time indexes (I_h) for stored fuel material weights and records of energy produced by such fuel in preparation for next operating interval. (See statements 3-93 through 3-98.) If any fuel discharged at the end of the current operating interval is sent to a storage repository including fuel to be shuffled immediately from one core zone to another, then calculate the discharged material weights and energy produced in the fuel assigned to the various repositories as specified by input data - statements (3-100) and (3-101).

35

Calculate stored fuel inventory costs, total and component fuel costs for the entire reactor (including out-of-pile inventories and levelized power costs as per boxes 29 through 35 of Figures 9.

36

Calculate total fuel weight inventories (combining in-pile and out-of-pile components) and the fissile doubling time - statements (4-274) through (4-286).

FIGURE 8. (continued)

2.6 Fuel Cost Calculations

If fuel cost output is requested, the following components of fuel cost are calculated (and combined to give total fuel cost):

1. fabrication cost
2. reprocessing cost
3. isotopic depletion cost (credit for a breeder reactor)
4. isotopic inventory cost
5. fabrication inventory cost
6. reprocessing negative inventory credit

The three components of inventory cost above are calculated for the fuel in the reactor, the fuel held in storage repositories, and the fuel tied up in fabrication and reprocessing operations.

The unit of fuel cost may be either $\text{¢}/10^6$ Btu or mills/kwh, as selected by input data. The fuel costs may be calculated by one of two methods, or by both methods, as specified by input data. For method 1, the fuel cost is based on costs accrued and energy produced in spent fuel discharged from the reactor at the end of the current operating interval (the one currently being calculated). Only the spent fuel is involved in the fuel cost output data for the current operating interval (in method 1) although much of the cost incurred and energy obtained with such spent fuel occurred in earlier operating intervals. Fabrication cost (for method 1) is calculated for each fuel batch loaded into the reactor and is based on the unit fabrication cost ($\text{\$/kg}$) provided as input data

for the reactor zone and for the operating interval in which the fuel batch is being loaded (at the beginning of the interval). Reprocessing cost for the batch is calculated when it is discharged as spent fuel and is based on the unit reprocessing cost provided as input data for the reactor zone and for the operating interval at the end of which the fuel is discharged for reprocessing. Depletion (credit) cost for the batch is calculated as a positive component based on the isotopic composition of the fresh batch and fuel isotopic values (\$/kg) provided as input data for the operating interval in which the batch is loaded, and a negative component (credit) based on the isotopic composition of the spent batch and fuel isotopic values provided as input data for the operating interval in which the batch is discharged. Fuel isotopic inventory cost for the batch is accrued for each operating interval time that the batch is in the reactor or held in a fuel storage repository, based on the fuel interest rates and the fuel isotopic values provided as input data for that operating interval and the isotopic concentrations of the batch averaged over the interval. Isotopic inventory cost for the batch is also accrued for the fabrication time based on the fresh batch isotopic concentrations and fuel interest rates and isotopic values provided as input for the operating interval in which the batch is loaded; and for the reprocessing time based on the spent fuel isotopic concentrations and fuel interest rates and isotopic values provided as input data for the operating interval in which the batch is discharged. Fabrication inventory cost for the batch is accrued for one-half of each operating interval time that the batch is in the reactor or held in a fuel storage repository, based on the previously calculated fabrication cost and the fabrication interest rate provided as input data for that operating interval, and for the fabrication time using the fabrication interest rate provided as input data for the operating interval in which the fresh fuel is loaded.

Reprocessing inventory cost for the batch (actually a credit) is accrued for one-half of each operating interval time that the batch is in the reactor or held in a storage repository, based on the reprocessing cost and the fabrication interest rate provided as input data for that operating interval, and for the reprocessing time using the fabrication interest rate provided as input data for the operating interval in which the fuel is discharged.*

Records are kept of the fuel batch cost components (calculated under method 1) as they accrue from one operating interval to another, except for the reprocessing cost which is not calculated until the batch is spent. At the end of the operating interval in which the spent fuel batch is discharged, the above calculated fuel cost components are divided by the energy produced by the batch accrued over all of the operating intervals that the batch has spent in the reactor. Total fuel cost for the batch is the sum of the six fuel cost components.

Fuel cost data calculated by method 1 is made available in the output data associated with the operating interval in which the spent fuel being costed is discharged. This output may be requested for all spent fuel batches for spent fuel batches discharged from selected zones only, as a combined fuel cost for all the spent fuel discharged from the reactor, as a combined fuel cost

* It may be noted in the detailed specifications that the reprocessing inventory cost is actually accrued for an assumed \$1 reprocessing cost until the operating interval is reached in which the spent fuel batch is discharged, and the accrued cost is then multiplied by the actual reprocessing cost. This is done simply for programming convenience since the unit reprocessing cost input data may not be available for operating intervals prior to the one in which the fuel batch is to be discharged for reprocessing.

for the batches discharged from selected zones (or composite zone groups), or any combinations of these fuel cost options. Further, each fuel cost may be requested as a total cost only or as a total cost, plus the six cost components. The combined fuel cost (or cost component) for all the batches discharged from the reactor (or from a selected zone of the reactor if more than one batch is discharged from the zone) is the sum of the individual batch costs (prior to division of batch energies) divided by the sum of the batch energies.

In method 2, the fuel cost is calculated on the basis of costs incurred for all fuel in-pile and out-of-pile for the current operating interval only and the energy produced by the entire reactor during that interval. There is no accrual of costs from one operating interval to another in method 2. Fabrication cost is calculated for the fresh fuel batches loaded into the reactor at the beginning of the operating interval; reprocessing cost is calculated for the spent fuel batches discharged at the end of the interval; depletion (credit) cost is calculated as the isotopic value of the fresh batches loaded at the beginning of the interval minus the isotopic value of the spent batches discharged at the end of the interval; isotopic inventory cost is calculated for all the fuel held in the reactor and in fuel storage repositories for the current operating interval time plus fabrication time for the fresh batches loaded at the beginning of the interval and reprocessing time for the spent batches discharged at the end of the interval; fabrication inventory cost is calculated for all the fuel held in the reactor and in fuel storage repositories for one-half of the current operating interval time plus the fabrication time for the fresh batches loaded at the beginning of the interval; and reprocessing inventory cost is calculated for all the fuel held in the reactor and in fuel storage repositories

for one-half of the current operating interval time plus the reprocessing time for the spent batches discharged at the end of the interval. Total fuel cost is the sum of these six cost components. All cost data used for the fuel cost calculations in method 2 - including interest rates, fuel isotopic values or parameters for obtaining such values, and unit costs for fabrication and reprocessing - are provided by the input data for the current operating interval.

Fuel cost output data calculated by method 2 may be requested as a combined cost for the entire reactor and/or as the contribution to this combined cost by selected zones. (A further breakdown of the cost contributed by each batch is not provided as output data, unlike the case with method 1 where fuel batch costs are the main interest, rather than an operating interval cost summed over all batches as in method 2.) All fuel costs calculated in method 2 (the total reactor cost as well as the zonal contributions to this cost) are divided by the energy produced by the entire reactor during the current operating interval unlike the case of method 1 where spent batch costs are divided by the corresponding batch energies, and combined reactor fuel costs are summed over the spent batches and divided by the sum of the spent batch energies. As in method 1, each fuel cost calculated by method 2 may be requested as a total cost only or as a total cost plus the six cost components. Inventory costs associated with fuel held in storage repositories during the current interval may also be requested in method 2.

Fuel isotopic values (\$/kg) are provided as direct input data - see data block 21 in Section 5. However, the value of fissile uranium may be calculated by a formula that provides this value as a function of the uranium enrichment, cost of separative work, cost of feed, enrichment of feed, and enrichment of

diffusion plant tails (see data block 2,1 in Section 5 and statements 4-136 through 4-140 in Section 3.4.5.3).

Fuel costs may be requested for a reference set of economic assumptions and for several alternate sets of economic assumptions.* Most of the input fuel cost data used in the reference calculations may be changed for the calculations done with the alternate input cost data, including fuel and fabrication interest rates, fuel isotopic values or parameters for obtaining such values for fissile uranium, and unit fabrication and reprocessing costs.

Levelized power cost is also calculated if a percent per annum discount factor is provided in the input data for such a calculation. The levelized power cost is calculated for either method 1 or 2, or both, consistent with the method(s) requested for all the fuel cost calculations. Output data provides levelized power cost for only the total fuel cost (not the six cost components) for the reference and each of the alternate sets of input cost data. Equations used for the calculation of levelized power costs are listed in Section 3.4.5.10.

* The terms "reference" and "alternate" have no significance to the code except for the order of computation. User may assign whatever meaning he wishes to the reference and alternate sets of cost data.

Output data blocks 51P through 51V, 52R through 52W, and 53D and 53E list and describe the various kinds of fuel cost data which may be obtained in accordance with the discussion above. Input data blocks 19 through 23 list and describe most of the input cost data used for the fuel cost calculations, input data block 1 includes the selectors for fuel cost method and fuel cost unit, and input data blocks 24 through 26 contain the selectors for printout of the various fuel costs that may be requested. The flow chart of Figure 9 outlines the sequence of fuel cost calculations - it is an expansion of portions of the output calculation flow chart of Figure 8 - and identifies the pertinent instructions and equations in Section 3.4.

FIGURE 9. FLOW CHART FOR FUEL COST CALCULATIONS*

* This chart is an expansion of boxes 33, 35 and 37 of the general output calculations flow chart of Figure 8. Note that the computation is in a zone loop within a zone-group loop when box 1 above is entered.

Figure 9. (continued)

8

If method 1 fuel cost calculations are requested, compute fuel fabrication costs for zone J_w as follows:

- a) If fresh fuel is loaded into zone J_w at beginning of operating interval, calculate fabrication cost (cents or mills) for each fuel batch loaded into the zone as per statement (4-108). (Note term involving δ' which is zero if zone J_w is not a member of a composite zone group, and which accrues costs for all the zone members in zone group g if this is a composite zone group. Such a term appears throughout the zone loop portion of the output calculations.)
- b) Do steps c) through e) below only if zone J_w is not a member of a composite zone group or else is the highest ($w = w_g$) member of such a group.
- c) If previously irradiated fuel is loaded into zone J_w from a storage repository (including shuffled fuel from another zone) at beginning of operating interval, transfer fabrication cost records for the loaded fuel batches from storage repository records to zone records as per statements (4-109) and (4-110).
- d) If spent fuel is discharged from zone J_w at end of interval, calculate fabrication fuel cost ($\text{¢}/10^6 \text{ Btu}$ or mills/kwh) for all fuel discharged from zone J_w , and for each such batch, and calculate contribution of zone J_w discharged fuel to the entire reactor fabrication cost (¢ or mills). See statements (4-111) through (4-114).
- e) If fuel discharged from zone J_w at end of interval is not spent (i.e., sent to storage for later irradiation or shuffled to another zone) then transfer fabrication cost record for the discharged batches from zone records to storage repository records as per statements (4-115) through (4-117).

9

If method 2 fuel cost calculations are requested, compute fuel fabrication costs for zone J_w as follows:

- a) If fresh fuel is loaded into zone J_w at beginning of operating interval, calculate fabrication costs (¢ or mills) of this fuel as per statement (4-121).
- b) Do steps c) and d) below only if zone J_w is not a member of a composite zone group or else is the highest ($w = w_g$) member of such a group.
- c) If fresh fuel is loaded into zone J_w at beginning of interval, calculate zone fabrication costs ($\text{¢}/10^6 \text{ Btu}$ or mills/kwh) and contribution of fuel loaded into zone to entire reactor fuel fabrication cost as per statements (4-122) and (4-123).
- d) If previously irradiated fuel is loaded into zone J_w (from storage or shuffled from another zone) at beginning of interval, set zone J_w fabrication cost equal to zero - statement (4-124).

FIGURE 9 (continued)

10

If method 1 fuel cost calculations are requested, compute fuel reprocessing costs for zone J_w as follows:

- a) If spent fuel is discharged from zone J_w at end of interval, calculate reprocessing cost (¢ or mills) for each batch discharged from the zone as per statement (4-125).
- b) Do steps c) and d) below only if zone J_w is not a member of a composite zone group or else is the highest member of such a group.
- c) If spent fuel is discharged from zone J_w , calculate reprocessing cost (¢/10⁶ Btu or mills/kwh) for all fuel discharged from the zone and for each of the batches discharged from the zone, and calculate the contribution of fuel discharged from zone J_w to the entire reactor reprocessing cost (¢ or mills) as per statements (4-126) through (4-129).
- d) If fuel discharged from zone J_w at end of interval is not spent, set reprocessing costs for the zone and each batch discharged from the zone equal to zero as per statements (4-130) and (4-131).

11

If method 2 fuel cost calculations are requested, compute fuel reprocessing costs for zone J_w as per statements (4-132) through (4-135). (Note that the logic is similar to that already covered in the operations of boxes 8 through 10 above.)

12

Do calculations of boxes 13 through 19 below only if zone J_w is not a member of a composite zone group or if it is the highest ($w = w_g$) member of such a group (except for note at bottom of box 19).

13

Calculate value of U-235 (\$/kg) by formula of statement (4-140) for all fuel batches discharged from zone J_w at end of operating interval if U-235 is present in such batches and cost of feed has been provided as input data (see statement 4-139).

14

Calculate values of all fuel isotopes (\$/kg) in batches discharged from zone J_w at end of interval as per statements (4-141) through (4-147).

15

If method 1 fuel cost calculations are requested, compute fuel depletion (credit) costs for zone J_w as follows:

- a) If fuel discharged from zone J_w at end of interval is spent, calculate batch and zone depletion costs and contribution of zone J_w to entire reactor depletion cost as per statements (4-148), and (4-150) through (4-153).
- b) If fuel discharged from zone J_w is to be stored for later exposure (or shuffled) transfer depletion (credit) cost record for batches being discharged from zone records to storage repository records as per statements (4-154) through (4-155).
- c) Repeat calculation of isotopic values for fuel loaded into zone J_w at beginning of interval as per statements (4-161) through (4-164).
- d) If fresh fuel is loaded into zone J_w at beginning of interval, calculate fuel isotopic costs for each loaded batch, for all the fuel loaded into the zone, and the zones contribution to the entire reactor isotopic fuel cost as per statement (4-165).
- e) If previously irradiated fuel is loaded into zone J_w at beginning of interval, transfer depletion cost records for loaded batches from storage repository records to zone records as per statements (4-167) through (4-169).
- f) Update batch numbers of zone J_w depletion cost records so they are correct for next operating interval - statement (4-174).

16

If method 2 fuel cost calculations are requested, compute fuel depletion (credit) costs as per statements (4-156), (4-157), (4-158), (4-160), (4-170), (4-171), and (4-173). (Note that the sequence of instructions in Section 3 for fuel depletion (credit) cost calculations follows a batch order rather than doing all of the method 1 calculations and then all of the method 2 calculations (if both methods are requested). The batch order was selected to reduce the number of fuel isotopic value computations required. For the same reason, some of the isotopic inventory cost instructions are inter-dispersed with the depletion cost instructions).

FIGURE 9 (continued)

17

If method 1 fuel cost calculations are desired, compute isotopic inventory costs for zone J_w as follows:

- a) Calculate isotopic inventory cost incurred by each fuel batch in the zone for the current operating interval time as per statement (4-176) through (4-179).
- b) If fresh fuel is loaded into zone J_w at beginning of operating interval, calculate isotopic inventory cost incurred by loaded batches for fabrication time as per statement (4-166).
- c) If spent fuel is discharged from zone J_w at end of interval, calculate isotopic inventory cost incurred by discharged batches for reprocessing time as per statement (4-149). (Note from the equations that the inventory costs are accrued for fabrication time (statement 4-166), through the different operating intervals (statement (4-179, and finally for reprocessing time (statement 4-149). Accrual of inventory cost for time stored in repositories (if any) is treated in a separate calculation - see box 30 below).
- d) If spent fuel is discharged from zone J_w at end of interval, also calculate zonal isotopic inventory cost and contribution of the zone to the entire reactor isotopic inventory cost as per statements (4-181) through (4-184).
- e) If fuel loaded into zone J_w at beginning of interval is not fresh fuel, transfer isotopic inventory cost record for loaded batches from storage repository records to zone records as per statement (4-168).
- f) If fuel discharged from zone J_w at end of interval is not spent fuel, transfer isotopic inventory cost record for discharged batches from zone records to storage repository records as per statement (4-185) and (4-186).
- g) Update batch numbers for zone J_w isotopic inventory cost records so they are correct for next operating interval - statement (4-187).

18

If method 2 fuel cost calculations are requested, compute isotopic inventory costs for zone J_w and contribution of zone to entire reactor isotopic inventory cost. Statements (4-157), (4-159) and (4-171) are the equations for reprocessing time and fabrication time inventories, statement (4-180) for the in-pile inventory for the operating interval time, and statements (4-189) adds zonal contribution to entire reactor isotopic inventory cost. Statement (4-188) converts ¢ to ¢/10⁶ Btu or mills to mills/kwh.

FIGURE 9. (continued)

Figure 9. (continued)

27

If there are any stored fuel repositories ($N_{\text{stor}}^{\text{max}} > 0$), set up a loop on the cost input data set index i' ($1 \leq i' \leq N_{\text{alt}}^{\text{max}} + 1$) and do the following operations:

- a) Read stored fuel repository cost records for cost input data set i' .
- b) If method 1 fuel cost calculations are requested, compute fabrication inventory costs and reprocessing inventory costs accrual in stored fuel for current operating interval time as per statements (4-229) and (4-230); and also update hold-up time index I_h of stored fuel repository cost records for next operating interval as per statements (4-231) through (4-242).
- c) If method 2 fuel cost calculations are requested, compute fabrication inventory costs and reprocessing inventory costs (credit) incurred by stored fuel for current operating interval time as per statements (4-243) and (4-244).

28

Go to box 36 of Figure 8.

29

Bypass operations of boxes 30 through 32 if there are no stored fuel repositories ($N_{\text{stor}}^{\text{max}} = 0$). Otherwise set up a loop on cost input data index i' ($1 \leq i' \leq N_{\text{alt}}^{\text{max}} + 1$) and perform the calculations as indicated.

30

Calculate isotopic inventory costs incurred by stored fuel for current operating interval time, by method 1 and/or method 2 as requested, as per statements (4-246) through (4-252).

31

If method 2 fuel cost calculations are requested, compute inventory costs summed over all stored fuel - for isotopic fuel, fabrication, and reprocessing, as well as the sum of these three inventory components - see statements (4-253) through (4-256). Add stored fuel inventory cost components to entire reactor cost components and combine to get total fuel cost as per statements (4-264) through (4-267).

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If method 1 fuel cost calculations are requested, write updated stored fuel repository records for cost input data set i' . Convert fuel costs from ¢ to ¢/10⁶ Btu or from mills to mills/kwh and add components to get total fuel cost - statements (4-257) through (4-263).

FIGURE 9. (continued)

2.7 Interpolation Routine

Upon completion of the output calculations, and if the last operating interval has not been completed, the code proceeds to set up the regional material reactivity worths, reaction rate cross sections, fluxes, volumes, and reference material concentrations and the corresponding reference multiplication factor K_{ref} needed for the burnup and other computational routines of the next operating interval. The interpolation routine specified here for setting up these parameters represents a new approach to fuel management and burnup computations, which is intended to make it economically feasible to perform extensive fuel management studies of the scope indicated in Section I. The success achieved to date with synthesis methods for fast reactors makes it appear that the interpolation routine approach adopted here will not significantly limit the range of fast power reactor fuel management and burnup problems amenable to accurate computation by the code.

The specified interpolation routine is very simple in application. It is just assumed that each of the quantities mentioned above (regional material reactivity worths, reaction rate cross sections, etc.) can be calculated as a linear combination of two such quantities obtained from two earlier multigroup diffusion theory cases.* This linear combination is actually

* Other adequate representation of the energy and space dependent neutron transport equation.

just an interpolation between (or extrapolation of) the two quantities obtained from the earlier multigroup cases. If these quantities are designated as X_A and X_B (where, for example, X_A is a regional fission cross section for a given isotope obtained from multigroup case A and X_B the fission cross section for the same isotope and region obtained from multigroup case B.) Then the interpolated quantity X (in the example cited, an interpolated fission cross section for the isotope and region under consideration) to be used for the next operating interval is calculated as follows:

$$X = X_A + \frac{(B^{\text{int}} - A^{\text{int}})(X_B - X_A)}{B^{\text{int}} - A^{\text{int}}} \quad (5)$$

where A^{int} and B^{int} are interpolation end points dependent on the material concentrations of the two reactors considered in the multigroup cases A and B, and R^{int} is an interpolation index dependent on the material concentrations of the reactor calculated for the end of the preceding operating interval.

The interpolation index is calculated as follows:

$$R_{\text{int}} = \frac{G_0 + \sum_{\ell=1}^{L_{\text{max}}} G_{\ell} \sum_{j=J_{\text{min}}}^{J_{\text{max}}} N_{\ell,j} V_j^*}{H_0 + \sum_{\ell=1}^{L_{\text{max}}} H_{\ell} \sum_{j=J_{\text{min}}}^{J_{\text{max}}} N_{\ell,j} V_j^*} \quad (6)$$

where $N_{\ell,j}$ is the concentration of material ℓ in region j ; V_j^* is unity, average neutron flux in region j , or neutron flux integrated over volume of region j dependent on input data selection; and G_ℓ and H_ℓ values (and G_0 , H_0) are input data coefficients. The summations over the materials and regions are also made as input data selections. As mentioned above A^{int} and B^{int} are calculated using the same formula as Equation (6) above, except that the regional material concentrations $N_{\ell,j}$ are those corresponding to the two multigroup cases A and B, respectively.

The form of the right side of Equation (6) allows a great deal of flexibility in the selection of the function of material composition that determines the value of R^{int} (and also A^{int} and B^{int}). The formula allows a simple function of the ratio of one isotopic concentration to another (say Pu-239 to U-235), total fuel isotopic concentration, Pu-241 concentration, and fission-product concentration, or linear combinations or ratios of these as examples of material concentration functions that may be of interest.

The value of R^{int} computed according to Equation (6) will lie between the values of A^{int} and B^{int} if the isotopic composition of the reactor (more directly the material concentration function of the reactor) remains between that of the reactors calculated for multigroup cases A and B for all operating intervals calculated. However, input data parameters may be provided which will prevent R^{int} from exceeding the larger of A^{int} or B^{int} by more than some specified amount or from falling below the smaller of A^{int} or B^{int} by more than some other specified amount (see F_a^{out} and F_b^{out} in data block 2 of Section 5.2). Also, R^{int} may be made to change its value to either A^{int} or B^{int} if it falls within some specified

range of one or the other of these end point values (see F_a^{in} and F_b^{in} in data block 2 of Section 5.2). This makes it possible to obtain an abrupt switch from $R^{int} = A^{int}$ to $R^{int} = B^{int}$ (done by setting $F_b^{in} = 1 - F_a^{in}$) when the value of R^{int} calculated from Equation (6) reaches some point between A^{int} and B^{int} dependent on the selected value of F_a^{in} .

Another input data option permits an abrupt change from $R^{int} = A^{int}$ to $R^{int} = B^{int}$ from some specified operating interval I_{switch} is reached. If this option is exercised and I_{switch} is made larger than the highest operating interval number to be calculated, the data of multigroup case A will be used throughout the problem and the data for multigroup case B need not then be provided.

The flow chart of Figure 10 outlines the sequence of calculations performed for the interpolation of multigroup data for the new operating interval and identifies the pertinent instructions and equations in Section 3.3.

FIGURE 10. FLOW CHART FOR MULTIGROUP DATA INTERPOLATION ROUTINE

2.8 Data Replacement and Fuel Reload in Zones of Fixed Isotopic Content or Zones Receiving Stored Fuel

Prior to the fuel reload calculations for the new operating interval, the code checks whether or not some of the data used in the preceding operating interval is to be changed in accordance with input instructions and replacement data provided - and makes the requested changes. This replaceable data is mainly instructions pertaining to fuel discharge and fuel reload, fuel cost data, and printout instructions, (data blocks 9 through 26 in Section 5) and data blocks 5 and 6 which includes operating information such as operating interval time and time allowance, load factor, power rating, desired burnup and burnup allowance, etc.

Fuel reload calculations, mainly involving the determination of isotopic concentrations for the fuel batches loaded into the reactor, are calculated first for the zones of fixed isotopic content (zones whose fissile "enrichments" are not adjusted in successive iterations to satisfy K_{eff} requirement - usually the case for blanket zones) and then for zones receiving fuel from storage repositories (which includes fuel immediately shuffled from other zones). The flow chart of Figure 11 indicates the sequence of these (and the data replacement) calculations and identifies the pertinent instructions and equations in Section 3.3.

Figure 11. Flow chart for data replacement and calculations of fuel reload for fixed isotopic and stored fuel zones.

2.9 Calculations for Fuel Reload in Zones of Variable Isotopic Content

The flow chart of Figure 12 outlines the fissile recycle and makeup computations performed in order to obtain the beginning-of-interval isotopic concentrations for the first iteration burnup calculation of the new operating interval, and identifies the pertinent instructions and equations in Section 3.3.

A feature of the recycle and makeup scheme adopted is that the code initially calculates the amounts of recycle and makeup materials in the reload fuel of each of the variable isotopic content zones in such a manner as to satisfy a specified power split between these zones, as well as to satisfy reactivity requirements for the new operating interval. Sources of preferred recycle material, backup recycle material, fissile makeup, and fertile makeup for each of these zones is specified by input data. The code follows these specifications to the extent permitted by availability of requested recycle materials. Following the initial determination of the amounts of recycle material of each kind required to satisfy reactivity requirements and the specified power distribution, the code checks the demand for each such material against what is available in the pertinent recycle repository. When the code finds an insufficiency of any such recycle material source, it makes substitutions using backup recycle materials or fissile makeup materials. Adjustments in fertile makeup material are made concurrent with these substitutions in order to maintain the specified total fuel atom density for the reload fuel batches of each zone; and the net effect of all of the isotopic adjustments on reactivity is forced to be zero (i.e., the reactivity worth of the reload fuel in any given zone remains the same as was initially established to satisfy the power split and reactivity requirements for the

new operating interval - before adjustments had to be made to allow for insufficiency of certain recycle materials).

The relationships involved in the calculation of recycle and/or makeup material required for reload fuel in the variable isotopic content zones are described below.

Total weight W_v of reload fuel to zone J_v is

$$W_v = \left[\sum_{\ell=1}^4 f_v^{(\ell)} \right] W_v^{(L_v)} \quad (7)$$

where $\ell = 1, 2, 3$, and 4 represent respectively the preferred recycle material source, the backup recycle material source, the makeup fissile source, and the makeup fertile source.* The $f_v^{(\ell)}$ factors are proportional to the weights of these four different kinds of fuel sources. The code sets up the $f_v^{(\ell)}$ values in the following way:

* As an example, the preferred recycle source for a given zone might be plutonium discharged from the reactor core two operating intervals ago, the backup recycle source plutonium discharged from the blankets at the same time, the fissile makeup source a plutonium isotopic mix characteristic of that discharged from water reactors, and the fertile makeup source depleted uranium tails. A backup recycle source need not be specified, nor even a preferred recycle source if it is not desired to use recycled material in the zone under consideration. However, fissile and fertile makeup sources must be specified for every variable isotopic content zone.

If a preferred recycle source is specified (by input data) and it is found that there is some of the requested material available, $f_v^{(1)}$ is set equal to unity, and $f_v^{(2)}$ and $f_v^{(3)}$ are set equal to zero. Otherwise $f_v^{(1)}$ is set equal to zero; and the procedure is then repeated for the backup recycle source, with $f_v^{(2)}$ set equal to unity and $f_v^{(3)}$ set equal to zero if a backup recycle source is specified and some of that material is available, or else $f_v^{(2)}$ is set equal to zero and $f_v^{(3)}$ equal to unity. (Note that it appears to be assumed here that if any of the requested recycle material is available, there is enough of it to satisfy the full demand for such material. This assumption is retained only until an initial composition of the reload fuel for all of the variable isotopic zones has been obtained; and then substitutions are made to allow for insufficiencies of recycle materials as indicated above in the second paragraph of this section - Section 2.9.) The fertile makeup factor $f_v^{(4)}$ is obtained from the relationship for total fuel isotopic atom concentration N_v per batch of reload fuel in zone J_v , which is

$$N_v = \left[\sum_{l=1}^4 f_v^{(l)} N_v^{(l)} \right] W_v^{(L_v)} \quad (8)$$

where $N_v^{(l)}$ is the fuel isotopic atom concentration contributed by a unit weight (1 kg) of source material of kind l distributed uniformly throughout zone J_v divided by the number of reload batches placed into the zone. Solving equation (8) for $f_v^{(4)}$ yields:

$$f_v^{(4)} = \frac{N_v}{W_v^{(L_v)}} - \sum_{l=1}^3 f_v^{(l)} N_v^{(l)} \quad (9)$$

N_v is obtained from input data and $N_v^{(\ell)}$ is easily calculated (see statements 3-180, 3-186, and 3-187).

The quantity $W_v^{(L_v)}$ in the above equations is thus the weight of source material of kind $\ell = L_v$ corresponding to the lowest ℓ for which the factor $f_v^{(\ell)} = f_v^{(L_v)}$ is found to be non-zero. The values of $W_v^{(L_v)}$ for the different zones are calculated by requiring (1) that the power ratios between the variable isotopic content zones be the same as those specified by input data, and (2) that the reactor have a K_{eff} value at the beginning of the operating interval which will satisfy the required reactivity for the new operating interval. The power split relationship for zones v and v_o is:

$$P_v^{(a)} + W_v^{(L_v)} \sum_{\ell=1}^4 f_v^{(\ell)} P_v^{(\ell)} = P_v \left[P_{v_o}^{(a)} + W_{v_o}^{(L_{v_o})} \sum_{\ell=1}^4 f_{v_o}^{(\ell)} P_{v_o}^{(\ell)} \right] \quad (10)$$

where $P_v^{(a)}$, $P_{v_o}^{(a)}$ are the power contributions in zones J_v and J_{v_o} respectively due to the fuel held over in these zones from the preceding operating interval. (These are easily calculated from the known isotopic concentrations and the fission cross sections obtained from the interpolation routine - see Section 2.7). $P_v^{(\ell)}$ and $P_{v_o}^{(\ell)}$ are the power contributions, respectively in zones J_v and J_{v_o} of a unit weight (1 kg) of source material of kind ℓ distributed uniformly over the zone (also easily calculated - see statements 3-179, 3-185, and 3-187). P_v is the ratio of power in zone J_v to that in zone J_{v_o} specified by the input data (or in some cases calculated from the power distribution of the earlier run multigroup case A). The factors $f_v^{(\ell)}$ are set $\ell = 1, 2$, and 3 as indicated above, and $f_v^{(4)}$ can be replaced by the expression of equation (9).

Substitution of the right side of equation (9) for $f_v^{(4)}$ in equation (10) yields the equation of statement (3-199) for the relationship between $W_v^{(L_v)}$ and W_{v_o} which is of the form:

$$W_v^{(L_v)} = A_v W_{v_o}^{(L_{v_o})} + B_v \quad (11)$$

where A_v and B_v are known quantities (i.e., calculated by the code using data readily available as input data or from earlier calculations).

The relationship of equation (11) thus satisfies the power split requirement and leaves only one unknown quantity, namely the weight $W_{v_o}^{(L_{v_o})}$ of source kind $l = L_{v_o}$ for reload fuel of zone J_{v_o} , to be determined by the reactivity requirement. The code selects the zone J_{v_o} as the one which has been designated by input data as zone $J_{v_o} = 1$ - see data block 12 of Section 5 (and, therefore, the zone chosen by the user to have the v index of $v = v_o$ in the reload instructions should be a zone of of major importance in terms of its power and reactivity contributions). If no fuel batches are to be loaded into zone J_{v_o} at the beginning of the new operating interval, the code selects zone J_{v_o} to be the next zone in the v -listing of the input data (i.e., $v_o = v_o + 1$ if there is no refueling of zone J_{v_o} for the new operating interval; and if there is also no refueling of zone J_{v_o} , the code selects $v_o = v_o + 2$, etc.).

The reactivity (K_{eff}) relationship used to obtain $W_{v_o}^{(L_{v_o})}$ is equivalent to the following:

$$K_{\text{new fuel}}^{\text{variable}} = K_{\text{interval}}^{\text{end}} + (\Delta K)_{\text{burnup}} - (K_{\text{old fuel}} + K_{\text{new fuel}}^{\text{fixed}}) \quad (12)$$

where $K_{\text{new fuel}}^{\text{variable}}$ is the required K_{eff} contribution by reload fuel put into the variable isotopic content zones, $K_{\text{interval}}^{\text{end}}$ is the value of K_{eff} required by input data at the end of the operating interval with all shim control rods presumably withdrawn (ordinarily 1.0 except to allow for reactivity effects that may not be taken into account by the calculations performed), $(\Delta K)_{\text{burnup}}$ is the excess reactivity required for fuel burnup and is estimated from the burnup reactivity required for the preceding operating interval and the times of the preceding and the new operating intervals, $K_{\text{old fuel}}$ is the K_{eff} contributed by the fuel (and burnable poison if present) held over from the preceding interval, and $K_{\text{new fuel}}^{\text{fixed}}$ is the K_{eff} contributed by reload fuel placed into fixed isotopic content zones (usually blankets) and into zones receiving previously irradiated fuel from storage repositories (including fuel shuffled from other zones) and includes any reload burnable poison that may be placed in any of the reactor zones. $(K_{\text{old fuel}} + K_{\text{new fuel}}^{\text{fixed}})$ is easily calculated by the code since the regional isotopic concentrations involved are established and reactivity differences between these regional isotopic concentrations and those of the reference composition corresponding to the reference K_{eff} - see data block 34 in Section 5 - are computed using the material and regional reactivity worths $R_{m,j}$ - also described in data block 34.

Therefore, $K_{\text{new fuel}}^{\text{variable}}$, is calculated from the quantities on the right side of eqn. (12), which are either input data or computed data now available to the code. The relationship between $K_{\text{new fuel}}^{\text{variable}}$ and the weights of recycle and source material loaded into the variable isotopic content zones is

$$K_{\text{new fuel}}^{\text{variable}} = \sum_{v=v_0}^{v_{\text{max}}} \left(\sum_{\ell=1}^4 f_v^{(\ell)} R_v^{(\ell)} \right) w_v^{(L_v)} \quad (13)$$

where $R_v^{(l)}$ is the reactivity contributed by a unit weight (1 kg) of source kind l distributed uniformly throughout zone J_v (easily calculated in accordance with statements 3-177, 3-184, and 3-187 and the summation over v includes all of the variable isotopic content zones being refueled. Substitution of the expression for $W_v^{(L_v)}$ from eqn. (13) yields

$$K_{\text{new fuel}}^{\text{variable}} = \left(\sum_{v=v_0}^{v_{\max}} R_v^{(b)} \right) + \left(\sum_{v=v_0}^{v_{\max}} R_v^{(x)} \right) W_{v_0}^{(L_{v_0})} \quad (14)$$

where $R_v^{(b)}$ is given by the expression of statement (3-190) - the δ_{v,v_0} appearing in the second term on the right side is a Kronecker delta function - and $R_v^{(x)}$ is given by statements (3-192) and (3-193) for respectively $v=v_0$ and $v > v_0$.

Eqn. (14) is solved for $W_{v_0}^{(L_{v_0})}$. * The $W_v^{(L_v)}$ values for $v > v_0$ and the factors $f_v^{(4)}$ are then calculated from eqns. (13) and (9). Thus all of the $f_v^{(l)}$ and $W_v^{(L_v)}$ terms required for the calculation of recycle and makeup fuel weights in the reload fuel of variable isotopic content zones have been obtained.

At this point in the calculation, the code checks each recycle material source to determine whether the demand for such recycle material by all of the variable isotopic content zones exceeds the amount available. If the demand for a given recycle material source is found to overrun the supply, the code re-distributes the amount available among the zones which received that material as a preferred recycle source or as a backup recycle source because there was

*Statement (3-195) is equivalent to the solution of eqn. (14). It may be noted that some of the terms used in the derivation above are different from the ones used in the detailed specifications of Section 3.30. This was done to avoid having to explain here certain details of the calculations which do not contribute significantly to an understanding of the computational approach adopted.

no material available in the preferred source. The redistribution is done by applying the same reduction factor (a fraction equal to the ratio of supply to demand) to all of the aforementioned zones. The resulting deficiency in fissile material is then made up in each zone with backup recycle material (to the extent that it is available) and/or fissile makeup material. The fertile makeup is adjusted during this process to maintain a fixed total fuel atom concentration in the reload fuel of each zone, and the net effect on reactivity of the adjustments in each zone is held to zero. Mathematically, this process of adjustment for short supply of recycle material is one of changing the $f_v^{(\ell)}$ and $W_v^{(L_v)}$ values consistent with the amount of recycle materials available and with restraints imposed on these changes in accordance with the following equations:

$$\left(\sum_{\ell=1}^4 f_v^{(\ell)'} N_v^{(\ell)} \right) W_v^{(L_v)'} = \left(\sum_{\ell=1}^4 f_v^{(\ell)} N_v^{(\ell)} \right) W_v^{(L_v)} \quad (15)$$

$$\left(\sum_{\ell=1}^4 f_v^{(\ell)'} R_v^{(\ell)} \right) W_v^{(L_v)'} = \left(\sum_{\ell=1}^4 f_v^{(\ell)} R_v^{(\ell)} \right) W_v^{(L_v)} \quad (16)$$

where the primed terms are the adjusted values and the unprimed the unadjusted ones. Eqn. (15) maintains the desired total fuel atom concentration and eqn. (16) maintains the originally calculated K_{eff} . The power split originally calculated will generally be altered slightly in the adjustment process.

FIGURE 12. FLOW CHART FOR RELOAD FUEL CALCULATIONS FOR ZONES OF VARIABLE ISOTOPIC CONTENT

FIGURE 12. (continued)

2.10 Establishment of First Core Conditions

The computational routines for fuel reload in the variable isotopic zones covered in Section 2.9 complete the operating interval loop which starts with the burnup routine. In order to enter the loop for the first time (for the first operating interval) some initial indexes and parameters must be set, isotopic composition must be established for the first core, and the interpolation routine end points and index for the first interval must be calculated.

If the problem being run is a restart case, isotopic concentrations and much of the other required initial data will have been calculated from a previous problem run and provided in a format (on tape or cards) directly usable as input data.* If the problem is not a restart case (six other options for the first core fuel load are available as were described in Section 1.4.6) then the regional and batch isotopic concentrations for the first core have to be calculated from the composition of multigroup case A (see discussion of interpolation routine in Section 2.7) or provided as separate input. The flow chart of figure 13 outlines the sequence of the calculations performed to establish the first core conditions and identifies the pertinent instructions and equations in Section 3.2.

* The restart option will be included in Version II of FUMBLE.

FIGURE 13. FLOW CHART FOR INITIAL CALCULATIONS
AND ESTABLISHMENT OF FIRST CORE CONDITIONS

FIGURE 13. (continued)

2.11 Input Data - Checking Routine and Limits

An extensive input data checking routine precedes each problem run. This data checking procedure specified in Section 3.1, was provided because of the rather large amount and variety of input data required to exercise the many options of the code. If input errors are found, the checking routine prints out identifications of the errors detected and stops the problem.

The kinds of input data required and a tentative functional grouping of such data into blocks of data is given in Section 5.2. Each input data quantity is listed by math symbol and by FORTRAN symbol (blocks 1 through 27 contain the input quantities used for most cases run) and is given an identification number that includes the block number. A description of each quantity is given in sufficient detail to indicate how it is used in the computations and the limits imposed on the values that may be assigned to the quantity and, where applicable, the conditions under which these limits apply.

The input data checking routine searches for several different types of errors that can be made in the preparation of the input data. The careless error is one type illustrated by examples such as (1) assigning the same number to two different zones, (2) indicating that a given zone is both a fixed isotopic content zone and a variable isotopic content zone, (3) number of zones receiving stored fuel plus number of variable isotopic content plus number of fixed isotopic content does not add up to total number of zones, (4) number of materials in isotopic burnup chains plus fission products and burnable poison does not add up to maximum number of materials specified, (5) indicator shows that overlay input data on isotopic fission energies is to be provided and no such data appears, (6) negative value assigned to fuel reprocessing time, (7) contradictory input data given as to whether operating interval time is held constant or varied, - and many other such errors that are included among the error checks

listed in Section 3.1. It will be noted that there is a redundancy in a few of the input quantities requested; and these have the purpose of checking for inconsistencies arising mainly from careless errors.

The checking routine includes some search for errors that indicate the user misunderstood the units that should be used. An example of this type of error is the listing of a positive fuel annual interest rate less than one percent, which indicates that the user erroneously provided a fraction instead of a percent value. Another example is the specification of fractional material contributions to the total atom concentration in a fixed isotopic zone such that the sum of the fractions adds up to something significantly different from unity; and this would indicate that material atom concentrations were used instead of fractional contributions to the total atom concentration.

Another type of error is that of exceeding limits imposed on the various data quantities. A tentative set of limits was imposed on the computational model to hold the computer memory required to about 40,000 words with moderate use of variable dimensioning in the programming logic and the checking routine searches for violations of these limits.

Another type of error involved in the input data checking routine is the violation of restrictions imposed in order to avoid excessive complexity in the computational logic. As one important example, if a given reactor zone either discharges fuel to a stored fuel repository or is loaded with fuel taken from a stored fuel repository (and this includes fuel which is shuffled between that zone and other zones) then there can be only one region in such a zone. This imposes the disadvantage of having a large number of zones, with a concurrent large amount of input and output data that would otherwise not be required. This disadvantage can be removed so far as the output data is concerned by combining several such zones in a single composite zone (see description in block 25A of Section 5.2). It is also required that a given fuel storage repository accept discharged fuel from only one reactor zone (and, hence, from only one region) at the end of any one operating interval.

The use of a composite zone (mentioned above) serves the additional useful purpose of providing a check against a possible erroneous ordering of fuel transferred between the reactor and fuel storage repositories. For example, a fuel subassembly (representative of a batch of such subassemblies) may consist of a core region and several axial blanket regions. The different regions must be stored in different repositories (for computational purposes only - not the real fuel); and when such stored fuel is later reloaded into the reactor, the core and axial blanket regions taken from the different repositories must be restored to their initial alignment (even though the fuel subassembly may be reloaded into reactor zones different from those of its earlier exposure). The input data checking routine guards against input errors that would cause misalignment of the different regions of fuel subassemblies undergoing transfer to and from storage repositories; but such checking is done only if the different regions (zones) of the subassembly are designed to be a composite zone group.

Another example of a restriction imposed to reduce computational complexity, which is checked by the input data checking routine, is the limitation of a zone designation to one of three types for refueling considerations. A zone may receive previously irradiated fuel from a storage repository, or it may receive fuel of a fixed isotopic composition, or it may be a variable isotopic content zone and receive recycled and makeup fuel materials of composition as required to satisfy reactivity and other conditions (see Section 2.9). However, the reload fuel received by a zone cannot be a combination of the above three (i.e., if a zone receives previously irradiated fuel from a storage repository, that zone cannot also receive a fresh source of recycle and/or makeup fuel in the same refueling etc.). Similarly, a given zone may discharge fuel for reprocessing or for storage and later additional burnup (including immediate shuffling to another zone) at the end of any given refueling interval; but the zone cannot discharge a portion of its fuel for reprocessing and another portion for storage in the same interval. The practical effect of these restrictions is that they may require the user to break the reactor computational model into smaller zones for certain problems run (e.g., where fuel from stored repositories is to be loaded adjacent to a new load of fresh fuel). Again, the use of a composite zone grouping is useful in such a case to combine zonal output data from many small zones into a smaller number of zone groups.

The input data checking routine also guards against errors that would prevent preparation of input data required for a restart case to be run later (see item 1-33 in data block 1 of Section 5.2). One of the restart options allows the user to prepare such input data (at the end of the current problem) for a new problem case which may have a smaller number of zones and regions than the current case and which may have no stored fuel repositories even though the current case may have such repositories. The purpose of this option is to allow the user to simplify the reactor computational model as the refueling scheme approaches an equilibrium condition and thereby, to obtain improved computation speed and more convenient (simpler) input and output data. (It was noted in the preceding paragraph that a larger-than-desired number of zones might be required in order to accommodate certain refueling schemes, such as loading previously exposed fuel from a storage repository adjacent to (or intermixed with) a load of freshly fabricated fuel. Such refueling operations would be expected to be of interest mainly for the first few operating intervals after reactor startup; and complexities added to the computational model to accommodate these operations could be removed for the remaining operating interval by using the restart option.) In order to condense the number of zones and regions for a restart case, it is necessary that zones of the current problem to be combined into a single zone for the restart case hold the same number of fuel batches and that such zones discharge the same number of fuel batches at the end of the last operating interval of the current problem case.* Items E-14 through E-27 of the input checking routine assures that these conditions are satisfied and that other errors are not present in the specification of the restart computational model before allowing the current problem to be run.

*

These requirements on numbers of fuel batches are not limiting to problem flexibility since what is designated as a batch for the code can be just a fraction of an actual fuel batch (i.e., a multiple of code batches may be loaded into or discharged from any given reactor zone at any refueling and may represent just one actual fuel batch.

SECTION III

DETAILED SPECIFICATIONS3.1 INPUT DATA CHECKING

After input data are read into core storage, data tests are performed and I_{halt} indicators are set up as follows if any of the listed data violations occur.

A. Set $I_{halt} = 11$ and go to statement 1-28 if any of the following occur:

1. $i_{max} \leq 0$
2. $I_{max} \leq 0$ or $I_{max} < I_{init}$
3. $n_{fp}^{max} < 1$ or $n_{fp}^{max} > 2$
4. $m_{max}^{fuel} = 5$ or 6 and $n_{fp}^{max} = 2$
5. $\delta_{pois} = 0$ and $m_{max} \neq m_{max}^{fuel} + n_{fp}^{max}$
6. $\delta_{pois} = 1$ and $m_{max} \neq m_{max}^{fuel} + n_{fp}^{max} + 1$
7. $m_{max}^{fuel} \neq 5, 6, 7, \text{ or } 11$
8. $J_{max} \leq 0$
9. $j_{max} \leq 0$ or $j_{max} > J_{max}$
10. $L_{max} > M_{max}$
11. $l'_{max} > J_{max}$
12. $\delta_{switch}^{interp} > 0$ and $F_a^{out}, F_a^{in}, F_b^{out}, \text{ or } F_b^{in} \neq 0$
13. $\delta_{wt}^{interp} \neq 0, 1, \text{ or } 2$
14. $\delta_E^{overlay} > 0$ and $E_m^{input} \leq 0$ for any m ($m=1 \text{ ---- } m_{max}^{fuel}$)
15. $\delta_{norm}^{th} \neq 0$ or 1
16. $\delta_1^{(a)} = 0, \delta_{restart} = 1$ and $N_v^{fuel} \leq 0$ for $(1 \leq v \leq J_{max})$

17. $\delta_1^{(a)} = 0$, $\delta_{\text{restart}} = 1$ and $P_v \leq 0$ for $(1 \leq v \leq J_{\text{max}})$
18. $N_{\text{max}}^{\text{stor}} > N_{\text{max}}^{\text{Pu}} > N_{\text{max}}^{\text{fis U}} > N_{\text{max}}^{\text{tot U}}$ (if any of the inequalities occurs)

B. Set $I_{\text{halt}} = 12$ and go to statement (1-28) if any of the following occur:

1. $j_J > j_1$ $1 \leq i \leq J-1$, $1 \leq J \leq J_{\text{max}}$
2. $j_{J_{\text{max}}} > j_{\text{max}}$
3. $J_b > 0$ and $B = 0$ for any b , $1 \leq b \leq J_{\text{max}}$
4. $J_b > 0$ and either $j_{pk} = 0$ or $p^{pk} = 0$ for any p , $1 \leq p \leq J_{\text{max}}$
5. $J_g > J_{\text{max}}$
6. $J_a = 0$ and $J_v = 0$, or $J_a \neq 0$ and $J_v \neq 0$
7. $N_{\text{dis}}^{(J)} > N_J^{\text{bat}}$, or $N_J^{\text{bat}} > N_{\text{max}}^{\text{bat}}$, $1 \leq J \leq J_{\text{max}}$
8. N_d^{stor} or $N_d^{\text{stor 2}} < 0$, also N_d^{stor} or $N_d^{\text{stor 2}} > N_{\text{max}}^{\text{tot U}}$ for any d ,
 $1 \leq d \leq J_{\text{max}}$
9. $N_J^{\text{rec 1}} < 0$ or $N_J^{\text{rec 1}} > N_{\text{max}}^{\text{tot U}}$ for $1 \leq J \leq J_{\text{max}}$
10. N_J^{mkp} or $N_J^{\text{oth}} < 0$, also N_J^{mkp} or $N_J^{\text{oth}} > N_{\text{max}}$, for $1 \leq J \leq J_{\text{max}}$
11. $I_J^{\text{rec 1}}$ or $I_J^{\text{rec 2}} < 0$, also $I_J^{\text{rec 1}}$ or $I_J^{\text{rec 2}} > I_{\text{max}}^{\text{REC}}$

C. Set $I_{\text{halt}} = 13$ and go to statement (1-28) if any of the following occur:

1. $k_{\text{max}} > 0$ and overlay input cards are missing
2. $k_{\text{max}} > 0$ and $I_k \leq I_{k-1}$ for $2 \leq k \leq I_{\text{max}}$

D. Set $I_{\text{halt}} = 14$ and go to statement (1-28) if the following occurs:

1. PROBLEM EXCEEDS CORE LIMITS

E. Set $I_{\text{halt}} = 15$ and go to statement (1-28) if any of the following occur:

1. $\ell'_{\text{max}} > 0$ and $J_{\ell'} = 0$ for $1 \leq \ell' < J_{\text{max}}$

2. $L_{\max} > 0$, and $M_L = 0$ or $M_L > m_{\max}$ for $1 \leq L \leq L_{\max}$
3. $L_{\max} > 0$ and both $G_L = 0$ and $H_L = 0$ for $1 \leq L \leq L_{\max}$
4. $L_{\max} > 1$ and $M_L = M_{L'}$, for $L' > L$, $2 \leq L \leq L_{\max}$
5. $L_{\max} = 0$ and either $G_o = 0$ or $H_o = 0$

F. Set $I_{\text{halt}} = 16$ and go to statement (1-28) if any of the following occur:

1. $I_J^{\text{nu}} \geq I_{\text{init}}$ and $N_{n'}^J > N_J^{\text{bat}}$ for $1 \leq J \leq J_{\max}$, $1 \leq n' \leq I_J^{\text{cy}}$
2. $I_{\text{init}} \leq I_J^{\text{nu}} \leq I_{\max}$ and $\left(\frac{I_J^{\text{nu}} - I_{\text{init}} + 1}{I_J^{\text{cy}}} \right) \neq \text{integer}$ for $1 \leq J \leq J_{\max}$
3. $I_{\text{init}} \leq I_J^{\text{nu}} \leq I_{\max}$ and if $N_J^{\text{bat}} \neq \sum_{n'=1}^{I_J^{\text{cy}}} N_{n'}^J$ for $1 \leq J \leq J_{\max}$
4. $I_{\text{init}} \leq I_J^{\text{nu}} \leq I_{\max}$ and either $N_c^J < 1$ or $N_c^J > N_J^{\text{bat}}$ for $1 \leq J \leq J_{\max}$
5. $I_{\text{init}} < I_J^{\text{nu}} \leq I_{\max}$ and $I_J^{\text{cy}} > 1$, and either $N_{n'}^J \neq 0$
or $N_{n'}^J \neq N_{n''}^J$ for $n'' < n'$, $2 \leq n' \leq I_J^{\text{cy}}$, $1 \leq J \leq J_{\max}$

G. Set $I_{\text{halt}} = 17$ and go to statement (1-28) if any of the following occur:

1. $\sum_{q=1}^{q_{\max}^{(N)}} W_{q,N} = 0$ for $1 \leq N \leq N_{\max}$
2. $M_{q,N} < 1$ or $M_{q,N} > M_{\max}^{\text{fuel}}$ for $1 \leq q \leq q_{\max}^{(N)}$, $1 \leq N \leq N_{\max}$
3. $q_{\max}^{(N)} > 1$ and $M_{q,N} = M_{q',N}$ for $q' \neq q$, $2 \leq q \leq q_{\max}^{(N)}$, $1 \leq N \leq N_{\max}$
4. $J_a > 0$ and $0.999 > \sum_{q=1}^{B_{\max}^N} W_{q,n} > 1.001$ for $N=J_a$ and $1 \leq a \leq J_{\max}$

H. Set $I_{\text{halt}} = 18$ and go to statement (1-28) if the following occur:

1. $N_{\text{max}}^{\text{stor}} > N_{\text{max}}^{\text{stor}}$
2. $J_{\text{max}}' \leq 0$ or $J_{\text{max}}' > J_{\text{max}}$
3. $j_{\text{max}}' \leq 0$, or $j_{\text{max}}' > j_{\text{max}}$
4. $j_{\text{max}}' \neq j_{\text{max}}$ and $N_{j_{\text{max}}}^R \neq j_{\text{max}}^*$

I. Set $I_{\text{halt}} = 19$ and go to statement (1-28) if any of the following occur:

1. $N_d^{\text{stor}} = N_{d'}^{\text{stor}}$ for $d' \neq d$ and N_d^{stor} or $N_{d'}^{\text{stor}} \leq N_{\text{max}}^{\text{stor}}$
2. $N_v^{\text{rec } 1} = N_{v'}^{\text{rec } 1}$ for $v \neq v'$ and $N_v^{\text{rec } 1}$ or $N_{v'}^{\text{rec } 1} \leq N_{\text{max}}^{\text{stor}}$
3. $F_{\text{mult}}(N) \leq 0$ or $F_{\text{mult}}(N) > 1$ for $N_{\text{max}}^{\text{stor}} + 1 \leq N \leq N_{\text{max}}^{\text{tot } U}$
4. $N_v^{\text{rec } 1} = 0$ and $N_v^{\text{rec } 2} \neq 0$ and $J_v > 0$, $1 \leq v \leq J_{\text{max}}$.
5. $N_v^{\text{mkp}} = 0$ or $N_v^{\text{oth}} = 0$ and $J_v > 0$, $1 \leq v \leq J_{\text{max}}$
6. $N_v^{\text{mkp}} > N_{\text{max}}$, or $N_v^{\text{oth}} > N_{\text{max}}$ and $J_v > 0$, $1 \leq v \leq J_{\text{max}}$
7. $N_v^{\text{rec } 1} < 0$ or $N_v^{\text{rec } 1} > N_{\text{max}}^{\text{tot } U}$, $1 \leq v \leq J_{\text{max}}$
8. $N_v^{\text{rec } 2} \leq N_{\text{max}}^{\text{stor}}$ or $N_v^{\text{rec } 2} > N_{\text{max}}^{\text{tot } U}$, $1 \leq v \leq J_{\text{max}}$
9. $(\delta_{\text{rec } v}^{\text{mix}}) > 0$, and either $N_v^{\text{rec } 1} = 0$ or $N_v^{\text{rec } 2} = 0$ for $J_v > 0$ and $1 \leq v \leq J_{\text{max}}$
10. $I_v^{\text{stor}} > I_{\text{max}}^{\text{stor}}$ for $J_v > 0$, $N_v < N_v^{\text{stor}}$, $1 \leq v \leq J_{\text{max}}$

* For $j_{\text{max}}' \neq j_{\text{max}}$, $N_{j_{\text{max}}'-1}^R + 1$ to $N_{j_{\text{max}}'}^R$ describe regions to be combined.

For j_{max}'

11. $M_{\max}^{\text{fuel}} = 6$ or 11 and $N_v^{\text{rec } \ell} > N_{\max}^{\text{Pu}}$ and $I_v^{\text{rec } \ell} = 0$ for $\ell = 1$ and 2,

$$J_v > 0, \quad 1 \leq v \leq J_{\max}$$

J. Set $I_{\text{halt}} = 20$ and go to Statement (1-28) if any of the following occur:

1. $\delta_{\text{pois}} = 0$ and $N_{m_{\max}, v}^{(o)} > 0$, $J_v > 0$, $1 \leq v \leq J_{\max}$
2. $A_t^{\text{cont}} < 0$ or $A_t^{\text{cont}} > 1$
3. $P_v < 0$ and $J_v > 0$ for $1 \leq v \leq J_{\max}$

K. Set $I_{\text{halt}} = 21$ and go to statement (1-28) if any of the following occur:

1. $L_{\text{fab}} + L_{\text{repr}} \geq 1$
2. $T_{\text{repr}} \leq 0$
3. $T_{\text{fab}} \leq 0$
4. $e^{\text{th}} > 1$ or $e^{\text{th}} \leq 0$

L. Set $I_{\text{halt}} = 25$ and go to statement (1-28) if any of the following occur:

If $\delta_{\text{meth}}^{\text{cost}} > 0$, and $1 \leq i \leq \text{NALTMX}^*$

1. $m_{\max}^{\text{fuel}} = 5$ and $N_{\max}^{\text{val}(i')} \neq 1$ or 4.
2. $m_{\max}^{\text{fuel}} = 6$ and $N_{\max}^{\text{val}(i')} \neq 0, 1, 6$ or 5.
3. $m_{\max}^{\text{fuel}} = 7$ and $N_{\max}^{\text{val}(i')} \neq 1, 4$, or 6.
4. $m_{\max}^{\text{fuel}} = 11$ and $N_{\max}^{\text{val}(i')} \neq 1, 4$, or 10.

* i' is the indicator on fuel cost input data assumptions, with $i' = 1$ being the reference set. By setting up a loop on i' ($1 \leq i' \leq N_{\text{alt}}^{\text{max}}$) input data check tests are conducted on all of the input data sets of economic assumptions.

5. $C_{\text{feed}}^{(i')} > 0$ and either $C_{\text{sep}}^{(i')} \leq 0$ or $E_{\text{tails}}^{(i')} \leq 0$.
6. $C_{\text{feed}}^{(i')} = 0$ and either $C_{\text{sep}}^{(i')} \neq 0$ or $E_{\text{tails}}^{(i')} \neq 0$.
7. $C_{\text{feed}}^{(i')} > 0$ and either $N_{\text{max}}^{\text{val}(i')} > 0$ if $m_{\text{max}}^{\text{fuel}} = 6$, or
 $N_{\text{max}}^{\text{val}(i')} > 4$ if $m_{\text{max}}^{\text{fuel}} \neq 6$.
8. $C_{\text{feed}}^{(i')} > 0$ and $R_{25}^{23(i')} = 0$ and $m_{\text{max}}^{\text{fuel}} = 6$ or 11.
9. $(1 \geq P_{\text{fuel}}^{\text{int}(i')} \geq 100)$ or $(1 \geq P_{\text{fab}}^{\text{int}(i')} \geq 100)$
10. $P_{\text{lev}}^{\text{int}} > 0$ and $1 \geq P_{\text{lev}}^{\text{int}(i')} \geq 100$
11. $U_h^{\text{fab}(i')} = 0$ or $U_h^{\text{repr}(i')} = 0$ for $1 \leq h \leq h_{\text{max}}$.

M. Set $I_{\text{halt}} = 26$ and go to statement (1-28) if any of the following occur:

1. $\delta_{\text{reac}}^{\text{out}} = 0$ and $(\delta_{\text{reac}}^{\text{disch}} + \delta_{\text{reac}}^{\text{load}} + \delta_{\text{reac}}^{\text{mid inv}} + \delta_{\text{reac}}^{\text{end inv}} + \delta_{\text{reac}}^{\text{cost}} + \delta_{\text{reac}}^{\text{cost comp}}) \neq 0$.
2. $\delta_{\text{meth}}^{\text{cost}} = 0$ and either $\delta_{\text{reac}}^{\text{cost}} > 0$ or $\delta_{\text{reac}}^{\text{cost comp}} > 0$.
3. $W_J = 0$ for any J ($1 \leq J \leq J_{\text{max}}$)
4. $\delta_g^{\text{out}} = 0$ and $(\delta_g^{\text{disch}} + \delta_g^{\text{load}} + \delta_g^{\text{mid inv}} + \delta_g^{\text{end inv}} + \delta_g^{\text{cost}} + \delta_g^{\text{cost comp}}) \neq 0$, for $1 \leq g \leq g_{\text{max}}$.
5. $\delta_g^{\text{cost meth}} = 0$ and $(\delta_g^{\text{cost}} + \delta_g^{\text{cost comp}}) \neq 0$ for $1 \leq g \leq g_{\text{max}}$.
6. $\delta_{\text{meth}}^{\text{cost}} = 0$ and $\sum_{g=1}^{g_{\text{max}}} (\delta_g^{\text{cost}} + \delta_g^{\text{cost comp}}) \neq 0$.

7. $\delta_g^{\text{cost meth}} = 1$ and $\delta_{\text{meth}}^{\text{cost}} \neq 1$ or 3; or $\delta_g^{\text{cost meth}} = 2$ and $\delta_{\text{meth}}^{\text{cost}} \neq 2$ or 3;
 or $\delta_g^{\text{cost meth}} = 3$ and $\delta_{\text{meth}}^{\text{cost}} \neq 3$.

8. $\delta_{\text{inv}}^{\text{stor}} \neq 0$ or $\delta_{\text{inv cost}}^{\text{stor}} \neq 0$ and $N_{\text{max}}^{\text{stor}} = 0$.

Make the following additional data checks and alterations as indicated below.

If $\epsilon_p^{(1)} = 0$, set $\epsilon_p^{(1)} = 0.001$.

If $\epsilon_p^{(2)} = 0$, set $\epsilon_p^{(2)} = 0.01$.

If $i_{\text{max}} > 20$, set $i_{\text{max}} = 20$.

3.2 Initial Calculations and Establishment of the First Core Conditions

3.2.1 Setup of Initial Indices, Miscellaneous Data for First Interval, and Multigroup Interpolation Factors

$$\text{Set } I = I_{\text{init}}, i = 1, \text{ and } I_{\text{halt}} = 0 \quad (2-1)$$

$$\begin{aligned} \text{Set } m_{241} = 4 \text{ if } m_{\text{max}}^{\text{fuel}} \neq 6; m_{233} = 2 \text{ if } m_{\text{max}}^{\text{fuel}} = 6. \\ = 7 \text{ if } m_{\text{max}}^{\text{fuel}} = 11. \end{aligned} \quad (2-2)$$

$$\text{Set } \lambda_{241} = 1.67 \times 10^{-9}; \text{Set } \lambda_{233} = 2.93 \times 10^{-7}. \quad (2-3)$$

$$\begin{aligned} \text{Set } E'_1 = 211, E'_2 = 211, E'_3 = 211, E'_4 = 211, E'_5 = 211, \\ E'_6 = 203, E'_7 = 203; E'_8 = 203, E'_9 = 203, E'_{10} = 203, \\ E'_{11} = 203. \end{aligned} \quad (2-4)$$

$$\begin{aligned} \text{Set } A'_1 = 238.03, A'_2 = 239, A'_3 = 240, A'_4 = 241, A'_5 = 242, \\ A'_6 = 232.04, A'_7 = 233, A'_8 = 233, A'_9 = 234, A'_{10} = 235, \\ A'_{11} = 236, A'_{12} = 238, A'_{13} = 234 \end{aligned} \quad (2-5)$$

$$\text{Set } A'_{14} = 1 \text{ if } A_{\text{mmax}}^{\text{wt}} = 0. \quad (2-6)$$

$$\text{Set } A'_{14} = A_{\text{mmax}}^{\text{wt}} \text{ if } A_{\text{mmax}}^{\text{wt}} > 0. \quad (2-7)$$

Calculate

$$E_m = E'_m \text{ for } 1 \leq m \leq 11 \text{ if } m_{\max}^{\text{fuel}} = 11. \quad (2-8)$$

$$E_m = E'_{m+5} \text{ for } 1 \leq m \leq 6 \text{ if } m_{\max}^{\text{fuel}} = 6. \quad (2-9)$$

$$E_m = E'_m \text{ for } 1 \leq m \leq 5 \text{ if } m_{\max}^{\text{fuel}} = 5 \text{ or } 7. \quad (2-10)$$

$$E_6 = E'_{10} \text{ and } E_7 = E'_{11} \text{ if } m_{\max}^{\text{fuel}} = 7. \quad (2-11)$$

$$\text{If } \delta_E^{\text{overlay}} > 0 \text{ and if } E_m^{\text{input}} > 0 \text{ for } 1 \leq m \leq m_{\max}^{\text{fuel}}, \quad (2-12)$$

$$\text{set } E_m = E_m^{\text{input}}$$

Calculate

$$(A_m^{\text{wt}}/602.5) = A'_m/602.5 \text{ for } 1 \leq m \leq m_{\max}^{\text{fuel}} \text{ if } m_{\max}^{\text{fuel}} = 11. \quad (2-13)$$

$$(A_m^{\text{wt}}/602.5) = A'_{m+5}/602.5 \text{ for } 1 \leq m \leq 6 \text{ and } (A_7^{\text{wt}}/602.5) = \quad (2-14)$$

$$\frac{A'_{13}}{602.5} \text{ if } m_{\max}^{\text{fuel}} = 6.$$

$$(A_m^{\text{wt}}/602.5) = A'_m/602.5 \text{ for } 1 \leq m \leq 5 \text{ if } m_{\max}^{\text{fuel}} = 5 \text{ or } 7. \quad (2-15)$$

$$(A_6^{\text{wt}}/602.5) = A'_{10}/602.5 \text{ and } (A_7^{\text{wt}}/602.5) = A'_{11}/602.5 \quad (2-16)$$

$$\text{if } m_{\max}^{\text{fuel}} = 7.$$

$$(A_{m_{\max}^{\text{fuel}}+1}^{\text{wt}}/602.5) = A'_{12}/602.5 \text{ if } m_{\max}^{\text{fuel}} \neq 6. \quad (2-17)$$

$$(A_{m_{\max}}^{\text{fuel}+2} / 602.5) = A'_{13} / 602.5 \text{ if } n_{\text{fp}}^{\max} = 2. \quad (2-18)$$

$$(A_{m_{\max}}^{\text{wt}} / 602.5) = A'_{14} / 602.5 \text{ if } \delta_{\text{pois}} = 1. \quad (2-19)$$

$$\text{Set } F_{\text{feed}} = (0.01422 - 1) [\log_e (\frac{0.00711}{1-0.00711})] \quad (2-20)$$

Calculate

$$A^{\text{int}} = \frac{G_o + \sum_{L=1}^{L_{\max}} G_L \sum_{\ell'=1}^{\ell'_{\max}} \sum_{j=j_{J_{\ell'}-1}+1}^{j_{J_{\ell'}}} v_j^{(a)*} N_{M_L,j}^{(a)}}{H_o + \sum_{L=1}^{L_{\max}} H_L \sum_{\ell'=1}^{\ell'_{\max}} \sum_{j=j_{J_{\ell'}-1}+1}^{j_{J_{\ell'}}} v_j^{(a)*} N_{M_L,j}^{(a)}} \quad (2-21)$$

$$B^{\text{int}} = \frac{G_o + \sum_{L=1}^{L_{\max}} G_L \sum_{\ell'=1}^{\ell'_{\max}} \sum_{j=j_{J_{\ell'}-1}+1}^{j_{J_{\ell'}}} v_j^{(b)*} N_{M_L,j}^{(b)}}{H_o + \sum_{L=1}^{L_{\max}} H_L \sum_{\ell'=1}^{\ell'_{\max}} \sum_{j=j_{J_{\ell'}-1}+1}^{j_{J_{\ell'}}} v_j^{(b)*} N_{M_L,j}^{(b)}} \quad (2-22)$$

$$\text{where } v_j^{(a)*} = 1 \text{ if } \delta_{wt}^{\text{interp}} = 0 \quad (2-23)$$

$$= v_j^{(a)} \text{ if } \delta_{wt}^{\text{interp}} = 1$$

$$= v_j^{(a)} \phi_j^{(a)} = \phi_j^{(a)} \text{ if } \delta_{wt}^{\text{interp}} = 2$$

$$\text{and } v_j^{(b)*} = 1 \text{ if } \delta_{wt}^{\text{interp}} = 0 \quad (2-24)$$

$$= v_j^{(b)} \text{ if } \delta_{wt}^{\text{interp}} = 1$$

$$+ v_j^{(b)} \phi_j^{(b)} = \phi_j^{(b)} \text{ if } \delta_{wt}^{\text{interp}} = 2$$

$$\text{If } \delta_1^{(a)} \neq 0 \text{ or if } \delta_{\text{restart}} = 0, \text{ set } T_{\text{yr}}^{\text{acc}} = E_{\text{acc}}' = E_{\text{acc}}^{\text{lev}} = E_{\text{acc}} = C_{\text{lev}}^{\text{acc}} = 0. \quad (2-25)$$

3.2.2 Initial Core Isotopic Concentrations and Refueling Parameters

If $\delta_1^{(a)} = 0$, go to "Read Statement" preceding statement (2-69).

* See Data Block 34 of Section 5.

Calculate

$$\phi_j = \phi_j / V_j \text{ for } 1 \leq j \leq j_{\max} \quad (2-26)$$

If $\delta_1^{(a)} = 1$, set $N_{\text{dis}}^{(J)'} = N_J^{\text{bat}}$

$$\text{and set } N_{m,j,n}^{(o)} = \frac{1}{N_j^{\text{bat}}} \sum_{j=j_{J-1}+1}^{j_J} v_j N_{m,j}^{(r)} / \sum_{j=j_{J-1}+1}^{j_J} v_j \quad (2-27)$$

for $1 \leq J \leq J_{\max}$; $j_{J-1} + 1 \leq j \leq j_J$; $1 \leq n \leq N_J^{\text{bat}}$;

$1 \leq m \leq m_{\max}$.

If $\delta_1^{(a)} = 1$, also set

$$E_{J,n}^{(o)\text{th}} = 0 \text{ and } W_{J,n}^{(o)} = \sum_{m=1}^{m_{\max}^{\text{fuel}} + n_{\text{bp}}^{\max}} \left(\frac{A_{\text{wt}}^m}{602.5} \right) \sum_{j=j_{J-1}+1}^{j_J} v_j N_{m,j,n}^{(o)} \quad (2-28)$$

for $1 \leq J \leq J_{\max}$; $1 \leq n \leq N_J^{\text{bat}}$;

If $\delta_1^{(a)} = 1$, go to statement (2-53) (2-29)

Calculate R_p , renormalize fluxes, Z_j , and $\sigma_{m,j}$ as per statements (3-1)

thru (3-7) - except replace summation over n terms in statement 3-2 by

$$N_{m,j}^{(r)} \quad (2-30)$$

Do loop on v ($1 \leq v \leq J_{\max}$)

If $JV_v = 0$ skip to the next value of v (not a variable enriched zone) (2-31)

Do loop on j ($j_{J_v-1} + 1 \leq j \leq j_{J_v}$)

$$\text{If } m_{\max}^{\text{fuel}} = 6 \text{ set } m_{\text{hi}} = M_{\max}^{\text{fuel}} \text{ and set } m_{\text{low}} = 1 \quad (2-32)$$

$$\text{Otherwise, set } m_{\text{low}} = 1 \text{ and } m_{\text{hi}} = 5 \quad (2-33)$$

Do loop on m ($m_{\text{low}} \leq m \leq m_{\text{hi}}$)

Calculate

$$\text{If } \delta_1^{(a)} = 2 \text{ (input atom concentrations are averaged over a startup operating interval)}^1$$

$$e_m = N_{J_v}^{\text{bat}} (1.0 - \exp(-10^{-24} \sigma_{m,j} Z_j)) / (10^{-24} \sigma_{m,j} Z_j) \quad (2-34)$$

$$\text{If } \delta_1^{(a)} = 3 \text{ (input atom concentrations are given for the end of a startup operating interval)}^1$$

$$e_m = N_{J_v}^{\text{bat}} \exp(-10^{-24} \sigma_{m,j} Z_j) \quad (2-35)$$

$$\text{If } \delta_1^{(a)} = 4 \text{ (input atom concentrations are given for the beginning of an equilibrium operating interval)}^1$$

$$e_m = N_{\text{dis}}^{(J_v)} \left[\frac{1 - \exp(-10^{-24} \sigma_{m,j} Z_j N_{J_v}^{\text{bat}} / N_{\text{dis}}^{(J_v)})}{1 - \exp(-10^{-24} \sigma_{m,j} Z_j)} \right] \quad (2-36)$$

$$\text{If } \delta_1^{(a)} = 5 \text{ (input atom concentrations are averaged over the equilibrium operating interval)}^1$$

$$e_m = N_{\text{dis}}^{(J_v)} \left[\frac{1.0 - \exp(-10^{-24} \sigma_{m,j} Z_j N_{J_v}^{\text{bat}} / N_{\text{dis}}^{(J_v)})}{(10^{-24} \sigma_{m,j} Z_j)} \right] \quad (2-37)$$

¹ See Appendix A for the derivation of the different values of e_m .

If $\delta_1^{(a)} = 6$ (input atom concentrations are given for the end of an equilibrium operating interval)

$$e_m = N_{dis}^J \left[\frac{1 - \exp(-10^{-24} \sigma_{m,j} Z_j N_J^{bat} / N_{dis}^{(J)})}{\exp(10^{-24} \sigma_{m,j} Z_j) - 1} \right] \quad (2-38)$$

If $m = m_{low}$ calculate $N_{m,j,1}^{(o)} = N_{m,j}^{(r)} / e_m$ (2-39)

set $A_{1,1} = N_{m,j,1}^{(o)}$ (2-40)

If $m > m_{low}$, Calculate $A_{m,m'}$ for $m_{low} \leq m' \leq m-1$ as per statement (2-41)

(3-28)

Also calculate

$$N_{m,j,1}^{(o)} = \frac{N_{m,j}^{(r)} - \sum_{m'=m_{low}}^{m-1} A_{m,m'} (e_{m'} - e_m)}{e_m} \quad (2-42)$$

$$\text{and set } A_{m,m} = N_{m,j,1}^{(o)} - \sum_{m'=m_{low}}^{m-1} A_{m,m'} \quad (2-43)$$

End loop on m ($m_{low} \leq m \leq m_{hi}$)

If $m_{max}^{fuel} = 5$ or 6 skip to statement (2-44)

Set $m_{low} = 6$ and $m_{hi} = m_{max}^{fuel}$ (2-45)

Repeat loop on m

If $\delta_{\text{pois}} = 1$ and if $N_{m_{\text{max}},j} > 0$, calculate

$$N_{m_{\text{max}},j,1}^{(o)} = N_{m_{\text{max}},j}^{(r)} / e_{m_{\text{max}}} \quad (2-46)$$

where $e_{m_{\text{max}}}$ is calculated by the appropriate method described above
(Statements 2-34 through 2-38)

If $\delta_1^{(a)} \geq 4$ Go to Statement 2-50

Calculate (for $1 \leq n \leq N_{J_v}^{\text{bat}}$)

$$N_{m,j,n}^{(o)} = \frac{1}{N_{J_v}^{\text{bat}}} \sum_{j=j_{J_v-1}+1}^{j_{J_v}} v_j N_{m,j,1}^{(o)} / \sum_{j=j_{J_v-1}+1}^{j_{J_v}} v_j \quad (2-47)$$

for $1 \leq m \leq m_{\text{max}}$

$$E_{J_v,n}^{(o)\text{th}} = 0 \quad (2-48)$$

$$w_{J_v,n}^{(o)} = \left(\sum_{m=1}^{m_{\text{max}}^{\text{fuel}}} \left(\frac{A_m^{\text{wt}}}{602.5} \right) N_{m,j_{J_v},n}^{(o)} \right) \left(\sum_{j=j_{J_v-1}+1}^{j_{J_v}} v_j \right) \quad (2-49)$$

If $\delta_1^{(a)} \leq 3$ Go to statement preceding Statement 2-53 (2-50)

Calculate the beginning-of-cycle fuel isotopic concentrations for each fuel batch in the equilibrium operating cycle as follows:

$$N_{m,j,i}^{(o)} = \sum_{n=1}^{m-1} A_{m,n} (E_{n,j}^i - E_{m,j}^i) + N_{m,j,1}^{(o)} E_{m,j}^i \quad (2-51)$$

where $E_{m,j}^i = \exp(-10^{-24} \sigma_{m,j} Z_j i)$,

for $(0 \leq i \leq NP = N_{J_v}^{bat} / N_{dis}^{J_v})$

note for $N_{dis}^{J_v}$ greater than 1, $N_{m,j,1}^{(o)}$ will be the same for 2 or more batches.

Equation 2-51 is solved using the burnup sequence in Section 3.3.2. The accumulated batch average energy by zone, $E_{J_v,n}^{(o)th}$ is also computed according to Statement 3-33 and the accumulated fuel weight, $W_{J_v,n}^{(o)}$ (2-52) is computed from equation 2-48.

End loop on j.

End loop on v

If $0 < \delta_1^{(a)} \leq 3$, Set $N_{dis}^{(J)'} = N_J^{bat}$ for

$$1 \leq J \leq J_{max} \quad (2-53)$$

If $4 \leq \delta_1^{(a)} \leq 6$ or $\delta_1^{(a)} = 0$ Set $N_{dis}^{(J)'} = N_{dis}^{(J)}$

for $1 \leq J \leq J_{max}$

Calculate $N_{m,j,n}^{(o)}$, $E_{J,n}^{(o)th}$ and $W_{J,n}^{(o)}$ for zones of fixed initial composition as in Section 3.3.9.

$$\text{Set } R^{(b)} = 0 \quad (2-54)$$

Do loop on v ($v_o^{in} \leq v \leq v_{max}$)

$$\underline{\text{Set}} f_v^{(1)} = f_v^{(2)} = R_v^{(1)} = R_v^{(2)} = P_v^{(1)} = P_v^{(2)} = N_v^{(1)} = N_v^{(2)} = 0. \quad (2-55)$$

$$\underline{\text{Set}} L_v = 3. \quad (2-56)$$

$$\underline{\text{Set}} m_{1,v}^{rec1}, m_{1,v}^{rec2}, m_{2,v}^{rec1}, m_{2,v}^{rec2}, (\delta_{rec1,v}^{totU}), \text{ and } (\delta_{rec2,v}^{totU}), \text{ as per statements (3-193), (3-194), and (3-194a).} \quad (2-57)$$

$$\underline{\text{Set}} f_v^{(3)} = 1. \quad (2-58)$$

$$\underline{\text{If}} N_v^{fuel} = 0, \underline{\text{calculate}} N_v^{fuel} = \sum_{m=1}^{m_{max}^{fuel}} N_{m,j_v}^{(o)}, N_J^{bat} \quad (2-59)$$

$$\underline{\text{If}} \delta_{pois} = 1 \text{ and } N_{m_{max},v}^{(o)} = 0, \underline{\text{calculate}} \quad (2-60)$$

$$N_{m_{max},v}^{(o)} = N_{m_{max},j_v}^{(o)}, N_J^{bat}.$$

$$\underline{\text{Calculate}} R_v^{(3)} \text{ and } N_v^{(3)} \text{ as per statements (3-206) and (3-208); and} \quad (2-61)$$

$$\underline{\text{compute}} R_v^{(4)} \text{ and } N_v^{(4)} \text{ as per statement (3-208a).}$$

$$\underline{\text{Calculate}} R_v^{(b)} = \sum_{j=j_{J_v}-1+1}^{j_{J_v}} \sum_{m=1}^{m_{max}} R_{m,j} \sum_{n=N_J^{bat}-N_{dis}^{(J_v)}+1}^{N_{dis}^{(J_v)}} N_{m,j,n}^{(o)} \quad (2-62)$$

$$\text{if } N_{dis}^{(J_v)} > 0.$$

$$R_v^{(b)} = 0 \quad \text{if } N_{dis}^{(J_v)} = 0. \quad (2-63)$$

$$R^{(b)} = R^{(b)} + R_v^{(b)} \quad (2-64)$$

$$\text{Calculate } P_v^{(a)} = \sum_{j=j_{J_v}-1+1}^{j_{J_v}} v_{j\phi_j} \sum_{m=1}^{m_{\max}^{\text{fuel}}} \sigma_{f_{m,j}} \sum_{n=1}^{N_J^{\text{bat}}} N_{m,j,n}^{(o)} \quad (2-65)$$

$$\text{If } P_v = 0, \text{ calculate } P_v = P_v^{(a)} / P_{v_o}^{(a)} \quad (2-66)$$

$$\text{If } v = v_o^{\text{in}}, \text{ set } v_o = v \text{ if } N_{dis}^{(J_v)} > 0, \text{ set } v_o = v + 1 \text{ if } N_{dis}^{(J_v)} = 0. \quad (2-67)$$

$$\text{If } v > v_o^{\text{in}} \text{ and if } v = v_o, \text{ set } v_o = v + 1 \text{ if } N_{dis}^{(J_v)} = 0. \quad (2-68)$$

End loop on v.

Go to First Flux Adjustment - statement (3-1).

If $\delta_1^{(a)} = 0$ and $\delta_{\text{restart}} = 0$, Read $N_{m,j,n}^{\text{input}}$ (data block 29) and set

$$N_{m,j,n}^{(o)} = N_{m,j,n}^{\text{input}} \quad (2-69)$$

for $1 \leq J \leq J_{\text{max}}; j_{J-1} + 1 \leq j \leq j_J; 1 \leq n \leq N_J^{\text{bat}}; 1 \leq m \leq m_{\text{max}}.$

If $\delta_1^{(a)} = 0$ and $\delta_{\text{restart}} = 1$, Read data blocks 29, 30A, 30B, 30C, 33, (2-70) and 35 (not necessarily in that order - see Section 3.4.7).*

If $\delta_1^{(a)} = 0$ and $\delta_{\text{restart}} = 1$, also read sub-blocks of data block 36,37, (2-71)

and 38 and arrange on peripheral unit to the extent required by computer memory limits. (blocks 37 and 38 are required only if $N_{\text{max}}^{\text{stor}} > 0$.)*

Go to interpolation Routine - Statement (3-129a).

If $\delta_1^{(a)} = 0$ and $\delta_{\text{restart}} = 0$, Read "Fuel Batch Energy Data ($E_{J,n}^{(o)}$)th" (2-72)

for $1 \leq J \leq J_{\text{max}}$ and $1 \leq n \leq N_J^{\text{bat}}$ and "Fuel Discharge Data" ($N_{\text{dis}}^{(J)}$ and n_J^{dis})*. This is data block 30A and 30B.

If $\delta_{\text{switch}}^{\text{interp}} > 0$, set $R^{\text{int}} = A^{\text{int}}$ (2-73)

* The option $\delta_1^{(a)} = 0$ is not included in the present version of the code.

If $\delta_{\text{switch}}^{\text{interp}} = 0$, calculate

$$R^{\text{int}} = \frac{G_o + \sum_{L=1}^{L_{\text{max}}} G_L \sum_{\ell'=1}^{\ell'_{\text{max}}} \sum_{j=j_{J_{\ell'}-1}+1}^{j_{J_{\ell'}}} v_j^{(a)} \sum_{n=1}^{N_{J_{\ell'}}^{\text{bat}}} N_{M_L,j,n}^{(o)}}{H_o + \sum_{L=1}^{L_{\text{max}}} H_L \sum_{\ell'=1}^{\ell'_{\text{max}}} \sum_{j=j_{J_{\ell'}-1}+1}^{j_{J_{\ell'}}} v_j^{(a)*} \sum_{n=1}^{N_{J_{\ell'}}^{\text{bat}}} N_{M_L,j,n}^{(o)}} \quad (2-74)$$

and adjustments of R^{int} as per statements (3-131) thru (3-137).

$v_j^{(a)*}$ is 1, $v_j^{(a)}$, or $\phi_j^{(a)}$ as per Equation (2-26).

Calculate $N_{m,j}^{(r)}$ as per statement (3-138); and also $R_{m,j}$, $\sigma_{f,m,j}$, $\sigma_{c,m,j}$,

ϕ_j , V_j , and K_{ref} as per statements (3-139) through (3-145) and accompanying instructions.

Calculate (for $1 \leq n \leq N_J^{\text{bat}}$, $1 \leq J \leq J_{\text{max}}$)

$$W_{J,n}^{(o)} = \sum_{j=j_{J_v-1}+1}^{j_{J_v}} v_j \sum_{m=1}^{M_{\text{max}}^{\text{fuel}} + n_{\text{fp}}} \left(\frac{A_m^{\text{wt}}}{602.5} \right) (N_{m,j,n}^{(o)}) \quad (2-75)$$

Return to Equation (2-54).

3.3 Computations in Operating Interval Loop (Except Output Routine)

3.3.1 First Flux Adjustment (Based on Rated Power at Beginning of Operating Interval)

Flux normalization factor is set $R_p = 1$ if $\delta_{\text{norm}}^{\text{th}} = 1$. (3-1)

If $\delta_{\text{norm}}^{\text{th}} = 0$, calculate

$$R_p = \frac{p^{\text{th}}}{1.6 \times 10^{-19} \sum_{j=1}^{j_{\text{max}}} \sum_{j=j_{j-1}+1}^{j_j} v_j \phi_j \sum_{m=1}^{m_{\text{max}}^{\text{fuel}}} E_m \sigma_{f,m,j} \sum_{n=1}^{N_j^{\text{bat}}} N_{m,j,n}^{(o)}} \quad (3-2)$$

Set $I_t = 0$. (3-3)

Set $R_p^{(1)} = 0$, $p_o^{\text{th}} = 0$, $\bar{p}_1^{\text{th}} = 0$. (3-4)

Set $\phi_j = R_p \phi_j$ for $1 \leq j \leq j_{\text{max}}$. (3-5)

If $i = 1$, set $\delta_{\text{burn}} = 0$ and $\delta_{\text{only}}^{\text{stor}} = 0$. (3-5a)

3.3.2 Isotopic Concentrations at End of Operating Interval

Calculate irradiation fluences

$$Z_j = 8.64 \times 10^4 T f \phi_j \text{ for } 1 \leq j \leq j_{\text{max}}, \quad (3-6)$$

$$\text{and } \sigma_{r,m,j} = \sigma_{f,m,j} + \sigma_{c,m,j} \text{ for } 1 \leq j \leq j_{\text{max}}; 1 \leq m \leq m_{\text{max}}. \quad (3-7)$$

If $m_{\max}^{\text{fuel}} = 5, 7, \text{ or } 11$, calculate

$$\sigma_{r_{4,j}} = \sigma_{r_{4,j}} + \left(\frac{10^{24} \lambda_{241}}{f \phi_j} \right) \text{ for } 1 \leq j \leq j_{\max} \quad (3-8)$$

If $m_{\max}^{\text{fuel}} = 6 \text{ or } 11$, calculate

$$\sigma_{r_{m_{\max}^{\text{fuel}}-4,j}} = \sigma_{r_{m_{\max}^{\text{fuel}}-4,j}} + \left(\frac{10^{24} \lambda_{233}}{f \phi_j} \right) \quad (3-9)$$

Do loop on J ($1 \leq J \leq J_{\max}$) through statement (3-39). (3-10)

Set $E_{J,n}^{\text{th}} = 0$ for $1 \leq n \leq N_J^{\text{bat}}$ (3-11)

Do loop on j ($j_{J-1} + 1 \leq j \leq j_J$) through statement (3-39). (3-12)

If $j = j_{\text{pk}}$, set $P_{j_{\text{pk}},n}^{\text{th}} = 0$ for $1 \leq n \leq N_J^{\text{bat}}$ and set $J_{\text{pk}} = J$. (3-13)

If $m_{\max}^{\text{fuel}} = 6$ or if $\sum_{m=1}^5 \sum_{n=1}^{N_J^{\text{bat}}} N_{m,j,n}^{(o)} = 0$, set $m_{\text{hi}} = m_{\max}^{\text{fuel}}$; (3-14) *

and set $m_{\text{low}} = 1$ if $m_{\max}^{\text{fuel}} = 6$, set $m_{\text{low}} = 6$ if $m_{\max}^{\text{fuel}} \neq 6$.

Otherwise set $\delta_{\text{ur}} = 1$, $m_{\text{low}} = 1$, $m_{\text{hi}} = 5$. (3-15) *

* These instructions need be executed for only the first region, $j = j_{J-1} + 1$, of each zone J .

$$\text{If } m^{\text{fuel}} = 5 \text{ or } 7, \text{ or } 11, \text{ and } \sum_{m=6}^9 \sum_{n=1}^{N_J^{\text{bat}}} N_{m,j,n}^{(o)} = 0, \text{ set } \delta_{\text{thor}} = 0.$$

(3-16)*

$$\text{If } \delta_{\text{ur}} = 0, \text{ also set } m_{\text{low}} = m_{\text{max}}^{\text{fuel}} - 1.$$

$$\text{Otherwise, set } \delta_{\text{thor}} = 1.$$

(3-17)*

$$\text{If } \delta_{\text{thor}} = 1, \text{ or if } m_{\text{max}}^{\text{fuel}} = 5, \text{ or if } \sum_{n=1}^{N_J^{\text{bat}}} N_{m_{\text{max}}^{\text{fuel}}-1,j,n}^{(o)} = 0,$$

$$\text{set } \delta_{235} = 0.$$

(3-18)*

$$\text{Otherwise, set } \delta_{235} = 1.$$

(3-19)*

$$\text{Do loop on } n \text{ (} 1 \leq n \leq N_J^{\text{bat}} \text{) through statement (3-39).}$$

(3-20)

$$\text{If } \delta_{235} = 0 \text{ and } m_{\text{low}} = m_{\text{max}}^{\text{fuel}} - 1, \text{ bypass loop on } m - \text{ see statement (3-23)} \quad (3-21)$$

$$\text{Set } N_{(m_{\text{max}}^{\text{fuel}}+n_{\text{fp}}),j,n}^{(e)} = N_{(m_{\text{max}}^{\text{fuel}}+n_{\text{fp}}),j,n}^{(o)} \text{ for } 1 \leq n_{\text{fp}} \leq n_{\text{fp}}^{\text{max}}. \quad (3-22)$$

* See footnote on preceding page.

Do loop on m ($m_{\text{low}} \leq m \leq m_{\text{hi}}$) through statement (3-35). (3-23)

If $m = m_{\text{low}}$ and $m_{\text{low}} = 1$, set $n_{\text{fp}} = 1$. (3-24)

If $m = m_{\text{low}}$ and $m_{\text{low}} \neq 1$, set $n_{\text{fp}} = n_{\text{fp}}^{\text{max}}$. (3-25)

If $m = m_{\text{low}}$, set $A_{1, m_{\text{low}}} = N_{m, j, n}^{(o)}$. (3-26)

Set $m'' = m + 1 - m_{\text{low}}$. (3-27)

If $m > m_{\text{low}}$, calculate $A_{m'', m'}$ for $m_{\text{low}} \leq m' \leq m - 1$ as follows:

$$A_{m'', m'} = A_{m''-1, m'} \left[\frac{(1 - \delta_{m, m_{233}+1}) \sigma_{c, m-1, j} + \delta_{m, m_{233}+1} \left(\frac{10^{24} \lambda_{233}}{f \phi_j} \right)}{\sigma_{r, m, j} - \sigma_{r, m', j}} \right] \quad (3-28)$$

$$+ \delta_{m, m_{233}+2} (\delta_{m', m_{233}-1} + \delta_{m', m_{233}}) \left(\frac{\sigma_{c, m_{233}, j} A_{m_{233}, m'}}{\sigma_{r, m, j} - \sigma_{r, m', j}} \right)$$

$$\text{and also } A_{m'', m} = N_{m, j, n}^{(o)} - \sum_{m'=m_{\text{low}}}^{m-1} A_{m'', m'} \quad (3-29)$$

Calculate $e_m = \exp(-10^{24} \sigma_{r,m,j} z_j)$ (3-30) *

$$N_{m,j,n}^{(e)} = \sum_{m'=m_{low}}^m A_{m'',m'} e_{m'} \quad (3-31)$$

Calculate contribution of material m to fission-product concentration and to energy production:

$$N_{(m_{max}^{fuel} + n_{fp}),j,n}^{(e)} = N_{(m_{max}^{fuel} + n_{f,p}),j,n}^{(e)} \quad (3-32)$$

$$+ z_j \sum_{m'=m_{low}}^m \sigma_{f,m',j} A_{m'',m'} \left(\frac{1 - e_{m'}}{10^{-24} \sigma_{r,m',j} z_j} \right)$$

$$E_{J,n}^{th} = E_{J,n}^{th} + 1.855 \times 10^{-24} v_j z_j$$

(3-33)

$$\sum_{m'=m_{low}}^m \left[E_{m',j} \sigma_{f,m',j} A_{m'',m'} \left(\frac{1 - e_{m'}}{10^{-24} \sigma_{r,m',j} z_j} \right) \right]$$

* This instruction need be executed only for the first batch of each region (for n=1 only in the n-logs).

If $j = j_{pk}$, calculate

$$p_{j_{pk},n}^{th} = p_{j_{pk},n}^{th} + 1.855 \times 10^{-24} z_j$$

(3-34)

$$\sum_{m' = m_{low}}^m \left[E_{m', \sigma_{f_{m',j}}} A_{m'',m'} \left(\frac{1 - e_{m'}}{10^{-24} \sigma_{r_{m',j}} z_j} \right) \right]$$

End of m loop.

If $m_{low} = 1$, and $\delta_{ur} = 1$, and $\delta_{thor} = 1$, set $m_{low} = 6$ and

(3-35)

$$m_{hi} = 11.$$

Repeat loop on m - see statement (3-23).

If $m_{low} = 1$, $\delta_{ur} = 1$, $\delta_{thor} = 0$, and $\delta_{235} = 1$,

(3-36)

$$\text{set } m_{low} = m_{max}^{fuel} - 1 \text{ and } m_{hi} = m_{max}^{fuel}.$$

Repeat loop on m.

If $m_{low} = 1$, $\delta_{thor} = 0$, and $\delta_{235} = 0$; or if $m_{low} = 6$; (3-37)

or if $m_{low} = 10$, then calculate poison concentrations

as follows:

If $\delta_{pois} = 0$, go past statement (3-39) to End of Loop statements. (3-38)

If $\delta_{pois} = 1$ and $N_{m_{max},j,n}^{(o)} > 0$, calculate

$$N_{m_{max},j,n}^{(e)} = N_{m_{max},j,n}^{(o)} \exp(-10^{-24} \sigma_{r_{m_{max},j}} Z_j) \quad (3-39)$$

End of n loop; end of j loop; end of J loop.

3.3.3 Second Flux Adjustment (Based on Rated Power Averaged Over Operating Interval) and Power Criteria Tests

Calculate

$$\bar{p}^{th} = \left(\sum_{J=1}^{J_{\max}} \sum_{n=1}^{N_J^{bat}} E_{J,n}^{th} \right) / 8.64 \times 10^4 \text{ Tf} \quad (3-40)$$

$$\text{If } \delta_{\text{norm}}^{th} = 1, \text{ go to statement (3-51).} \quad (3-41)$$

$$\text{If } I_t = 2, \text{ go to statement (3-51).} \quad (3-42)$$

$$\text{If } |\bar{p}^{th} - p^{th}| \leq \epsilon_p^{(1)} p^{th} \text{ to to statement (3-52).} \quad (3-43)$$

$$\text{Set } \bar{p}_1^{th} = \bar{p}^{th} \text{ and } R_p^{(1)} = R_p \quad (3-44)$$

Calculate

$$p_e^{th} = \sum_{J=1}^{J_{\max}} \sum_{j=j_{J-1}+1}^{j_J} v_j \phi_j \sum_{m=1}^{m_{\max}^{fuel}} E_m \sigma_{f,m,j} \sum_{n=1}^{N_J^{bat}} N_{m,j,n}^{(e)} \quad (3-45)$$

$$a_r = \frac{1}{R_p^{(1)}} \log_e \frac{p_1^{th}}{p_e^{th}} \quad (3-46)$$

$$R_p = \frac{1}{a_r} [\log_e (1 - a_r R_p^{(1)})] \quad (3-47)$$

(Note that $R_p \rightarrow R_p^{(1)}$ as $a_r \rightarrow 0$.)

$$\text{Set } I_t = 2. \quad (3-48)$$

$$\text{Set } P_o^{th} = \frac{R_p}{R_p^{(1)}} P^{th} \quad (3-49)$$

$$\text{Set } \phi_j = \frac{R_p}{R_p^{(1)}} \phi_j \text{ for } 1 \leq j \leq j_{\max} \quad (3-50)$$

Return to statement (3-6) and repeat all calculations for end-of-interval isotopic concentrations through statement (3-40).

$$\text{If } |\bar{P}_{th} - P^{th}| > \epsilon_p^{(2)} P^{th}, \text{ set } I_{halt} = 1 \text{ and go to output calculations.} \quad (3-51)$$

3.3.4 Test on Reactivity Criterion, Calculation of Burnup Reactivity,
and Adjustment of Fissile Loading Parameter

Calculate

$$K = K_{\text{ref}} + \sum_{J=1}^{J_{\text{max}}} \sum_{j=j_{J-1}+1}^{j_J} \sum_{m=1}^{m_{\text{max}}} \quad (3-52)$$

$$R_{m,j} \left[\left(\sum_{n=1}^{N_J^{\text{bat}}} N_{m,j,n}^{(e)} \right) - N_{m,j}^{(r)} \right]$$

If $(K^{(e)} - \Delta K^-) \leq K \leq (K^{(e)} + \Delta K^{(e)})$ is satisfied, calculate (3-53)

$$(\Delta K)_{\text{burnup}} = \sum_{J=1}^{J_{\text{max}}} \sum_{j=j_{J-1}+1}^{j_J} \sum_{m=1}^{m_{\text{max}}} R_{m,j} \quad (3-54)$$

$$\sum_{n=1}^{N_J^{\text{bat}}} (N_{m,j,n}^{(e)} - N_{m,j,n}^{(o)})$$

and go to statement (3-58).

If $i \geq i_{\max}$, set $I_{\text{halt}} = 2$ and go to output calculations. (3-54a)

If $N_{J_v}^{\text{recl}} \leq N_{\max}^{\text{stor}}$ for all v ($1 \leq v \leq J_{\max}$), calculate $(\Delta K)_{\text{burnup}}$ as (3-54b)
per statement (3-54) and go to statement (3-395).

If $i = 1$, set $K^{(i-1)} = K$. (3-54c)

If $i = 1$, or if $\delta_{\text{burn}} = 1$ or if $\delta_{\text{only}}^{\text{stor}} = 1$, calculate (3-55)

$$\Delta K_{\text{adj}} = K^{(e)} - K^{(i-1)}.$$

If $i > 1$, and if $\delta_{\text{burn}} = 0$, and if $\delta_{\text{only}}^{\text{stor}} = 0$,

set $K^{(i-2)} = K^{(i-1)}$; $K^{(i-1)} = K$ (3-56)

and calculate $\Delta K_{\text{adj}} = \frac{(K^{(e)} - K^{(i-2)}) (K^{(e)} - K^{(i-1)})}{K^{(i-1)} - K^{(i-2)}}$ (3-57)

Set $i = i + 1$ and go to statement (3-242) - "Fissile Content Adjustments for Next Iteration". (3-57a)

Tests on Burnup, Power Peaking, and Control Criteria

For those zones b ($1 \leq b \leq J_{\max}$) with $JB_{J_b} \neq 0$, and $N_{dis}^{(J_b)} \neq 0$ (3-58)

$$B^{(1)} = \frac{\sum_{n=1}^{N_{dis}^{(J_b)}} E_{J_b,n}^{th}}{10^{-3} \sum_{n=1}^{N_{dis}^{(J_b)}} W_{J_b,n}^{(o)}} \quad (3-59)$$

$$B^{(o)} = \frac{\sum_{n=1}^{N_{dis}^{(J_b)}} E_{J_b,n}^{(o)th}}{10^{-3} \sum_{n=1}^{N_{dis}^{(J_b)}} W_{J_b,n}^{(o)}} \quad (3-60)$$

$$B = B^{(o)} + B^{(1)} \quad (3-61)$$

If $B_{test} > 0$ and $\Delta B_{test} > 0$, check if

$$(B_{test} - \Delta B_{test}) \leq B \leq (B_{test} + \Delta B_{test}) \quad (3-62)$$

If statement (3-62) is satisfied, or if either B_{test} or

ΔB_{test} is zero, go to statement (3-82). (3-63)

If statement (3-62) is not satisfied and if either $\delta_{\text{burn}} = 1$ or (3-64)

$\delta_{\text{only}}^{\text{stor}} = 1$, then set $I_{\text{halt}} = 3$ and go to output calculations.

If statement (3-62) is not satisfied and $\delta_{\text{burn}} = 0$ (with $i < i_{\text{max}}$)

set $\delta_{\text{burn}} = 1$ and set $i = i + 1$. (3-65)

If $B > (B_{\text{test}} + \Delta B_{\text{test}})$, go to statement (3-72). (3-66)

Test if $T \left(\frac{B_{\text{test}} - \Delta B_{\text{test}} - B}{B^{(1)}} \right) \leq \Delta T$. (3-67)

If statement (3-67) is not satisfied, set $I_{\text{halt}} = 3$ and go to output calculations. (3-68)

Test if $T \left(\frac{B_{\text{test}} - B}{B^{(1)}} \right) \leq \Delta T$ (3-69)

If statement (3-69) is satisfied, calculate

$$T = T_{\text{orig}} \left(\frac{B_{\text{test}} - \frac{1}{2} \Delta B_{\text{test}} - B^{(0)}}{B^{(1)}} \right) \quad (3-70)$$

If statement (3-69) is not satisfied, calculate

$$T = \frac{T_{\text{orig}}}{2} \left[1 + \frac{\Delta T}{T_{\text{orig}}} + \left(\frac{B_{\text{test}} - \Delta B_{\text{test}} - B^{(0)}}{B^{(1)}} \right) \right] \quad (3-71)$$

Go to statement (3-79).

$$\text{Test if } T \left(\frac{B - B_{\text{test}} - \Delta B_{\text{test}}}{B^{(1)}} \right) \leq \Delta T \quad (3-72)$$

If statement (3-72) is not satisfied, set $I_{\text{halt}} = 3$ and go to output calculations. (3-73)

$$\text{Test if } (B - B_{\text{test}} - \Delta B_{\text{test}}) \leq B^{(1)} \quad (3-74)$$

If statement (3-74) is not satisfied, set $I_{\text{halt}} = 3$ and go to output calculations. (3-75)

$$\text{Test if } T \left(\frac{B - B_{\text{test}}}{B^{(1)}} \right) \leq \Delta T \quad (3-76)$$

If statement (3-76) is satisfied, calculate

$$T = T_{\text{orig}} \left(\frac{B_{\text{test}} + \frac{1}{2} \Delta B_{\text{test}} - B^{(o)}}{B^{(1)}} \right) \quad (3-77)$$

If statement (3-76) is not satisfied, calculate

$$T = \frac{T_{\text{orig}}}{2} \left[1 - \frac{\Delta T}{T_{\text{orig}}} + \left(\frac{B_{\text{test}} + \Delta B_{\text{test}} - B^{(o)}}{B^{(1)}} \right) \right] \quad (3-78)$$

$$\text{Set } \Delta K_{\text{adj}}^{(i-1)} = \Delta K_{\text{adj}} \text{ and } K^{(i-1)} = K, \text{ and} \quad (3-79)$$

$$\text{calculate } \Delta K_{\text{adj}} = \Delta K_{\text{adj}}^{(i-1)} - \left(\frac{T - T_{\text{orig}}}{T_{\text{orig}}} \right) (\Delta K)_{\text{burnup}}. \quad (3-80)$$

Go to statement (3-242) - "Fissile Content Adjustment for
Next Iteration". (3-81)

For those zones p ($1 \leq p \leq J_{\max}$) with $JP_J = 2$

$$p^{pk} = \left(\sum_{n=1}^{N_J^{bat}} p_{j_{pk}}^{th} \right) \left(\sum_{p=1}^{p_{\max}} \sum_{j=j_{J_p-1}+1}^{j_{J_p}} v_j \right) / \sum_{p=1}^{p_{\max}} \sum_{n=1}^{N_J^{bat}} E_{J_p,n}^{th} \quad (3-82)$$

If $p^{pk} > p_{\text{test}}^{pk}$, set $I_{\text{halt}} = 4$, and go to output calculations. (3-83)

If $|(\Delta K)_{\text{burnup}}| > (\Delta K)_{\text{control}}^{\text{burn}}$, set $I_{\text{halt}} = 5$, and go to
output calculations. (3-84)

3.3.5 Adjustments of Recycled Fuel Repositories for Loaded Fuel

For $1 \leq J \leq J_{\max}$, do the following:

$$\underline{\text{Set}} \ N'_{\text{dis}}^{(J)} = N_{\text{dis}}^{(J)} \quad (3-85)$$

$$\underline{\text{If}} \ I > I_J^{\text{nu}}, \underline{\text{set}} \ N_{\text{dis}}^{(J)} = N_c^{(J)} \quad (3-86)$$

$$\underline{\text{If}} \ I \leq I_J^{\text{nu}}, \underline{\text{calculate}} \quad (3-87)$$

$$n' = (I - I_{\text{init}} + 1) - I_J^{\text{cy}} \left[\text{highest integer} \leq \left(\frac{I - I_{\text{init}}}{I_J^{\text{cy}}} \right) \right]$$

$$\underline{\text{and set}} \ N_{\text{dis}}^{(J)} = N_{n'}^{(J)} \quad (3-88)$$

$$\underline{\text{If}} \ I = I_{\text{init}} \text{ and } \delta_{\text{restart}} = 0, \underline{\text{go to}} \text{ statement (3-114)}. \quad (3-88a)$$

For Recycle Repositories $(N_{\text{max}}^{\text{stor}} + 1) \leq N \leq N_{\text{max}}^{\text{Pu}}$ and $0 \leq I_h \leq 3$, do following:

$$w_{m,N}^{(I_h)} = \frac{w_{m,N}^{(I_h)} w_N^{(I_h)}}{\sum_{m=2}^5 w_{m,N}^{(I_h)}} \text{ for } 2 \leq m \leq 5. \quad (3-89)$$

For $N_{\max}^{\text{Pu}} + 1 \leq N \leq N_{\max}^{\text{fisU}}$ and $0 \leq I_h \leq 3$, do the following:

$$w_{m,N}^{(I_h)} = \frac{w_{m,N}^{(I_h)} w_N^{(I_h)}}{\sum_{m=m_{\max}^{\text{fuel}}-3+2\delta_{7,m}^{\text{fuel}}}^{m_{\max}^{\text{fuel}}} w_{m,N}^{(I_h)}} \quad \text{for } (m_{\max}^{\text{fuel}} - 3 + 2\delta_{7,m}^{\text{fuel}}) \leq m \leq m_{\max}^{\text{fuel}} \quad (3-90)$$

For $N_{\max}^{\text{fisU}} + 1 \leq N \leq N_{\max}^{\text{totU}}$ and $0 \leq I_h \leq 3$, do the following:

$$w_{m,N}^{(I_h)} = \frac{w_{m,N}^{(I_h)} w_N^{(I_h)}}{w_{1,N}^{(I_h)} + \sum_{m=m_{\max}^{\text{fuel}}-3+2\delta_{7,m}^{\text{fuel}}}^{m_{\max}^{\text{fuel}}} w_{m,N}^{(I_h)}} \quad (3-91)$$

for $m = 1$ and for $(m_{\max}^{\text{fuel}} - 3 + 2\delta_{7,m}^{\text{fuel}}) \leq m \leq m_{\max}^{\text{fuel}}$.

3.3.6 Adjustments of Recycle and Stored Fuel Repository Records for Discharged Fuel

Go to statement (3-103).* (3-92)

Do loop on N ($1 \leq N \leq N_{\max}^{\text{stor}}$). (3-93)

If $I_{\max}^{\text{stor}} > 1$, do loop on I_h ($I_{\max}^{\text{stor}} \geq I_h \geq 2$). (3-94)

$$W_{m,N}^{(I_h)} = W_{m,N}^{(I_h-1)} e^{-8.64 \times 10^4 T_{\delta_{m,m}}^{241} \lambda_{241}} \quad \text{for } 1 \leq m \leq m_{\max}. \quad (3-95)$$

$$E_N^{(I_h)^{\text{th}}} = E_N^{(I_h-1)^{\text{th}}} \quad (3-96)$$

End loop on I_h .

* It is computationally more efficient to bypass statements (3-93) through (3-101) at this point, and to perform these operations later during the output routine - see Section 3.4.5.8.

Calculate for $1 \leq m \leq m_{\max}$,

$$W_{m,N}^{(1)} = (1 - \delta_{m,m_{233}}) W_{m,N}^{(o)} e^{-8.64 \times 10^4 T \delta_{m,m_{241}} \lambda_{241}} + \delta_{m,m_{233}+1} W_{m_{233},N}^{(o)} \quad (3-97)$$

$$W_{m,N}^{(o)} = 0. \quad (3-97a)$$

Calculate

$$E_N^{(1)th} = E_N^{(o)th} \quad (3-98)$$

$$E_N^{(o)th} = 0 \quad (3-98a)$$

End Loop on N.

Do loop on d ($1 \leq d \leq J_{\max}$)

Skip to next d if $N_d^{stor} > N_{\max}^{stor}$

(3-99)

$$W_{m,N_d^{stor}}^{(o)} = \left(\frac{A_m^{wt}}{602.5} \right) v_{j_{J_d}} \sum_{n=1}^{N_{dis}^{(J_d)}} N_{m,j_{J_d},n} \quad (3-100)$$

$$E_N^{(o)th} = \sum_{n=1}^{N_{dis}^{(J_d)}} E_{J_d,n}^{(o)th} \quad (\text{see statement 4-13}). \quad (3-101)$$

End loop on d.

Go to statement (4-245).

(3-102)

If $(N_{\max}^{\text{Pu}} - N_{\max}^{\text{stor}}) > 0$ and if $m_{\max}^{\text{fuel}} \neq 6$, do loop on N

$$(N_{\max}^{\text{stor}} + 1 \leq N \leq N_{\max}^{\text{Pu}})$$

(3-103)

Calculate for $2 \leq m \leq 5$,

$$W_{m,N}^{(3)} = (W_{m,N}^{(2)} + W_{m,N}^{(2)}) e^{-8.64 \times 10^4 T_{m,m_{241}} \delta_{m,m_{241}} \lambda_{241}} \quad (3-104)$$

$$W_{m,N}^{(2)} = W_{m,N}^{(1)} e^{-8.64 \times 10^4 T_{m,m_{241}} \delta_{m,m_{241}} \lambda_{241}} \quad (3-105)$$

$$W_{m,N}^{(1)} = W_{m,N}^{(0)} e^{-8.64 \times 10^4 T_{m,m_{241}} \delta_{m,m_{241}} \lambda_{241}} \quad (3-106)$$

$$W_{m,N}^{(0)} = 0. \quad (3-107)$$

End loop on N $(N_{\max}^{\text{stor}} + 1 \leq N \leq N_{\max}^{\text{Pu}})$.

If $(N_{\max}^{\text{fisU}} - N_{\max}^{\text{Pu}}) > 0$ and $m_{\max}^{\text{fuel}} \neq 5$, do loop on N ,

$$(N_{\max}^{\text{Pu}} + 1 \leq N \leq N_{\max}^{\text{fisU}}). \quad (3-108)$$

Calculate for $(m_{\max}^{\text{fuel}} - 3 + 2\delta_{7, m_{\max}^{\text{fuel}}}) \leq m \leq m_{\max}^{\text{fuel}}$,

$$W_{m,N}^{(3)} = W_{m,N}^{(3)} + W_{m,N}^{(2)} \quad (3-109)$$

$$W_{m,N}^{(2)} = W_{m,N}^{(1)} \quad (3-110)$$

$$W_{m,N}^{(1)} = W_{m,N}^{(0)} + \delta_{m, m_{233}+1} W_{m_{233}, N}^{(0)} \quad (3-111)$$

$$W_{m,N}^{(0)} = 0. \quad (3-112)$$

End loop on N $(N_{\max}^{\text{Pu}} + 1 \leq N \leq N_{\max}^{\text{fisU}})$.

If $(N_{\max}^{\text{totU}} - N_{\max}^{\text{fisU}}) > 0$, and if $m_{\max}^{\text{fuel}} > 6$, do loop on N , (3-113)

$$(N_{\max}^{\text{fisU}} + 1 \leq N \leq N_{\max}^{\text{totU}}).$$

Calculate for $m = 1$ and for $(m_{\max}^{\text{fuel}} - 3 + 2\delta_{7, m_{\max}^{\text{fuel}}}) \leq m \leq m_{\max}^{\text{fuel}}$,

the same as statements (3-109) through (3-112).

End loop on N $(N_{\max}^{\text{fisU}} + 1 \leq N \leq N_{\max}^{\text{totU}})$.

Do loop on d ($1 \leq d \leq J_{\max}^{\text{stor}}$) (3-114)
 Skip to next d if both $N_d^{\text{stor}} \leq N_{\max}^{\text{stor}}$ and $N_d^{\text{stor}^2} \leq N_{\max}^{\text{stor}}$

If $m_{\max}^{\text{fuel}} \neq 6$, calculate

$$W_{m, N_d^{\text{Pu rec}}}^{(o)} = F_{\text{mult}}^{(N_d^{\text{Pu rec}})} (1-L_{\text{repr}}) (1-L_{\text{fab}}) \left(\frac{A_m^{\text{wt}}}{602.5} \right)$$

(3-115)

$$\cdot \sum_{j=j_{J_d-1}+1}^{j_{J_d}} v_j \sum_{n=1}^{N_{\text{dis}}^{(J_d)}} N_{m,j,n}^{(e)}$$

for $2 \leq m \leq 5$.

if $m_{\max}^{\text{fuel}} \neq 5$, calculate

$$W_{m, N_d^{\text{Urec}}}^{(o)} = F_{\text{mult}}^{(N_d^{\text{Urec}})} (1-L_{\text{repr}}) (1-L_{\text{fab}}) \left(\frac{A_m^{\text{wt}}}{602.5} \right)$$

(3-116)

$$\cdot \sum_{j=j_{J_d-1}+1}^{j_{J_d}} v_j \sum_{n=1}^{N_{\text{dis}}^{(J_d)}} N_{m,j,n}^{(e)}$$

for $m_{\max}^{\text{fuel}} - 3 + 2\delta_{7, m_{\max}^{\text{fuel}}} \leq m \leq m_{\max}^{\text{fuel}}$,

and also for $m = 1$ if $N_{\max}^{\text{fisU}} + 1 \leq N_d^{\text{Urec}} \leq N_{\max}^{\text{totU}}$.

If $m_{\max}^{\text{fuel}} = 6$ or 11, calculate

$$W_{m_{233}, N_d}^{(o), N_d^{\text{Urec}}} = F_{\text{mult}}^{(N_d^{\text{Urec}})} (1-L_{\text{repr}}) (1-L_{\text{fab}}) \left(\frac{A_m^{\text{wt}}}{602.5} \right)$$

$$\sum_{j=j_{J_d-1}+1}^{j_{J_d}} v_j \sum_{n=1}^{N_{\text{dis}}^{(J_d)}} N_{m_{233}, j, n}^{(e)} \quad (3-117)$$

End loop on d

Do loop on N ($N_{\max}^{\text{stor}} + 1 \leq N \leq N_{\max}^{\text{Pu}}$) if $m_{\max}^{\text{fuel}} \neq 6$.

Calculate

$$W_{m, N}^{(3)} = W_{m, N}^{(3)} + \sum_{I_h = I_h^{(N, 3)}}^2 W_{m, N}^{(I_h)} \quad \text{for } 2 \leq m \leq 5. \quad (3-119)$$

$$W_N^{(I_h)} = \sum_{m=2}^5 W_{m, N}^{(I_h)} \quad \text{for } 0 \leq I_h \leq 3. \quad (3-120)$$

End loop on N ($N_{\max}^{\text{stor}} + 1 \leq N \leq N_{\max}^{\text{Pu}}$)

Do loop on N ($N_{\max}^{\text{Pu}} + 1 \leq N \leq N_{\max}^{\text{totU}}$) if $m_{\max}^{\text{fuel}} \neq 5$. (3-121)

$$W_{m,N}^{(3)} = W_{m,N}^{(3)} + \sum_{I_h = I_h^{(N,3)}}^2 W_{m,N}^{(I_h)} \quad (3-122)$$

for $m_{\max}^{\text{fuel}} - 3 + 2\delta_{7,m_{\max}^{\text{fuel}}} \leq m \leq m_{\max}^{\text{fuel}}$.

$$W_N^{(I_h)} = \sum_{m=m_{\max}^{\text{fuel}}-3+2\delta_{7,m_{\max}^{\text{fuel}}}}^{m_{\max}^{\text{fuel}}} W_{m,N}^{(I_h)} \quad \text{for } 0 \leq I_h \leq 3. \quad (3-123)$$

End loop on N ($N_{\max}^{\text{Pu}} + 1 \leq N \leq N_{\max}^{\text{totU}}$).

Do loop on N ($N_{\max}^{\text{fisU}} + 1 \leq N \leq N_{\max}^{\text{totU}}$) if $m_{\max}^{\text{fuel}} > 6$. (3-124)

$$W_{1,N}^{(3)} = W_{1,N}^{(3)} + \sum_{I_h = I_h^{(N,3)}}^2 W_{1,N}^{(I_h)} \quad (3-125)$$

$$W_N^{(I_h)} = W_N^{(I_h)} + W_{1,N}^{(I_h)} \quad \text{for } 0 \leq I_h \leq 3. \quad (3-126)$$

End loop on N ($N_{\max}^{\text{fisU}} + 1 \leq N \leq N_{\max}^{\text{totU}}$).

Go to statement (4-1) of Output Calculations. (3-127)

3.3.7 Interpolation of Data from Multigroup Cases for Next Operating Interval

If $I_{\text{halt}} \neq 0$, stop. Computation is completed. (3-128)

Set $I = I + 1$, $i = 1$, $T_{I-1} = T$ (3-129)

If $\delta_{\text{switch}}^{\text{interp}} > 0$ and $I \neq I_{\text{switch}}$, or if $A^{\text{int}} = B^{\text{int}}$, go to statement (3-146). (3-129a)

If $\delta_{\text{switch}}^{\text{interp}} > 0$ and $I = I_{\text{switch}}$, set $R^{\text{int}} = B^{\text{int}}$ and go to

"read statement" preceding statement (3-138). (3-129b)

If $\delta_{\text{switch}}^{\text{interp}} = 0$, calculate

$$R^{\text{int}} = \frac{G_0 + \sum_{L=1}^{L_{\text{max}}} G_L \sum_{\ell'=1}^{\ell'_{\text{max}}} \sum_{j=j_{J_{\ell'}-1}+1}^{j_{J_{\ell'}}} v_j^* \sum_{n=1}^{N_{J_{\ell'}}^{\text{bat}}} N_{L,j,n}^{(e)}}{H_0 + \sum_{L=1}^{L_{\text{max}}} H_L \sum_{\ell'=1}^{\ell'_{\text{max}}} \sum_{j=j_{J_{\ell'}-1}+1}^{j_{J_{\ell'}}} v_j^* \sum_{n=1}^{N_{J_{\ell'}}^{\text{bat}}} N_{L,j,n}^{(e)}} \quad (3-130)$$

where $v_j^* = 1$, v_j , or $v_j \phi_j$ for $\delta_{\text{wt}}^{\text{interp}}$ respectively 0, 1, or 2.

If $A^{int} > B^{int}$, then

$$(1) \quad \underline{\text{Set}} \ R^{int} = A^{int} + F_a^{out} (A^{int} - B^{int})$$

$$\underline{\text{if}} \ R^{int} > \left[A^{int} + F_a^{out} (A^{int} - B^{int}) \right] \quad (3-131)$$

$$(2) \quad \underline{\text{Set}} \ R^{int} = A^{int}$$

$$\underline{\text{if}} \ A^{int} \geq R^{int} \geq \left[A^{int} - F_a^{in} (A^{int} - B^{int}) \right] \quad (3-132)$$

$$(3) \quad \underline{\text{Set}} \ R^{int} = B^{int}$$

$$\underline{\text{if}} \ B^{int} \leq R^{int} < \left[B^{int} + F_b^{in} (A^{int} - B^{int}) \right] \quad (3-133)$$

$$(4) \quad \underline{\text{Set}} \ R^{int} = B^{int} - F_b^{out} (A^{int} - B^{int})$$

$$\underline{\text{if}} \ R^{int} < \left[B^{int} - F_b^{out} (A^{int} - B^{int}) \right] \quad (3-134)$$

If $A^{int} < B^{int}$, then

$$(1) \quad \underline{\text{Set}} \ R^{int} = A^{int} + F_a^{out} (A^{int} - B^{int})$$

$$\underline{\text{if}} \ R^{int} < \left[A^{int} + F_a^{out} (A^{int} - B^{int}) \right] \quad (3-135)$$

$$(2) \quad \underline{\text{Set}} \ R^{int} = A^{int}$$

$$\underline{\text{if}} \ A^{int} \leq R^{int} \leq \left[A^{int} - F_a^{in} (A^{int} - B^{int}) \right] \quad (3-136)$$

$$(3) \quad \underline{\text{Set}} \ R^{int} = B^{int}$$

$$\underline{\text{if}} \ B^{int} \geq R^{int} > \left[B^{int} + F_b^{in} (A^{int} - B^{int}) \right] \quad (3-136a)$$

$$\begin{aligned}
 (4) \quad & \underline{\text{Set}} \quad R^{\text{int}} = B^{\text{int}} - F_b^{\text{out}} (A^{\text{int}} - B^{\text{int}}) \\
 & \underline{\text{if}} \quad R^{\text{int}} > \left[B^{\text{int}} - F_b^{\text{out}} (A^{\text{int}} - B^{\text{int}}) \right] \quad (3-137)
 \end{aligned}$$

Read, into Common Block 2, data block 39 ($N_{m,j}^{(a)}$; $N_{m,j}^{(b)}$) sub-block for Zone J=1, and calculate

$$N_{m,j}^{(r)} = N_{m,j}^{(a)} + \left(\frac{R^{\text{int}} - A^{\text{int}}}{A^{\text{int}} - B^{\text{int}}} \right) (N_{m,j}^{(a)} - N_{m,j}^{(b)}) \quad (3-138)$$

for $j_{J-1} + 1 \leq j \leq j_J$; $1 \leq m \leq m_{\text{max}}$.

Read, into Common Block 2, data block 39 ($\phi_j^{(a)}$; $\phi_j^{(b)}$) sub-block for Zone J=1 and ($v_j^{(a)}$; $v_j^{(b)}$) sub-block for Zone J=1, and calculate

$$\phi_j = \frac{\phi_j^{(a)}}{v_j^{(a)}} + \left(\frac{R^{\text{int}} - A^{\text{int}}}{A^{\text{int}} - B^{\text{int}}} \right) \left(\frac{\phi_j^{(a)}}{v_j^{(a)}} - \frac{\phi_j^{(b)}}{v_j^{(b)}} \right) \quad (3-139)$$

for $j_{J-1} + 1 \leq j \leq j_J$.

$$v_j = v_j^{(a)} + \left(\frac{R^{\text{int}} - A^{\text{int}}}{A^{\text{int}} - B^{\text{int}}} \right) (v_j^{(a)} - v_j^{(b)}) \quad (3-140)$$

for $j_{J-1} + 1 \leq j \leq j_J$.

If $J > 1$, repeat statements (3-138) through (3-140) for other zones

$$2 \leq J \leq J_{\max} \quad (3-141)$$

Read, into Common Block 2, data block 39 $(R_{m,j}^{(a)}; R_{m,j}^{(b)})$ sub-blocks for Zone

$J=1$ and calculate

$$R_{m,j} = R_{m,j}^{(a)} + \left(\frac{R_{\text{int}}^{\text{int}} - A_{\text{int}}^{\text{int}}}{A_{\text{int}}^{\text{int}} - B_{\text{int}}^{\text{int}}} \right) (R_{m,j}^{(a)} - R_{m,j}^{(b)}) \quad (3-142)$$

for $j_{J-1} + 1 \leq j \leq j_J; 1 \leq m \leq m_{\max}$.

Repeat this procedure [leading to statements like (3-138) and (3-142)] to

obtain $\sigma_{f,m,j}$ and $\sigma_{c,m,j}$ from respectively

$(\sigma_{f,m,j}^{(a)}; \sigma_{f,m,j}^{(b)})$ and $(\sigma_{c,m,j}^{(a)}; \sigma_{c,m,j}^{(b)})$ data sub-blocks for

$$\text{Zone } J = 1. \quad (3-143)$$

Repeat statements (3-142) and (3-143) for other zones $2 \leq J \leq J_{\max}$. (3-144)

Read, into Common Block 2, $K_{\text{ref}}^{(a)}$ and $K_{\text{ref}}^{(b)}$ and calculate

$$K_{\text{ref}} = K_{\text{ref}}^{(a)} + \left(\frac{R_{\text{int}}^{\text{int}} - A_{\text{int}}^{\text{int}}}{A_{\text{int}}^{\text{int}} - B_{\text{int}}^{\text{int}}} \right) (K_{\text{ref}}^{(a)} - K_{\text{ref}}^{(b)}) \quad (3-145)$$

3.3.8 Set up Computations for Reactor Reload

$$\text{Calculate } N_{m,j,n}^{(o)} = N_{m,j,(n+N_{dis}^{(J)})}^{(e)} \quad (3-146)$$

$$\text{for } 1 \leq J \leq J_{max}; (j_{J-1} + 1) \leq j \leq j_J,$$

$$1 \leq n \leq (N_J^{bat} - N_{dis}^{(J)}); 1 \leq m \leq m_{max}.$$

$$\text{Calculate } E_{J,n}^{(o)th} = E_{J,(n+N_{dis}^{(J)})}^{(o)th} \quad (3-147)$$

$$W_{J,n}^{(o)} = W_{J,(n+N_{dis}^{(J)})}^{(o)} \text{ for } 1 \leq J \leq J_{max}, \quad (3-148)$$

$$1 \leq n \leq (N_J^{bat} - N_{dis}^{(J)}).$$

If $k_{max} > 0$ and $I_k = I$ for $(1 \leq k \leq I_{max})$

Read input data from cards for operating Interval I
(i.e., the next operating interval) (3-149)

3.3.9 Reload for Zones of Fixed Initial Isotopic

Set $R^{(a)} = 0$, $R^{(b)} = 0$ and $R^{(x)} = 0$ (3-150)

Do loop on a' ($1 \leq a' \leq J_{\max}$) (3-151)

Skip to next a' if $N_{\text{dis}}^{(J_{a'})} = 0$, or if $JA_{Ja'} = 0$

Set $N = JA_{Ja'}$

Do loop on j ($j_{Ja',-1}+1 \leq j \leq j_{Ja',-1}$)

Do loop on n ($N_{Ja'}^{\text{bat}} - N_{\text{dis}}^{(J_{a'})} + 1 \leq n \leq N_{Ja'}^{\text{bat}}$)

Do loop on m ($1 \leq m \leq q_{\max}^{(N)}$)

$m' = M_{m,N}$ (3-152)

$N_{m',j,n}^{(o)} = W_{m,N} N_{Ja'}^{\text{fuel}} + \delta_{m',m_{\max}} \delta_{\text{pois}} N_{m_{\max},Ja'}^{(o)}$ (3-153)

end loop on m

end loop on n

end loop on j

Set $E_{Ja',n}^{(o)\text{th}} = 0$, and (3-154)

$$W_{Ja',n}^{(o)} = \left(\sum_{m=1}^{m_{\max}^{\text{fuel}} + n_{\text{fp}}^{\max}} \left(\frac{A_m^{\text{wt}}}{602.5} \right) N_{m,j_{Ja'},n}^{(o)} \right) \left(\sum_{j=j_{Ja',-1}+1}^{j_{Ja'}} v_j \right) \quad (3-155)$$

for ($N_{Ja'}^{\text{bat}} - N_{\text{dis}}^{(J_{a'})} + 1 \leq n \leq N_{Ja'}^{\text{bat}}$)

$$R^{(a)} = R^{(a)} + \sum_{j=j_{J_{a'}-1}+1}^{j_{J_{a'}}} \cdot \sum_{m=1}^{m_{\max}} R_{m,j}$$

$$\left[\left(\sum_{n=1}^{N_{J_{a'}}^{\text{bat}}} N_{m,j,n}^{(o)} - N_{m,j}^{(r)} \right) \right] \quad (3-156)$$

end loop on a'

3.3.10 Reload for Zones Receiving Stored (or Shuffled) Fuel

Calculate loop on v ($1 \leq v \leq J_{\max}$). (3-157)

If $N_{\text{dis}}^{(J_v)} = 0$ or $N_{J_v}^{\text{rec } 1} > N_{\max}^{\text{stor}}$, skip to next v (3-158)

$$N_{m,j,n}^{(o)} = \left[\left(\frac{602.5}{A_m^{\text{wt}}} \right) W_{m,N_v^{\text{stor}}}^{(I_v^{\text{stor}})} / \left(N_{\text{dis}}^{(J_v)} \right) v_{j_{J_v}} \right] + \delta_{m,m_{\max}} N_{m_{\max},v}^{(o)} \delta_{\text{pois}} \quad (3-159)$$

for $(j_{J_v-1} + 1) \leq j \leq j_{J_v}$; $(N_{J_v}^{\text{bat}} - N_{\text{dis}}^{(J_v)} + 1) \leq n \leq N_{J_v}^{\text{bat}}$;

and $1 \leq m \leq m_{\max}$.

$$E_{J_v,n}^{(o)th} = \frac{1}{N_{\text{dis}}^{(J_v)}} E_{N_v^{\text{stor}}}^{(I_v^{\text{stor}})th} \quad (3-160)$$

for $(N_{J_v}^{\text{bat}} - N_{\text{dis}}^{(J_v)} + 1) \leq n \leq N_{J_v}^{\text{bat}}$.

$$W_{J_v, n}^{(o)} = \frac{1}{\binom{J_v}{N_{dis}}} \left[\sum_{m=1}^{m_{max}} W_{m, N_v^{stor}}^{(I_v^{stor})} - \delta_{pois} W_{m_{max}, N_v^{stor}}^{(I_v^{stor})} \right] \quad (3-161)$$

$$\text{for } (N_{J_v}^{bat} - N_{dis}^{(J_v)} + 1) \leq n \leq N_{J_v}^{bat}.$$

$$W_{m, N_v^{stor}}^{(I_v^{stor})} = 0 \text{ for } 1 \leq m \leq m_{max}. \quad (3-162)$$

Also do same as Equation (3-156) with $a' = v$. (3-163)

End loop on v .

3.3.11 Reload of Burnable Poison Material in Variable Isotopic Content Zones

If $\delta_{\text{pois}} = 0$, skip to statement (3-165). Otherwise, do the following

for $1 \leq v \leq J_{\text{max}}$,

If $N_{m_{\text{max}},v}^{(o)} = 0$ skip to next v

Set $N_{m_{\text{max}},j,n}^{(o)} = N_{m_{\text{max}},v}^{(o)}$ for $(j_{J_v-1} + 1) \leq j \leq j_{J_v}$; (3-164)

$$(N_{J_v}^{\text{bat}} - N_{\text{dis}}^{(J_v)} + 1) \leq n \leq N_J^{\text{bat}}$$

$$\begin{aligned} \text{Calculate } R^{(a)} = R^{(a)} + & \sum_{j=j_{J_v-1}+1}^{j_{J_v}} \sum_{m=1}^{m_{\text{max}}} R_{m,j} \left[\left(\sum_{n=1}^{N_{J_v}^{\text{bat}} - N_{\text{dis}}^{(J_v)}} N_{m,j,n}^{(o)} \right) - N_{m,j}^{(r)} \right] \\ & + \delta_{\text{pois}} R_{m_{\text{max}},j} \sum_{n=N_{J_v}^{\text{bat}} - N_{\text{dis}}^{(J_v)} + 1}^{N_{J_v}^{\text{bat}}} N_{m_{\text{max}},j,n}^{(o)} \end{aligned} \quad (3-165)$$

If $N_{J_v}^{\text{recl}} \leq N_{\text{max}}^{\text{stor}}$ for all v ($1 \leq v \leq J_{\text{max}}$), go to "First Flux Adjustment" - Statement (3-1). (3-166)

3.3.12 Estimate of Reload Fuel Requirements for Variable Isotopic Content Zones

Set $V_0 = 1$ Do loop on v ($1 \leq v \leq J_{\max}$) (3-167)

If $v = v_0$ and $N_{\text{dis}}^{(J_v)} = 0$, $N_{J_v}^{\text{recl}} \leq N_{\max}^{\text{stor}}$, set $v_0 = v_0 + 1$. (3-168)

Go to next v in above loop if $N_{\text{dis}}^{(J_v)} = 0$, or $N_{J_v}^{\text{recl}} \leq N_{\max}^{\text{stor}}$ (3-169)

Set up indexes $(\delta_{\text{recl}}^{\text{totU}})_v$, $(m_1^{\text{recl}})_v$ and $(m_2^{\text{recl}})_v$ as follows

(for $\ell = 1$ and 2);

If $(N_{\max}^{\text{stor}} + 1) \leq N_v^{\text{recl}} \leq N_{\max}^{\text{Pu}}$, set $(\delta_{\text{recl}}^{\text{totU}})_v = 0$, (3-170)

$m_{1,v}^{\text{recl}} = 2$, and $m_{2,v}^{\text{recl}} = 5$.

If $(N_{\max}^{\text{Pu}} + 1) \leq N_v^{\text{recl}} \leq N_{\max}^{\text{fisU}}$, set $(\delta_{\text{recl}}^{\text{totU}})_v = 0$ and (3-171)

also set $m_{1,v}^{\text{recl}} = 3$ and $m_{2,v}^{\text{recl}} = 6$ if $m_{\max}^{\text{fuel}} = 6$;

set $m_{1,v}^{\text{recl}} = 8$ and $m_{2,v}^{\text{recl}} = 11$ if $m_{\max}^{\text{fuel}} = 11$,

set $m_{1,v}^{\text{recl}} = 6$ and $m_{2,v}^{\text{recl}} = 7$ if $m_{\max}^{\text{fuel}} = 7$.

If $(N_{\max}^{\text{fisU}} + 1) \leq N_v^{\text{recL}} \leq N_{\max}^{\text{totU}}$, set $(\delta_{\text{recL}}^{\text{totU}}) = 1$ if $m_{\max}^{\text{fuel}} \neq 6$, (3-172)

set $(\delta_{\text{recL}}^{\text{totU}}) = 0$ if $m_{\max}^{\text{fuel}} = 6$, and set $m_{1,v}^{\text{recL}}$ and $m_{2,v}^{\text{recL}}$

same as for statement (3-171).

Set $f_v^{(\ell)} = 1$ for $\ell = 1, 2$, and 3. Set $L_v = 1$. (3-173)

If $N_v^{\text{recL}} = 0$, set $f_v^{(\ell)} = R_v^{(\ell)} = P_v^{(\ell)} = N_v^{(\ell)} = 0$ for (3-174)

both $\ell = 1$ and $\ell = 2$; and set $L_v = 3$. Skip to statement (3-184).

If $W_{N_v^{\text{recL}}}^{(I_v^{\text{recL}})} \leq 0$, set $f_v^{(1)} = R_v^{(1)} = P_v^{(1)} = N_v^{(1)} = 0$; and (3-175)

set $L_v = 2$.

If $N_v^{\text{rec2}} = 0$ or if $W_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} \leq 0$, set $f_v^{(2)} = R_v^{(2)} = P_v^{(2)} = N_v^{(2)} = 0$; (3-176)

and set $L_v = 3$ if $f_v^{(1)} \neq 0$.

Calculate the following (for $\ell = 1$ if $f_v^{(1)} \neq 0$ and also for $\ell = 2$

if $f_v^{(2)} \neq 0$):

$$R_v^{(\ell)} = \frac{\sum_{j=j_{J_v}-1+1}^{j_{J_v}} \left[\sum_{m=m_{1,v}}^{m_{2,v}} \left(\frac{R_{m,j}^{(\text{rec})} W_{m,N_v}^{(\text{rec})}}{(A_m^{\text{wt}}/602.5)} \right) + \left(\delta_{\text{rec}}^{\text{totU}} \right)_v \frac{R_{1,j}^{(\text{rec})} W_{1,N_v}^{(\text{rec})}}{(A_1^{\text{wt}}/602.5)} \right]}{V_{J_v}^{(\text{rec})} W_{N_v}^{(\text{rec})}} \quad (3-177)$$

$$\text{where } V_{J_v} = \sum_{j=j_{J_v}-1+1}^{j_{J_v}} V_j \quad (3-178)$$

$$P_v^{(\ell)} = \frac{\sum_{j=j_{J_v}-1+1}^{j_{J_v}} V_j \phi_j \left[\sum_{m=m_{2,v}}^{m_{2,v}} \left(\frac{\sigma_{f,m,j}^{(\text{rec})} W_{m,N_v}^{(\text{rec})}}{(A_m^{\text{wt}}/602.5)} \right) + \left(\delta_{\text{rec}}^{\text{totU}} \right)_v \frac{\sigma_{f,1,j}^{(\text{rec})} W_{1,N_v}^{(\text{rec})}}{(A_1^{\text{wt}}/602.5)} \right]}{V_{J_v}^{(\text{rec})} W_{N_v}^{(\text{rec})}} \quad (3-179)$$

$$N_v^{(\ell)} = \frac{\sum_{j=j_{J_v}-1+1}^{j_{J_v}} \left[\sum_{m=m_{1,v}}^{m_{2,v}} \left(\frac{W_{m,N_v}^{(\text{rec})}}{(A_m^{\text{wt}}/602.5)} \right) + \left(\text{totU}_{\text{rec}} \right)_v \frac{W_{1,N_v}^{(\text{rec})}}{(A_m^{\text{wt}}/602.5)} \right]}{V_{J_v}^{(\text{rec})} W_{N_v}^{(\text{rec})} N_{\text{dis}}^{(J_v)}} \quad (3-180)$$

If $(\delta_{\text{rec}}^{\text{mix}})_v = 0$ and if $L_v = 1$, set $f_v^{(2)} = 0$; if $L_v = 2$ and $f_v^{(2)} = 0$, set $L_v = 3$. (3-181)

If $(\frac{mix}{rec})_v = 1$ and if $L_v = 1$, calculate

$$f_v^{(2)} = f_v^{(1)} \quad \frac{W_{N_{rec2}}^{(I_v^{rec2})}}{W_{N_{rec1}}^{(I_v^{rec1})}} \quad (3-182)$$

If $L_v \neq 3$, set $f_v^{(3)} = 0$. (3-183)

$$R_v^{(3)} = \frac{\sum_{j=j_{J_v-1}+1}^{j_{J_v}} \sum_{q=1}^{q_{max}^{(N_v^{mkp})}} \frac{R_{m,j} W_{q,N_v^{mkp}}}{(A_m^{wt}/602.5)}}{V_{J_n} \left(\sum_{q=1}^{q_{max}^{(N_v^{mkp})}} W_{q,N_v^{mkp}} \right)} \quad (3-184)$$

$$P_v^{(3)} = \frac{\sum_{j=j_{J_v-1}+1}^{j_{J_v}} V_j \phi_j \sum_{q=1}^{q_{max}^{(N_v^{mkp})}} \frac{\sigma_{f_{m,j}} W_{q,N_v^{mkp}}}{(A_m^{wt}/602.5)}}{V_{J_n} \left(\sum_{q=1}^{q_{max}^{(N_v^{mkp})}} W_{w,N_v^{mkp}} \right)} \quad (3-185)$$

$$R_v^{(\ell)} = \frac{\sum_{j=j_{J_v}-1+1}^{j_{J_v}} \left[\sum_{m=m_{1,v}}^{m_{2,v}} \left(\frac{R_{m,j}^{(\ell)} W_{m,N_v}^{(\ell)}}{(A_m^{wt}/602.5)} \right) + \left(\delta_{rec}^{totU} \right)_v \frac{R_{1,j}^{(\ell)} W_{1,N_v}^{(\ell)}}{(A_1^{wt}/602.5)} \right]}{V_{J_v} W_{N_v}^{(\ell)}} \quad (3-177)$$

$$\text{where } V_{J_v} = \sum_{j=j_{J_v}-1+1}^{j_{J_v}} V_j \quad (3-178)$$

$$P_v^{(\ell)} = \frac{\sum_{j=j_{J_v}-1+1}^{j_{J_v}} V_j \phi_j \left[\sum_{m=m_{2,v}}^{m_{2,v}} \left(\frac{\sigma_{f,m,j}^{(\ell)} W_{m,N_v}^{(\ell)}}{(A_m^{wt}/602.5)} \right) + \left(\delta_{rec}^{totU} \right)_v \frac{\sigma_{f,1,j}^{(\ell)} W_{1,N_v}^{(\ell)}}{(A_1^{wt}/602.5)} \right]}{V_{J_v} W_{N_v}^{(\ell)}} \quad (3-179)$$

$$N_v^{(\ell)} = \frac{\sum_{j=j_{J_v}-1+1}^{j_{J_v}} \left[\sum_{m=m_{1,v}}^{m_{2,v}} \left(\frac{W_{m,N_v}^{(\ell)}}{(A_m^{wt}/602.5)} \right) + \left(\delta_{rec}^{totU} \right)_v \frac{W_{1,N_v}^{(\ell)}}{(A_1^{wt}/602.5)} \right]}{V_{J_v} W_{N_v}^{(\ell)} N_{dis}^{(J_v)}} \quad (3-180)$$

If $(\delta_{rec}^{mix})_v = 0$ and if $L_v = 1$, set $f_v^{(2)} = 0$; if $L_v = 2$ and $f_v^{(2)} = 0$, set $L_v = 3$. (3-181)

If $(\text{mix})_{\text{rec } v} = 1$ and if $L_v = 1$, calculate

$$f_v^{(2)} = f_v^{(1)} \quad \frac{W_{N_{\text{rec}2}}^{(I_v^{\text{rec}2})}}{W_{N_{\text{rec}1}}^{(I_v^{\text{rec}1})}} \quad (3-182)$$

If $L_v \neq 3$, set $f_v^{(3)} = 0$.

(3-183)

$$R_v^{(3)} = \frac{\sum_{j=j_{J_v}-1+1}^{j_{J_v}} \sum_{q=1}^{q_{\text{max}}^{(N_v^{\text{mkp}})}} \frac{R_{m,j} W_{q,N_v^{\text{mkp}}}}{(A_m^{\text{wt}}/602.5)}}{v_{J_n} \left(\sum_{q=1}^{q_{\text{max}}^{(N_v^{\text{mkp}})}} W_{q,N_v^{\text{mkp}}} \right)} \quad (3-184)$$

$$P_v^{(3)} = \frac{\sum_{j=j_{J_v}-1+1}^{j_{J_v}} v_{j \phi_j} \sum_{q=1}^{q_{\text{max}}^{(N_v^{\text{mkp}})}} \frac{\sigma_{f_{m,j}} W_{q,N_v^{\text{mkp}}}}{(A_m^{\text{wt}}/602.5)}}{v_{J_n} \left(\sum_{q=1}^{q_{\text{max}}^{(N_v^{\text{mkp}})}} W_{w,N_v^{\text{mkp}}} \right)} \quad (3-185)$$

$$N_v^{(3)} = \frac{\sum_{j=j_{J_v}-1+1}^{j_{J_v}} \sum_{q=1}^{q_{\max}^{(N_v^{mkp})}} \frac{W_{q,N_v^{mkp}}}{(A_m^{wt}/602.5)}}{v_{J_n} \left(\sum_{q=1}^{q_{\max}^{(N_v^{mkp})}} W_{q,N_v^{mkp}} \right) N_{dis}^{(J_v)}} \quad (3-186)$$

Calculate $R_v^{(4)}$, $P_v^{(4)}$ and $N_v^{(4)}$ same as equations (3-184) thru (3-186),
except replace N_v^{mkp} by N_v^{oth} (3-187)
 wherever former appears in these equations.

Calculate

$$P_v^{(a)} = \sum_{j=j_{J_v}-1+1}^{j_{J_v}} v_{j\phi_j} \sum_{m=1}^{m_{\max}^{fuel}} \sigma_{f_{m,j}} \sum_{n=1}^{N_{J_v}^{bat} - N_{dis}^{(J_v)}} N_{m,j,n}^{(o)} \quad (3-188)$$

$$\text{If } v > v_o \text{ and if } \sum_{\ell=L_v}^3 f_v^{(\ell)} \left(P_v^{(\ell)} - \frac{N_v^{(\ell)} P_v^{(4)}}{N_v^{(4)}} \right) = 0, \text{ set } I_{halt} = 7 \text{ and} \quad (3-189)$$

go to Output Calculations.

$$R_v^{(b)} = \frac{N_v^{\text{fuel}} R_v^{(4)}}{N_v^{(4)}} + (1 - \delta_{v, v_o})$$

$$\frac{\left[\sum_{\ell=L_v}^3 f_v^{(\ell)} R_v^{(\ell)} - \frac{N_v^{(\ell)} R_v^{(4)}}{N_v^{(4)}} \right] \left[P_v P_{v_o}^{(a)} - P_v^{(a)} + \frac{P_v N_{v_o}^{\text{fuel}} P_{v_o}^{(4)}}{N_{v_o}^{(4)}} - \frac{N_v^{\text{fuel}} P_v^{(4)}}{N_v^{(4)}} \right]}{\sum_{\ell=L_v}^3 f_v^{(\ell)} \left(P_v^{(\ell)} - \frac{N_v^{(\ell)} P_v^{(4)}}{N_v^{(4)}} \right)} \quad (3-190)$$

$$R^{(b)} = R^{(b)} + R_v^{(b)} \quad (3-191)$$

If $v = v_o$, calculate

$$R_{v_o}^{(x)} = \sum_{\ell=L_{v_o}}^3 f_{v_o}^{(\ell)} \left[R_{v_o}^{(\ell)} - \frac{N_{v_o}^{(\ell)} R_{v_o}^{(4)}}{N_{v_o}^{(4)}} \right] \quad (3-192)$$

If $v > v_o$, calculate

$$R_v^{(x)} = \frac{P_v \left[\sum_{\ell=L_{v_o}}^3 f_{v_o}^{(\ell)} \left(P_{v_o}^{(\ell)} - \frac{N_{v_o}^{(\ell)} P_{v_o}^{(4)}}{N_{v_o}^{(4)}} \right) \right] \left[\sum_{\ell=L_v}^3 f_v^{(\ell)} \left(R_v^{(\ell)} - \frac{N_v^{(\ell)} R_v^{(4)}}{N_v^{(4)}} \right) \right]}{\left[\sum_{\ell=L_v}^3 f_v^{(\ell)} \left(P_v^{(\ell)} - \frac{N_v^{(\ell)} P_v^{(4)}}{N_v^{(4)}} \right) \right]} \quad (3-193)$$

$$\text{Set } R^{(x)} = R^{(x)} + R_v^{(x)} \quad (3-194)$$

End loop on v

Calculate (if $v = v_o$)

$$W_{v_o}^{(L_{v_o})} = \frac{K^{(e)} - K_{ref} - (\Delta K)_{burnup} \left[A_T^{cont} + (1 - A_T^{cont}) \left(\frac{T}{T_{I-1}} \right) \right] - R^{(a)} - R^{(b)}}{R^{(x)}} \quad (3-195)$$

If $W_{v_o}^{(L_{v_o})} \leq 0$, set $I_{halt} = 8$ and go to Output Calculations. (3-196)

$$f_{v_o}^{(4)} = \frac{N_{v_o}^{fuel}}{N_{v_o}^{(4)} W_{v_o}^{(L_v)}} - \sum_{l=L_{v_o}}^3 f_{v_o}^{(l)} \frac{N_{v_o}^{(l)}}{N_{v_o}^{(4)}} \quad (3-197)$$

Calculate (for $v_o + 1 \leq v \leq J_{max}$)

Go to next v if $N_{dis}^{(J_v)} = 0$ or $N_{J_v}^{recl} \leq N_{max}^{stor}$ (3-198)

$$W_v^{(L_v)} = \left[\frac{P_v \sum_{l=L_v}^3 f_{v_o}^{(l)} \left(P_{v_o}^{(l)} - \frac{N_{v_o}^{(l)} P_{v_o}^{(4)}}{N_{v_o}^{(4)}} \right)}{\sum_{l=L_v}^3 f_v^{(l)} \left(P_v^{(l)} - \frac{N_v^{(l)} P_v^{(4)}}{N_v^{(4)}} \right)} \right] W_{v_o}^{(L_{v_o})} + \left[\frac{P_v P_{v_o}^{(a)} - P_v^{(a)} + \left(\frac{P_v N_{v_o}^{fuel} P_{v_o}^{(4)}}{N_{v_o}^{(4)}} \right) - \left(\frac{N_v^{fuel} P_v^{(4)}}{N_v^{(4)}} \right)}{\sum_{l=L_v}^3 f_v^{(l)} \left(P_v^{(l)} - \frac{N_v^{(l)} P_v^{(4)}}{N_v^{(4)}} \right)} \right] \quad (3-199)$$

If $W_v^{(L_v)} \leq 0$, set $I_{halt} = 8$ and go to Output Calculations. (3-200)

$$f_v^{(4)} = \frac{N_v^{fuel}}{N_v^{(4)} W_v^{(L_v)}} - \sum_{\ell=L_v}^3 f_v^{(\ell)} N_v^{(\ell)} / N_v^{(4)} \quad (3-201)$$

3.3.13 Correction of Reload Requirements for Unavailability of Recycle Material

Do loop on N ($N_{max}^{stor} + 1 \leq N \leq N_{max}^{totU}$): (3-202)

Do loop on I_h ($0 \leq I_h \leq 3$) (3-203)

If $I_h < 3$ and $W_N^{(I_h)} \leq 0$, go to next I_h (3-204)

If $I_h = 3$ and $W_N^{(I_h)} \leq 0$, go to next N. (3-205)

Calculate

$$W = \sum_{v=v_0}^{v_{max}} \left[(\delta_{N,N_v^{rec1}})(\delta_{I_h,I_v^{rec1}}) f_v^{(1)} + (\delta_{2,L_v})(\delta_{N,N_v^{rec2}})(\delta_{I_h,I_v^{rec2}}) f_v^{(2)} \right] W_v^{(L_v)} \quad (3-206)$$

If $W \leq W_N^{(I_h)}$, set $W_N^{(I_h)} = W_N^{(I_h)} - W$ and go to next I_h (or next N if $I_h = 3$). (3-207)

Do loop on v ($v_0 \leq v \leq J_{max}$). (3-208)

Skip to the next v if $N_{dis}^{J_v} = 0$, or $N_{J_v}^{rec1} \leq N_{max}^{stor}$

If $L_v > 2$, go to next element of triple loop (i.e., next v if $v < v_{\max}$). (3-209)

If $L_v = 1$, skip to "If statements" preceeding equation (3-215). (3-210)

If $L_v = 2$ and if $N_v^{\text{rec2}} = N$ and if $I_v^{\text{rec2}} = I_h$, then adjust $W_v^{(L_v)}$, $f_v^{(3)}$, and $f_v^{(4)}$ as follows:

$$W_v^{(L_v)} = W_v^{(L_v)} \frac{W_N^{(I_h)}}{W} \quad (3-211)$$

$$f_v^{(3)} = \frac{R_v^{(2)} \left(\frac{W}{W_N^{(I_h)}} \right) - 1 + f_v^{(4)} R_v^{(4)} \frac{W}{W_N^{(I_h)}} + \frac{R_v^{(4)}}{N_v^{(4)}} \left(N_v^{(2)} - \frac{N_v^{\text{fuel}}}{W_v^{(L_v)}} \right)}{R_v^{(3)} - \frac{R_v^{(4)} N_v^{(3)}}{N_v^{(4)}}} \quad (3-212)$$

$$f_v^{(4)} = \frac{N_v^{\text{fuel}}}{N_v^{(4)} W_v^{(L_v)}} - \frac{N_v^{(2)}}{N_v^{(4)}} - \frac{f_v^{(3)} N_v^{(3)}}{N_v^{(4)}} \quad (3-213)$$

If either $f_v^{(3)}$ or $f_v^{(4)}$ is negative, or if $R_v^{(3)} N_v^{(4)} = R_v^{(4)} N_v^{(3)}$, set $I_{\text{halt}} = 9$

and go to Output Calculation; otherwise, go to next element or triple loop. (3-214)

If $L_v = 1$ and if $N_v^{\text{rec1}} = N$ and if $I_v^{\text{rec1}} = I_h$, then adjust $W_v^{(L_v)}$, $f_v^{(2)}$, $f_v^{(3)}$, and $f_v^{(4)}$ as follows:

$$W_v^{(L_v)} = \frac{W_N^{(I_h)}}{W} W_v^{(L_v)} \quad (3-215)$$

If $f_v^{(2)} > 0$, or if $f_v^{(2)} \neq 0$ and $N_v^{\text{rec2}} = 0$ and $W_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} > 0$

calculate as follows [otherwise skip to statement (3-220)].

$$f_v^{(2)} = \frac{R_v^{(1)} \left(\frac{W}{W_N^{(I_h)}} - 1 \right) + f_v^{(4)} R_v^{(4)} \frac{W}{W_N^{(I_h)}} + \frac{R_v^{(4)}}{N_v^{(4)}} \left(N_v^{(1)} - \frac{N_v^{\text{fuel}}}{W_v^{(L_v)}} \right) + f_v^{(2)} R_v^{(2)} \frac{W}{W_N^{(I_h)}}}{R_v^{(2)} - \frac{R_v^{(4)} N_v^{(2)}}{N_v^{(4)}}} \quad (3-216)$$

$$f_v^{(4)} = \frac{N_v^{\text{fuel}}}{N_v^{(4)} W_v^{(L_v)}} - \frac{N_v^{(1)}}{N_v^{(4)}} - \frac{f_v^{(2)} N_v^{(2)}}{N_v^{(4)}} \quad (3-217)$$

If either $f_v^{(2)}$ or $f_v^{(4)}$ is negative, or if $R_v^{(2)} N_v^{(4)} = R_v^{(4)} N_v^{(2)}$, set $I_{\text{halt}} = 9$

and go to Output Calculations; (3-218)

otherwise, go to next element of triple loop. (3-219)

If $f_v^{(2)} = 0$, and either $N_v^{\text{rec2}} = 0$ or $W_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} \leq 0$, calculate

$$f_v^{(3)} = \frac{R_v^{(1)} \left(\frac{W}{W_N^{(I_h)}} - 1 \right) + f_v^{(4)} R_v^{(4)} \frac{W}{W_N^{(I_h)}} + \frac{R_v^{(4)}}{N_v^{(4)}} \left(N_v^{(1)} - \frac{N_v^{\text{fuel}}}{W_v^{(L_v)}} \right)}{R_v^{(3)} - \frac{R_v^{(4)} N_v^{(3)}}{N_v^{(4)}}} \quad (3-220)$$

$$f_v^{(4)} = \frac{N_v^{\text{fuel}}}{N_v^{(4)} W_v^{(L_v)}} - \frac{N_v^{(1)}}{N_v^{(4)}} - \frac{f_v^{(3)} N_v^{(3)}}{N_v^{(4)}} \quad (3-221)$$

If either $f_v^{(3)}$ or $f_v^{(4)}$ is negative, or if $R_v^{(3)} N_v^{(4)} = R_v^{(4)} N_v^{(3)}$,
set $I_{\text{halt}} = 9$ and go to Output Calculations. (3-222)

Otherwise, go to next element of triple loop. (3-223)

End Loop on v

If $W > W_N^{(I_h)}$, set $W_N^{(I_h)} = 0$. (3-224)

End loop I_h . End loop on N.

Do (another) loop on N ($N_{\text{max}}^{\text{stor}} + 1 \leq N \leq N_{\text{max}}^{\text{totU}}$).

Do loop on I_h ($0 \leq I_h \leq 3$).

Calculate

$$W = \sum_{v=v_0}^{v_{\text{max}}} (\delta_{N, N_v^{\text{rec2}}}) (\delta_{I_h, I_v^{\text{rec2}}}) (\delta_{1, L_v}) f_v^{(2)} W_v^{(1)} \quad (3-225)$$

If $W \leq W_N^{(I_h)}$, set $W_N^{(I_h)} = W_N^{(I_h)} - W$ and go to next I_h (or next N if $I_h = 3$) (3-226)

Do loop on v ($v_0 \leq v \leq J_{\text{max}}^{(J)}$) (3-227)

Skip to next v if $N_{\text{dis}}^{(J)} = 0$, or $N_{J_v}^{\text{rec1}} \leq N_{\text{max}}^{\text{stor}}$

If $L_v > 1$, go to next element of triple loop (i.e., next v if $v < v_{\text{max}}$). (3-228)

If $N_v^{\text{rec2}} = N$ and if $I_v^{\text{rec2}} = I_h$, and if $f_v^{(2)} > 0$, then adjust $f_v^{(2)}$, $f_v^{(3)}$,
 and $f_v^{(4)}$ as follows:

$$f_v^{(2)} = f_v^{(2)} \frac{W_N^{(I_h)}}{W} \quad (3-229)$$

$$f_v^{(3)} = \frac{f_v^{(2)} R_v^{(2)} \left(\frac{W}{W_N^{(I_h)}} - 1 \right) + f_v^{(4)} R_v^{(4)} + \frac{R_v^{(4)}}{N_v^{(4)}} \left(N_v^{(1)} + f_v^{(2)} N_v^{(2)} - \frac{N_v^{fuel}}{W_v^{(L_v)}} \right)}{R_v^{(3)} - \frac{R_v^{(4)} N_v^{(3)}}{N_v^{(4)}}} \quad (3-230)$$

$$f_v^{(4)} = \frac{N_v^{fuel}}{N_v^{(4)} W_v^{(L_v)}} - \frac{N_v^{(1)}}{N_v^{(4)}} - \frac{f_v^{(2)} N_v^{(2)}}{N_v^{(4)}} - \frac{f_v^{(3)} N_v^{(3)}}{N_v^{(4)}} \quad (3-231)$$

If either $f_v^{(3)}$ or $f_v^{(4)}$ is negative, or if $R_v^{(3)} N_v^{(4)} = R_v^{(4)} N_v^{(3)}$,
set $I_{halt} = 9$ and go to Output Calculations. (3-232)

End loop on v.

If $W > W_N^{(I_h)}$, set $W_N^{(I_h)} = 0$. (3-233)

End loop on I_h . End loop on N.

3.3.14 Initial Isotopic Concentrations for First Iteration of New Operating Interval

Do loop on v (3-234)

If $N_{dis}^{(J_v)} = 0$, or $N_{J_v}^{recl} \leq N_{max}^{stor}$, go to next v. (3-235)

Do loop on j ($j_{J_v} + 1 \leq j \leq j_{J_v}$).

Do loop on m ($1 \leq m \leq m_{max}^{fuel}$).

$$\begin{aligned}
 N_{m,j,n}^{(o)} = & \left[\sum_{l=L_v}^2 \frac{f_v^{(l)} \sum_{m=m_1}^{m_2} \delta_{m,m} W_{n,N_v}^{(l, \text{recl})} + \delta_{m,1} \left(\delta_{\text{totU}}^{\text{recl}} \right)_v W_{1,N_v}^{(l, \text{recl})}}{\sum_{m=m_1}^{m_2} \left(W_{m,N_v}^{(l, \text{recl})} \right) + \left(\delta_{\text{rec}}^{\text{totU}} \right)_v W_{1,N_v}^{(l, \text{recl})}} \right. \\
 & + \frac{f_v^{(3)} \sum_{q=1}^{q_{\max}^{(N_v^{\text{mkp}})}} \delta_{m,M_{q,N_v^{\text{mkp}}}} W_{q,N_v^{\text{mkp}}}}{\sum_{q=1}^{q_{\max}^{(N_v^{\text{mkp}})}} W_{q,N_v^{\text{mkp}}}} \\
 & + \left. \frac{f_v^{(4)} \sum_{q=1}^{q_{\max}^{(N_v^{\text{mkp}})}} \delta_{m,M_{q,N_v^{\text{oth}}}} W_{q,N_v^{\text{oth}}}}{\sum_{q=1}^{q_{\max}^{(N_v^{\text{oth}})}} W_{q,N_v^{\text{oth}}}} \right] \left[\frac{W_v^{(L_v)}}{v_J \left(\frac{A_m}{602.5} \right) \left(N_{\text{dis}}^{(J_v)} \right)} \right] \quad (3-236)
 \end{aligned}$$

for $(N_{J_v}^{\text{bat}} - N_{\text{dis}}^{(J_v)} + 1) \leq n \leq N_{J_v}^{\text{bat}}$

$$N_{m,j,n}^{(o)} = 0 \text{ for } m_{\max}^{\text{fuel}} + 1 \leq m \leq m_{\max}^{\text{fuel}} + n_{\text{fp}}^{\max}; (N_{J_v}^{\text{bat}} - N_{\text{dis}}^{(J_v)} + 1) \leq n \leq N_{J_v}^{\text{bat}}. \quad (3-237)$$

End of loop on j ($j_{J_v-1} + 1 \leq j \leq j_{J_v}$). End of loop on m ($1 \leq m \leq m_{\max}$). (3-238)

$$E_{J_v, n}^{(o)th} = 0 \quad (3-239)$$

$$W_{J_v, n}^{(o)} = W_v^{(L_v)} \sum_{\ell=L_v}^4 f_v^{(\ell)} N_{dis}^{(J_v)} \quad (3-240)$$

for $(N_{J_v}^{bat} - N_{dis}^{(J_v)} + 1) \leq n \leq N_{J_v}^{bat}$

End of loop on v

If $\delta_{restart}^{prep} > 0$ and $I > I_{max}$ Go to statement 4-289. (3-241)

Go to First Flux Adjustment statement (3-1). (3-241a)

3.3.15 Fissile Content Adjustment for Next Iteration

If $I = I_{init}$, and if either (1) $\delta_1^{(a)*} > 0$ or (2) $\delta_1^{(a)} = 0$ with $\delta_{restart} = 0$,
go to statement (3-385). (3-242)

Do loop on v ($v_o \leq v \leq J_{max}$). (3-243)

If $N_{dis}^{(J_v)} = 0$, or $N_{J_v}^{recl} \leq N_{max}^{stor}$, go to next v in loop. (3-244)

Calculate

$$\Delta R = \Delta K_{adj} \left(\frac{R_v^{(b)} + R_v^{(x)} W_{v_o}^{(L_{v_o})}}{R^{(b)} + R^{(x)} W_v^{(L_{v_o})}} \right) \quad (3-245)$$

If $f_v^{(3)} = 0$, go to statement (3-289).. (3-246)

If $f_v^{(3)} > 0$, calculate

$$\Delta f^{(3)} = \frac{\Delta R}{W_v^{(L_v)} R_v^{(3)} - \frac{R_v^{(4)} N_v^{(3)}}{N_v^{(4)}}} \quad (3-247)$$

If $R_v^{(3)} N_v^{(4)} = R_v^{(4)} N_v^{(3)}$, set $I_{\text{halt}} = 9$ and go to Output Calculations. (3-248)

$$\Delta f^{(4)} = - \frac{N_v^{(3)} \Delta f^{(3)}}{N_v^{(4)}} \quad (3-249)$$

If $\Delta f^{(3)} < (-f_v^{(3)})$, go to statement (3-257). (3-249a)

If $L_v < 3$, set $f_v^{(3)} = f_v^{(3)} + \Delta f^{(3)}$ (3-250)

and $f_v^{(4)} = f_v^{(4)} + \Delta f^{(4)}$ (3-251)

If $L_v = 3$, set $W_v^{(L_v)} = W_v^{(L_v)} (1 + \Delta f^{(3)})$ (3-252)

and $f_v^{(4)} = \frac{f_v^{(4)} + \Delta f^{(4)}}{1 + \Delta f^{(3)}}$ (3-253)

and set $I_{\text{halt}} = 10$ and go to Output Calculations if $\Delta f^{(3)} = -1$. (3-254)

and set $I_{\text{halt}} = 9$ and go to Output Calculations if $f_v^{(4)} < 0$. (3-255)

Go to statement (3-380). (3-256)

If $\Delta f^{(3)} < (-f_v^{(3)})$, calculate

$$\Delta R = \Delta R + f_v^{(3)} W_v^{(L_v)} \left(R_v^{(3)} - \frac{R_v^{(4)} N_v^{(3)}}{N_v^{(4)}} \right) \quad (3-257)$$

$$\underline{\text{Set}} \quad f_v^{(4)} = f_v^{(3)} + \frac{f_v^{(3)} N_v^{(3)}}{N_v^{(4)}} \quad (3-258)$$

$$\underline{\text{Set}} \quad f_v^{(3)} = 0. \quad (3-259)$$

$$\underline{\text{If}} \quad L_v = 3, \underline{\text{set}} \quad I_{\text{halt}} = 10 \text{ and } \underline{\text{go to Output Calculations.}} \quad (3-260)$$

$$\underline{\text{If}} \quad f_v^{(2)} = 0, \underline{\text{go to statement (3-280).}} \quad (3-261)$$

$$\underline{\text{If}} \quad f_v^{(2)} > 0, \underline{\text{calculate}}$$

$$\Delta f^{(2)} = \frac{\Delta R}{W_v^{(L_v)} \left(R_v^{(2)} - \frac{R_v^{(4)} N_v^{(2)}}{N_v^{(4)}} \right)} \quad (3-262)$$

$$\Delta f^{(4)} = - \frac{N_v^{(2)} \Delta f^{(2)}}{N_v^{(4)}} \quad (3-263)$$

$$\underline{\text{If}} \quad R_v^{(2)} N_v^{(4)} = R_v^{(4)} N_v^{(2)}, \underline{\text{set}} \quad I_{\text{halt}} = 9 \text{ and } \underline{\text{go to Output Calculations.}} \quad (3-264)$$

$$\underline{\text{If}} \quad \Delta f^{(2)} < (-f_v^{(2)}), \underline{\text{go to statement (3-275).}} \quad (3-265)$$

$$\underline{\text{If}} \quad L_v = 1, \underline{\text{set}} \quad f_v^{(2)} = f_v^{(2)} + \Delta f^{(2)} \quad (3-266)$$

$$\underline{\text{and}} \quad f_v^{(4)} = f_v^{(2)} + \Delta f^{(4)} \quad (3-267)$$

$$\underline{\text{and}} \quad W_{N_{\text{rec2}}^{(I_v^{\text{rec2}})}} = W_{N_{\text{rec2}}^{(I_v^{\text{rec2}})}} - \Delta f^{(2)} W_v^{(L_v)} \quad (3-268)$$

$$\text{If } L_v = 2, \text{ set } W_v^{(L_v)} = W_v^{(L_v)} (1 + \Delta f^{(2)}) \quad (3-269)$$

$$\text{and } f_v^{(4)} = \frac{f_v^{(4)} + \Delta f^{(4)}}{1 + \Delta f^{(2)}} \quad (3-270)$$

$$\text{and } W_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} = W_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} - \Delta f^{(2)} W_v^{(L_v)} \quad (3-271)$$

$$\text{and set } I_{\text{halt}} = 10 \text{ and go to Output Calculations, if } \Delta f^{(2)} = -1, \quad (3-272)$$

$$\text{and set } I_{\text{halt}} = 9 \text{ and go to Output Calculations, if } \Delta f_v^{(4)} < 0. \quad (3-273)$$

$$\text{Go to statement (3-380).} \quad (3-274)$$

$$\text{If } \Delta f_v^{(2)} < (-f_v^{(2)}), \text{ calculate}$$

$$\Delta R = \Delta R + f_v^{(2)} W_v^{(L_v)} \left(R_v^{(2)} - \frac{R_v^{(4)} N_v^{(2)}}{N_v^{(4)}} \right) \quad (3-275)$$

$$\text{Set } f_v^{(4)} = f_v^{(4)} + \frac{f_v^{(2)} N_v^{(2)}}{N_v^{(4)}} \quad (3-276)$$

$$\text{Set } f_v^{(2)} = 0 \quad (3-277)$$

$$\text{and } W_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} = W_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} + f_v^{(2)} W_v^{(L_v)} \quad (3-278)$$

$$\text{If } L_v = 2, \text{ set } I_{\text{halt}} = 10, \text{ and go to Output Calculations.} \quad (3-279)$$

Calculate

$$\Delta f^{(1)} = \frac{\Delta R}{W_v^{(L_v)} \left(R_v^{(1)} - \frac{R_v^{(4)} N_v^{(1)}}{N_v^{(4)}} \right)} \quad (3-280)$$

If $R_v^{(1)} N_v^{(4)} = R_v^{(4)} N_v^{(1)}$, set $I_{\text{halt}} = 9$, and go to Output Calculations. (3-281)

$$\Delta f^{(4)} = \frac{N_v^{(1)} \Delta f^{(1)}}{N_v^{(4)}} \quad (3-282)$$

If $\Delta f^{(1)} \leq (-f_v^{(1)})$, set $I_{\text{halt}} = 10$ and go to Output Calculations. (3-283)

$$\text{Set } W_v^{(L_v)} = W_v^{(L_v)} (1 + \Delta f^{(1)}) \quad (3-284)$$

$$\text{and } W_{N_v^{\text{recl}}}^{(I_v^{\text{recl}})} = W_{N_v^{\text{recl}}}^{(I_v^{\text{recl}})} - \frac{\Delta f_1 W_v^{(L_v)}}{1 + \Delta f^{(1)}} \quad (3-285)$$

$$\text{Set } f_v^{(4)} = \frac{f_v^{(4)} + \Delta f^{(4)}}{1 + \Delta f^{(1)}} \quad (3-286)$$

If $f_v^{(4)} < 0$, set $I_{\text{halt}} = 9$ and go to Output Calculations. (3-287)

Go to statement (3-380). (3-288)

If $f_v^{(2)} = 0$, go to statement (3-347). (3-289)

If $f_v^{(2)} > 0$, calculate

$$\Delta f^{(2)} = \frac{\Delta R}{w_v^{(L_v)} \left(R_v^{(2)} - \frac{R_v^{(4)} N_v^{(2)}}{N_v^{(4)}} \right)} \quad (3-290)$$

$$\Delta f^{(4)} = \frac{N_v^{(2)} \Delta f^{(2)}}{N_v^{(4)}} \quad (3-291)$$

If $R_v^{(2)} N_v^{(4)} = R_v^{(4)} N_v^{(2)}$, set $I_{\text{halt}} = 9$ and go to Output Calculations. (3-292)

If $\Delta f^{(2)} < (-f_v^{(2)})$, go to statement (3-333). (3-293)

If $\Delta f^{(2)} > \left(\frac{w_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})}}{w_v^{(L_v)}} \right)$ and if $w_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} > 0$, (3-294)

go to statement (3-305).

If $\Delta f^{(2)} \left(\frac{w_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})}}{w_v^{(L_v)}} \right)$ and if $w_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} \leq 0$, go to statement (3-312). (3-295)

If $L_v = 1$, set $f_v^{(2)} = f_v^{(2)} + \Delta f^{(2)}$ (3-296)

and $f_v^{(4)} = f_v^{(4)} + \Delta f^{(4)}$ (3-297)

and $w_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} = w_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} - \Delta f^{(2)} w_v^{(L_v)}$ (3-298)

$$\text{If } L_v = 2, \text{ set } W_v^{(L_v)} = W_v^{(L_v)} (1 + \Delta f^{(2)}) \quad (3-299)$$

$$\text{and } f_v^{(4)} = \frac{f_v^{(4)} + \Delta f^{(4)}}{1 + \Delta f^{(2)}} \quad (3-300)$$

$$\text{and } W_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} = W_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} - \frac{\Delta f^{(2)} W_v^{(L_v)}}{1 + \Delta f^{(2)}} \quad (3-301)$$

$$\text{and set } I_{\text{halt}} = 10 \text{ and go to Output Calculations if } \Delta f^{(2)} = -1. \quad (3-302)$$

$$\text{Set } I_{\text{halt}} = 9 \text{ and go to Output Calculations if } f_v^{(4)} < 0. \quad (3-303)$$

$$\text{Go to statement (3-380)}. \quad (3-304)$$

$$\text{If } \Delta f^{(2)} > \frac{W_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})}}{W_v^{(L_v)}} \text{ and } W_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} > 0, \text{ calculate}$$

$$\Delta R = \Delta R - W_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} \left(R_v^{(2)} - \frac{R_v^{(4)} N_v^{(2)}}{N_v^{(4)}} \right) \quad (3-305)$$

$$\text{If } L_v = 2, \text{ set } W_v^{(L_v)} = W_v^{(L_v)} + W_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} \quad (3-306)$$

$$\text{and } f_v^{(4)} = f_v^{(4)} \left(1 - \frac{W_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})}}{W_v^{(L_v)}} \right) - \frac{N_v^{(2)} W_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})}}{W_v^{(L_v)} N_v^{(4)}} \quad (3-307)$$

$$\text{and } W_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} = 0. \quad (3-308)$$

$$\text{If } L_v = 1, \text{ set } f_v^{(4)} = f_v^{(4)} - \frac{w_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} N_v^{(2)}}{w_v^{(L_v)} N_v^{(4)}} \quad (3-309)$$

$$\text{and } f_v^{(2)} = f_v^{(2)} + \frac{w_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})}}{w_v^{(L_v)}} \quad (3-310)$$

$$\text{and } w_{N_v^{\text{rec2}}}^{(I_v^{\text{rec2}})} = 0. \quad (3-311)$$

$$\text{If } L_v = 2 \text{ or if } w_{N_v^{\text{rec1}}}^{(I_v^{\text{rec1}})} \leq 0, \text{ go to statement (3-326)..} \quad (3-312)$$

Calculate

$$\Delta f^{(1)} = \frac{\Delta R}{w_v^{(L_v)} \left(R_v^{(1)} - \frac{R_v^{(4)} N_v^{(1)}}{N_v^{(4)}} \right)} \quad (3-313)$$

$$\Delta f^{(4)} = \frac{N_v^{(1)} \Delta f^{(1)}}{N_v^{(4)}} \quad (3-314)$$

$$\text{If } R_v^{(1)} N_v^{(4)} = R_v^{(4)} N_v^{(1)}, \text{ set } I_{\text{halt}} = 9 \text{ and go to Output Calculations.} \quad (3-315)$$

$$\text{If } \Delta f^{(1)} > \left(\frac{w_{N_v^{\text{rec1}}}^{(I_v^{\text{rec1}})}}{w_v^{(L_v)}} \right), \text{ go to statement (3-322)..} \quad (3-316)$$

$$\underline{\text{Set}} \quad W_v^{(L_v)} = W_v^{(L_v)} (1 + \Delta f^{(1)}) \quad (3-317)$$

$$\underline{\text{and}} \quad f_v^{(4)} = \frac{f_v^{(4)} + \Delta f^{(4)}}{1 + \Delta f^{(1)}} \quad (3-318)$$

$$\underline{\text{and}} \quad W_{N_v^{\text{recl}}}^{(I_v^{\text{recl}})} = W_{N_v^{\text{recl}}}^{(I_v^{\text{recl}})} - \frac{\Delta f^{(1)} W_v^{(L_v)}}{1 + \Delta f^{(1)}} \quad (3-319)$$

$$\underline{\text{If}} \quad f_v^{(4)} < 0, \text{ set } I_{\text{halt}} = 9, \text{ and } \underline{\text{go to Output Calculations.}} \quad (3-320)$$

$$\underline{\text{Go to statement (3-380).}} \quad (3-321)$$

$$\underline{\text{If}} \quad \Delta f^{(1)} > \left(\frac{W_{N_v^{\text{recl}}}^{(I_v^{\text{recl}})}}{W_v^{(L_v)}} \right), \underline{\text{calculate}} \quad -$$

$$\Delta R = \Delta R - W_{N_v^{\text{recl}}}^{(I_v^{\text{recl}})} \left(R_v^{(1)} - \frac{R_v^{(4)} N_v^{(1)}}{N_v^{(4)}} \right) \quad (3-322)$$

$$\underline{\text{Set}} \quad W_v^{(L_v)} = W_v^{(L_v)} + W_{N_v^{\text{recl}}}^{(I_v^{\text{recl}})} \quad (3-323)$$

$$\underline{\text{and}} \quad f_v^{(4)} = f_v^{(4)} \left(1 - \frac{W_{N_v^{\text{recl}}}^{(I_v^{\text{recl}})}}{W_v^{(L_v)}} \right) - \frac{N_v^{(1)} W_{N_v^{\text{recl}}}^{(I_v^{\text{recl}})}}{N_v^{(4)} W_v^{(L_v)}} \quad (3-324)$$

$$\underline{\text{and}} \quad W_{N_v^{\text{recl}}}^{(I_v^{\text{recl}})} = 0. \quad (3-325)$$

Calculate

$$\Delta f^{(3)} = \frac{\Delta R}{W_v^{(L_v)} \left(R_v^{(3)} - \frac{R_v^{(4)} N_v^{(3)}}{N_v^{(4)}} \right)} \quad (3-326)$$

If $R_v^{(3)} N_v^{(4)} = R_v^{(4)} N_v^{(3)}$, set $I_{halt} = 9$ and go to Output Calculations. (3-327)

$$\Delta f^{(4)} = - \frac{N_v^{(3)} \Delta f^{(3)}}{N_v^{(4)}} \quad (3-328)$$

Set $f_v^{(3)} = f_v^{(3)} + \Delta f^{(3)}$ (3-329)

and $f_v^{(4)} = f_v^{(4)} + \Delta f^{(4)}$ (3-330)

If $f_v^{(4)} < 0$, set $I_{halt} = 9$ and go to Output Calculations. (3-331)

Go to statement (3-380). (3-332)

If $\Delta f^{(2)} < (-f_v^{(2)})$, calculate

$$\Delta R = \Delta R + f_v^{(4)} + \frac{f_v^{(2)} N_v^{(3)}}{N_v^{(4)}} \quad (3-333)$$

Set $f_v^{(2)} = 0$. (3-334)

Set $f_v^{(4)} = f_v^{(4)} + \frac{f_v^{(2)} N_v^{(3)}}{N_v^{(4)}}$ (3-335)

and $W_{N_v^{rec2}}^{(I_v^{rec2})} = W_{N_v^{rec2}}^{(I_v^{rec2})} + f_v^{(2)} W_v^{(L_v)}$ (3-336)

If $L_v > 1$, set $I_{halt} = 10$ and go to Output Calculations. (3-337)

Calculate

$$\Delta f^{(1)} = \frac{\Delta R}{W_v^{(L_v)} \left(R_v^{(1)} - \frac{R_v^{(4)} N_v^{(1)}}{N_v^{(4)}} \right)} \quad (3-338)$$

If $R_v^{(1)} N_v^{(4)} = R_v^{(4)} N_v^{(1)}$, set $I_{halt} = 9$ and go to Output Calculations. (3-339)

$$\Delta f^{(4)} = \frac{N_v^{(1)} \Delta f^{(1)}}{N_v^{(4)}} \quad (3-340)$$

If $\Delta f^{(1)} \leq (-f_v^{(1)})$, set $I_{halt} = 10$ and go to Output Calculations. (3-341)

$$\text{Set } W_v^{(L_v)} = W_v^{(L_v)} (1 + \Delta f^{(1)}) \quad (3-342)$$

$$\text{and } W_{N_v^{recl}}^{(I_v^{recl})} = W_{N_v^{recl}}^{(I_v^{recl})} - \frac{\Delta f^{(1)} W_v^{(L_v)}}{1 + \Delta f^{(1)}} \quad (3-343)$$

$$\text{and } f_v^{(4)} = \frac{f_v^{(4)} + \Delta f^{(4)}}{1 + \Delta f^{(1)}} \quad (3-344)$$

If $f_v^{(4)} < 0$, set $I_{halt} = 9$ and go to Output Calculations. (3-345)

Go to statement (3-380). (3-346)

If $f_v^{(2)} = 0$ and $f_v^{(3)} = 0$, calculate

$$\Delta f^{(1)} = \frac{\Delta R}{w_v^{(L_v)} \left(R_v^{(1)} - \frac{R_v^{(1)} N_v^{(1)}}{N_v^{(4)}} \right)} \quad (3-347)$$

$$\Delta f^{(4)} = - \frac{N_v^{(1)} \Delta f^{(1)}}{N_v^{(4)}} \quad (3-348)$$

If $\Delta f^{(1)} \leq (-f_v^{(1)})$, set $I_{halt} = 10$ and go to Output Calculations. (3-349)

If $\Delta f^{(1)} > \left(\frac{w_v^{(I_v^{recl})}}{N_v^{recl}} / w_v^{(L_v)} \right)$, go to statement (3-356). (3-350)

$$\text{Set } w_v^{(L_v)} = w_v^{(L_v)} (1 + \Delta f^{(1)}) \quad (3-351)$$

$$\text{and } \frac{w_v^{(I_v^{recl})}}{N_v^{recl}} = \frac{w_v^{(I_v^{recl})}}{N_v^{recl}} - \frac{\Delta f^{(1)} w_v^{(L_v)}}{1 + \Delta f^{(1)}} \quad (3-352)$$

$$\text{and } f_v^{(4)} = \frac{f_v^{(4)} + \Delta f^{(4)}}{1 + \Delta f^{(1)}} \quad (3-353)$$

If $f_v^{(4)} < 0$, set $I_{halt} = 9$ and go to Output Calculations. (3-354)

Go to statement (3-380). (3-355)

If $\Delta f^{(1)} > \left(\frac{W_{N_v}^{(I_v^{rec1})}}{W_v^{(L_v)}} \right)$, calculate

$$\Delta R = \Delta R - W_{N_v}^{(I_v^{rec1})} \left(R_v^{(1)} - \frac{R_v^{(4)} N_v^{(1)}}{N_v^{(4)}} \right) \quad (3-356)$$

$$W_v^{(L_v)} = W_v^{(L_v)} + W_{N_v}^{(I_v^{rec1})} \quad (3-357)$$

$$f_v^{(4)} = f_v^{(4)} \left(1 - \frac{W_{N_v}^{(I_v^{rec1})}}{W_v^{(L_v)}} \right) - \frac{N_v^{(1)} W_{N_v}^{(I_v^{rec1})}}{N_v^{(4)} W_v^{(L_v)}} \quad (3-358)$$

$$W_{N_v}^{(I_v^{rec1})} = 0. \quad (3-359)$$

If $N_v^{rec2} = 0$, or if $W_{N_v}^{(I_v^{rec2})} \leq 0$, go to statement (3-374). (3-360)

$$\text{Set } \Delta f^{(2)} = \frac{\Delta R}{W_v^{(L_v)} \left(R_v^{(2)} - \frac{R_v^{(4)} N_v^{(2)}}{N_v^{(4)}} \right)} \quad (3-361).$$

If $R_v^{(2)} N_v^{(4)} = R_v^{(4)} N_v^{(2)}$, set $I_{halt} = 9$ and go to Output Calculations. (3-362).

$$\text{Set } \Delta f^{(4)} = - \frac{N_v^{(2)} f_v^{(2)}}{N_v^{(4)}} \quad (3-363)$$

$$\text{If } \Delta f^{(2)} > \left(\frac{W_{N_v^{rec2}}^{(I_v^{rec2})}}{W_v^{(L_v)}} \right), \text{ go to statement (3-370).} \quad (3-364)_2$$

$$\text{Set } f_v^{(2)} = f_v^{(2)} + \Delta f^{(2)} \quad (3-365)$$

$$\text{and } f_v^{(4)} = f_v^{(4)} + \Delta f^{(4)} \quad (3-366)$$

$$\text{and } W_{N_v^{rec2}}^{(I_v^{rec2})} = W_{N_v^{rec2}}^{(I_v^{rec2})} - \Delta f^{(2)} W_v^{(L_v)} \quad (3-367)$$

$$\text{If } f_v^{(4)} < 0, \text{ set } I_{halt} = 9 \text{ and go to Output Calculations.} \quad (3-368)$$

$$\text{Go to statement (3-380).} \quad (3-369)$$

$$\text{If } \Delta f^{(2)} > \left(\frac{W_{N_v^{rec2}}^{(I_v^{rec2})}}{W_v^{(L_v)}} \right), \text{ calculate}$$

$$\Delta R = \Delta R - W_{N_v^{rec2}}^{(I_v^{rec2})} \left(R_v^{(2)} - \frac{R_v^{(4)} N_v^{(2)}}{N_v^{(4)}} \right) \quad (3-370)$$

$$f_v^{(4)} = f_v^{(4)} - \frac{W_{N_v^{rec2}}^{(I_v^{rec2})} N_v^{(2)}}{W_v^{(L_v)} N_v^{(4)}} \quad (3-371)$$

$$f_v^{(2)} = f_v^{(2)} + \frac{W_{N_v^{rec2}}^{(I_v^{rec2})}}{W_v^{(L_v)}} \quad (3-372)$$

$$W_{N_v^{rec2}}^{(I_v^{rec2})} = 0. \quad (3-373)$$

and calculate

$$\Delta f^{(3)} = \frac{\Delta R}{W_v^{(L_v)} \left(R_v^{(3)} - \frac{R_v^{(4)} N_v^{(3)}}{N_v^{(4)}} \right)} \quad (3-374)$$

$$\Delta f^{(4)} = - \frac{N_v^{(3)} \Delta f^{(3)}}{N_v^{(4)}} \quad (3-375)$$

If $R_v^{(3)} N_v^{(4)} = R_v^{(4)} N_v^{(3)}$, set $I_{halt} = 9$ and go to Output Calculations. (3-376)

Set $f_v^{(3)} = f_v^{(3)} + \Delta f^{(3)}$ (3-377)

and $f_v^{(4)} = f_v^{(4)} + \Delta f^{(4)}$ (3-378)

If $f_v^{(4)} < 0$, set $I_{halt} = 9$ and go to Output Calculations. (3-379)

End loop on v.

Do loop on j ($j_{J_v-1} + 1 \leq j \leq j_{J_v}$). (3-380)

Do loop on m ($1 \leq m \leq m_{max}^{fuel}$). (3-381)

Calculate $N_{m,j,n}^{(o)}$ as per statement (3-236). (3-382)

for $(N_{J_v}^{bat} - N_{dis}^{(J_v)} + 1) \leq n \leq N_{J_v}^{bat}$.

End loop on m. End loop on j.

Calculate $W_{J_v, n}^{(o)}$ as per statement (3-240). (3-383)

for $(N_{J_v}^{(bat)} - N_{dis}^{(J_v)} + 1) \leq n \leq N_{J_v}^{bat}$. (3-384)

If $I = I_{init}$, and if either (1) $\delta_1^{(a)} > 0$ or (2) $\delta_1^{(a)} = 0$ with

$$\delta_{restart} = 0,$$

Do loop on v ($v_o \leq v \leq J_{max}$). (3-385)

If $N_{dis}^{(J_v)} = 0$, or $N_{J_v}^{recl} \leq N_{max}^{stor}$, go to next v in loop. (3-386)

Calculate

$$\Delta R = \Delta K_{adj} \frac{R_v^{(b)}}{R^{(b)}} \quad (3-387)$$

$$\Delta f^{(3)} = \frac{\Delta R}{R_v^{(3)} - \frac{R_v^{(4)} N_v^{(3)}}{N_v^{(4)}}} \quad (3-388)$$

$$\Delta f^{(4)} = - \frac{N_v^{(3)} \Delta f^{(3)}}{N_v^{(4)}} \quad (3-389)$$

If $R_v^{(3)} N_v^{(4)} = R_v^{(4)} N_v^{(3)}$, set $I_{halt} = 9$ and go to Output Calculations. (3-390)

Calculate (for $j_{J_v-1} + 1 \leq j \leq j_{J_v}$; $1 \leq m \leq m_{fuel}^{max}$; $N_{J_v}^{bat} - N_{dis}^{(J_v)} + 1 \leq n \leq N_{J_v}^{bat}$)

$$N_{m,j,n}^{(o)} = N_{m,j,n}^{(o)} + \left[\frac{\Delta f^{(3)} \sum_{q=1}^{q_{\max}^{(N_v^{mkp})}} \delta_{m,M_{q,N_v^{mkp}}} W_{q,N_v^{mkp}}}{\sum_{q=1}^{q_{\max}^{(N_v^{mkp})}} W_{q,N_v^{mkp}}} + \frac{\Delta f^{(4)} \sum_{q=1}^{q_{\max}^{(N_v^{oth})}} \delta_{m,M_{q,N_v^{oth}}} W_{q,N_v^{oth}}}{\sum_{q=1}^{q_{\max}^{(N_v^{mkp})}} W_{q,N_v^{oth}}} \right] / N_{dis}^{(J_v)} \left(\frac{A_m^{wt}}{602.5} \right) V_J \quad (3-391)$$

where $V_J = \sum_{j=j_{J_v-1}+1}^{j_{J_v}} V_J$ (3-392)

Calculate (for $N_{J_v}^{bat} - N_{dis}^{(J_v)} + 1 \leq n \leq N_{J_v}^{bat}$)

$$W_{J_v,n}^{(o)} = V_J \sum_{m=1}^{m_{\max}^{fuel} + n_{fp}^{\max}} \left(\frac{A_m^{wt}}{602.5} \right) N_{m,j_{J_v},n} \quad (3-393)$$

End loop on v. Go to "First Flux Adjustment" - statement (3-1). (3-394)

3.3.16 Time Adjustment for Next Iteration If There Are No Variable Fissile Zones

$$N_{J_v}^{\text{recl}} \leq N_{\text{max}}^{\text{stor}} \text{ for all } (1 \leq v \leq J_{\text{max}})$$

If $\delta_{\text{only}}^{\text{stor}} > 0$, set $I_{\text{halt}} = 51$ and go to Output Calculations. (3-395)

Set $\delta_{\text{only}}^{\text{stor}} = 1$ and $K^{(i-1)} = K$. (3-396)

Set $i = i + 1$ and $T_{\text{orig}} = T$. (3-397)

Set $r_{\text{st}} = 1$ if $(\Delta K)_{\text{burnup}} \geq 0$; set $r_{\text{st}} = -1$ if $(\Delta K)_{\text{burnup}} < 0$. (3-398)

If $K^{(i-1)} > K^{(e)} + \Delta K^{(e)}$, go to statement (3-403). (3-399)

If $\left[K^{(e)} - \Delta K^{(e)} - K^{(i-1)} \right] > \frac{\Delta T}{T_{\text{orig}}} r_{\text{st}} (\Delta K)_{\text{burnup}}$,

set $I_{\text{halt}} = 51$ and go to Output Calculations. (3-400)

If $\left[K^{(i-1)} + \frac{\Delta T}{T_{\text{orig}}} r_{\text{st}} (\Delta K)_{\text{burnup}} \right] \leq K^{(e)}$,

set $T = T_{\text{orig}} + r_{\text{st}} \Delta T$ and go to statement (3-406). (3-401)

Otherwise, calculate

$T = T_{\text{orig}} \left[1 + \frac{K^{(e)} - K^{(i-1)}}{(\Delta K)_{\text{burnup}}} \right]$ and go to statement (3-406). (3-402)

If $\left[K^{(i-1)} - (K^{(e)} + \Delta K^{(e)}) \right] > \frac{\Delta T}{T_{\text{orig}}} r_{\text{st}} (\Delta K)_{\text{burnup}}$,

set $I_{\text{halt}} = 51$ and go to Output Calculations. (3-403)

$$\text{If } \left[K^{(i-1)} - \frac{\Delta T}{T_{\text{orig}}} r_{\text{st}} (\Delta K)_{\text{burnup}} \right] \geq K^{(e)},$$

set $T = T_{\text{orig}} - r_{\text{st}} \Delta T$ and go to statement (3-406).

(3-404)

Otherwise, calculate

$$T = T_{\text{orig}} \left[1 - \frac{K^{(i-1)} - K^{(e)}}{(\Delta K)_{\text{burnup}}} \right]$$

(3-405)

Go to "First Flux Adjustment" - statement (3-1).

(3-406)

3.4 OUTPUT CALCULATIONS

3.4.1 Dump on Error Halt and Restart Preparation

If $I_{halt} \neq 0$, set up to print I , i , I_t , and I_{halt} (data block 51A). (4-1)

If $I_{halt} \neq 0$ and $\delta_{dump} = 1$, write all data blocks (essentially a core dump) and stop. (4-2)

If $I = I_{max}$ and $\delta_{restart}^{prep} > 0$, set $T^{restart} = T$. (4-3)

$$(\Delta K)_{burnup}^{restart} = (\Delta K)_{burnup}. \quad (4-4)$$

If $I_{halt} = 0$ and $I = I_{max}$, set $I_{halt} = 6$. (4-5)

Set up to print I , i , I_t and I_{halt} ; and if $I_{max} = 6$, also set up to print "Last Interval". (4-6)

3.4.2 Breeding Ratio, Regional and Batch Material Concentrations, and Recycle Repository Inventories

If $\delta_{BR} > 0$, calculate breeding ratio as follows:

$$R_{init}^{breed} = \left[\sum_{J=1}^{J_{max}} \sum_{j=j_{J-1}+1}^{j_J} \phi_j v_j \sum_{n=1}^{N_J^{bat}} \left(1 - \delta_{m_{max}^{fuel},6} \right) \left(\sigma_{c_{1,j}}^{N_{1,j,n}^{(o)}} + \sigma_{c_{3,j}}^{N_{3,j,n}^{(o)}} \right) \right. \\ \left. + \left(1 - \delta_{m_{max}^{fuel},5} \right) \left(1 - \delta_{m_{max}^{fuel},7} \right) \left(\sigma_{c_{m_{max}^{fuel}-2,j}}^{N_{m_{max}^{fuel}-2,j,n}^{(o)}} \right) \right. \\ \left. + \sigma_{c_{m_{max}^{fuel}-5,j}}^{N_{m_{max}^{fuel}-5,j,n}^{(o)}} \right]$$

$$\begin{aligned}
 & \div \left\{ \sum_{J=1}^{J_{\max}} \sum_{j=j_{J-1}+1}^{j_J} \phi_j V_j \sum_{n=1}^{N_j^{\text{bat}}} \left(1 - \delta_{m_{\max}^{\text{fuel}},6} \right) \left(\sigma_{r_{2,j}} N_{2,j,n}^{(o)} + \sigma_{r_{4,j}} N_{4,j,n}^{(o)} \right) \right. \\
 & + \left(1 - \delta_{m_{\max}^{\text{fuel}},5} \right) \left[\sigma_{r_{m_{\max}^{\text{fuel}}-1,j}} N_{m_{\max}^{\text{fuel}}-1,j,n}^{(o)} \right. \\
 & + \left(1 - \delta_{m_{\max}^{\text{fuel}},7} \right) \left(\sigma_{r_{m_{\max}^{\text{fuel}}-3,j}} N_{m_{\max}^{\text{fuel}}-3,j,n}^{(o)} \right. \\
 & \left. \left. + \sigma_{c_{m_{\max}^{\text{fuel}}-4,j}} N_{m_{\max}^{\text{fuel}}-4,j,n}^{(o)} \right) \right] \left. \right\} : \quad (4-7)
 \end{aligned}$$

$$\begin{aligned}
 R_{\text{init}}^{\text{breed}} &= [\text{Same as Equ. (4-7), except replace all } N_{m,j,n}^{(o)} \text{ terms by } N_{m,j,n}^{(e)} \\
 &\quad (\text{for } m \text{ values as indicated above).}] \quad (4-8)
 \end{aligned}$$

$$\bar{R}^{\text{breed}} = \frac{1}{2} \left(R_{\text{end}}^{\text{breed}} + R_{\text{init}}^{\text{breed}} \right) \quad (4-9)$$

$$\text{If } \delta_{\text{BR}} = 0, \text{ set } R_{\text{init}}^{\text{breed}} = R_{\text{end}}^{\text{breed}} = \bar{R}^{\text{breed}} = 0. \quad (4-10)$$

If $\delta_{\text{init}}^{\text{core}} > 0$, calculate block 55 output data:

$$N_{m,j}^{(o)} = \sum_{n=1}^{N_{J_w}^{\text{bat}}} N_{m,j,n}^{(o)} \quad (4-11)$$

for $1 \leq m \leq m_{\text{max}}; 1 \leq j \leq j_{\text{max}}$.

If $\delta_{\text{end}}^{\text{core}} > 0$, calculate block 56 output data:

$$N_{m,j}^{(e)} = \sum_{n=1}^{N_{J_w}^{\text{bat}}} N_{m,j,n}^{(e)} \quad (4-12)$$

for $1 \leq m \leq m_{\text{max}}; 1 \leq j \leq j_{\text{max}}$.

3.4.3 Set Up Calculations for Zonal and Reactor Output Data

Calculate

$$E_{J,n}^{(o)} = E_{J,n}^{(o)th} + E_{J,n}^{th} \quad (4-13)$$

for $1 \leq J \leq J_{max}$ and $1 \leq n \leq N_J^{bat}$.

$$P(e) = e^{th} \bar{P}^{th} \quad (4-14)$$

If $I = I_{init}$, and $\delta_1^{(a)} > 0$ or $\delta_{restart} = 0$, set $T_{yr}^{acc} = 0$. (4-15)

Calculate

$$T_{yr}^{acc} = T_{yr}^{acc} \left(\frac{T}{365.25} \right) \quad (4-16)$$

At this point, all output quantities for data blocks 51A through 51D have been calculated (except T_{doub}) and can be set up for output print format.

Calculate

$$E_{int} = 24 \times 10^3 \text{ fTP}^{th} [\delta_{unit}^{cost} e^{th} + .00341 (1 - \delta_{unit}^{cost})] \quad (4-17)$$

Make the following settings:

$$E' = 0, E_{int} = 0, W_{out} = 0, P_{out}^{tot} = 0, U_{out}^{tot} = 0, U_{out}^{fis} = 0,$$

$$W_m^{out} = W_m^{in} = W_m^{mid\ inv} = W_m^{end\ inv} = 0 \text{ for } 1 \leq m \leq m_{max},$$

$$W_{in} = P_{in}^{tot} = P_{in}^{fis} = U_{in}^{tot} = U_{in}^{fis} = 0,$$

$$W_{end\ inv} = P_{end\ inv}^{tot} = P_{end\ inv}^{fis} = U_{end\ inv}^{tot} = U_{end\ inv}^{fis} = 0,$$

$$W_{mid\ inv} = P_{mid\ inv}^{tot} = P_{mid\ inv}^{fis} = U_{mid\ inv}^{tot} = U_{mid\ inv}^{fis} = 0,$$

$$C_{i'}^{tot} = C_{i'}^{fab} = C_{i'}^{repr} = C_{i'}^{cred} = C_{i'}^{inv} = C_{i'}^{fab\ inv} = C_{i'}^{repr\ inv} = 0,$$

$$C_{i'}^{tot} = C_{i'}^{fab} = C_{i'}^{repr} = C_{i'}^{cred} = C_{i'}^{inv} = C_{i'}^{fab\ inv} = C_{i'}^{repr\ inv} = 0,$$

$$\text{for } 1 \leq i' \leq N_{alt}^{max} \quad (4-18)$$

$$\text{Do loop on } g \ (1 \leq g \leq g_{max}) \quad (4-19)$$

$$\begin{aligned} \text{If } \delta_{meth}^{cost} = 0 \text{ and if } & \left(\delta_{reac}^{disch} + \delta_{reac}^{load} + \delta_{reac}^{mid\ inv} + \delta_{rec}^{end\ inv} + \delta_g^{disch} \right. \\ & \left. + \delta_g^{load} + \delta_g^{mid\ inv} + \delta_g^{end\ inv} \right) = 0, \text{ go to next } g \text{ in loop.} \end{aligned} \quad (4-20)$$

$$\text{Do loop on } w \ (w_{g-1} + 1 \leq w \leq w_g) \quad (4-21)$$

$$\text{If } N_{J_w}^{stor} \leq N_{max}^{stor}, \text{ set } N_{J_w}^{st\ dis} = N_{J_w}^{stor} \quad (4-22)$$

$$\text{Otherwise, set } N_{J_w}^{st\ dis} = 0. \quad (4-23)$$

$$\begin{aligned} \text{If } N_{J_w}^{\text{recl}} \leq N_{\text{max}}^{\text{stor}}, \text{ set } N_{J_w}^{\text{st load}} &= N_{J_w}^{\text{recl}} \\ \text{and } I_{J_w}^{\text{st load}} &= I_{J_w}^{\text{stor}}. \text{ Otherwise, set } N_{J_w}^{\text{st load}} = I_{J_w}^{\text{st load}} = 0. \end{aligned} \quad (4-24)$$

$$\begin{aligned} \text{Set } n_1^{\text{dis}} &= n_{J_w}^{\text{dis}}; n_2^{\text{dis}} = n_{J_w}^{\text{dis}} + N_{\text{dis}}^{(J_w)} - 1; n_1^{\text{load}} = n_{J_w}^{\text{dis}} + N_{J_w}^{\text{bat}} - N_{\text{dis}}^{(J_w)}; \\ n_2^{\text{load}} &= n_{J_w}^{\text{dis}} + N_{J_w}^{\text{bat}} - 1. \end{aligned} \quad (4-25)$$

$$\text{Set } N'_n = n - 1 + n_1^{\text{dis}} \text{ for } 1 \leq n \leq N_{J_w}^{\text{bat}}. \quad (4-26)$$

$$\text{If } \delta_g^{\text{group}} = 0 \text{ or if } w = w_{g-1} + 1, \text{ set } \delta'_{gp} = 0. \text{ Otherwise, set } \delta'_{gp} = 1. \quad (4-27)$$

3.4.4 Zonal and Reactor Fuel Discharged, Loaded, and Weight Inventory

3.4.4.1 Beginning-and-End-of-Interval Fuel Weights, Broken Down by Batch and Material, and Energy Produced by Discharged Fuel

(Continue in w and g loops).

Calculate

$$W_{m,J_w,n}^{(e)} = \delta'_{gp} W_{m,J_w,n}^{(e)} + \left(\frac{A_m}{602.5} \right) \sum_{j=j_{J_w-1}+1}^{j_{J_w}} V_j^{N(e)} \quad (4-28)$$

$$\text{for } 1 \leq n \leq N_{J_w}^{\text{bat}}; 1 \leq m \leq m_{\text{max}}.$$

$$W_{m,J_w,n}^{(o)} = \delta'_{gp} W_{m,J_w,n}^{(o)} + \left(\frac{A_m}{602.5} \right) \sum_{j=j_{J_w-1}+1}^{j_{J_w}} V_j^{N(o)} \quad (4-29)$$

$$\text{for } 1 \leq n \leq N_{J_w}^{\text{bat}}; 1 \leq m \leq m_{\text{max}}.$$

If $N_{J_w}^{st\ dis} = 0$, calculate

$$E'_{J_w,n} = \delta'_{gp} E'_{J_w,n} + 24 \times 10^3 E_{J_w,n}^{(o)th} \left[\delta_{unit}^{cost} e^{th} + .0034 (1 - \delta_{unit}^{cost}) \right] \quad (4-30)$$

for $1 \leq n \leq N_{dis}^{(J_w)}$

and if $\delta_g^{group} = 0$, or if $w = w_g$, also calculate

$$E'_{J_w} = \sum_{n=1}^{N_{dis}^{(J_w)}} E'_{J_w,n} \quad (4-31)$$

$$E' = E' + E'_{J_w} \quad (4-32)$$

Calculate

$$E_{J_w}^{int} = \delta'_{gp} E_{J_w}^{int} + \sum_{n=1}^{N_{J_w}^{bat}} E_{J_w,n}^{th} \quad (4-33)$$

$$\bar{P}_{J_w}^{th} = E_{J_w}^{int} / fT \quad (4-34)$$

$$E_{J_w}^{int} = 24 \times 10^3 E_{J_w}^{int} \left[\delta_{unit}^{cost} e^{th} + .0034 (1 - \delta_{unit}^{cost}) \right] \quad (4-35)$$

3.4.4.2 Discharged Fuel Weights and End-of-Interval Inventory Weights

If $\left(\delta_g^{\text{disch}} + \delta_g^{\text{end inv}} \right) > 0$, calculate

$$B_{J_w} = \sum_{J_w} \frac{\sum_{n=1}^{N_{\text{dis}}^{(J_w)}} E_{J_w,n}^{(o)th}}{10^3} \sum_{J_w} \sum_{n=1}^{N_{\text{dis}}^{(J_w)}} W_{J_w,n}^{(o)} \quad (4-36)$$

$$B_{J_w,n} = \sum_{J_w} \frac{E_{J_w,n}^{(o)th}}{10^3} \sum_{J_w} W_{J_w,n}^{(o)} \quad (4-37)$$

for $1 \leq n \leq N_{J_w}^{\text{bat}}$

If $\delta_g^{\text{group}} = 0$ or if $w = w_g$, calculate as per statements (4-38) through (4-69):

If $m_{\text{max}}^{\text{fuel}} = 6$, set $P_{J_w,n}^{\text{tot}(e)*} = P_{J_w,n}^{\text{fis}(e)*} = 0$ for $1 \leq n \leq N_{J_w}^{\text{bat}}$, (4-38)

and set $P_{J_w,n}^{\text{tot}(o)*} = P_{J_w,n}^{\text{fis}(o)*} = 0$ for $N_{J_w}^{\text{bat}} - N_{\text{dis}}^{(J_w)} + 1 \leq n \leq N_{J_w}^{\text{bat}}$ (4-39)

and set $P_{J_w}^{\text{tot out}} = P_{J_w}^{\text{fis out}} = P_{J_w}^{\text{tot in}} = P_{J_w}^{\text{fis in}} = P_{J_w}^{\text{tot mid inv}}$
 $= P_{J_w}^{\text{fis mid inv}} = P_{J_w}^{\text{tot end inv}} = P_{J_w}^{\text{fis end inv}} = 0$ (4-40)

* Superscript (e)* is identified with superscript "out" in output data block 52C and with superscript "end inv" in output data block 52O.
 Superscript (o)* is identified with superscript "in" in output data block 52G.

If $\left(\delta_{\text{reac}}^{\text{disch}} + \delta_{\text{reac}}^{\text{end inv}} + \delta_{\text{g}}^{\text{disch}} + \delta_{\text{g}}^{\text{end inv}} + \delta_{\text{meth}}^{\text{cost}} \right) > 0$, do calculations
through statement (4-69) . (4-41)

$$W_{J_w}^{\text{out}} = \delta_{\text{gp}}' W_{J_w}^{\text{out}} + \sum_{n=1}^{N_{\text{dis}}^{(J_w)}} W_{J_w,n}^{(o)} \quad (4-42)$$

If $m_{\text{max}}^{\text{fuel}} \neq 6$, calculate

$$p_{J_w,n}^{\text{fis}(e)*} = W_{2,J_w,n}^{(e)} + W_{4,J_w,n}^{(e)} \quad (4-43)$$

for $1 \leq n \leq N_{\text{dis}}^{(J_w)}$ if $\left(\delta_{\text{reac}}^{\text{end inv}} + \delta_{\text{g}}^{\text{end inv}} \right) = 0$;

for $1 \leq n \leq N_{J_w}^{\text{bat}}$ if $\left(\delta_{\text{reac}}^{\text{end inv}} + \delta_{\text{g}}^{\text{end inv}} \right) = 0$.

$$p_{J_w,n}^{\text{tot}(e)*} = p_{J_w,n}^{\text{fis}(e)} + W_{3,J_w,n}^{(e)} + W_{5,J_w,n}^{(e)} \quad (4-44)$$

for same range of n as Equ. (4-43).

$$p_{J_w}^{\text{tot out}} = \sum_{n=1}^{N_{\text{dis}}^{(J_w)}} p_{J_w,n}^{\text{tot}(e)*} \quad (4-45)$$

$$p_{J_w}^{\text{fis out}} = \sum_{n=1}^{N_{\text{dis}}^{(J_w)}} p_{J_w,n}^{\text{fis}(e)*} \quad (4-46)$$

* See footnote on preceding page (4-8).

Calculate

$$\begin{aligned}
 U_{J_w, n}^{\text{tot}(e)*} &= \left(1 - \delta_{m_{\max}^{\text{fuel}}, 6} \right) W_{1, J_w, n}^{(e)} \\
 &+ \left(1 - \delta_{m_{\max}^{\text{fuel}}, 5} \right) \sum_{m=m_{\max}^{\text{fuel}}-4+3\delta_{m_{\max}^{\text{fuel}}, 7}}^{m_{\max}^{\text{fuel}}} W_{m, J_w, n}^{(e)} \quad (4-47)
 \end{aligned}$$

for same range of n as Equ. (4-43) ..

$$\begin{aligned}
 U_{J_w, n}^{\text{fis}(e)*} &= \left(1 - \delta_{m_{\max}^{\text{fuel}}, 5} \right) \left[W_{m_{\max}^{\text{fuel}}-1, J_w, n}^{(e)} \right. \\
 &\left. + \left(1 - \delta_{m_{\max}^{\text{fuel}}, 7} \right) \left(W_{m_{\max}^{\text{fuel}}-3, J_w, n}^{(e)} + W_{m_{\max}^{\text{fuel}}-4, J_w, n}^{(e)} \right) \right] \quad (4-48)
 \end{aligned}$$

for same range of n as Equ. (4-43) .

$$U_{J_w}^{\text{tot out}} = \sum_{n=1}^{N_{\text{dis}}^{(J_w)}} U_{J_w, n}^{\text{tot}(e)*} \quad (4-49)$$

$$U_{J_w}^{\text{fis out}} = \sum_{n=1}^{N_{\text{dis}}^{(J_w)}} U_{J_w, n}^{\text{fis}(e)*} \quad (4-50)$$

$$P_{out}^{tot} = P_{out}^{tot} + P_{J_w}^{tot out} \quad (4-51)$$

$$P_{out}^{fis} = P_{out}^{fis} + P_{J_w}^{fis out} \quad (4-52)$$

$$U_{out}^{tot} = U_{out}^{tot} + U_{J_w}^{tot out} \quad (4-53)$$

$$U_{out}^{fis} = U_{out}^{fis} + U_{J_w}^{fis out} \quad (4-54)$$

$$W_{out} = W_{out} + W_{J_w}^{out} \quad (4-55)$$

If $\delta_g^{disch} > 2$ or if $\delta_{reac}^{disch} > 1$, calculate

$$W_{J_w}^{out} = \sum_{n=1}^{N_{dis}^{(J_w)}} W_{m,J_w,n}^{(e)} \quad \text{for } 1 \leq m \leq m_{max}. \quad (4-56)$$

If $\delta_g^{end inv} > 2$ or if $\delta_{reac}^{end inv} > 1$, calculate

$$W_{m,J_w}^{end inv} = \sum_{n=N_{dis}^{(J_w)} + 1}^{N_{J_w}^{bat}} W_{m,J_w,n}^{(e)} \quad \text{for } 1 \leq m \leq m_{max}. \quad (4-57)$$

If $\delta_{\text{reac}}^{\text{disch}} > 1$, calculate

$$W_m^{\text{out}} = W_m^{\text{out}} + W_{m,J_w}^{\text{out}} \quad \text{for } 1 \leq m \leq m_{\text{max}}. \quad (4-58)$$

If $\delta_{\text{reac}}^{\text{end inv}} > 1$, calculate

$$W_m^{\text{end inv}} = W_m^{\text{end inv}} + W_{m,J_w}^{\text{end inv}} \quad (4-59)$$

If $(\delta_{\text{reac}}^{\text{end inv}} + \delta_g^{\text{end inv}}) > 0$, calculate

$$P_{J_w}^{\text{tot end inv}} = \sum_{n=1}^{N_{J_w}^{\text{bat}}} P_{J_w,n}^{\text{tot}(e)*} \quad \text{if } m_{\text{max}}^{\text{fuel}} \neq 6. \quad (4-60)$$

$$P_{J_w}^{\text{fis end inv}} = \sum_{n=1}^{N_{J_w}^{\text{bat}}} P_{J_w,n}^{\text{fis}(e)*} \quad \text{if } m_{\text{max}}^{\text{fuel}} \neq 6. \quad (4-61)$$

$$U_{J_w}^{\text{tot end inv}} = \sum_{n=1}^{N_{J_w}^{\text{bat}}} U_{J_w,n}^{\text{tot}(e)*} \quad (4-62)$$

$$U_{J_w}^{\text{fis end inv}} = \sum_{n=1}^{N_{J_w}^{\text{bat}}} U_{J_w,n}^{\text{fis}(e)*} \quad (4-63)$$

$$P_{\text{end inv}}^{\text{tot}} = P_{\text{end inv}}^{\text{tot}} + P_{J_w}^{\text{tot end inv}} \quad (4-64)$$

$$P_{\text{end inv}}^{\text{fis}} = P_{\text{end inv}}^{\text{fis}} + P_{J_w}^{\text{fis end inv}} \quad (4-65)$$

$$U_{\text{end inv}}^{\text{tot}} = U_{\text{end inv}}^{\text{tot}} + U_{J_w}^{\text{tot end inv}} \quad (4-66)$$

$$U_{\text{end inv}}^{\text{fis}} = U_{\text{end inv}}^{\text{fis}} + U_{J_w}^{\text{fis end inv}} \quad (4-67)$$

$$W_{J_w}^{\text{end inv}} = \sum_{n=1}^{N_{J_w}^{\text{bat}}} W_{J_w,n}^{(o)} \quad (4-68)$$

$$W_{\text{end inv}} = W_{\text{end inv}} + W_{J_w}^{\text{end inv}} \quad (4-69)$$

3.4.4.3 Loaded Fuel Weights at Beginning of Interval

If $(\delta_{\text{reac}}^{\text{load}} + \delta_g^{\text{load}} + \delta_{\text{meth}}^{\text{cost}}) > 0$, do calculations through statement (4-86). (4-70)

$$W_{J_w}^{\text{in}} = \delta_{gP} W_{J_w}^{\text{in}} \sum_{n=N_{J_w}^{\text{bat}} - N_{\text{dis}}(J_w) + 1}^{N_{J_w}^{\text{bat}}} W_{J_w,n}^{(o)} \quad (4-71)$$

If $\delta_g^{\text{group}} = 0$ or if $w = w_g$, calculate as per statements (4-72) through (4-86) :

$$W_{\text{in}} = W_{\text{in}} + W_{J_w}^{\text{in}} \quad (4-72)$$

If $m_{\text{fuel}} \leq 6$, calculate

$$p_{J_w, n}^{\text{fis(o)*}} = w_{2, J_w, n}^{(o)} + w_{4, J_w, n}^{(o)} \quad (4-73)$$

$$\text{for } N_{J_w}^{\text{bat}} - N_{\text{dis}}'(J_w) + 1 \leq n \leq N_{J_w}^{\text{bat}}$$

$$p_{J_w, n}^{\text{tot(o)*}} = p_{J_w, n}^{\text{fis(o)}} + w_{3, J_w, n}^{(o)} + w_{5, J_w, n}^{(o)} \quad (4-74)$$

$$\text{for } N_{J_w}^{\text{bat}} - N_{\text{dis}}'(J_w) + 1 \leq n \leq N_{J_w}^{\text{bat}}$$

$$p_{J_w}^{\text{tot in}} = \sum_{n=N_{J_w}^{\text{bat}} - N_{\text{dis}}'(J_w) + 1}^{N_{J_w}^{\text{bat}}} p_{J_w, n}^{\text{tot(o)*}} \quad (4-75)$$

$$p_{J_w}^{\text{fis in}} = \sum_{n=N_{J_w}^{\text{bat}} - N_{\text{dis}}'(J_w) + 1}^{N_{J_w}^{\text{bat}}} p_{J_w, n}^{\text{fis(o)*}} \quad (4-76)$$

Calculate

$$\begin{aligned}
 U_{J_w, n}^{\text{tot(o)*}} = & \left(1 - \delta_{m_{\text{max}}^{\text{fuel}}, 6} \right) W_{1, J_w, n}^{(o)} \\
 & + \left(1 - \delta_{m_{\text{max}}^{\text{fuel}}, 5} \right) \sum_{m=m_{\text{max}}^{\text{fuel}}-4}^{m_{\text{max}}^{\text{fuel}}} \delta_{m_{\text{max}}^{\text{fuel}}, 7} W_{m, J_w, n}^{(o)} \quad (4-77)
 \end{aligned}$$

$$\text{for } N_{J_w}^{\text{bat}} - N_{\text{dis}}^{(J_w)} + 1 \leq n \leq N_{J_w}^{\text{bat}}.$$

$$\begin{aligned}
 U_{J_w, n}^{\text{fis(o)*}} = & \left(1 - \delta_{m_{\text{max}}^{\text{fuel}}, 5} \right) \left[W_{m_{\text{max}}^{\text{fuel}}-1, J_w, n}^{(o)} \right. \\
 & \left. + \left(1 - \delta_{m_{\text{max}}^{\text{fuel}}, 7} \right) \left(W_{m_{\text{max}}^{\text{fuel}}-3, J_w, n}^{(o)} + W_{m_{\text{max}}^{\text{fuel}}-4, J_w, n}^{(o)} \right) \right] \quad (4-78)
 \end{aligned}$$

$$\text{for } N_{J_w}^{\text{bat}} - N_{\text{dis}}^{(J_w)} + 1 \leq n \leq N_{J_w}^{\text{bat}}.$$

$$U_{J_w}^{\text{tot in}} = \sum_{n=N_{J_w}^{\text{bat}}-N_{\text{dis}}^{(J_w)}+1}^{N_{J_w}^{\text{bat}}} U_{J_w, n}^{\text{tot(o)*}} \quad (4-79)$$

$$U_{J_w}^{fis\ in} = \sum_{n=N_{J_w}^{bat}-N_{dis}^{(J_w)}+1}^{N_{J_w}^{bat}} U_{J_w,n}^{fis(o)*} \quad (4-80)$$

$$W_{in} = W_{in} + W_{J_w}^{in} \quad (4-81)$$

$$P_{in}^{tot} = P_{in}^{tot} + P_{J_w}^{tot\ in}$$

$$P_{in}^{fis} = P_{in}^{fis} + P_{J_w}^{fis\ in} \quad (4-82)$$

$$U_{in}^{tot} = U_{in}^{tot} + U_{J_w}^{tot\ in} \quad (4-83)$$

$$U_{in}^{fis} = U_{in}^{fis} + U_{J_w}^{fis\ in} \quad (4-84)$$

If $\delta_{reac}^{load} > 1$ or if $\delta_g^{load} > 2$, calculate

$$W_{m,J_w}^{in} = \sum_{n=N_{J_w}^{bat}-N_{dis}^{(J_w)}+1}^{N_{J_w}^{bat}} W_{m,J_w,n}^{(o)} \quad \text{for } 1 \leq m \leq m_{max} \quad (4-85)$$

If $\delta_{reac}^{load} > 1$, calculate

$$W_m^{in} = W_m^{in} + W_{m,J_w}^{in} \quad \text{for } 1 \leq m \leq m_{max} \quad (4-86)$$

3.4.4.4 Average Fuel Inventory Weights During Operating Interval

If $\left(\delta_{\text{reac}}^{\text{mid inv}} + \delta_{\text{g}}^{\text{mid inv}} + \delta_{\text{meth}}^{\text{cost}} \right) > 0$, calculate

$$W_{m,J_w,n}^{\text{mid inv}} = \delta_{\text{gp}}' W_{m,J_w,n}^{\text{mid inv}} + \frac{1}{2} \left(W_{m,J_w,n}^{(o)} + W_{m,J_w,n}^{(e)} \right) \quad (4-87)$$

for $1 \leq m \leq m_{\text{max}}; 1 \leq n \leq N_{J_w}^{\text{bat}}$.

If $\left(\delta_{\text{reac}}^{\text{mid inv}} + \delta_{\text{g}}^{\text{mid inv}} + \delta_{\text{meth}}^{\text{cost}} \right) > 0$, do calculations through

statement (4-104).

(4-88)

$$W_{J_w}^{\text{mid inv}} = \delta_{\text{gp}}' W_{J_w}^{\text{mid inv}} + \sum_{n=1}^{N_{J_w}^{\text{bat}}} W_{J_w,n}^{(o)} \quad (4-89)$$

If $\delta_{\text{g}}^{\text{group}} = 0$ or if $w = w_{\text{g}}$, calculate as per statements (4-90) through (4-104):

$$P_{J_w,n}^{\text{fis mid inv}} = \left(1 - \delta_{m_{\text{max}},6}^{\text{fuel}} \right) \left(W_{2,J_w,n}^{\text{inv}} + W_{4,J_w,n}^{\text{inv}} \right) \quad (4-90)$$

$$P_{J_w,n}^{\text{tot mid inv}} = \left(1 - \delta_{m_{\text{max}},6}^{\text{fuel}} \right) \left(W_{3,J_w,n}^{\text{inv}} + W_{5,J_w,n}^{\text{inv}} \right) + P_{J_w,n}^{\text{fis inv}} \quad (4-91)$$

$$U_{J_w,n}^{\text{tot mid inv}} = 1 - \left(\delta_{m_{\text{max}}^{\text{fuel}},6} \right) W_{1,J_w,n}^{\text{mid inv}} + \left(1 - \delta_{m_{\text{max}}^{\text{fuel}},5} \right) \sum_{m=m_{\text{fuel}}^{\text{max}}-4+3\delta_{m_{\text{max}}^{\text{fuel}},7}}^{m_{\text{max}}^{\text{fuel}}} W_{m,J_w,n}^{\text{mid inv}} \quad (4-92)$$

$$U_{J_w,n}^{\text{fis mid inv}} = \left(1 - \delta_{m_{\text{max}}^{\text{fuel}},5} \right) \left[W_{m_{\text{max}}^{\text{fuel}}-1,J_w,n}^{\text{inv}} + \left(1 - \delta_{m_{\text{max}}^{\text{fuel}},7} \right) \left(W_{m_{\text{max}}^{\text{fuel}}-4,J_w,n}^{\text{inv}} + W_{m_{\text{max}}^{\text{fuel}}-3,J_w,n}^{\text{inv}} \right) \right] \quad (4-93)$$

$$P_{J_w}^{\text{fis mid inv}} = \sum_{n=1}^{N_{J_w}^{\text{bat}}} P_{J_w,n}^{\text{fis mid inv}} \quad (4-94)$$

$$P_{J_w}^{\text{tot mid inv}} = \sum_{n=1}^{N_{J_w}^{\text{bat}}} P_{J_w,n}^{\text{tot mid inv}} \quad (4-95)$$

$$U_{J_w}^{\text{tot mid inv}} = \sum_{n=1}^{N_{J_w}^{\text{bat}}} U_{J_w,n}^{\text{tot mid inv}} \quad (4-96)$$

$$U_{J_w}^{\text{fis mid inv}} = \sum_{n=1}^{N_{J_w}^{\text{bat}}} U_{J_w,n}^{\text{fis mid inv}} \quad (4-97)$$

$$W_{\text{mid inv}} = W_{\text{mid inv}} + W_{J_w}^{\text{mid inv}} \quad (4-98)$$

$$P_{\text{mid inv}}^{\text{tot}} = P_{\text{mid inv}}^{\text{tot}} + P_{J_w}^{\text{tot mid inv}} \quad (4-99)$$

$$P_{\text{mid inv}}^{\text{fis}} = P_{\text{mid inv}}^{\text{fis}} + P_{J_w}^{\text{fis mid inv}} \quad (4-100)$$

$$U_{\text{mid inv}}^{\text{tot}} = U_{\text{mid inv}}^{\text{tot}} + U_{J_w}^{\text{tot mid inv}} \quad (4-101)$$

$$U_{\text{inv}}^{\text{fis}} = U_{\text{mid inv}}^{\text{fis}} + U_{J_w}^{\text{fis mid inv}} \quad (4-102)$$

If $\delta_g^{\text{mid inv}} > 2$ or $\delta_{\text{reac}}^{\text{mid inv}} > 1$, calculate

$$W_{m,J_w}^{\text{mid inv}} = \sum_{n=1}^{N_{J_w}^{\text{bat}}} W_{m,J_w,n}^{\text{mid inv}} \quad (4-103)$$

$$W_m^{\text{mid inv}} = W_m^{\text{mid inv}} + W_{m,J_w}^{\text{mid inv}} \quad (4-104)$$

3.4.5 Zonal and Reactor Fuel Costs

(Continue loops on w and g)

If $\delta_{\text{meth}}^{\text{cost}} = 0$, go to end of loop following statement (4-224). (4-105)

$$h = JH_J$$

Set $i' = 1$ and go to statement (4-136). (4-106)

3.4.5.1 Fabrication Cost

If $\delta_{\text{meth}}^{\text{cost}} = 1$ or 3, calculate as follows through statement (4-117): (4-107)

If $N_{J_w}^{\text{st load}} = 0$, calculate

$$C_{J_w, n}^{\text{fab}(i')} = \delta_{\text{gp}}' C_{J_w, n}^{\text{fab}(i')} + U_h^{\text{fab}(i')} w_{J_w, n}^{(o)} \left[10^3 \delta_{\text{unit}}^{\text{cost}} + 10^2 (1 - \delta_{\text{unit}}^{\text{cost}}) \right] \quad (4-108)$$

for $N_{J_w}^{\text{bat}} - N_{\text{dis}}'(J_w) + 1 \leq n \leq N_{J_w}^{\text{bat}}$.

If $\delta_g^{\text{group}} = 0$ or if $w = w_g$, calculate as per statments (4-109) through (4-117):

If $N_{J_w}^{\text{st load}} \neq 0$, calculate

$$C_{J_w, n}^{\text{fab}(i')} = \frac{1}{N_{\text{dis}}^{(J_w)}} C_{N_{J_w}^{\text{st load}}, I_{J_w}^{\text{st load}}}^{\text{fab}(i')} \quad (4-109)$$

for $N_{J_w}^{\text{bat}} - N_{\text{dis}}^{(J_w)} + 1 \leq n \leq N_{J_w}^{\text{bat}}$

and set $C_{N_{J_w}^{\text{st load}}, I_{J_w}^{\text{st load}}}^{\text{fab}(i')} = 0$. (4-110)

If $N_{J_w}^{\text{st dis}} = 0$ and if $N_{\text{dis}}^{(J_w)} > 0$, calculate

$$C_{J_w}^{\text{fab}(i')} = \sum_{n=1}^{N_{\text{dis}}^{(J_w)}} C_{J_w, n}^{\text{fab}(i')} \quad (4-111)$$

$$C_{i'}^{\text{fab}} = C_{i'}^{\text{fab}} + C_{J_w}^{\text{fab}(i')} \quad (4-112)$$

$$C_{J_w, n}^{\text{fab}(i')*} = C_{J_w, n}^{\text{fab}(i')} / E_{J_w, n}' \quad (4-113)$$

for $1 \leq n \leq N_{\text{dis}}^{(J_w)}$.

* Asterisk used with batch fuel cost components to identify block 52 output data (as distinguished from block 36 working data).

$$C_{J_w}^{fab(i')} = C_{J_w}^{fab(i')} / E_{J_w}' \quad (4-114)$$

If $N_{J_w}^{st\ dis} \neq 0$, calculate

$$C_{N_{J_w}^{st\ dis}}^{fab(i')} = \sum_{n=1}^{N_{dis}^{(J_w)}} C_{J_w,n}^{fab(i')} \quad (4-115)$$

$$C_{J_w,n}^{fab(i')} = 0 \quad \text{for } 1 \leq n \leq N_{dis}^{(J_w)}. \quad (4-116)$$

$$C_{J_w}^{fab(i')} = 0. \quad (4-117)$$

Go to statement (4-121). (4-118)

$$\text{Set } C_{J_w,n}^{fab(i')} = C_{J_w,n}^{fab(i')} + N_{dis}^{(J_w)} \quad \text{for } 1 \leq n < N_{J_w}^{bat} - N_{dis}^{(J_w)} \quad (4-119)$$

Go to "If statement" listed after statement (4-212). (4-120)

If $\delta_{meth}^{cost} = 2$ or 3 and $N_{J_w}^{st\ load} = 0$, calculate

$$C_{J_w}^{fab(i')} = \delta_{gp}' C_{J_w}^{fab(i')} + \left[\sum_{n=N_{J_w}^{bat} - N_{dis}^{(J_w)} + 1}^{N_{J_w}^{bat}} w_{J_w,n}^{(o)} \right] \left[10^3 \delta_{unit}^{cost} + 10^2 (1 - \delta_{unit}^{cost}) \right] U_h^{fab(i')} \quad (4-121)$$

and if $\delta_g^{\text{group}} = 0$, or if $w = w_g$, also calculate as per statements (4-122) through (4-124):

$$C_{J_w}^{\text{fab}(i')} = C_{J_w}^{\text{fab}(i')} / E_{\text{int}} \quad (4-122)$$

$$C_{i'}^{\text{fab}} = C_{i'}^{\text{fab}} + C_{J_w}^{\text{fab}(i')} \quad (4-123)$$

If $\delta_{\text{meth}}^{\text{cost}} = 2$ or 3 and $N_{J_w}^{\text{st load}} \neq 0$, set

$$C_{J_w}^{\text{fab}(i')} = 0. \quad (4-124)$$

3.4.5.2 Reprocessing Cost

If $\delta_{\text{meth}}^{\text{cost}} = 1$ or 3, calculate as follows through statement (4-131):

If $N_{J_w}^{\text{st dis}} = 0$ and if $N_{\text{dis}}^{(J_w)} > 0$, calculate

$$C_{J_w, n}^{\text{repr}(i')*} = \delta_{\text{gp}} C_{J_w, n}^{\text{repr}(i')*} + U_h^{\text{repr}(i')} W_{J_w, n}^{(o)} \left[10^3 \delta_{\text{unit}}^{\text{cost}} + 10^2 (1 - \delta_{\text{unit}}^{\text{cost}}) \right] \quad (4-125)$$

for $1 \leq n \leq N_{\text{dis}}^{(J_w)}$.

If $\delta_g^{\text{group}} = 0$ or if $w = w_g$, calculate as per statements (4-126) through (4-131):

$$C_{J_w}^{\text{repr}(i')} = \sum_{n=1}^{N_{\text{dis}}^{(J_w)}} C_{J_w,n}^{\text{repr}(i')} \quad (4-126)$$

$$C_{J_w,n}^{\text{repr}(i')} = C_{J_w,n}^{\text{repr}(i')} / E'_{J_w,n} \quad (4-127)$$

for $1 \leq n \leq N_{\text{dis}}^{(J_w)}$.

$$C_{i'}^{\text{repr}} = C_{i'}^{\text{repr}} + C_{J_w}^{\text{repr}(i')} \quad (4-128)$$

$$C_{J_w}^{\text{repr}(i')} = C_{J_w}^{\text{repr}(i')} / E'_{J_w} \quad (4-129)$$

If $N_{J_w}^{\text{st dis}} \neq 0$, calculate

$$C_{J_w,n}^{\text{repr}(i')} = 0 \text{ for } 1 \leq n \leq N_{\text{dis}}^{(J_w)}. \quad (4-130)$$

$$C_{J_w}^{\text{repr}(i')} = 0. \quad (4-131)$$

If $\delta_{\text{meth}}^{\text{cost}} = 2$ or 3 and $N_{J_w}^{\text{st dis}} = 0$, calculate

$$C_{J_w}^{\text{repr}(i')} = U_h^{\text{repr}(i')} \left[10^3 \delta_{\text{unit}}^{\text{cost}} + 10^2 (1 - \delta_{\text{unit}}^{\text{cost}}) \right] \sum_{n=1}^{N_{\text{dis}}^{(J_w)}} W_{J_w,n}^{(o)} \quad (4-132)$$

If $\delta_g^{\text{group}} = 0$ or if $w = w_g$, calculate as per statements (4-133) through (4-135):

$$C_{J_w}^{\text{repr}(i')} = C_{J_w}^{\text{repr}(i')} / E_{\text{int}} \quad (4-133)$$

$$C_{i'}^{\text{repr}} = C_{i'}^{\text{repr}} + C_{J_w}^{\text{repr}(i')} \quad (4-134)$$

If $\delta_{\text{meth}}^{\text{cost}} = 2$ or 3 and $N_{J_w}^{\text{st dis}} \neq 0$, set

$$C_{J_w}^{\text{repr}(i')} = 0.$$

Go to statement (4-138).

(4-135)

3.4.5.3 Isotopic Fuel Values

If $C_{\text{feed}}^{(i')} > 0$, calculate

$$F_{\text{tails}} = (2E_{\text{tails}}^{(i')} - 1) \left[\log_e \left(\frac{E_{\text{tails}}^{(i')}}{1 - E_{\text{tails}}^{(i')}} \right) \right] \quad (4-136)$$

$$A_{\text{enr}} = \left[\frac{C_{\text{feed}}^{(i')}}{C_{\text{sep}}^{(i')}} - (F_{\text{feed}} - F_{\text{tails}}) \right] / (.00711 - E_{\text{tails}}^{(i')}) \quad (4-137)$$

Go to statement (4-140).

If $\delta_g^{\text{group}} = 0$ or if $w = w_g$, calculate as per statements (4-138) through (4-139):

Do loop on n ($1 \leq n \leq N_{\text{dis}}^{(J_w)}$). (4-138)

Set $v_{\text{enr}} = 0$ if $C_{\text{feed}}^{(i')} = 0$, or if $m_{\text{max}}^{\text{fuel}} = 5$, or if $U_{J_w, n}^{\text{tot}(e)*} = 0$, or if
 $U_{J_w, n}^{\text{fis}(e)*} = 0$. (4-139)

(See earlier footnote - page III-94, for explanation of superscripts (e)* and (o)*.)

Otherwise, calculate

$$v_{\text{enr}} = C_{\text{sep}}^{(i')} \left[\left(\frac{2 U_{J_w, n}^{\text{fis}(e)*}}{U_{J_w, n}^{\text{tot}(e)*}} - 1 \right) \log_e \left(\frac{U_{J_w, n}^{\text{fis}(e)*}}{U_{J_w, n}^{\text{tot}(e)*} - U_{J_w, n}^{\text{fis}(e)*}} \right) - F_{\text{tails}} \right. \\ \left. + A_{\text{enr}} \left(\frac{U_{J_w, n}^{\text{fis}(e)*}}{U_{J_w, n}^{\text{tot}(e)*}} - .00711 \right) \right] \left(\frac{U_{J_w, n}^{\text{tot}(e)*}}{U_{J_w, n}^{\text{fis}(e)*}} \right) \quad (4-140)$$

If $v_{\text{enr}} \neq 0$, set $v_{m_{\text{max}}^{\text{fuel}}-1} = v_{\text{enr}}$; and set $v'_{m_{\text{max}}^{\text{fuel}}} = 0$. (4-141)

If $v_{\text{enr}} \neq 0$ and if $m_{\text{max}}^{\text{fuel}} = 6$ or 11, set $v'_{m_{\text{max}}^{\text{fuel}}-3} = v'_{m_{\text{max}}^{\text{fuel}}-4} = R_{25}^{23(i')} v_{\text{enr}}$;

and set $v'_{m_{\text{max}}^{\text{fuel}}-2} = 0$; and if $m_{\text{max}}^{\text{fuel}} = 11$, set $v'_6 = 0$. (4-142)

$$\text{If } m_{\max}^{\text{fuel}} = 6 \text{ and } N_{\max}^{\text{val}(i')} = 4, \text{ set } v'_m = v_{m-1}^{(i')} \text{ for } 2 \leq m \leq 5. \quad (4-144)$$

$$\text{If } m_{\max}^{\text{fuel}} = 6 \text{ and } N_{\max}^{\text{val}(i')} = 1, \text{ set } v'_2 = v_1^{(i')}, v'_3 = 0, v'_4 = v_1^{(i')}, v'_5 = 0. \quad (4-145)$$

$$\text{If } v_{\text{enr}} = 0 \text{ and } N_{\max}^{\text{val}(i')} = m_{\max}^{\text{fuel}} - 1, \text{ set } v'_m = v_{m-1}^{(i')} \text{ for } 2 \leq m \leq m_{\max}^{\text{fuel}}. \quad (4-146)$$

$$\begin{aligned} \text{If } v_{\text{enr}} = 0 \text{ and } m_{\max}^{\text{fuel}} = 6 \text{ and } N_{\max}^{\text{val}(i')} = 1, \text{ set } v'_2 &= v_1^{(i')} R_{25}^{23(i')}, \\ v'_3 &= v_1^{(i')} R_{25}^{23(i')}, v'_4 = 0, v'_5 = v_1^{(i')}, \text{ and } v'_6 = 0. \end{aligned} \quad (4-147)$$

3.4.5.4 Fuel Depletion (Credit) Cost*

If $\delta_{\text{meth}}^{\text{cost}} = 1$ or 3, calculate as follows through statement (4-155):

If $N_{J_w}^{\text{st dis}} = 0$, calculate

$$\begin{aligned} C_{J_w, n}^{\text{cred}(i')} &= C_{J_w, n}^{\text{cred}(i')} - \left[10^3 \frac{\text{cost}}{\text{unit}} + 10^2 \left(1 - \frac{\text{cost}}{\text{unit}} \right) \right] (1 - L_{\text{repr}}) \\ &\quad \cdot \sum_{m=2}^{m_{\max}^{\text{fuel}}} v'_m w_{m, J_w, n}^{(e)} e^{-8.64 \times 10^4 T_{\text{repr}} \delta_{m, m_{241}} \lambda_{241}} \end{aligned} \quad (4-148)$$

* Calculations of fuel inventory cost occurred during fabrication and reprocessing are also specified in this section because fuel isotopic values used for these calculations are identical with those used for the fuel depletion (credit) cost calculations. This is a factor when isotopic values are "enrichment" - dependent, as may be the case for U-235 and U-233 if these isotopes are present.

$$\begin{aligned}
C_{J_w, n}^{inv(i')} &= C_{J_w, n}^{inv(i')} + \left[10^3 \delta_{unit}^{cost} + 10^2 \left(1 - \delta_{unit}^{cost} \right) \right] \left(\frac{10^{-2} p_{int(i')}^{fuel}}{365.25} \right) \\
&\cdot T^{repr} \left(1 - \frac{L_{repr}}{2} \right) \sum_{m=2}^{fuel_{max}} v_m' w_{m, J_w, n}^{(e)} \\
&\cdot e^{-8.64 \times 10^4 \left(\frac{T_{repr}}{2} \right)} \delta_{m, m_{241}} \lambda_{241}
\end{aligned} \tag{4-149}$$

If $n = N_{dis}^{(J_w)}$ and $N_{J_w}^{st dis} = 0$, calculate

$$C_{J_w}^{cred(i')} = \sum_{n=1}^{N_{dis}^{(J_w)}} C_{J_w}^{cred(i')} \tag{4-150}$$

$$C_{i'}^{cred} = C_{i'}^{cred} + C_{J_w}^{cred(i')} \tag{4-151}$$

$$C_{J_w, n}^{cred(i')*} = C_{J_w, n}^{cred(i')} / E_{J_w, n}' \quad \text{for } 1 \leq n \leq N_{dis}^{(J_w)}. \tag{4-152}$$

$$C_{J_w}^{cred(i')} = C_{J_w}^{cred(i')} / E_{J_w}' \tag{4-153}$$

If $n = N_{dis}^{(J_w)}$ and $N_{J_w}^{st\ dis} = 0$, calculate

$$C_{N_{J_w}^{st\ dis}}^{cred(i')} = \sum_{n=1}^{N_{dis}^{(J_w)}} C_{J_w, n}^{cred(i')} \quad (4-154)$$

$$C_{J_w}^{cred(i')} = 0 \text{ and } C_{J_w, n}^{cred(i')*} = 0 \text{ for } 1 \leq n \leq N_{dis}^{(J_w)}. \quad (4-155)$$

If $\delta_{meth}^{cost} = 2 \text{ or } 3$ and $N_{J_w}^{st\ dis} = 0$, calculate as follows through statement (4-159):

If $n = 1$, calculate

$$C_{J_w}^{cred(i')} = - \left[10^3 \delta_{unit}^{cost} + 10^2 (1 - \delta_{unit}^{cost}) \right] (1 - L_{repr}) \cdot \sum_{m=2}^{m_{max}^{fuel}} v_m' w_{m, J_w, n}^{(e)} e^{-8.64 \times 10^4 T_{repr} \delta_{m, m_{241}} \lambda_{241}} \quad (4-156)$$

$$C_{J_w}^{inv(i')} = 10^3 \left[\delta_{unit}^{cost} + 10^2 (1 - \delta_{unit}^{cost}) \right] \left(\frac{10^{-2} P_{fuel}^{int(i')}}{365.25} \right) T_{repr} \left(1 - \frac{L_{repr}}{2} \right) \cdot \sum_{m=2}^{m_{max}^{fuel}} v_m' w_{m, J_w, n}^{(e)} e^{-8.64 \times 10^4 \left(\frac{T_{repr}}{2} \right) \delta_{m, m_{241}} \lambda_{241}} \quad (4-157)$$

If $n > 1$, calculate

$$C_{J_w}^{\text{cred}(i')} = C_{J_w}^{\text{cred}(i')} - \left[10^3 \delta_{\text{unit}}^{\text{cost}} + 10^2 (1 - \delta_{\text{unit}}^{\text{cost}}) \right] (1 - L_{\text{repr}}) \cdot \sum_{m=2}^{m_{\text{max}}^{\text{fuel}}} v_m' W_{m,J_w,n}^{(e)} e^{-8.64 \times 10^4 T_{\text{repr}} \delta_{m,m_{241}}} \lambda_{241} \quad (4-158)$$

$$C_{J_w}^{\text{inv}(i')} = C_{J_w}^{\text{inv}(i')} + \left[10^3 \delta_{\text{unit}}^{\text{cost}} + 10^2 (1 - \delta_{\text{unit}}^{\text{cost}}) \right] \left(\frac{10^{-2} p_{\text{fuel}}^{\text{int}(i')}}{365.25} \right) T_{\text{repr}} \left(1 - \frac{L_{\text{repr}}}{2} \right) \sum_{m=2}^{m_{\text{max}}^{\text{fuel}}} v_m' W_{m,J_w,n}^{(e)} e^{-8.64 \times 10^4 \left(\frac{T_{\text{repr}}}{2} \right) \delta_{m,m_{241}}} \lambda_{241} \quad (4-159)$$

If $\delta_{\text{meth}}^{\text{cost}} = 2$ or 3 and $N_{J_w}^{\text{st dis}} \neq 0$, set

$$C_{J_w}^{\text{cred}(i')} = 0 \text{ and } C_{J_w}^{\text{inv}(i')} = 0. \quad (4-160)$$

End of loop on n ($1 \leq n \leq N_{\text{dis}}^{(J_w)}$).

Do loop on n ($N_{J_w}^{bat} - N_{dis}^{(J_w)} + 1 \leq n \leq N_{J_w}^{bat}$). (4-161)

Repeat operations of statements (4-140) through (4-147), with the following modifications for equation (4-140): (4-162)

(1). Replace $U_{J_w,n}^{fis(e)*}$ with $U_{J_w,n}^{fis(o)*}$ (4-163)

(2). Replace $U_{J_w,n}^{tot(e)*}$ with $U_{J_w,n}^{tot(o)*}$ (4-164)

If $\delta_{meth}^{cost} = 1$ or 3, calculate as follows through statement (4-169):

If $N_{J_w}^{st load} = 0$, calculate

$$C_{J_w,n}^{cred(i')} = C_{J_w,n}^{cred(i')} - \left[10^3 \delta_{unit}^{cost} + 10^2 (1 - \delta_{unit}^{cost}) \right] (1 - L_{repr})$$

$$\cdot \sum_{m=2}^{m_{max}^{fuel}} v_m' w_{m,J_w,n}^{(e)} e^{-8.64 \times 10^4 T_{repr} \delta_{m,m_{241}} \lambda_{241}} \quad (4-165)$$

$$C_{J_w}^{inv(i')} = \left[10^3 \delta_{unit}^{cost} + 10^2 \left(1 - \delta_{unit}^{cost} \right) \right] \left(\frac{10^{-2} P_{fuel}^{int(i')}}{365.25} \right) T_{fab} \left(\frac{1}{1 - \frac{1}{2} L_{fab}} \right) \sum_{m=2}^{m_{max}^{fuel}} V_m' W_{m,J_w,n}^{(o)} e^{8.64 T_{fab} \delta_{m,m_{241}} \lambda_{241}} \quad (4-166)$$

If $N_{J_w}^{st load} \neq 0$, calculate

$$C_{J_w,n}^{cred(i')} = \left(\frac{1}{N_{dis}'(J_w)} \right) C_{N_{J_w}^{st load}, I_{J_w}^{st load}}^{cred(i')} \quad (4-167)$$

$$C_{J_w,n}^{inv(i')} = \left(\frac{1}{N_{dis}'(J_w)} \right) C_{N_{J_w}^{st load}, I_{J_w}^{st load}}^{inv(i')} \quad (4-168)$$

If $N_{J_w}^{st load} \neq 0$, and if $n = N_{J_w}^{bat}$, set

$$C_{N_{J_w}^{st load}, I_{J_w}^{st load}}^{cred(i')} = 0 \text{ and } C_{N_{J_w}^{st load}, I_{J_w}^{st load}}^{inv(i')} = 0. \quad (4-169)$$

If $\delta_{meth}^{cost} = 2$ or 3 and if $N_{J_w}^{st load} = 0$, calculate

$$C_{J_w}^{cred(i')} = C_{J_w}^{cred(i')} + \left[10^3 \delta_{unit}^{cost} + 10^2 (1 - \delta_{unit}^{cost}) \right] \left(\frac{1}{1 - L_{fab}} \right) \sum_{m=2}^{m_{max}^{fuel}} v_m' W_{m,J_w,n}^{(o)} e^{8.64 T_{fab} \delta_{m,m_{241}} \lambda_{241}} \quad (4-170)$$

$$C_{J_w}^{inv(i')} = C_{J_w}^{inv(i')} + \left[10^3 \delta_{unit}^{cost} + 10^2 (1 - \delta_{unit}^{cost}) \right] \left(\frac{10^{-2} P_{fuel}^{int(i')}}{365.25} \right)$$

:

$$T_{fab} \left(\frac{1}{1 - \frac{1}{2} L_{fab}} \right) \sum_{m=2}^{m_{max}^{fuel}} v_m' W_{m,J_w,n}^{(o)} e^{8.64 \times 10^4 \left(\frac{T_{fab}}{2} \right) \delta_{m,m_{241}} \lambda_{241}} \quad (4-171)$$

If $\delta_{meth}^{cost} = 2$ or 3 and if $N_{J_w}^{bat}$, calculate

$$C_{J_w}^{cred(i')} = C_{J_w}^{cred(i')} / E_{int} \quad (4-172)$$

$$C_{i'}^{cred} = C_{i'}^{cred} + C_{J_w}^{cred(i')} \quad (4-173)$$

End of loop on n ($N_{J_w}^{bat} - N_{dis}^{(J_w)} + 1 \leq n \leq N_{J_w}^{bat}$).

If $\delta_{\text{meth}}^{\text{cost}} = 1$ or 3, calculate

$$C_{J_w, n}^{\text{cred}(i')} = C_{J_w, n + N_{\text{dis}}^{(J_w)}}^{\text{cred}(i')} \quad \text{for } 1 \leq n \leq N_{J_w}^{\text{bat}} - N_{\text{dis}}^{(J_w)}. \quad (4-174)$$

3.4.5.5 Fuel Inventory Interest Cost

At this point, the fuel inventory cost components associated with the fabrication and reprocessing operations (for zone J_w fuel) have been calculated - see footnote at beginning of Section 3.4.5.4. Fuel inventory cost records have also been transferred for loaded fuel previously held in storage repositories. In this section, the in-pile fuel inventory costs will be added.

Do loop on n ($1 \leq n \leq N_{J_w}^{\text{bat}}$). (4-175)

Repeat operations of statements (4-140) through (4-147), with the following modifications for equation (4-140): (4-176)

(1). Replace $U_{J_w, n}^{\text{fis}(e)*}$ with $U_{J_w, n}^{\text{fis mid inv}}$ (4-177)

(2). Replace $U_{J_w, n}^{\text{tot}(e)*}$ with $U_{J_w, n}^{\text{tot mid inv}}$ (4-178)

If $\delta_{\text{meth}}^{\text{cost}} = 1$ or 3, calculate

$$C_{J_w, n}^{\text{inv}(i')} = C_{J_w, n}^{\text{inv}(i')} + \left[10^3 \delta_{\text{unit}}^{\text{cost}} + 10^2 (1 - \delta_{\text{unit}}^{\text{cost}}) \right] \left(\frac{10^{-2} P_{\text{fuel}}^{\text{int}(i')} T}{365.25} \right) \cdot \sum_{m=2}^{m_{\text{fuel}}^{\text{max}}} V_m' W_{m, J_w, n}^{\text{mid inv}} \quad (4-179)$$

If $\delta_{\text{meth}}^{\text{cost}} = 2$ or 3, calculate

$$C_{J_w}^{\text{inv}(i')} = C_{J_w}^{\text{inv}(i')} + \left[10^3 \delta_{\text{unit}}^{\text{cost}} + 10^2 (1 - \delta_{\text{unit}}^{\text{cost}}) \right] \left(\frac{10^{-2} P_{\text{fuel}}^{\text{int}(i')} T}{365.25} \right) \cdot \sum_{m=2}^{m_{\text{fuel}}^{\text{max}}} V_m' W_{m, J_w, n}^{\text{mid inv}} \quad (4-180)$$

End of loop on n ($1 \leq n \leq N_{J_w}^{\text{bat}}$).

If $\delta_{\text{meth}}^{\text{cost}} = 1$ or 3 and if $N_{J_w}^{\text{st dis}} = 0$, and if $N_{\text{dis}}^{(J_w)} > 0$, calculate

$$C_{J_w}^{\text{inv}(i')} = \sum_{n=1}^{N_{\text{dis}}^{(J_w)}} C_{J_w, n}^{\text{inv}(i')} \quad (4-181)$$

$$C_{i'}^{inv} = C_{i'}^{inv} + C_{J_w}^{inv(i')} \quad (4-182)$$

$$C_{J_w, n}^{inv(i')*} = C_{J_w, n}^{inv(i')} / E_{J_w, n}' \quad \text{for } 1 \leq n \leq N_{dis}^{(J_w)} \quad (4-183)$$

$$C_{J_w}^{inv(i')} = C_{J_w}^{inv(i')} / E_{J_w}' \quad (4-184)$$

If $\delta_{meth}^{cost} = 1$ or 3 and if $N_{J_w}^{st dis} \neq 0$, calculate

$$C_{N_{J_w}^{st dis}}^{inv(i')} = \sum_{n=1}^{N_{dis}^{(J_w)}} C_{J_w, n}^{inv(i')} \quad (4-185)$$

$$C_{J_w}^{inv(i')} = 0 \text{ and } C_{J_w, n}^{inv(i')*} = 0 \text{ for } 1 \leq n \leq N_{dis}^{(J_w)} \quad (4-186)$$

If $\delta_{meth}^{cost} = 1$ or 3, calculate

$$C_{J_w, n}^{inv(i')} = C_{J_w, n + N_{dis}^{(J_w)}}^{inv(i')} \text{ for } 1 \leq n \leq N_{J_w}^{bat} - N_{dis}^{(J_w)} \quad (4-187)$$

If $\delta_{meth}^{cost} = 2$ or 3, calculate

$$C_{J_w}^{inv(i')} = C_{J_w}^{inv(i')} / E_{int} \quad (4-188)$$

$$C_{i'}^{inv} = C_{i'}^{inv} + C_{J_w}^{inv(i')} \quad (4-189)$$

3.4.5.6 Fabrication Inventory and Reprocessing Negative Inventory Interest Costs

If $\delta_{\text{meth}}^{\text{cost}} = 1$ or 3, calculate as follows through statement (4-211):

If $N_{J_w}^{\text{st load}} = 0$, calculate as follows for $N_{J_w}^{\text{bat}} - N_{\text{dis}}^{(J_w)} + 1 \leq n \leq N_{J_w}^{\text{bat}}$:

$$C_{J_w, n}^{\text{fab inv}(i')} = C_{J_w, n}^{\text{fab}(i')} \left(T_{\text{fab}} + \frac{T}{2} \right) \left(\frac{10^{-2} p_{\text{fab}}^{\text{int}(i')}}{365.25} \right) \quad (4-190)$$

$$C_{J_w, n}^{\text{repr inv}(i')} = - \left[10^3 \delta_{\text{unit}}^{\text{cost}} + 10^2 (1 - \delta_{\text{unit}}^{\text{cost}}) \right] \left(\frac{10^{-2} p_{\text{fab}}^{\text{int}(i')}}{365.25} \right) \left(\frac{T}{2} \right) \quad (4-191)$$

If $N_{J_w}^{\text{st load}} \neq 0$, calculate as follows for $N_{J_w}^{\text{bat}} - N_{\text{dis}}^{(J_w)} + 1 \leq n \leq N_{J_w}^{\text{bat}}$:

$$C_{J_w, n}^{\text{fab inv}(i')} = \left(C_{N_{J_w}^{\text{st load}}, I_{J_w}^{\text{st load}}}^{\text{fab inv}(i')} / N_{\text{dis}}^{(J_w)} \right) + C_{J_w, n}^{\text{fab}(i')} \left(\frac{T}{2} \right) \left(\frac{10^{-2} p_{\text{fab}}^{\text{int}(i')}}{365.25} \right) \quad (4-192)$$

$$C_{J_w, n}^{\text{repr inv}(i')} = \left(C_{N_{J_w}^{\text{st load}}, I_{J_w}^{\text{st load}}}^{\text{repr inv}(i')} / N_{\text{dis}}^{(J_w)} \right) - \left[10^3 \delta_{\text{unit}}^{\text{cost}} + 10^2 (1 - \delta_{\text{unit}}^{\text{cost}}) \right] \left(\frac{10^{-2} p_{\text{fab}}^{\text{int}(i')}}{365.25} \right) \left(\frac{T}{2} \right) \quad (4-193)$$

If $N_{J_w}^{\text{st load}} \neq 0$, set

$$C_{N_{J_w}^{\text{st load}}, I_{J_w}^{\text{st load}}}^{\text{fab inv}(i')} = 0 \text{ and } C_{N_{J_w}^{\text{st load}}, I_{J_w}^{\text{st load}}}^{\text{repr inv}(i')} = 0. \quad (4-194)$$

Calculate as follows for $1 \leq n \leq N_{J_w}^{\text{bat}} - N_{\text{dis}}^{(J_w)}$:

$$C_{J_w, n}^{\text{fab inv}(i')} = C_{J_w, n}^{\text{fab inv}(i')} + C_{J_w, n}^{\text{fab}(i')} \left(\frac{T}{2} \right) \left(\frac{10^{-2} P_{\text{fab}}^{\text{int}(i')}}{365.25} \right) \quad (4-195)$$

$$C_{J_w, n}^{\text{repr inv}(i')} = C_{J_w, n}^{\text{repr inv}(i')} - \left[10^3 \delta_{\text{unit}}^{\text{cost}} + 10^2 (1 - \delta_{\text{unit}}^{\text{cost}}) \right]$$

$$\cdot \left(\frac{10^{-2} P_{\text{fab}}^{\text{int}(i')}}{365.25} \right) \left(\frac{T}{2} \right) \quad (4-196)$$

If $N_{J_w}^{\text{st dis}} = 0$ and if $N_{\text{dis}}^{(J_w)} > 0$, calculate

$$C_{J_w}^{\text{fab inv}(i')} = \sum_{n=1}^{N_{\text{dis}}^{(J_w)}} C_{J_w, n}^{\text{fab inv}(i')} \quad (4-197)$$

$$C_{i'}^{\text{fab inv}} = C_{i'}^{\text{fab inv}} + C_{J_w}^{\text{fab inv}(i')} \quad (4-198)$$

$$C_{J_w, n}^{\text{fab inv}(i')*} = C_{J_w, n}^{\text{fab inv}(i')} / E_{J_w, n}' \text{ for } 1 \leq n \leq N_{\text{dis}}^{(J_w)}. \quad (4-199)$$

$$C_{J_w}^{\text{fab inv}(i')} = C_{J_w}^{\text{fab inv}(i')} / E_{J_w}' \quad (4-200)$$

If $N_{J_w}^{st\ dis} = 0$ and if $N_{dis}^{(J_w)} > 0$, calculate

$$C_{J_w, n}^{repr\ inv(i')} = \delta'_{gp} C_{J_w, n}^{repr\ inv(i')} + U_h^{repr(i')} W_{J_w, n}^{(o)} \\ \left\{ C_{J_w, n}^{repr\ inv(i')} - \left[10^3 \delta_{unit}^{cost} + 10^2 (1 - \delta_{unit}^{cost}) \right] \right. \\ \left. \cdot \left(\frac{10^{-2} P_{fab}^{int(i')}}{365.25} \right) T_{repr} \right\} \quad (4-201) \\ \text{for } 1 \leq n \leq N_{dis}^{(J_w)}$$

If $\delta_g^{group} = 0$ or if $w = w_g$, calculate as per statements (4-202) through (4-212) and then statement (4-119) following (4-212):

If $N_{J_w}^{st\ dis} = 0$ and if $N_{dis}^{(J_w)} > 0$, calculate

$$C_{J_w}^{repr\ inv(i')} = \sum_{n=1}^{N_{dis}^{(J_w)}} C_{J_w, n}^{repr\ inv(i')} \quad (4-202)$$

$$C_{i'}^{repr\ inv} = C_{i'}^{repr\ inv} + C_{J_w}^{repr\ inv(i')} \quad (4-203)$$

$$C_{J_w, n}^{repr\ inv(i')*} = C_{J_w, n}^{repr\ inv(i')} / E'_{J_w, n} \quad \text{for } 1 \leq n \leq N_{dis}^{(J_w)} \quad (4-204)$$

$$C_{J_w}^{repr\ inv(i')} = C_{J_w}^{repr\ inv(i')} / E'_{J_w} \quad (4-205)$$

If $N_{J_w}^{st \cdot dis} \neq 0$, calculate

$$C_{N_{J_w}^{st \cdot dis}}^{fab \ inv(i')} = \sum_{n=1}^{N_{dis}^{(J_w)}} C_{J_w, n}^{fab \ inv(i')} \quad (4-206)$$

$$C_{N_{J_w}^{st \cdot dis}}^{repr \ inv(i')} = \sum_{n=1}^{N_{dis}^{(J_w)}} C_{J_w, n}^{repr \ inv(i')} \quad (4-207)$$

$$C_{J_w}^{fab \ inv(i')} = 0 \text{ and } C_{J_w, n}^{fab \ inv(i')}^* = 0 \text{ for } 1 \leq n \leq N_{dis}^{(J_w)}. \quad (4-208)$$

$$C_{J_w}^{repr \ inv(i')} = 0 \text{ and } C_{J_w, n}^{repr \ inv(i')}^* = 0 \text{ for } 1 \leq n \leq N_{dis}^{(J_w)}. \quad (4-209)$$

Calculate

$$C_{J_w, n}^{fab \ inv(i')} = C_{J_w, n + N_{dis}^{(J_w)}}^{fab \ inv(i')} \text{ for } 1 \leq n \leq N_{J_w}^{bat} - N_{dis}^{(J_w)}. \quad (4-210)$$

$$C_{J_w, n}^{repr \ inv(i')} = C_{J_w, n + N_{dis}^{(J_w)}}^{repr \ inv(i')} \text{ for } 1 \leq n \leq N_{J_w}^{bat} - N_{dis}^{(J_w)}. \quad (4-211)$$

Go to statement (4-119). (4-212)

If $\delta_{\text{meth}}^{\text{cost}} = 2$ or 3, calculate as follows through statement (4-220):

$$\begin{aligned}
 C_{J_w}^{\text{fab inv}(i')} &= \delta_{\text{gp}}' C_{J_w}^{\text{fab inv}(i')} + U_h^{\text{fab}(i')} \left(\frac{10^{-2} P_{\text{fab}}^{\text{int}(i')}}{365.25} \right) \\
 &\cdot \left[10^3 \delta_{\text{unit}}^{\text{cost}} + 10^2 (1 - \delta_{\text{unit}}^{\text{cost}}) \right] \left(T_{\text{fab}} \cdot \sum_{n=N_{J_w}^{\text{bat}} - N_{\text{bat}}'(J_w) + 1}^{N_{J_w}^{\text{bat}}} W_{J_w,n}^{(o)} + \frac{T}{2} \right. \\
 &\quad \left. \sum_{n=1}^{N_{J_w}^{\text{bat}}} W_{J_w,n}^{(o)} \right)
 \end{aligned} \tag{4-213}$$

If $N_{J_w}^{\text{st load}} \neq 0$, calculate

$$\begin{aligned}
 C_{J_w}^{\text{fab inv}(i')} &= \delta_{\text{gp}}' C_{J_w}^{\text{fab inv}(i')} + U_h^{\text{fab}(i')} \left(\frac{10^{-2} P_{\text{fab}}^{\text{int}(i')}}{365.25} \right) \left[10^3 \delta_{\text{unit}}^{\text{cost}} \right. \\
 &\quad \left. + 10^2 (1 - \delta_{\text{unit}}^{\text{cost}}) \right] \frac{T}{2} \sum_{n=1}^{N_{J_w}^{\text{bat}}} W_{J_w,n}^{(o)}
 \end{aligned} \tag{4-214}$$

If $N_{J_w}^{st\ dis} = 0$, calculate

$$C_{J_w}'^{repr\ inv(i')} = \delta_{gp}' C_{J_w}'^{repr\ inv(i')} - U_h^{repr(i')} \left(\frac{10^{-2} p_{fab}^{int(i')}}{365.25} \right) \cdot \left[10^3 \delta_{unit}^{cost} + 10^2 (1 - \delta_{unit}^{cost}) \right] \left[T_{repr} \sum_{n=1}^{N_{dis}^{(J_w)}} W_{J_w,n}^{(o)} + \frac{T}{2} \sum_{n=1}^{N_{J_w}^{bat}} W_{J_w,n}^{(o)} \right] \quad (4-215)$$

If $N_{J_w}^{st\ dis} \neq 0$, calculate

$$C_{J_w}'^{repr\ inv(i')} = \delta_{gp}' C_{J_w}'^{repr\ inv(i')} - U_h^{repr(i')} \left(\frac{10^{-2} p_{fab}^{int(i')}}{365.25} \right) \cdot \left[10^3 \delta_{unit}^{cost} + 10^2 (1 - \delta_{unit}^{cost}) \right] \left[\frac{T}{2} \sum_{n=1}^{N_{J_w}^{bat}} W_{J_w,n}^{(o)} \right] \quad (4-216)$$

If $\delta_g^{group} = 0$ or if $w = w_g$, calculate as per statements (4-217) through (4-220):

Calculate

$$C_{J_w}'^{fab\ inv(i')} = C_{J_w}'^{fab\ inv(i')} / E_{int} \quad (4-217)$$

$$C_{J_w}'^{repr\ inv(i')} = C_{J_w}'^{repr\ inv(i')} / E_{int} \quad (4-218)$$

$$C_{i'}^{fab\ inv} = C_{i'}^{fab\ inv} + C_{J_w}^{fab\ inv(i')} \quad (4-219)$$

$$C_{i'}^{repr\ inv} = C_{i'}^{repr\ inv} + C_{J_w}^{repr\ inv(i')} \quad (4-220)$$

3.4.5.7 Zonal Total Fuel Cost and Set Up to Repeat Cost Calculations for Alternate Economic Assumptions

If $\delta_g^{group} = 0$ or if $w = w_g$, calculate as per statements (4-221) through (4-223).

If $\delta_{meth}^{cost} = 1$ or 3, calculate

$$C_{J_w, n}^{tot(i')} = C_{J_w, n}^{fab(i')} + C_{J_w, n}^{repr(i')} + C_{J_w, n}^{cred(i')} + C_{J_w, n}^{inv(i')} + C_{J_w, n}^{fab\ inv(i)} + C_{J_w, n}^{repr\ inv(i')} \quad \text{for } 1 \leq n \leq N_{dis}^{(J_w)}. \quad (4-221)$$

$$C_{J_w}^{tot(i')} = C_{J_w}^{fab(i')} + C_{J_w}^{repr(i')} + C_{J_w}^{cred(i')} + C_{J_w}^{inv(i')} + C_{J_w}^{fab\ inv(i')} + C_{J_w}^{repr\ inv(i')} \quad (4-222)$$

If $\delta_{\text{meth}}^{\text{cost}} = 2$ or 3 , calculate

$$\begin{aligned} C_{J_w}^{\text{tot}}(i') &= C_{J_w}^{\text{fab}}(i') + C_{J_w}^{\text{repr}}(i') + C_{J_w}^{\text{cred}}(i') + C_{J_w}^{\text{inv}}(i') \\ &\quad + C_{J_w}^{\text{fab inv}}(i') + C_{J_w}^{\text{repr inv}}(i') \end{aligned} \quad (4-223)$$

If $i' < N_{\text{alt}}^{\text{max}}$, set $i' = i' + 1$ and go to statement (4-136). (4-224)

End of loop on w.

End of loop on g.

3.4.5.8 Stored Fuel Inventory Interest Costs

If $N_{\max}^{\text{stor}} = 0$, go to statement (4-227). (4-225)

Go to statement (3-93). (4-226)

(Note that statements (3-93) through (3-101) update the stored fuel weight inventory for the end of the operating interval condition; and statement (3-102) returns the calculations to the instructions that follow below for computation of the fuel inventory cost - fissile and fertile if latter has any worth associated with fuel held in storage during the operating interval just completed.)

Do loop on i' ($1 \leq i' \leq N_{\text{alt}}^{\max}$) (4-227)

If $N_{\max}^{\text{stor}} = 0$, go to statement (4-257) (4-228)

If $\delta_{\text{meth}}^{\text{cost}} = 1$ or 3, calculate as follows for $1 \leq N \leq N_{\max}^{\text{stor}}$;

$$I_{\max}^{\text{stor}} - 1 \geq I_h \geq 0:$$

$$C_{N, I_h+1}^{\text{fab inv}(i')} = C_{N, I_h}^{\text{fab inv}(i')} + C_{N, I_h}^{\text{fab}(i')} \left(\frac{10^{-2} p_{\text{fab}}^{\text{int}(i')}}{365.25} \right) \left(\frac{T}{2} \right) \quad (4-229)$$

$$C_{N, I_h+1}^{\text{repr inv}(i')} = C_{N, I_h}^{\text{repr inv}(i')} - \left[10^3 \delta_{\text{unit}}^{\text{cost}} + 10^2 (1 - \delta_{\text{unit}}^{\text{cost}}) \right] \left(\frac{10^{-2} p_{\text{fab}}^{\text{int}(i')}}{365.25} \right) \\ \cdot \left(\frac{T}{2} \right) \sum_{m=1}^{m_{\text{fuel}}^{\text{max}} + n_{\text{fp}}^{\text{max}}} W_{m, N}^{(I_h+1)} \quad (4-230)$$

$$C_{N, I_h+1}^{\text{fab}(i')} = C_{N, I_h}^{\text{fab}(i')} \quad (4-231)$$

$$C_{N, I_h+1}^{\text{inv}(i')} = C_{N, I_h}^{\text{inv}(i')} \quad (4-232)$$

$$C_{N, I_h+1}^{\text{cred}(i')} = C_{N, I_h}^{\text{cred}(i')} \quad (4-233)$$

If $\delta_{\text{meth}}^{\text{cost}} = 1$ or 3, calculate for $1 \leq N \leq N_{\text{max}}^{\text{stor}}$:

$$C_{N, 0}^{\text{fab inv}(i')} = C_N^{\text{fab inv}(i')} \quad (4-234)$$

$$C_N^{\text{fab inv}(i')} = 0. \quad (4-235)$$

$$C_{N, 0}^{\text{repr inv}(i')} = C_N^{\text{repr inv}(i')} \quad (4-236)$$

$$C_N^{\text{repr inv}(i')} = 0. \quad (4-237)$$

$$C_{N,0}^{fab(i')} = C_N^{fab(i')} \quad (4-238)$$

$$C_N^{fab(i')} = 0 \quad (4-239)$$

$$C_{N,o}^{cred(i')} = C_N^{cred(i')} \quad (4-240)$$

$$C_N^{cred(i')} = 0. \quad (4-241)$$

$$C_{N,0}^{inv(i')} = C_N^{inv(i')} \quad (4-242)$$

$$C_N^{inv(i')} = 0. \quad (4-243)$$

If $\delta_{meth}^{cost} = 2$ or 3 , calculate as follows for $1 \leq N \leq N_{max}^{stor}$; $I_{max}^{stor} \geq I_h \geq 1$:

$$C_{N,I_h}^{fab inv(i')} = U_h^{fab(i')} \sum_{m=1}^{m_{max}^{fuel} + n_{fp}^{max}} W_{m,N}^{(I_h)} \left(\frac{10^{-2} p_{fab}^{int(i')}}{365.25} \right) \left(\frac{T}{2} \right) \cdot \left[10^3 \delta_{unit}^{cost} + 10^2 (1 - \delta_{unit}^{cost}) \right] / E_{int} \quad (4-244)$$

$$C_{N,I_h}^{repr inv(i')} = C_{N,I_h}^{fab inv(i')} U_h^{repr(i')} / U_h^{fab(i')} \quad (4-245)$$

If $C_{feed}^{(i')} > 0$, repeat operations of statements (4-136) and (4-137).

Do loop on N ($1 \leq N \leq N_{max}^{stor}$). (4-246)

Do loop on I_h ($I_{max}^{stor} \geq I_h \geq 1$). (4-247)

$$\text{If } \sum_{m=2}^{m_{max}^{fuel}} W_{m,N}^{(I_h)} = 0, \text{ go to next element of double loop.} \quad (4-247a)$$

Repeat operations of statements (4-140) through (4-147) with the following changes in equation (4-140):

(4-248)

(1). Replace $U_{J_w,n}^{fis(e)*}$ with $W_{m_{max}^{fuel}-1,N}^{(I_h)} + W_{m_{max}^{fuel}-3,N}^{(I_h)} 1-\delta_{7,m_{max}^{fuel}}$ (4-249)

(2). Replace $U_{J_w,n}^{tot(e)*}$ with $W_{1,N}^{(I_h)} 1-\delta_{6,m_{max}^{fuel}} + \sum_{m=m_{max}^{fuel}-3+2\delta_{7,m_{max}^{fuel}}}^{m_{max}^{fuel}} W_{m,N}^{(I_h)}$ (4-250)

If $\delta_{meth}^{cost} = 1$ or 3, calculate

$$C_{N,I_h}^{inv(i')} = C_{N,I_h}^{inv(i')} + \left[10^3 \delta_{unit}^{cost} + 10^2 (1 - \delta_{unit}^{cost}) \right] \left(\frac{10^{-2} P_{fuel}^{int(i')} T}{365.25} \right) \cdot \sum_{m=2}^{m_{max}^{fuel}} V'_m W_{m,N}^{(I_h)} e^{8.64 \times 10^4 \left(\frac{T}{2} \right) \delta_{m,m_{241}} \lambda_{241}} \quad (4-251)$$

If $\delta_{meth}^{cost} = 2$ or 3, calculate

$$C_{N,I_h}^{inv(i')} = \left[10^3 \delta_{unit}^{cost} + 10^2 (1 - \delta_{unit}^{cost}) \right] \left(\frac{10^{-2} P_{fuel}^{int(i')} T}{365.25} \right) \left[\sum_{m=2}^{m_{max}^{fuel}} V'_m W_{m,N}^{(I_h)} e^{8.64 \times 10^4 \left(\frac{T}{2} \right) \delta_{m,m_{241}} \lambda_{241}} \right] / E_{int} \quad (4-252)$$

End loop on I_h .End loop on N.If $\delta_{\text{meth}}^{\text{cost}} = 2$ or 3, calculate

$$C_{i'}^{\text{st inv}} = \sum_{N=1}^{N_{\text{max}}^{\text{stor}}} \sum_{I_h=1}^{I_{\text{max}}^{\text{stor}}} C_{N, I_h}^{\text{inv}(i')} \quad (4-253)$$

$$C_{i'}^{\text{st fab inv}} = \sum_{n=1}^{N_{\text{max}}^{\text{stor}}} \sum_{I_h=1}^{I_{\text{max}}^{\text{stor}}} C_{N, I_h}^{\text{fab inv}(i')} \quad (4-254)$$

$$C_{i'}^{\text{st repr inv}} = \sum_{n=1}^{N_{\text{max}}^{\text{stor}}} \sum_{I_h=1}^{I_{\text{max}}^{\text{stor}}} C_{N, I_h}^{\text{repr inv}(i')} \quad (4-255)$$

$$C_{i'}^{\text{st tot inv}} = C_{i'}^{\text{inv}} + C_{i'}^{\text{fab inv}} + C_{i'}^{\text{repr inv}} \quad (4-256)$$

3.4.5.9 Final Reactor Cost Summations

(Continue loop on i').

If $\delta_{\text{meth}}^{\text{cost}} = 1$ or 3, calculate

$$C_{i'}^{\text{fab}} = C_{i'}^{\text{fab}} / E' \quad (4-257)$$

$$C_{i'}^{\text{repr}} = C_{i'}^{\text{repr}} / E' \quad (4-258)$$

$$C_{i'}^{\text{cred}} = C_{i'}^{\text{cred}} / E' \quad (4-259)$$

$$C_{i'}^{\text{inv}} = C_{i'}^{\text{inv}} / E' \quad (4-260)$$

$$C_{i'}^{\text{fab inv}} = C_{i'}^{\text{fab inv}} / E' \quad (4-261)$$

$$C_{i'}^{\text{repr inv}} = C_{i'}^{\text{repr inv}} / E' \quad (4-262)$$

$$C_{i'}^{\text{tot}} = C_{i'}^{\text{fab}} + C_{i'}^{\text{repr}} + C_{i'}^{\text{cred}} + C_{i'}^{\text{inv}} + C_{i'}^{\text{fab inv}} + C_{i'}^{\text{repr inv}} \quad (4-263)$$

If $\delta_{\text{meth}}^{\text{cost}} = 2$ or 3, calculate

$$C_{i'}^{\text{inv}} = C_{i'}^{\text{inv}} + C_{i'}^{\text{st inv}} \quad (4-264)$$

$$C_{i'}^{\text{fab inv}} = C_{i'}^{\text{fab inv}} + C_{i'}^{\text{st fab inv}} \quad (4-265)$$

$$C_{i'}^{\text{repr inv}} = C_{i'}^{\text{repr inv}} + C_{i'}^{\text{st repr inv}} \quad (4-266)$$

$$C_{i'}^{\text{tot}} = C_{i'}^{\text{fab}} + C_{i'}^{\text{repr}} + C_{i'}^{\text{cred}} + C_{i'}^{\text{inv}} + C_{i'}^{\text{fab inv}} + C_{i'}^{\text{repr inv}} \quad (4-267)$$

3.4.5.10 Accumulated Energy and Levelized Power Cost

Calculate $E'_{acc} = E'_{acc} + E'$ (4-268)

$$E_{acc} = E_{acc} + E_{int} \quad (4-269)$$

Calculate

$$E'_{acc}{}^{levP} = E'_{acc}{}^{lev}$$

$$E'_{acc}{}^{lev} = E'_{acc}{}^{lev} + E' e^{-.01P_{lev}^{int} \left(T_{yr}^{acc} - \frac{T}{730.5} \right)} \quad (4-270)$$

$$E_{acc}{}^{levP} = E_{acc}{}^{lev}$$

$$E_{acc}{}^{lev} = E_{acc}{}^{lev} + E_{int} e^{-.01P_{lev}^{int} \left(T_{yr}^{acc} - \frac{T}{730.5} \right)} \quad (4-271)$$

If $\delta_{meth}^{cost} = 1$ or 3 and if $P_{lev}^{int} > 0$, calculate

$$C_{i'}^{lev} = \frac{1}{E'_{acc}{}^{lev}} \left[C_{i'}^{lev} \left(E'_{acc}{}^{levP} \right) + C_{i'}^{tot} \left\{ E'_{acc}{}^{lev} - E'_{acc}{}^{levP} \right\} \right] \quad (4-272)$$

for $1 \leq i' \leq N_{alt}^{max} + 1$.

If $\delta_{meth}^{cost} = 2$ or 3 and if $P_{lev}^{int} > 0$, calculate

$$C_{i'}^{lev} = \frac{1}{C_{acc}^{lev}} \left[C_{i'}^{lev} \left(E_{acc}{}^{levP} \right) + C_{i'}^{tot} \left\{ E_{acc}{}^{lev} - E_{acc}{}^{levP} \right\} \right] \quad (4-273)$$

for $1 \leq i' \leq N_{alt}^{max} + 1$.

3.4.6 Total System Weight Inventory and Doubling Time

Output data blocks 53 are now calculated except for 53B and 53C, which are computed as follows:

If $N_{\max}^{\text{stor}} = 0$, go to statement (4-279).

$$W_m^{\text{stor}} = \sum_{N=1}^{N_{\max}^{\text{stor}}} \sum_{I_h=1}^{I_{\max}^{\text{stor}}} W_{m,N}^{(I_h)} \quad \text{for } 1 \leq m \leq m_{\max}. \quad (4-274)$$

$$W_{\text{stor}} = \sum_{m=1}^{m_{\max}^{\text{fuel}} + n_{\text{fp}}^{\max}} W_m^{\text{stor}} \quad (4-275)$$

$$p_{\text{stor}}^{\text{fis}} = \left(1 - \delta_{6,m_{\max}^{\text{fuel}}}\right) \left(W_2^{\text{stor}} + W_4^{\text{stor}}\right) \quad (4-276)$$

$$p_{\text{stor}}^{\text{tot}} = p_{\text{stor}}^{\text{fis}} + \left(1 - \delta_{6,m_{\max}^{\text{fuel}}}\right) \left(W_3^{\text{stor}} + W_5^{\text{stor}}\right)$$

$$U_{\text{stor}}^{\text{fis}} = \left(1 - \delta_{5,m_{\max}^{\text{fuel}}}\right) \left[W_{m_{\max}^{\text{fuel}}-1}^{\text{stor}} + \left(1 - \delta_{7,m_{\max}^{\text{fuel}}}\right) W_{m_{\max}^{\text{fuel}}-3}^{\text{stor}} \right] \quad (4-277)$$

$$U_{\text{stor}}^{\text{tot}} = U_{\text{stor}}^{\text{fis}} + \left(1 - \delta_{6,m_{\max}^{\text{fuel}}}\right) W_1^{\text{stor}} + W_{m_{\max}^{\text{fuel}}}^{\text{stor}} + \left(1 - \delta_{7,m_{\max}^{\text{fuel}}}\right) W_{m_{\max}^{\text{fuel}}-2}^{\text{stor}} \quad (4-278)$$

If $N_{\max}^{\text{stor}} = 0$, set weight and cost data quantities in blocks 53B through 53E equal to zero. (4-279)

Output data blocks 51M and 51N are calculated as follows:

$$\begin{aligned}
 W_m^{\text{sys}} = & W_m^{\text{mid inv}} + W_m^{\text{stor}} e^{8.64 \times 10^4 \left(\frac{T}{2}\right) \delta_{m,m_{241}} \lambda_{241}} \\
 & + \left(\frac{1}{1 - \frac{1}{2} L_{\text{fab}}} \right) W_m^{\text{in}} \left(\frac{T_{\text{fab}}}{T} \right) e^{8.64 \times 10^4 \left(\frac{T_{\text{fab}}}{2}\right) \delta_{m,m_{241}} \lambda_{241}} \\
 & + \left(1 - \frac{L_{\text{repr}}}{2} \right) W_m^{\text{out}} \left(\frac{T_{\text{repr}}}{T} \right) e^{-8.64 \times 10^4 \left(\frac{T_{\text{repr}}}{2}\right) \delta_{m,m_{241}} \lambda_{241}}
 \end{aligned} \quad (4-280)$$

for $1 \leq m \leq m_{\max}$.

$$\begin{aligned}
 W_{\text{sys}} = & W_{\text{mid inv}} + W_{\text{stor}} + W_{\text{in}} \left(\frac{T_{\text{fab}}}{T} \right) \left(\frac{1}{1 - \frac{1}{2} L_{\text{fab}}} \right) + W_{\text{out}} \left(\frac{T_{\text{repr}}}{T} \right) \\
 & \cdot \left(1 - \frac{L_{\text{repr}}}{2} \right)
 \end{aligned} \quad (4-281)$$

$$\begin{aligned}
 p_{\text{sys}}^{\text{tot}} = & p_{\text{mid inv}}^{\text{tot}} + p_{\text{in}}^{\text{tot}} \left(\frac{T_{\text{fab}}}{T} \right) \left(\frac{1}{1 - \frac{1}{2} L_{\text{fab}}} \right) + p_{\text{stor}}^{\text{tot}} - W_{m_{241}}^{\text{stor}} \\
 & \cdot \left(e^{-8.64 \times 10^4 \lambda_{241} T/2} - 1 \right) \left(1 - \delta_{6,m_{\max}}^{\text{fuel}} \right)
 \end{aligned} \quad (4-282)$$

$$\begin{aligned}
 P_{\text{sys}}^{\text{fis}} = & P_{\text{mid inv}}^{\text{fis}} + P_{\text{in}}^{\text{tot}} \left(\frac{T_{\text{fab}}}{T} \right) \left(\frac{1}{1 - \frac{1}{2} L_{\text{fab}}} \right) + P_{\text{out}}^{\text{tot}} \left(\frac{T_{\text{repr}}}{T} \right) \left(1 - \frac{L_{\text{repr}}}{2} \right) \\
 & + P_{\text{stor}}^{\text{fis}} - W_{\text{m}241}^{\text{stor}} \left(e^{8.64 \times 10^4 \lambda_{241} T/2} - 1 \right) \left(1 - \delta_{6, \text{m}^{\text{fuel}}_{\text{max}}} \right)
 \end{aligned} \quad (4-283)$$

$$\begin{aligned}
 U_{\text{sys}}^{\text{tot}} = & U_{\text{mid inv}}^{\text{tot}} + U_{\text{in}}^{\text{tot}} \left(\frac{T_{\text{fab}}}{T} \right) \left(\frac{1}{1 - \frac{1}{2} L_{\text{fab}}} \right) + U_{\text{out}}^{\text{tot}} \left(\frac{T_{\text{repr}}}{T} \right) \left(1 - \frac{L_{\text{repr}}}{2} \right) \\
 & + U_{\text{stor}}^{\text{tot}}
 \end{aligned} \quad (4-284)$$

$$\begin{aligned}
 U_{\text{sys}}^{\text{fis}} = & U_{\text{mid inv}}^{\text{fis}} + U_{\text{in}}^{\text{fis}} \left(\frac{T_{\text{fab}}}{T} \right) \left(\frac{1}{1 - \frac{1}{2} L_{\text{fab}}} \right) + U_{\text{out}}^{\text{fis}} \left(\frac{T_{\text{repr}}}{T} \right) \left(1 - \frac{L_{\text{repr}}}{2} \right) \\
 & + U_{\text{stor}}^{\text{fis}}
 \end{aligned} \quad (4-285)$$

$$\begin{aligned}
 \text{If } & \left[\left(P_{\text{out}}^{\text{fis}} + U_{\text{out}}^{\text{fis}} \right) \left(1 - L_{\text{repr}} \right) - \left(P_{\text{in}}^{\text{fis}} + U_{\text{in}}^{\text{fis}} \right) \left(\frac{1}{1 - L_{\text{fab}}} \right) - \left(1 - \delta_{6, \text{m}^{\text{fuel}}_{\text{max}}} \right) \right. \\
 & \cdot W_4^{\text{stor}} \left(e^{8.64 \times 10^4 T \lambda_{241}} - 1 \right) \left. \right] > 0; \text{ calculate approximate doubling}
 \end{aligned}$$

time as follows:

$$\begin{aligned}
 T_{\text{double}} = & \left[0.693 (T/365.25) \cdot (P_{\text{sys}}^{\text{fis}} + U_{\text{sys}}^{\text{fis}}) \right] / \left[\left(P_{\text{out}}^{\text{fis}} + U_{\text{out}}^{\text{fis}} \right) \right. \\
 & \left. (1 - L_{\text{repr}}) - (P_{\text{in}}^{\text{fis}} + U_{\text{in}}^{\text{fis}}) \left(\frac{1}{1 - L_{\text{fab}}} \right) - \left(1 - \delta_{6, \text{m}^{\text{fuel}}_{\text{max}}} \right) \right. \\
 & \left. W_4^{\text{stor}} \left(e^{8.64 \times 10^4 T \lambda_{241}} - 1 \right) \right]
 \end{aligned} \quad (4-286)$$

This completes the calculation of all output data quantities for the operating interval (except for restart data if $\delta_{\text{restart}}^{\text{prep}} > 1$). Set up to write output data in accordance with data printout selectors in blocks 24, 25 and 26.

If $\delta_{\text{rest}}^{\text{prep}} = 0$ and $I = I_{\text{max}}$, halt all calculations (4-287)

Write on a peripheral unit the accumulated cost data for stored fuel repositories and for the reactor fuel that is not discharged at the end of the current operating interval.

GO to statement 3-128. (4-288)

3.4.7 Restart Data*

If $\delta_{\text{restart}}^{\text{prep}} = 1$, write data blocks 29, 30A, 30B, 30C, 32, 33, 35, 36, 37, and 38 in the order and format as required for input to a restart case - see statements (2-70) and (2-71). Blocks 37 and 38 are not used $N_{\text{max}}^{\text{stor}} = 0$. Block 36 may be stored on a peripheral unit at this point in the computation; and also data blocks 37 and 38 if $N_{\text{max}}^{\text{stor}} > 0$. Stop the computation if all output data has been set up for printout. (4-289)

If $\delta_{\text{restart}}^{\text{prep}} = 2$, do calculations through statement (4-304). (4-290)

If $N_{\text{max}}^{\text{stor}} = N_{\text{max}}^{\text{stor}}$, go to statement (4-296). (4-291)

If $N_{\text{max}}^{\text{stor}} = 0$, make following adjustments to indices ($N \rightarrow N'$) in data block 33: (4-292)

$$W_{N'}^{(I_h)} = W_{N' + N_{\text{max}}^{\text{stor}}}^{(I_h)} \quad \text{for } 1 \leq N' \leq N_{\text{max}}^{\text{totU}} - N_{\text{max}}^{\text{stor}}; 0 \leq I_h \leq 3. \quad (4-293)$$

$$W_{m, N'}^{(I_h)} = W_{m, N' + N_{\text{max}}^{\text{stor}}}^{(I_h)} \quad (4-294)$$

$$\text{for } 1 \leq N' \leq N_{\text{max}}^{\text{totU}} - N_{\text{max}}^{\text{stor}}; 0 \leq I_h \leq 3;$$

$$\text{and for } 2 \leq m \leq 5 \text{ if } 1 \leq N' \leq N_{\text{max}}^{\text{Pu}} - N_{\text{max}}^{\text{stor}},$$

$$\text{or for } m_{\text{max}}^{\text{fuel}} - 3 + 2\delta_7 \leq m \leq m_{\text{max}}^{\text{fuel}} \text{ if } N_{\text{max}}^{\text{Pu}} - N_{\text{max}}^{\text{stor}} + 1 \leq N' \leq N_{\text{max}}^{\text{totU}} - N_{\text{max}}^{\text{stor}},$$

$$\text{and also for } m=1 \text{ for } N_{\text{max}}^{\text{fisU}} - N_{\text{max}}^{\text{stor}} + 1 \leq N' \leq N_{\text{max}}^{\text{totU}} - N_{\text{max}}^{\text{stor}}.$$

*The restart option is not available in Version I of FUMBLE.

$$W_{m_{233}, N'}^{(o)} = W_{m_{233}, N' + N_{ax}^{stor}} \quad \text{for } N_{max}^{Pu} - N_{max}^{stor} + 1 \leq N' \leq N_{max}^{totU} - N_{max}^{stor} \quad (4-295)$$

If $J'_{max} = 0$, go to statement (4-304). (4-296)

Make following adjustments to data blocks 30A, 30B, and 30C (including change in block dimensions if $J'_{max} \neq J_{max}$): (4-297)

$$N_{dis}^{(J')} = N_{dis}^{(J'_i)} \quad \text{for } i=1 \text{ and for } 1 \leq J' \leq J'_{max}. \quad (4-298)$$

$$n_{J'}^{dis} = n_{dis}^{(J'_i)} \quad \text{for } i=1 \text{ and for } 1 \leq J' \leq J'_{max}. \quad (4-299)$$

$$E_{J',n}^{(o)th} = \sum_{i=1}^{N(J')} E_{J'_i,n}^{(o)th} \quad \text{for } 1 \leq J' \leq J'_{max}. \quad (4-300)$$

$$W_{J',n}^{(o)} = \sum_{i=1}^{N(J')} W_{J'_i,n}^{(o)} \quad \text{for } 1 \leq J' \leq J'_{max}. \quad (4-301)$$

Make following adjustments to data block 29 (including change in block dimensions if $j'_{max} \neq j_{max}$): (4-302)

$$N_{m,j',n}^{(o)} = \frac{\sum_{i=1}^{N(j')} N_{m,j'_i,n}^{(o)} v_{j'_i}}{\sum_{i=1}^{N(j')} v_{j'_i}} \quad (4-303)$$

for $1 \leq J' \leq J'_{\max}$; $j'_{J'-1} + 1 \leq j' \leq j'_{J'}$;

$1 \leq n \leq N_{\text{bat}}^{(J')}$; $1 \leq m \leq m_{\max}$.

Write data blocks 29, 30A, 30B, 30C, 33, 35, 36, 37, and 38 in the order and format as required for input to a restart problem using either a different reactor zone and region layout from the present problem or zero storage repositories or both. The dimensions and data values in some of these blocks may now have been adjusted corresponding to the primed quantities on the left sides of statements (4-293), (4-294), (4-295), (4-298), (4-299), (4-300), (4-301) and (4-303). See statements (2-70) and (2-71) for the use of restart data in the new problem. (4-304)

Blocks 37 and 38 are not used if $N_{\max}^{\text{stor}} = 0$. Block 36 may be stored on a peripheral unit at the point in the computation; and also blocks 37 and 38 if $N_{\max}^{\text{stor}} > 0$. Stop the computation if all output data has been set up for printout.

SECTION IVPROGRAM DESCRIPTION

FUMBLE utilizes an overlay structure consisting of a main program and eight separate links. The main program transfers control to the links and each link carries out a separate type of data handling or fuel management calculation. The broad program logic is illustrated by the block diagrams given in Figure 4.1.

The main program, in addition to controlling the link transfers, contains all the blank common used throughout the code; defines input, output and auxiliary equipment; and specifies the storage locations for all input, working and output data. The main program also contains several subroutines which are used frequently by the other links. They are briefly described as follows:

INTERP	Routine for interpolating between end point data including volumes, neutron fluxes, atom concentrations, material cross sections and material reactivity worths.
NORM	Normalizes the neutron flux level to satisfy the requirements for a specified rated power.
ZONE	Compute zone indicators (Number of batches, inclusive regions, batches discharged, etc.) for designated zones.

The order of the FUMBLE computations is indicated in Figure 4.1 and follows the discussion in Section III. The first link called by

FIGURE 4.1
MAIN PROGRAM LOGIC

FUMBLE is LINK A and it consists of the subroutines INIT1 and ERROR. INIT1 is utilized to read the input data and prepare the data according to the problem instructions. Endpoint data required for the interpolation routine are stored for later use. When a RESTART problem is being run, the component cost data (i.e., inventory, reprocessing, fabrication, etc.) for the reactor zones and stored fuel repositories (if used) are also saved on a peripheral unit. An error checkout procedure for the input data is carried out by the ERROR subroutine.

LINK B follows LINK A only for the first operating interval. This link contains the subroutine INIT2 and is primarily used to compute the atom concentrations, by batch, for each material in each core region at the beginning of the initial operating cycle. Zone parameters which can later be used to adjust the fissile enrichment are also computed in this subroutine.

LINK C includes the burnup computations and convergence tests for the average power, discharge fuel exposure and end-of-cycle reactivity. The neutron flux level, fissile enrichment and/or the operating interval may be adjusted, within limits, to satisfy the convergence tests. However, should the tests not be satisfied within a specified number of iterations or the peak power and burnup reactivity swing exceed specification limits, the problem will terminate. Subroutine BURN is utilized for the burnup computations and subroutine ADJUST is used to adjust the operating conditions when a convergence test has not been satisfied.

Stored and recycle fuel repositories are updated in subroutine STOR in LINK D. The repositories are updated by taking into account both the loaded and discharged fuel for the current operating interval.

LINKS E, F and G are used to prepare and write out all required output data. Atom concentrations and power at the beginning and end of the operating cycle, for all core regions, are written out in sub-

routine OUT1 in accordance with output instructions. The reactor breeding ratio is also calculated in OUT1 and component cost information for reactor zones and stored fuel repositories (if used) are read from peripheral units and saved for fuel cycle cost calculations which are carried out in LINKS F and G.

Loaded, average and discharge fuel weights, fuel burnup, energy and fuel cycle costs are computed in LINK F for the reactor composite zones. The subroutines which are used to carry out the computations and write out the results are OUT2, COST and WRIT. The results for the composite zones are combined in LINK G to give fuel cycle parameters and costs for the total reactor. If stored fuel repositories are used, their contribution to the total system is also determined in LINK G. The computations in LINK G are carried out by Subroutine OUT3.

LINK G completes the operations for the current operating interval and should this interval correspond to the last operating cycle and output data not be required for a RESTART case, the problem will terminate. Otherwise, control is transferred to LINK H and reactor parameter and atom concentrations are determined for the beginning of the next operating interval. Subroutine LOAD in LINK H also calls the interpolation routine and may read in cards which modify the operating instructions of the previous operating interval. LINKS H and A are inter-related and form a single overlay structure.

The last link, LINK I is used only to prepare and save data for a RESTART problem.* Subroutine RESTART in LINK I can be used to alter the number of fuel storage repositories, reactor zones and reactor regions, if requested, prior to writing the data on a save tape.

*The restart option is not available in Version I of FUMBLE.

SECTION V

DATA BLOCKS - GLOSSARY OF PHYSICS AND FORTRAN SYMBOLS

Data blocks contain the input data, working data and output data which are used by the code. The input data blocks were utilized as a guide for preparing the input instruction classes found in Section VI. However, the order of reading in data was revised to simplify the input preparation. For this reason, the data blocks and input classes are generally not alike.

5.1 Alphabetical Index to Physics Symbols

The physics symbols are listed in alphabetical order and are defined under the indicated block statement number in Section 5.2.

<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
A_r	ARPOW	44-14
$A_{m''}, m'$	ACO (MTPP, MTP)	42-3
A_{enr}	AENR	44-39
A_{int}	AINTE	44-40
A_{cont} A_t	ATICON	17-1
$A_m^{wt}/602.5$	AWT (MT)	43-2
A_m^{wt}	AWTP (MT)	43-5
$A_{m \max}^{wt}$	AWPOIS	2-18
B	BU	44-26 (51B-5)
B_{J_w}	BUW	52B-1
$B_{J_w, n}$	BUB (NB)	52C-2
B_{int}	BINT	44-41

<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
B _{test}	BTEST	2-9 (44-24)
B ^(o)	BUZ	44-27
B ⁽¹⁾	BUI	44-28
C _i ^{cred}	CRED (IN)	51Q-3
C _i ^{,cred}	CPCRED (IN)	51U-3
C _{J_w} ^{cred (1)}	CREDW (IN)	52S-3
C _{J_w} ^{,cred (1)}	CPCREW (IN)	52W-3
C _{J_{w,n}} ^{cred (1)}	CREDB (IN,NB)	52U-3
C _{J_{z,n}} ^{cred (1)}	CRED (JZ, NB, IN)	36-2
C _n ^{cred (1)}	CREDI (NS, IN)	38-7
C _{n, I_h} ^{cred (1)}	CSCRED (NS, IH, IN)	38-2
C _i ^{fab}	CFAD (IN)	51Q-1
C _i ^{l fab}	CPFAB (IN)	51U-1
C _{J_w} ^{fab (1)}	CFABW (IN)	52S-1
C _{J_w} ^{l fab (1)}	CPFABW (IN)	52W-1
C _{J_{w,n}} ^{fab (1)}	CFABB (IN, NB)	52U-1
C _{J_{z,n}} ^{fab (1)}	CFAB (JZ, NB, IN)	36-1
C _N ^{fab (1)}	CFABI (NS, IN)	38-6
C _{N, I_k} ^{fab (1)}	CSFAB (NS, IH, IN)	38-1
C _i ^{fab inv}	CFAIND (IN)	51Q-5
C _i ^{,fab inv}	CPFAIN (IN)	51U-5

<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
$C_{J_w}^{fab\ inv\ (i)}$	CFAINW (IN)	52S-5
$C_{J_w}'^{fab\ inv\ (i)}$	CPFINW (IN)	52W-5
$C_{J_w, n}^{fab\ inv\ (i)}$	CFAINB (IN, NB)	52U-5
$C_{J_z, n}^{fab\ inv\ (i)}$	CFABIN (JZ, NB, IN)	36-4
$C_N^{fab\ inv\ (i)}$	CFAINI (NS, IN)	38-9
$C_N'^{fab\ inv\ (i)}$	CPSFIN (NS, IN)	53E-3
$C_{N, I_h}^{fab\ inv\ (i)}$	CSFAIN (NS, IH, IN)	38-4
$C_{feed}^{(i)}$	CFEED (IN)	21-3
C_i^{inv}	CIND (IN)	51Q-4
$C_i'^{inv}$	CPINV (IN)	51U-4
$C_{J_w}^{inv(i)}$	CINW (IN)	52S-4
$C_{J_w}'^{inv\ (i)}$	CPINW (IN)	52W-4
$C_{J_w, n}^{inv\ (i)}$	CINVB (IN, NB)	52U-4
$C_{J_z, n}^{inv\ (i)}$	CINV (JZ, NB, IN)	36-3
$C_N^{inv\ (i)}$	CINVI (NS, IN)	38-8
$C_N'^{inv\ (i)}$	CPSIN (NS, IN)	53E-2
$C_{N, I_h}^{inv\ (i)}$	CSINV (NS, IH, IN)	38-3
C_i^{lev}	CLEV (IN)	51R-1
$C_i'^{lev}$	CPLEV (IN)	51V-1

<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
C_1^{repr}	CREPD (IN)	51Q-2
C_1^{repr}	CPREP (IN)	51U-2
$C_{J_w}^{\text{repr}} (i)$	CREPW (IN)	52S-2
$C_{J_w}^{\text{repr}} (i)$	CREPW (IN)	52W-2
$C_{J_w, n}^{\text{repr}} (i)$	CREPB (IN, NB)	52U-2
$C_1^{\text{repr inv}}$	CREIND (IN)	51Q-6
$C_1^{\text{repr inv}}$	CPREIN (IN)	51U-6
$C_{J_w}^{\text{repr inv}} (i)$	CREINW (IN)	52S-6
$C_{J_w}^{\text{repr inv}} (i)$	CPRINW (IN)	52W-6
$C_{J_w, n}^{\text{repr inv}} (i)$	CREINB (IN, NB)	52U-6
$C_{J_z, n}^{\text{repr inv}} (i)$	CREPIN (JZ, NB, IN)	36-5
$C_N^{\text{repr inv}} (i)$	CREINI (NS, IN)	38-10
$C_N^{\text{repr inv}} (i)$	CPSRIN (NS, IN)	53E-4
$C_{N, I_h}^{\text{repr inv}} (i)$	CSREIN (NS, IH, IN)	38-5
C_{sep}^1	CSEP (IN)	21-4
$C_1^{\text{St fab inv}}$	CPSFIT (IN)	53D-3
$C_1^{\text{St inv}}$	CPSIT (IN)	53D-2
$C_1^{\text{St repr inv}}$	CPSRIT (IN)	53D-4
$C_1^{\text{St tot inv}}$	CPSTIT (IN)	53D-5

<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
C_i^{tot}	CTOT (IN)	51P-1
$C_i'^{tot}$	CPTOT (IN)	51T-1
$C_{J_w}^{tot} (i)$	CTOTW (IN)	52R-1
$C_{J_w}^{tot} (i)$	CPTOTW (IN)	52V-1
$C_{J_w,n}^{tot} (i)$	CTOTB (IN, NB)	52T-3
d_{stor}	JDSTO	9-1
e^{th}	EFFIC	19-5
E	EDIS	51Q-2
E_{J_w}	EDISWP	52A-5
$E_{J_w,n}$	EDISWB (NB)	52T-2
E_{acc}	EACC	35-4 (51S-3)
E'_{acc}	EACCU	35-2 (51Q-3)
E_{acc}^{lev}	EACCLV	35-5 (51S-4)
E_{acc}^{lev}	EACLEV	35-3 (51Q-4)
E'_m	EMEVP (MT)	43-4
E_m^{input}	EMEV (MT)	28-1
E_{int}	EINT	51S-2
$E_{J_w}^{int}$	EINTW	52A-4

<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
E_{tails}^1	ETAIL (IN)	21-5
$E_{J_z, n}^{th}$	ETH (JZ, NB)	42-2
$E_{J_z, n}^{(o) th}$	EZTH (JZ, NB)	30B-1
$E_N^{(IH) th}$	ESTOTH (NS, IH)	37-2 (53A-2)
f	FLOD	2-6 (44-6) (51B-2)
$f_V^{(1)}$	SF (JZ, LR)	32-4
F_a^{in}	FAIN	2-15
F_a^{out}	FAOUT	2-14
F_b^{in}	FBIN	2-17
F_b^{out}	FBOUT	2-16
F_{feed}	FFEED	44-37
F_{mult}	FRMULT (NS)	9-4
F_{tails}	FTAILS	44-38
g	JG	40-1
g_{max}	NGMX	25A-2
G_L	GM (LINT)	6-3
G_o	GZER	6-1
h	NH	40-2
h_{max}	NHMX	22-1

<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
H_L	HM (LINT)	6-4
H_O	HZER	6-2
i'	IN	40-4
i	ITER	45-2 (40-3), (51A-2)
$i_{\max}$	ITERMX	1-5
I	IOP	(45-1, 51A-1, 51Q-1, 51S-1, 52A-2)
I_k	IOPT (KT)	3-1
I_{print}	IPRINT	1-10
I_{punch}	IPUNCH	1-11
I_s	IOPS (IOP)	27-1
I_j^{cy}	ICY (JZ)	7-3
I_h	IH	40-5
$I_h^{(N,3)}$	IHN 3 (NS)	15-1
I_{halt}	KWIT	45-4 (51A-4)
I_{init}	INIT	1-3
$I_{\max}$	IOPMX	1-4
I_J^{NU}	INU (JZ)	7-1

<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
$I_J^{\text{rec } 1}$	IHVS (JZ)	14-6
$I_J^{\text{rec } 2}$	IHV2 (JZ)	14-7
I_J^{stor}	IHVS (JZ)	13-2
$I_{\text{max}}^{\text{stor}}$	ISTOMX	1-15
I_{switch}	INTSWI	1-22
I_t	ITPOW	45-3 (51A-3)
j	JR	40-6
j_c	JRC (JZP)	4-5
j_J	JRZ (JZ)	3-2
j_{max}	JRMX	1-1
j'_{max}	JRMXP	4-3
j_{pk}	JRPK	1-14
J	JZ	40-7
JA_J	JAZ (JZ)	10-1
JB_J	JZB (JZ)	3-3
JC_J	JZC (JZP)	4-4
JL_J	JZL (JZ)	3-5
JP_J	JZP (JZ)	3-4
JV_J	JZV (JZ)	12-4

<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
JG_J	JWG (JZ)	25A-1
J_W	JW	52A-1
$J_{\max}$	JZMX	1-2
$J'_{\max}$	JZMXP	4-2
J_{pk}	JZPK	45-11
k	KT	40-8
$k_{\max}$	KTMX	1-9
K	EK	44-15 (51C-1)
$K^{(a)}$	REFKA	39-13
$K^{(b)}$	REFKB	39-14
$K^{(e)}$	ENDK	2-1
$K^{(i-1)}$	EKM1	44-22
$K^{(i-2)}$	EKM2	44-23
K_{ref}	REFK	34-7
L	LINT	40-9
$L_{\max}$	LINTMX	1-21
L_v	LREP (JZ)	31-2

<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
L_{fab}	FABL	19-4
L_{max}	LINTMX	1-21
L_{repr}	REPRL	19-3
m	MT	40-10
M_{233}	MT 233	45-13
M_{241}	MT 241	45-12
M_{max}^{fuel}	MFUMX	1-6
m_{max}	MTMX	1-8
$M_{1,v}^{rec 1}$	MTI (1)	31-3
$M_{2,v}^{rec 2}$	MT2 (1)	31-4
$M_{1,v}^{rec 2}$	MT1 (2)	31-5
$M_{2,v}^{rec 2}$	MT2 (2)	31-6
M_L	MTL (LINT)	3-6
$M_{q,n}$	MTS (NS, MQ)	8-2
n	NB	40-11
N	NS	40-12
$N_v^{(1)}$	SN (JZ, LR)	32-2
$N_{m,j}^{(o)}$	CNBR (MT, JR)	55-1
$N_{m, max, J}^{(o)}$	CNBPV (JZ)	17-2

<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
$N_{m,j}^{(a)}$	CNMA (MT, JR)	39-1
$N_{m,j}^{(b)}$	CNMB (MT, JR)	39-2
$N_{m,j}^{(e)}$	CNER (MT, JR)	56-1
$N_{m,j}^{(r)}$	CNR (MT, JR)	34-1
$N_{m,j,n}^{(o)}$	CNB (MT, JR, NB)	29-1 (57-1)
$N_{m,j,n}^{(e)}$	CNE (MT, JR, NB)	41-1 (58-1)
$N_n^{(j)}$	NUB (JZ, NPRI)	7-4
N'_n	NBP	52C-1, 52E-1
N_{alt}^{max}	NALTMX	23-1
N_J^{bat}	NBMX (JZ)	3-7
N_{max}^{bat}	NBHI	1-13
$N_c^{(j)}$	NCOBAT (JZ)	7-2
$N_{dis}^{(J)}$	NDIS (JZ)	30A-1
$N'_{dis}^{(J)}$	NLB (JZ)	30A-2 (43-8)
$N_{max}^{fis U}$	NFUMX	1-18
N_{fp}^{max}	NFPMX	1-7
N_J^{fuel}	CNF (JZ)	16-1
N_{int}	NINT	1-12

<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
$N_{\max}$	NSMX	1-20
N_j^{mkp}	NSV3(JZ, 3)	14-3
N_{N, I_h}^{orig}	NSORIG (NS, IH)	53E-5
N_j^{oth}	NSV4 (JZ, 4)	14-4
$N_{\max}^{\text{Pu}}$	NPUMX	1-17
$N_J^{\text{rec 1}}$	NSVS (JZ)	14-1
$N_J^{\text{rec 2}}$	NSV2 (JZ)	14-2
N_d^{stor}	NSDS (JZ)	9-2
$N_d^{\text{stor 2}}$	NSDS2 (JZ)	9-3
$N_{\max}^{\text{stor}}$	NSTOMX	1-16
$N_{\max}^{\text{stor}}$	NSTOMP	4-1
N_J^{stor}	NSVS (JZ)	13-1
$N_{\max}^{\text{tot U}}$	NTUMX	1-19
$N_{\max}^{\text{val (i)}}$	NVALMX (IN)	21-1
P_v	PFRA (JZ)	18-1
$P_v^{(a)}$	POWA (JZ)	32-5
$P^{(e)}$	PEL	51B-3

<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
$P_v^{(1)}$	SP (JZ, LR)	32-3
$P_{end\ inv}^{fis}$	PFEINV	51K-3
$P_{J_w}^{fis\ end\ inv}$	PFEIVW	52N-3
$P_{J_w, n}^{fis\ end\ inv}$	PFEIVB (NB)	520-4
P_{in}^{fis}	PFIN	51G-3
$P_{J_w}^{fis\ in}$	PFINW	52F-3
$P_{J_w, n}^{fis\ in}$	PFINB (NB)	52G-4
$P_{mid\ inv}^{fis}$	PFMINV	51I-3
$P_{J_w}^{fis\ mid\ inv}$	PFMIVW	52J-3
$P_{J_w, n}^{fis\ mid\ inv}$	PFMIVB (NB)	52K-4
P_{out}^{fis}	PFOUT	51E-3
$P_{J_w}^{fis\ out}$	PFOUTW	52B-4
$P_{J_w, n}^{fis\ out}$	PFOUTB (NB)	52C-5
P_{store}^{fis}	PFSTOR	53B-3
P_{sys}^{fis}	PFSYS	51M-3
$P_{fab}^{int\ (1)}$	PFAB (IN)	20-3
$P_{fuel}^{int\ (1)}$	PFU (IN)	20-2
P_{lev}^{int}	PLEV	20-1

<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
P^{pk}	PPK	44-29 (51C-3)
P_{test}^{pk}	PKTEST	2-8 (44-30)
P^{th}	PTH	2-7 (44-7)
P_{jw}^{th}	PTHW	52A-3
P_e^{th}	PENTH	44-10 (510-3)
$P_{jpk, n}^{th}$	PTHJPK (NB)	43-3
P_o^{th}	PZETH	44-9 (51D-2)
$\bar{P}^{th}$	PAVTH	44-8 (51B-4)
$\bar{P}_i^{th}$	PAVTHI	44-13
$P_{end\ inv}^{tot}$	PTEINV	51K-2
$P_{J_w}^{tot\ end\ inv}$	PTEIVW	52N-2
$P_{J_w, n}^{tot\ end\ inv}$	PTEIVB (NB)	520-3
P_{in}^{tot}	PTIN	51G-2
$P_{J_w}^{tot\ in}$	PTINW	52F-2
$P_{J_w, n}^{tot\ in}$	PTINB (NB)	52G-3
$P_{mid\ inv}^{tot}$	PTMINV	51I-2
$P_{J_w}^{tot\ mid\ inv}$	PTMIVW	52J-2
$P_{J_w, n}^{tot\ mid\ inv}$	PTMIVB (NB)	52K-2
P_{out}^{tot}	PTOUT	51E-2

<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
$P_{J_w}^{tot \text{ out}}$	PTOUTB (NB)	52C-4
P_{stor}^{tot}	PTSTOR	53B-2
P_{sys}^{tot}	PTSYS	51M-2
q	MQ	40-13
$q_{max}^{(N)}$	MQMX (NS)	8-1
r_{st}	RST	44-35
$R^{(a)}$	RAA	32-11
$R_{m,j}^{(a)}$	RKA (MT, JR)	39-3
$R^{(b)}$	RBB	32-10
$R_v^{(b)}$	RB (JZ)	32-8
$R_{m,j}^{(b)}$	RKB (MT, JR)	39-4
$R_v^{(1)}$	SR (JZ, LR)	32-1
$R_{m,j}^{(r)}$	RKR (MT, JR)	34-2
$R^{(x)}$	RXX	32-9
$R_v^{(x)}$	RX (JZ)	32-7
$\bar{R}^{breed}$	BRAVG	51C-4
R_{end}^{breed}	BREND	51D-5
R_{init}^{breed}	BRINIT	51D-4
R_{int}	RINT	44-42

<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
R_p	RP	44-11 (51D-1)
R'_p	RPI	44-12
$R_{25}^{23} (i)$	R2325 (IN)	21-7
T	TDA	2-4 (44-1)(51B-1)
T_{yr}^{acc}	TACYR	35-1 (51B-6)
T_{doub}	TDOUB	51C-5
T_{fab}	FABT	19-2
T_{I-1}	TIM1	44-4
T_{orig}	TORIG	44-3
$T_{orig_{I-1}}$	TORIMI	44-5
T_{repr}	REPRT	19-1
$U_h^{fab} (i)$	UFAB (NH, IN)	22-2
$U_{end\ inv}^{fis}$	UFEINV	51K-5
$U_{J_w}^{fis\ end\ inv}$	UFEIVW	52N-5
$U_{J_w, n}^{fis\ end\ inv}$	UFEIVB (NB)	52O-6
U_{in}^{fis}	UFIN	51G-5
$U_{J_w}^{fis\ in}$	UFINW	52F-5
$U_{J_w, n}^{fis\ in}$	UFINB (NB)	52G-6

<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
$U_{mid}^{fis} inv$	UFMINV	51I-5
$U_{J_w}^{fis} mid inv$	UFMIVW	52J-5
$U_{J_w, n}^{fis} mid inv$	UFMIVB (NB)	52K-6
U_{out}^{fis}	UFOUT	51E-5
$U_{J_w}^{fis} out$	UFOUTW	52B-6
$U_{J_w, n}^{fis} out$	UFOUTB (NB)	52C-7
U_{stor}^{fis}	UFSTOR	53B-5
U_{sys}^{fis}	UFSYS	51M-5
$U_h^{repr} (1)$	UREPR (NH, IN)	22-3
$U_{end}^{tot} inv$	UTEINV	51K-4
$U_{J_w}^{tot} end inv$	UTEIVW	52N-4
$U_{J_w, n}^{tot} end inv$	UTEIVB (NB)	52O-5
U_{in}^{tot}	UTIN	51G-4
$U_{J_w}^{tot} in$	UTINW	52F-4
$U_{J_w, n}^{tot} in$	UTINB (NB)	52G-5
$U_{mid}^{tot} inv$	UTMINV	51I-4
$U_{J_w}^{tot} mid inv$	UTMIVW	52J-4
$U_{J_w, n}^{tot} mid inv$	UTMIVB (NB)	52K-5

<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
U_{out}^{tot}	UTOUT	51E-4
$U_{Jw}^{tot out}$	UTOUTW	52B-5
$U_{Jw, n}^{tot out}$	UTQUTB (NB)	52C-6
U_{stor}^{tot}	UTSTOR	53B-4
U_{sys}^{tot}	UTSYS	51M-4
V_o^{in}	JZERO	12-3 (31-1)
V_{max}	JVMX	12-1
V_{stor}	JVSTO	12-2
V_j	VOL (JR)	34-6
$V_j^{(a)}$	VOLA (JR)	39-11
$V_j^{(b)}$	VOLB (JR)	39-12
V_m'	VALP (MTP)	43-6
$V_m^{(i)}$	VAL (IN, MTP)	21-2
V_{enr}	VENR	44-36
W	WV	44-31
$W_{j, n}^{(o)}$	WF (JZ, NB)	30C-1
$W_{M233, N}^{(o)}$	WRECPA (NS)	33-3 (54-3)
$W_N^{(Ih)}$	WTREC (NS, IH)	33-1 (54-2)

<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
$W_{m, N}^{Ih}$	WRECM (NS, IH, MT)	33-2 (54-1)
	WSTO (NS, IH, MT)	37-1 (53A-1)
$W_v^{(Lv)}$	WKG (JZ)	32-6
$W_{q, n}$	WS (NS, MQ)	8-3
$W_{end\ inv}$	WFEINV	51K-1
$W_m^{end\ inv}$	WEINV (MT)	51L-1
$W_{J_w}^{end\ inv}$	WEIVW	52N-1
$W_{m, jw}^{end, inv}$	WEIVM (MT)	52P-1
$W_{J_w, n}^{end\ inv}$	WEIVB (NB)	52O-2
$W_{m, jw, n}^{end\ inv}$	WEIVMB (MT, NB)	52Q-2
W_{in}	WFIN	51G-1
W_m^{in}	WIN (MT)	51H-1
$W_{J_w}^{in}$	WINW	52F-1
$W_{m, jw}^{in}$	WINM (MT)	52H-1
$W_{J_w, n}^{in}$	WINB (NB)	52G-2
$W_{m, jw, n}^{in}$	WINMB (MT, NB)	52I-2
$W_{mid\ inv}$	WFMINV	51I-1
$W_m^{mid\ inv}$	WMINV (MT)	51J-1
$W_{J_w}^{mid\ inv}$	WMIVW	52J-1

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<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
$W_{m, J_w}^{mid\ inv}$	WMIVM (MT)	52L-1
$W_{J_w, n}^{mid\ inv}$	WMIVB (NB)	52K-2
$W_{m, J_w, n}^{mid\ inv}$	WMIVMB (MT, NB)	52-M-2
W_{out}	WFOUT	51E-1
W_m^{out}	WOUT (MT)	51F-1
$W_{J_w}^{out}$	WOUTW	52B-2
W_{m, J_w}^{out}	WOUTM (MT)	52D-1
$W_{J_w, n}^{out}$	WOUTB (NB)	52C-3
$W_{m, J_w, n}^{out}$	WOUTMB (MT, NB)	52E-2
W_{stor}	WFSTOR	53B-1
W_m^{stor}	WSTORM (MT)	53C-1
W_{sys}	WFSYS	51M-1
W_m^{sys}	WSYS (MT)	51N-1
Z_j	ZEE (JR)	43-1

<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
$\delta_1^{(a)}$	INCORI	1-30
δ_{235}	IN235	45-7
$\delta_{alt}^{(1)}$	IALT	23-2
δ_{burn}	INBU	45-9
δ_{BR}	IBRAT	26-6
δ_{conc}	ICNB	26-1
$\delta_{core\ bat}$	ICNBRA	26-2
$\delta_{cost\ g}$	IZCO (NG)	25B-6
$\delta_{cost\ meth}$	ICOME	1-25
$\delta_{cost\ reac}$	IRECO	24-6
$\delta_{cost\ unit}$	ICOUN	1-26
$\delta_{cost\ comp\ g}$	IZCOCO (NG)	25B-7
$\delta_{cost\ comp\ reac}$	IRCOCO	24-7
$\delta_{cost\ meth\ g}$	IZCOME (NG)	25B-8
$\delta_{disch\ g}$	IZDIS (NG)	25B-2
$\delta_{disch\ reac}$	IREDIS	24-2
δ_{dump}	IDUMP	26-8

<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
δ end inv g	IZEI (NG)	25B-5
δ end inv reac	IREEI	24-5
δ group gr	IPRGP	25A-3
δ ' gp	IGP	45-8
δ interp switch	INTSW	1-23
δ interp wt	INTWT	1-24
δ load g	IZLOD (NG)	25B-3
δ load reac	IRELOD	24-3
δ mid inv g	IZMI (NG)	25B-4
δ mid inv reac	IREMI	24-4
δ mix rec, J	NSV5(JZ,5)	14-5
δ out g	IZOUT (NG)	25B-1
δ out reac	IREOUT	24-1
δ overlay E	INOVE	1-29
δ pois	INFOIS	1-27
δ prep restart	INPREP	1-32 (26-7)
δ rec inv	IRECYC	26-3

<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
δ_{restart}	INRESI	1-31
$\delta_{\text{stor inv}}$	ISTORE	26-4
$\delta_{\text{store inv cost}}$	ISTOIC	26-5
$\delta_{\text{stor only}}$	ISTON	45-10
$\delta_{\text{th norm}}$	INORM	1-28
δ_{thor}	INTHOR	45-6
$\delta_{\text{tot U rec}_1, J}$	MTU (1)	31-7
$\delta_{\text{tot U rec}_2, J}$	MTU (2)	31-8
δ_{ur}	INUR	45-5
ΔB_{test}	DBTEST	2-10 (44-25)
$\Delta_f^{(1)}$	DELSF (LR)	43-7
ΔK_-	DELKM	2-3 (44-16)
$\Delta K^{(e)}$	DELKE	2-2
ΔK_{adj}	DELKAJ	44-19
$\Delta K_{\text{adj}}^{(1-1)}$	DKAJMI	44-20
$\Delta K_{\text{adj}}^{(1-2)}$	DKAJM2	44-21
$(\Delta K)_{\text{burnup}}$	DELKBU	44-17 (51C-2)

<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>BLOCK STATEMENT NUMBER</u>
$(\Delta K)_{\text{control}}^{\text{burn}}$	DKBCON	2-11 (44-18)
ΔR	DELR	44-32
ΔT	DELTA	2-5 (44-2)
λ_{233}	D233	44-34
λ_{241}	D241	44-33
$\epsilon_P^{(1)}$	EPOW1	2-12
$\epsilon_P^{(2)}$	EPOW2	2-13
$\sigma_{m,j}^c$	SIGC (MT, JR)	34-4
$\sigma_{m,j}^{(a)}$	SIGCA (MT, JR)	39-7
$\sigma_{m,j}^{(b)}$	SIGCB (MT, JR)	39-8
$\sigma_{m,j}^f$	SIGF (MT, JR)	34-3
$\sigma_{m,j}^{(a)}$	SIGFA (MT, JR)	39-5
$\sigma_{m,j}^{(b)}$	SIGFB (MT, JR)	39-6
$\sigma_{m,j}^r$	SIGR (MT, JR)	42-1
ϕ_j	PHI (JR)	34-5
$\phi_j^{(a)}$	PHIA (JR)	39-9
$\phi_j^{(b)}$	PHIB (JR)	39-10

5.2 Working Data Blocks

The code user must provide the input data included in Data Blocks 1 through 27 below, consistent with the requirements of his problem and the limits and conditions discussed in the descriptions below. In general, the data in the aforementioned blocks are all that will be required in the category of "hand-prepared" input data. Data in Blocks 28, 29, 30A and 30B are generally working data (not input), but may be supplied as optional input or may be required as "hand-prepared" input data if a certain option (as indicated below) is selected for the initial core. Data in Blocks 30C, 33, 35, 36, 37, 38 and 41 must be provided as input only for a restart case; and computer output from an earlier run provides this restart case input in the required format on cards or tape. Data in Block 39 are required input data obtained from two multigroup diffusion cases run; however, to avoid a requirement for extensive "hand-prepared" input for each problem, an interface code is being developed that will process output from the 2-dimensional multigroup diffusion synthesis code, BISYN⁽³⁾, into the format required as input data for Block 39. Data in Blocks 31, 32, 35 and 42 through 45 below are just working data (not input) for all cases run.

DATA BLOCKS - Glossary of Physics and Fortran symbols (see alphabetical index to Physics and Fortran symbols at beginning of Section V.

DATA BLOCK 1 - General Fixed Point Constants (Input Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
1-1	$j_{\max}$	JRMX	Maximum number of regions. See Figure 2 for description of "region".
1-2	$J_{\max}$	JZMX	Maximum number of zones. See Figure 2 for description of "zone".
1-3	I_{init}	INIT	Identification number of first operating interval. (Does not have to be 1.)
1-4	$I_{\max}$	IOPMX	Maximum operating interval number. (An operating interval is the period from one refueling shutdown to another.)
1-5	$i_{\max}$	ITERMX	Maximum number of iterations permitted within any one operating interval to satisfy criteria on reactivity and burnup. Run will stop if $i_{\max}$ is exceeded.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
1-6	$M_{\text{max}}^{\text{fuel}}$	JRMX	Maximum number of fuel isotopes in burnup chains. Must be one of the following: 5 if only the U^{238} -Pu chain is used. 6 if only the Th^{232} -U chain is used. 7 if the U^{238} -Pu chain plus U-235 and U-236 is used. 11 if the complete U^{238} -Pu plus Th^{232} -U chains are used. Five isotopes are used in the U^{238} -Pu chain (Np-239 is bypassed) and six in the Th^{232} -U chain (Pa-233 is included.)*
1-7	$N_{\text{fp}}^{\text{max}}$	NFPMX	Maximum number of fission product aggregates. <u>Must be either 1 or 2; and can only be 1 if</u> <u>$M_{\text{max}}^{\text{fuel}} = 5$ or 6.</u>
1-8	M_{max}	MTMX	Maximum number of materials. <u>Must be</u> <u>$M_{\text{max}}^{\text{fuel}} + N_{\text{fp}}^{\text{max}}$ with no burnable poison, or</u> <u>$M_{\text{max}}^{\text{fuel}} + N_{\text{fp}}^{\text{max}} + 1$ with a burnable poison.</u> <u>$(M_{\text{max}} \leq 14)$</u>

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- * Material numbers for the U^{238} -Pu chain (if $M_{\text{max}}^{\text{fuel}} = 5$) are as follows:
1 U-238, 2 Pu-239, 3 Pu-240, 4 Pu-241, 5 Pu-242. Material numbers for U-235 and U-236 (if $M_{\text{max}}^{\text{fuel}} = 7$) are respectively $M_{\text{max}}^{\text{fuel}} - 1$ and $M_{\text{max}}^{\text{fuel}}$.
Material numbers for Th-232, Pa-233, U-233, and U-234 are 1, 2, 3, and 4, respectively for $M_{\text{max}}^{\text{fuel}} = 6$; 6, 7, 8 and 9 for $M_{\text{max}}^{\text{fuel}} = 11$.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
1-9	$k_{\max}$	KTMX	Maximum number of k-data arrays (see Data Block 4 below). If the k-data are to be held fixed for all operating intervals, $k_{\max}$ must be zero. ($k_{\max} < 15$).
1-10	I_{print}	IPRINT	<p>0 - if output data is to be printed out for all operating intervals.</p> <p>1 - If output data is to be printed out only for the operating intervals defined by I_s (see Data Block 27).</p> <p>2 - If output data is to be printed out only for the last operating interval.</p>
1-11	I_{punch}	IPUNCH	<p>0 - Punched cards are not requested.</p> <p>1 - Atom densities (BATCH AVERAGE) at mid-cycle of the last operating interval are punched out in the BISYN Format.</p> <p>2 - Atom densities (BATCH AVERAGE) at mid-cycle, beginning of interval and end of interval for the last operating interval are punched out in the BISYN Format.</p>
1-12	N_{int}	NINT	<p>0 - The interpolation routine is not used.</p> <p>1 - Interpolation is carried out from one operating interval to the next (including discontinuous jumps).</p> <p>2 - Interpolation is carried out between the beginning of an operating interval and end of the operating interval.</p>

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
1-13	$N_{\max}^{\text{bat}}$	NBHI	The maximum number of batches used in any zone.
1-14	j_{pk}	JRPK	Peak power region selected for power peaking test.
1-15	$I_{\max}^{\text{stor}}$	ISTOMX	Maximum number of operating intervals that any discharged fuel will be held in storage (out-of-pile) before being loaded into the reactor again.
1-16	$N_{\max}^{\text{stor}}$	NSTOMX	Maximum number of stored fuel repositories (see Figure 3). If all discharged fuel (for all operating intervals) will be sent to reprocessing, then $N_{\max}^{\text{stor}}$ must be zero.* However, $N_{\max}^{\text{stor}}$ must be greater than zero if discharged fuel is to be "shuffled" from one zone to another.
1-17	$N_{\max}^{\text{Pu}}$	NPUMX	Maximum identification number of a plutonium recycle repository (see Figure 3). The difference between $N_{\max}^{\text{Pu}}$ and $N_{\max}^{\text{stor}}$ is the number of Pu recycle repositories used.
1-18	$N_{\max}^{\text{fis U}}$	NFUMX	Maximum identification number of a uranium recycle repository which does not include U-238. (see Figure 3). Number of such repositories is $N_{\max}^{\text{fis U}} - N_{\max}^{\text{Pu}}$.

*Keep $I_{\max}^{\text{stor}}$ and $N_{\max}^{\text{stor}}$ as small as they can be to meet the requirements of the problem because computation cost in some cases will be very sensitive to the size of these input data quantities.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
1-19	$N_{\max}^{\text{tot U}}$	NTUMX	Maximum identification number of a uranium recycle repository which includes U-238 (see Figure 3). Number of such repositories is $N_{\max}^{\text{tot U}} - N_{\max}^{\text{fis U}}$.
1-20	$N_{\max}$	NSMX	Maximum identification number of a source of fissile or fertile make-up (see Figure 3).
1-21	$L_{\max}$	LINTMX	Number of materials (isotopes) to be used for calculation of the interpolation factor (or index) and end points on the data provided by the multigroup diffusion theory cases - see statements (3-130), (2-21), and (2-22). ($L_{\max} < 14$).
1-22	I_{switch}	INTSWI	I_{switch} denotes the operating interval number at which the interpolation factor makes a discontinuous jump from one end point to another (A^{int} to B^{int}), corresponding to the data provided by the two multigroup diffusion theory cases.
1-23	$\delta_{\text{interp switch}}$	INTSW	<p>0 If the interpolation factor is to be calculated by eqn (3-130) and then adjusted to be held within the bounds set by input quantities $F_a^{\text{out}}, F_a^{\text{in}}, F_b^{\text{in}}$ (see below) as per statements (3-131) through (3-137).</p> <p>1 If the interpolation factor is to make a discontinuous jump from A^{int} to B^{int} at the beginning of operating interval I_{switch}.</p>

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
1-24	δ_{wt}^{interp}	INTWT	<p>0 if v_j^*, $v_j^{(a)*}$, and $v_j^{(b)*}$ are 1 in equations (3-130), (2-24), (2-22), and (2-74).</p> <p>1 if v_j^*, $v_j^{(a)*}$, and $v_j^{(b)*}$ are equal to v_j.</p> <p>2 if v_j^*, $v_j^{(a)*}$, and $v_j^{(b)*}$ are equal to $v_j \phi_j$.</p>
1-25	δ_{meth}^{cost}	ICOME	<p>0 if no fuel cost calculations are desired.</p> <p>1 if fuel cost calculations are to be based on accrued cost components and total energy produced in individual fuel batches upon their discharge and reprocessing (discharged fuel basis).</p> <p>2 if fuel cost calculations are to be based on total fuel cost over a single operating interval, such that fabrication cost is for fuel batches loaded at the beginning of the interval, reprocessing cost for batches discharged at the end of the interval, etc. (operating interval basis).</p> <p>3 if fuel cost calculations are to be done by both methods (i.e., discharged fuel and operating interval bases).</p>
1-26	δ_{unit}^{cost}	ICOUN	<p>0 if unit of fuel cost is $\text{¢}/10^6 \text{ Btu}$</p> <p>1 if unit of fuel cost is mill/kwh^*</p>

* Should be requested only if $\delta_{meth}^{cost} = 2$ or if plant heat rate (thermal efficiency) is held the same for all operating intervals.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
1-27	δ_{pois}	INPOIS	0 if burnable poison material is not included (see No. 8 above). 1 if burnable poison material is included.
1-28	$\delta_{\text{norm}}^{\text{th}}$	INORM	0 if fluxes are to be normalized to the desired rated power level (see statements 3-1, 3-2, and 3-40 through 3-50). 1 if fluxes are not to be so normalized.
1-29	$\delta_E^{\text{overlay}}$	INOVE	0 if isotopic fission energies (MeV/fission) of statement (2-4) are to be used. 1 if new isotopic fission energies are to be supplied as input data (see Data Block 28).
1-30	$\delta_1^{(a)}$	INCORI	0 if estimated isotopic concentrations at beginning of first operating interval are to be supplied as independent input or as restart data from an earlier run. * 1 if estimated isotopic concentrations at beginning of first operating interval are the same as those used in multigroup diffusion theory case A. 2 if estimated isotopic concentrations at beginning of first operating interval are to be calculated from end-of-interval concentra- tions identical with those used in multi- group diffusion theory case A.

*The restart option is not available in Version I of FUMBLE.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
1-30	$\delta_1^{(a)}$	INCORI	3 If estimated isotopic concentrations at beginning of first equilibrium operating interval are to be calculated from beginning-of-interval concentrations identical with those used in multigroup diffusion case A.
(Continued)			
			4 If estimated isotopic concentrations at beginning of first equilibrium operating interval are to be calculated from mid-cycle concentrations identical with those used in multigroup diffusion case A.
			5 If estimated isotopic concentrations at beginning of first equilibrium operating interval are to be calculated from the end of interval concentrations identical with those used in multigroup diffusion case A.
1-31	δ_{restart}	INRESI	Used only if $\delta_1^{(a)} = 0$: 0 If first-core isotopic concentrations are supplied as independent input (see Data Block 29). 1 If a restart case with isotopic concentration and other data supplied as output from an earlier run.
1-32	$\delta_{\text{restart}}^{\text{prep}}$	INPREP	0 Means do not output restart data for a later run. * 1 Means prepare required restart data for a later run (see Data Blocks 29 through 39) as part of the output routine at the end of operating interval I_{max} . * 2 Means do same as 1 but, in addition, accommodate a change in the reactor zone and region layout and/or set number of stored fuel repositories equal to zero. The change in reactor zone and region layout must correspond to a reduction in zones and/or regions (i.e., two or more zones of the present case may be combined into one zone of the restart case; but the reverse cannot be done -- and ditto for regions). See additional data required (Nos. 3-10 through 3-17 below) if $\delta_{\text{restart}}^{\text{prep}} = 2$. *

*The restart option is not available in Version I of FUMBLE.

DATA BLOCK 2 - General Floating Point Constants (Input Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
2-1	$K^{(e)}$	ENDK	Multiplication factor, k_{eff} , desired at end of each operating interval. (Generally 1.0, but may be different from 1.0 to allow for reactivity effects not accounted for the in multigroup diffusion theory cases.)
2-2	$\Delta K^{(e)}$	DELKE	Excess reactivity permitted on the high side of $K^{(e)}$ to satisfy convergence criterion on reactivity (see statement 3-53).
2-3	ΔK^{-}	DELM	Reduced reactivity, K^{-} , permitted on the low side of $K^{(e)}$ to satisfy convergence criterion on reactivity (note that ΔK^{-} can be different from $\Delta K^{(e)}$. The latter involves only a consideration of computational convergence, whereas ΔK^{-} can express a willingness to shut down for refueling before running out of reactivity in addition to providing an allowance for computational convergence. ΔK^{-} must not be smaller than $\Delta K^{(e)}$).
2-4	T	TDA	Operating interval times T in days (including all shutdown and low power operating time associated with the interval).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
2-5	ΔT	DELTDA	Departure permitted from specified time T to satisfy the fuel burnup criterion is $\pm \Delta T$ in days.
2-6	f	FLOD	Load factor, f, converts total operating interval time to equivalent full power operating time.
2-7	P^{th}	PTH	Reactor rated power in thermal megawatts (or actually power of portion of reactor covered by the problem mesh if it is less than the complete reactor).
2-8	P_{test}^{pk}	PKTEST	Power peaking factor P_{test}^{pk} is used for the test on the power peaking criterion (see statements 3-82 and 3-83).
2-9	B_{test}	BTEST	Desired average burnup B_{test} (in thermal megawatt days per metric tonne of loaded U+Pu+Th atoms) for fuel discharged at end of operating interval from reactor zones designated in Data Block 3. Burnup B_{test} is used for the test on the burnup criterion (see statement 3-62).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
2-10	ΔB_{test}	DBTEST	Departure permitted from desired burnup, B_{test} , is $\pm \Delta B_{\text{test}}$ (see no. 2-9 above). * If $B_{\text{test}} > 0$, then $\Delta B_{\text{test}} > 0$ must also be satisfied.
2-11	$(\Delta K)_{\text{control}}^{\text{burn}}$	DKBCON	Maximum permitted reactivity change due to fuel (and burnable poison) burnup during an operating interval is $(\Delta K)_{\text{control}}^{\text{burn}}$ -- see statements (3-84) and (3-54).
2-12	$\epsilon_p^{(1)}$	EPOWI	Fraction used to test whether or not satisfactory power is reached after only the first flux normalization -- see statement (3-43). If $\epsilon_p^{(1)}$ is left zero in the input Data, the code sets $\epsilon_p^{(1)} = .001$.
2-13	$\epsilon_p^{(2)}$	EPOW2	Fraction used to test whether or not satisfactory power is reached after the second flux normalization -- see statement 3-51. If $\epsilon_p^{(2)}$ is left zero in the input data, the code sets $\epsilon_p^{(2)} = .01$.

* User must exercise caution if he wants a test on burnup criterion. Allowances for time adjustment, ΔT , and for burnup acceptability, ΔB_{test} , must be large enough that it is reasonably assured that they are compatible; otherwise, the problem will be terminated. If user desires the operating interval schedule to be strictly time-controlled, then he should either omit the burnup test by setting $B_{\text{test}} = 0$ or else make ΔB_{test} large enough to accommodate any reasonable uncertainty in the burnup.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
2-14	F_a^{out}	FAOUT	<p>See statements (3-130) through (3-137) on calculation of the interpolation factor, R^{int}, and the limitation of its value to the region within or near that bounded by the interpolation end points, A^{int} and B^{int}.</p> <p>See statements 2-21 and 2-22 for calculation of A^{int} and B^{int}.) Note, for example, that the combination $F_a^{out} = 0$, $F_b^{out} = 0$, $F_a^{in} = 0.5$, $F_b^{in} = 0.5$ may be selected to force R^{int} to be set equal to either A^{int} or B^{int}, whichever is closer to the R^{int} value initially calculated as per statement (3-130) -- if such a discontinuous change in the interpolation factor is desired.</p>
2-15	F_a^{in}	FAIN	
2-16	F_b^{out}	FBOUT	
2-17	F_b^{in}	FBIN	
2-18	$A_{M_{max}}^{wt}$	AWPOIS	<p>Atomic weight of burnable poison material (input only if $\delta_{pois} = 1$). Used to calculate weight (in Kg) of burnable poison material discharged, loaded, etc. If this data is unimportant, $A_{M_{max}}^{wt}$ can be set to zero and the code will arbitrarily use 1 for the atomic weight.</p>

DATA BLOCK 3 - Fixed-point Single-Array Quantities Designating Operation Intervals at which Data Changes Occur, Assignments on Regions to Zones, Materials and Zones Used for Calculation of Interpolation Factors, Zones Used for Burnup and Power Peaking Tests, and Number of Fuel Batches in Each Zone (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
3-1	I_k	IOPT(KT)	First operating interval in the k^{th} group of intervals covered by the k^{th} set of data in Data Block 4. ($I \leq k < k_{\text{max}}$; omit if $k_{\text{max}} = 0$).
3-2	j_J	JRZ(JZ)	Highest region number in zone J. Regions within a given zone are numbered consecutively -- see Figure 2 in Section 1.3.
3-3	JB_J	JZB(JZ)	0 If zone J_z is not used in the burnup test (see statement 2-9) 1 If zone J_z is to be used in the burnup test (see statement 2-9).
3-4	JP_J	JZP(JZ)	0 If zone J_z is not used in test of power peaking factor or the test of average rated power. 1 If zone J_z is to be used in test of average rated power. 2 If zone J_z is to be used both to test the average rated power and to test the power peaking factor.
3-5	JL_J	JZL(JZ)	0 If zone J_z is not used in the interpolation routine.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
3-5 (CONT)	JL_J	JZL(JZ)	1 If zone J_z is to be used in the interpolation routine (see statement 1-23).
3-6	M_L	MTL(LINT)	Materials M_L ($1 < L < L_{\max}$) are used for calculation of interpolation factor R^{int} and interpolation factor end points A^{int} and B^{int} -- see statements (3-130), (2-21), and (2-22).
3-7	N_J^{bat}	NBMX(JZ)	Number of fuel batches in zone J_z ($1 < J_z < J_{\max}$)*.

* N_J^{bat} values should be held as small as possible, over-and-above the specified limits, to hold down computation time. However, these values must be large enough to accommodate the smallest quantity of fuel to be loaded or discharged at any refueling associated with the operating interval through $I_{\max}$. Note that refueling instructions -- see Data Block 7 -- allow any specified integral number of these "smallest" batches to be replaced during anyone refueling. Also, it is not necessary to replace fuel in each zone at every refueling; so N_J^{bat} does not have to be made large in order to obtain a long in-pile exposure time for some zone such as an outer radial blanket.

DATA BLOCK 4 - Restart Data Which is used to Adjust the Number of Stored Fuel
Repositories, Reactor Zones and Reactor Regions.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
4-1	$N'_{\max}$	NSTOMP	Number of stored fuel repositories in new restart case.* (If $N'_{\max}$ is greater than 0, stored fuel repositories 1 through $N'_{\max}$ will not be changed.)
4-2	$J'_{\max}$	JZMXP	Number of zones in new restart case.**
4-3	$j'_{\max}$	JRMXP	Number of regions in new restart case.**
4-4	$Jc_{J'}$	JZC(JZP)	Listing of largest zone number in present case to be combined to form Zone J' of restart case ($1 < J' < J'_{\max}$) not required if $J'_{\max} = J_{\max}$
4-5	$jc_{j'}$	JRC(JZP)	Listing of largest region in Zone J' to be used in preparing a restart case not required if $j'_{\max} = j_{\max}$

* The restart option is not available in Version I of FUMBLE.

** Required as input data only if $\sigma_{\text{restart}}^{\text{prep}} = 2$ (see No. 1-32 above).

DATA BLOCK 6 - Coefficients for Calculation of Interpolation Factor (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
6-1	G_o	GZER	G_o is a constant and G_L values ($1 < L < L_{max}$) are materials coefficients used in the
6-2	H_o	HZER	numerator of the expression that calculates R^{int} , A^{int} , and B^{int} -- see statements (3-130),
6-3	G_L	GM(LINT)	(2-21), and (2-22). H_o and H_L ($1 < L < L_{max}$) are corresponding constants and material
6-4	H_L	HM(LINT)	coefficients used in the denominator. (See also nos. 1-21, 1-22, 1-23, 1-24, 1-25, 2-14, 2-15, 2-16, 2-17, 3-6, 3-7, and 3-8 above for other input data pertinent to the diffusion theory interpolation routine.)

DATA BLOCK 7 - Number of Fuel Batches Replaced in Each Zone at Each Refueling
(Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
7-1	I_J^{nu}	INU(JZ)	For those operating intervals, I , that satisfy the condition $I > I_J^{nu}$, the refueling for zone J ($1 < J < J_{max}$) becomes a uniform process in which a constant number of fuel batches, $N_c^{(J)}$, are replaced for all operating intervals through I_{max} . For $I < I_J^{nu}$, the number of fuel batches replaced in zone J at each refueling varies from one operating interval to another in accordance with input data nos. 7-3 and 7-4 below. If $I_J^{nu} < I_{init}$, as one extreme, then the uniform refueling for zone J applies for all operating intervals. If, on the other extreme, $I_J^{nu} > I_{max}$, then zone J does not attain a uniform refueling pattern for the entire problem.
7-2	$N_c^{(J)}$	NCOBAT(JZ)	See description of no. 7-1 above. $(1 < N_c^{(J)} < N_J^{bat}, \text{ for } 1 < J < J_{max})$.
7-3	I_J^{cy}	ICY(JZ)	I_J^{cy} is the number of elements $N_{n'}^{(J)}$ ($1 < n' < I_J^{cy}; 1 < J < J_{max}$) used to specify the number of batches replaced in zone J at

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
7-3 (CONT)	I_J^{cy}	ICY(JZ)	the end of each operating interval I which satisfied the condition $I < I_J^{nu}$ (see no. 7-4 below and 7-1 above).
7-4	$N_{n'}^{(J)}$	NUB (JZ, NPRI)	See statements (3-86), (3-87); and (3-88). $N_{n'}^{(J)}$ ($1 < n' < I_J^{cy}$; $1 < J < J_{max}$) is the number of fuel batches replaced in zone J at the end of operating interval I (if $I < I_J^{nu}$), where n' is related to I in accordance with statement (3-87).*

* For example, the combination $I_J^{nu} = I_{max} + 1$, $I_J^{cy} = 2$, $N_1^{(J)} = 2$ specifies a refueling sequence for zone J in which 2 fuel batches are replaced at the end of every second operating interval -- and no fuel is replaced at the end of intervals I_{init} , $I_{init} + 2$, $I_{init} + 4$, etc. -- this sequence continuing for the duration of the problem. Such a refueling sequence might be desirable for an outer radial blanket -- see footnote accompanying no. 3-9. Variations in the input quantities 7-1 through 7-4 allow almost any refueling sequence.

DATA BLOCK 8 - Isotopic Compositions of Fissile and Other (Mainly Fertile)
Makeup Sources (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
8-1	$q_{\max}^{(N)}$	MQMX(NS)	Maximum number of materials (isotopes) in makeup source N ($1 + N_{\max}^{\text{tot U}} < N < N_{\max}$). [*] ($q_{\max}^{(N)} < 10$).
8-2	$M_{S \ N}$	MTS (NS,MP)	Listing of material numbers ($1 < q < q_{\max}^{(N)}$; $1 + N_{\max}^{\text{tot U}} < N < N_{\max}$) corresponding to isotopes (in order of increasing q) in each source N. See no. 1-6 and accompanying footnote for material numbers. [*]
8-3	$W_{S \ N}$	WS (NS,MQ)	Relative isotopic weights of the different isotopes, q ($1 < q < q_{\max}^{(N)}$) in each source N ($1 + N_{\max}^{\text{tot U}} < N < N_{\max}$).

* If, for example, source N is plutonium discharged from a water reactor of isotopic composition (hypothetical) 60% Pu-239, 30% Pu-240, 8% Pu-241, and 2% Pu-242, then $q^{(N)} = 4$; $M_{1,N} = 2$; $M_{2,N} = 3$; $M_{3,N} = 4$; $M_{4,N} = 5$; and $W_{1,N}$, $W_{2,N}$, and $W_{4,N}$ are any four floating joint numbers that have the ratio 60:30:8:2.

DATA BLOCK 9 - Fuel Discharge Instruction Parameters Description

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
9-1	d_{stor}	JDSTO	Maximum number of zones discharging their fuel to stored fuel repositories (including fuel "shuffling") at the end of the operating interval.
9-2	N_d^{stor}	NSDS(JZ)	<p>Fuel storage repository or recycle repository designated as the principal receptacle (the only receptacle for stored fuel) for fuel discharged from zone J_z. N_d^{stor} must be different for different discharge zones and must be designated even if the fuel is simply being "shuffled" from zone J_z to another zone. Recycle repositories receiving discharged fuel must be designated as follows:</p> <ol style="list-style-type: none"> 1) $N_{max}^{stor} < N_d^{stor} < N_{max}^{Pu}$ receiving only plutonium 2) $N_{max}^{Pu} < N_d^{stor} < N_{max}^{Fu}$ receiving uranium except U-238 3) $N_{max}^{Fu} < N_d^{stor} < N_{max}^{Tu}$ receiving uranium including U-238
9-3	$N_d^{stor 2}$	NSDS2(JZ)	<p>Fuel recycle repository used as a secondary receptacle for fuel discharged from zone J_z. N_d^{stor} and $N_d^{stor 2}$ are used together for zones containing both plutonium and uranium and permits a separate accounting of plutonium and uranium inventory. For example, plutonium</p>

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
9-3 (CONT)	$N_d^{stor 2}$	NSDS2(JZ)	can be sent to repository N1, $N_{max}^{stor} < N1 = N_d^{stor} < N_{max}^{Pu}$ and uranium can be sent to repository N2, $N_{max}^{Pu} < N2 = N_d^{stor 2} < N_{max}^{Tu}$.
9-4	$F_{mult}^{(N)}$	FRMULT(NS)	A multiplier on the amount of recycle material designated for recycle repository $N(N_{max}^{stor} + 1 < N < N_{max}^{tot U})$ that is made available for recycle to the same reactor -- see statements (3-115) and (3-116). If $F_{mult}^{(N)}$ is less than unity, it indicates that other reactors are getting a higher priority on use of the available recycle material. If $F_{mult}^{(N)}$ is greater than unity, it indicates that this reactor is getting a higher than average priority for use of the available recycle material. (For most runs, it is expected that $F_{mult}^{(N)}$ will be set equal to unity. <u>$F_{mult}^{(N)}$ must be greater than zero, although it can be made arbitrarily small.</u>)

DATA BLOCK 10 - FIXED RELOAD SOURCE

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
10-1	JA_J	JAZ(JZ)	Identification index for source to be used in determining isotopic composition of fixed zone fuel (i.e., blanket zones) $1 \leq JA_J \leq N_{\max}$ Equal to zero for variable enriched zones.

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DATA BLOCK 11 - NOT USED AT PRESENT TIME

DATA BLOCK 12 - Listing of Zones Loaded with Fuel From Storage Repositories
and of Variable Fissile "Enrichment" Zones Utilizing Recycle
and/or Makeup Material (Input Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
12-1	$v_{\max}$	JVMX	Maximum number of zones loaded at beginning of operating interval with fuel from stored fuel repositories or of variable "enrichment" zones containing fresh fuel with recycle and/or makeup material as required to satisfy reactivity needs and a specified power distribution.
12-2	v_{stor}	JVSTO	Maximum number of zones loaded at beginning of operating interval with fuel taken from stored fuel repositories (including fuel "shuffled" directly from other zones). Note restriction imposed on any such zone in footnote accompanying no. 3-4. ($v_{\text{stor}} < v_{\max}$; see also 12-1 above).
12-3	v_o^{in}	JZERO	J_v^{in} is the first listed variable "enrichment" zone; i.e., the lowest v number in the listing of such zones.*
12-4	JV_J	JZV(JZ)	Listing of zones ($1 < v < v_{\max}$) in order of execution of loading instructions, (ie. 1, 2, 3, 4, 5, 6 etc.)

* In the present version of the code, zones receiving fuel from stored fuel repositories cannot receive additional fresh fuel at the beginning of the same operating interval. Only those zone J_v , which satisfy $v_o^{\text{in}} < v < v_{\max}$ can have a variable isotopic content. The latter is determined by the availability of recycle material, the selection of makeup material, and reactivity requirements.

DATA BLOCK 13 - Listing of Stored Fuel Repositories and Hold-Up Times forStored Fuel Loaded Into Reactor Zones (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
13-1	N_v^{stor}	NSVS(JZ)	<p>Stored fuel repository, $N=N_v^{\text{stor}}$, designated to supply fuel to zone J_v ($1 < v < v_{\text{stor}}$) at the beginning of an operating interval. Such a repository ($1 < N_v^{\text{stor}} < N_{\text{max}}^{\text{stor}}$)* must be designated even if fuel is simply being "shuffled" from another zone to zone J_v. N_v^{stor} must be different for the different v values (i.e., a given fuel storage repository can supply fuel to only one zone in any one refueling shutdown).</p>
13-2	I_v^{stor}	IHVS(JZ)	<p>Hold-up time for fuel supplied to zone J_v ($1 < v < v_{\text{stor}}$) from stored fuel repository N_v^{stor} is I_v^{stor} operating intervals. That is, the fuel being transferred from repository N_v^{stor} to zone J_v was discharged from the reactor and placed into storage at the beginning of operating interval $I-I_v^{\text{stor}}$. ($I_v^{\text{stor}} < I_{\text{max}}^{\text{stor}}$ -- see no, 1-15). If $I_v^{\text{stor}} = 0$, fuel is simply being "shuffled" into zone J_v from some other zone J_d identified in Data Block 9 by the condition that $N_d^{\text{stor}} = N_v^{\text{stor}}$.</p>

* See footnote accompanying no. 12-4 for required listing of N_v^{stor} repositories supplying fuel to a "composite" zone group.

DATA BLOCK 14 - Listing of Recycle Fuel Repositories and Recycle Hold-Up
Times and of Fissile and Other Makeup Sources for Loading
Fuel into Zones of Variable Fissile Content (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
14-1	N_V^{recl}	NSVS(JZ)	Preferred repository source of recycled material for zone J_V ($v_o^{\text{in}} < v < v_{\text{max}}$). Must be in range $N_{\text{max}}^{\text{stor}} + 1 < N_V^{\text{recl}} < N_{\text{max}}^{\text{tot U}}$. If $N_V^{\text{recl}} = 0$, recycle material will not be made available to zone J_V . (See Data Block 13 for J_V zone listing.)
14-2	N_V^{rec2}	NSV2(JZ)	Backup repository source of recycled material for zone J_V ($v_o^{\text{in}} < n < v_{\text{max}}$). [*] To be used if the preferred recycle source, N_V^{recl} , lacks adequate recycle material to satisfy the reactivity requirements (see variation from this in no. 14-5 below). Range restricted same as 14-1 above. If $N_V^{\text{recl}} = 0$, then N_V^{rec2} must also be zero; however, N_V^{rec2} may be zero (no backup repository source specified) even if $N_V^{\text{recl}} \neq 0$.

* Limitations on input data for recycle and makeup instructions are much less restrictive than for loading with fuel taken from stored fuel storage repositories. For example, N_V^{recl} can be the same for different zones J_V (ditto for N_V^{rec2} , N_V^{mkp} , and N_V^{oth}), whereas N_V^{stor} (see no. 13-1) has to be different for the different zones receiving fuel from storage repositories. The restriction of one region per zone that applies to zones transferring fuel to and from storage repositories does not apply in the recycle case (unless the recycle zone will transfer fuel to and from storage at some later operating interval in the problem run). The difference in limitations imposed arises from the fact that a recycle repository is just a record of the amount of recycle material of a given origin that is available, whereas a storage repository (or group of such repositories) contains actual fuel assemblies whose detailed physical relationships (e.g., alignment of core and axial blanket regions) must be maintained as the fuel assemblies are transferred from one location to another.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
14-3	N_V^{mkp}	NSV3(JZ)	<p>Fissile makeup source for zone J_V</p> <p>$(v_O^{in} < v < v_{max})$. * To be used if both preferred and backup repository recycle sources lack adequate recycle material to satisfy the reactivity requirements -- or if $N_V^{recl} = 0$. Must be in range $N_{max}^{tot U} + 1 < N_V^{mkp} < N_{max}$. N_V^{mkp} cannot be zero (i.e., a fissile makeup source must be specified.)</p>
14-4	N_V^{oth}	NSV4(JZ)	<p>Other makeup source (the main source of fertile material) for zone J_V $(v_O^{in} < v < v_{max})$. *</p> <p>Used to maintain the specified total fuel atom concentration -- see Data Block 16 as adjustments are made in the recycle and fissile makeup contents to satisfy reactivity requirements. Restricted to same range as N_V^{mkp} (see no. 14-3 above). N_V^{oth} cannot be zero.</p>

*See footnote at the bottom of previous page.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
14-5	$(\delta_{\text{rec}}^{\text{max}})_v$	NSV5(JZ)	<p>0 means N_v^{rec2} is a backup recycle source repository for zone J_v ($v_o^{\text{in}} < v < v_{\text{max}}$) as described in no. 14-2 above.</p> <p>1 means N_v^{rec1} and N_v^{rec2} are equally preferred and recycle material for zone J_v ($v_o^{\text{in}} < v < v_{\text{max}}$) is to be a mixture of materials in these two recycle repositories, with the mix ratio proportional to the weights of recycle material available in the two repositories.</p>
14-6	I_v^{rec1}	IHVS(JZ)	<p>Hold-up time in number of operating intervals for recycle material in repository N_v^{rec1} to be used in fuel loaded into zone J_v. I_v^{rec1} must be one of the following:</p> <p>0 (permitted only for Pu recycle -- $N_{\text{max}}^{\text{stor}} + 1 < N < N_{\text{max}}^{\text{Pu}}$ -- and not for U recycle due to Pa-233 decay problem). In any event, $I_v^{\text{rec1}} = 0$, representing a zero hold-up time for availability of recycle material, is not a realistic situation.</p> <p>1 means use only the recycle material that was discharged at the beginning of the operating interval which just preceeded the current one (i.e., a hold-up time of one operating interval).</p> <p>2 means use only the recycle material that has been out of the reactor for two operating intervals.</p>

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
14-6 (Contd)	I_v^{rec1}	IHVS(JZ)	3 means use all recycle material available in repository N_v^{rec1} that has been out of the reactor for <u>at least</u> $I_h^{(N_v^{\text{rec1}}, 3)}$ operating intervals. (see no. 15-1 below for listing of $I_h^{(N,3)}$ values.)
14-7	I_v^{rec2}	IHV2(JZ)	See no. 14-6 above. I_v^{rec2} has the same meaning in relationship to repository N_v^{rec2} as I_v^{rec1} to N_v^{rec1} .

DATA BLOCK 15 - Listing of Minimum Hold-up Times for Recycle Repositories(Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
15-1	$I_h^{(N,3)}$	IHN3(NS)	<p>See nos. 14-6 and 14-7 above. $I_h^{(N,3)}$ values ($N_{\max}^{\text{stor}} + 1 < N < N_{\max}^{\text{tot U}}$) are used only if I_v^{rec1} and/or I_v^{rec2} values are 3 for only v ($v_o^{\text{in}} < v < v_{\max}$). $I_h^{(N,3)}$ values are restricted as follows:</p> <p>$I_h^{(N,3)} = 0, 1, \text{ or } 2$ for $N_{\max}^{\text{stor}} + 1 < N < N_{\max}^{\text{Pu}}$ (Pu recycle repositories).</p> <p>$I_h^{(N,3)} = 1 \text{ or } 2$ for $N_{\max}^{\text{Pu}} + 1 < N < N_{\max}^{\text{tot U}}$ (U recycle repositories).</p>

DATA BLOCK 16 - Total Fuel Atom Concentrations for Zones of Variable Fissile
Content (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
16-1	N_J^{fuel}	CNF(JZ)	<p>Total fuel atom concentration (fissile plus fertile atoms per barn-cm) <u>per batch</u> of fresh fuel loaded into zone J_v ($v_o^{\text{in}} < v < v_{\text{max}}$) at beginning of operating intervals. This is proportional to the weight of fuel atoms in <u>one</u> batch loaded in zone J_v and inversely proportional to the <u>whole</u> volume of zone J_v. If $\delta_1^{(a)} > 0$ or if $\delta_{\text{restart}} = 0$, user may exercise the option of either supplying N_v^{fuel} values as input data, or he may set these values at zero in the Block 16 input data and the code will then calculate N_v^{fuel} values for Data Block 16 by summing over the initial fuel batch material concentrations that are either supplied directly as input data in Block 29 or are obtained from the atom concentrations of diffusion theory Case A. User may, in fact, exercise the mixed option of supplying N_v^{fuel} for some of the J_v zones ($v_o^{\text{in}} < v < v_{\text{max}}$); and setting the remainder at zero for code computation of these remaining N_v^{fuel} values. If $\delta_1^{(a)} = 0$ and $\delta_{\text{restart}} = 1$, N_v^{fuel} values must be supplied as input data.</p>

DATA BLOCK 17 - Burnable Poison Concentrations and Burnup Reactivity vs.Operating Time Parameter (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
17-1	A_T^{cont}	ATICON	<p>Factor used in first estimate of fuel burnup reactivity change for the next operating interval. (See statement 3-216. The long term in the numerator on the right hand side of the equation -- third term -- gives the first estimate of the next-interval burnup reactivity change.) If $A_T^{\text{cont}} = 0$, the estimated burnup reactivity is computed from that of the operating interval just completed assuming that burnup reactivity is directly proportional to the operating interval time. If $A_T^{\text{cont}} = 1$, the estimated burnup reactivity is set equal to that of the operating interval just completed. For A_T^{cont} between 0 and 1, the estimated burnup reactivity is assumed to be in part proportional to the operating interval time, depending on how close A_T^{cont} is to 1. Note that if $T = T_{I-1}$ (desired operating interval time the same as that of the interval just completed), the value of A_T^{cont} doesn't make any difference. ($0 < A_T^{\text{cont}} < 1$; and if the user is in doubt it is generally best to set</p> <p><u>$A_T^{\text{cont}} = 0.$</u>)</p>

DATA BLOCK 17 - Burnable Poison Concentrations and Burnup Reactivity vs.
Operating Time Parameter (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
17-2	$N_{M_{\max}}^{(o)}$	CNBPV(JZ)	<p>Concentration (atoms/barn-cm) of burnable poison material <u>per batch</u> loaded into zone J_v ($1 < v < v_{\max}$). If $\delta_1^{(a)} > 0$ or if $\delta_{\text{restart}} = 0$, user may exercise option similar to that for N_v^{fuel} (see no. 16-1 above) and either supply $N_{M_{\max}}^{(o)}$ values in the input to Block 17, or set any number of these values at zero in the Block 17 input and, hence, have the code compute such $N_{M_{\max}}^{(o)}$ values.</p>

DATA BLOCK 18 - Relative Power in Variable Fissile Zones (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
18-1	P_v	PFRA(JZ)	<p>Desired ratio of power in zone J_v to power in zone J_v in. If $\delta_1^{(a)} > 0$ or if $\delta_{\text{restart}} = 0$, user may exercise option of either listing P_v values in the Block 18 input data ($v_o^{\text{in}} < v < v_{\text{max}}$ -- and $P_{v_o}^{\text{in}}$ must then be set equal to 1), or he may set any of these values at zero in the Block 18 input data and the core will then calculate the missing P_v values using fission cross sections corresponding to diffusion theory Case A and initial isotopic concentrations also corresponding to Case A if $\delta_1^{(a)} > 0$ and supplied as separate input data to Block 29 if $\delta_1^{(a)} = 0$. (This option is similar to that described for no. 16-1 above.) If $\delta_1^{(a)} = 0$ and $\delta_{\text{restart}} = 1$, P_v values must be supplied as input data, with $P_{v_o}^{\text{in}}$ set equal to 1.</p>

DATA BLOCK 19 - Fabrication and Reprocessing Times and Fissile Losses and Thermal Efficiency (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
19-1	T_{repr}	REPRT	Average (or effective) reprocessing time (days), including cooling down, shipping, etc., for calculation of out-of-pile inventory and fuel cost.
19-2	T_{fab}	FABT	Average (or effective) fabrication time (days), including shipping, etc., for calculating out-of-pile inventory and fuel cost.
19-3	L_{repr}	REPRL	Fraction of fuel atoms lost in reprocessing.
19-4	L_{fab}	FABL	Fraction of fuel atoms lost in fabrication.
19-5	e^{th}	EFFIC	Thermal efficiency -- ratio of electrical to thermal power.

DATA BLOCK 20 - Interest Rates for Fuel and Fabrication Inventories and Discount
Rate for Calculation of Levelized Power Cost (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
20-1	P_{lev}^{int}	PLEV	Percent discount per annum on future fuel costs and future revenues from power generated. Used for computation of levelized power cost -- see statements (4-237 p) through (4-237 s) and note use of exponential in the computation. See also reference 7.
20-2	$P_{fuel}^{int(i)}$	PFU(IN)	Percent per annum interest rate for fuel inventory cost in alternate i' set of economic assumptions ($1 < i' < N_{alt}^{max}$) -- see no. 23-1 below.
20-3	$P_{fab}^{int(i)}$	PFAB (IN)	Percent per annum interest rate for fabrication inventory cost in alternate i' set of economic assumptions ($1 < i' < N_{alt}^{max}$) -- see no. 23-1 below.

DATA BLOCK 21 - Fuel Isotopic Values for Cost Calculations (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
21-1	$N_{\max}^{\text{val}}(i)$	NVALMX (IN)	<p>Number of isotopic fuel values listed for economic assumptions i. $N_{\max}^{\text{val}}(i)$ is restricted to the following:</p> <p><u>1 or 4 if $M_{\max}^{\text{fuel}} = 5$ (U^{238}-Pu chain only -- see no. 1-6 above).</u> <u>1</u> means a single value is assigned to Pu-239 and Pu-241; and no value is assigned to the other two Pu isotopes. <u>4</u> means that a separate value is assigned to each of the four Pu isotopes in the chain. A zero value is assumed for U-238.</p> <p><u>0, 1, or 5 if $M_{\max}^{\text{fuel}} = 6$ (Th^{232}-U chain only).</u> <u>0</u> means uranium isotopic values are to be calculated by "enrichment" formula -- see nos. 21-3 through 21-6 below. <u>1</u> means a single value as U-233) and no value is assigned to the other two U isotopes. <u>5</u> means a separate value is assigned to Pa-233, U-233, U-234, U-235, and U-236, and a zero value is assumed for Th-232.</p> <p><u>1, 4, or 6 if $M_{\max}^{\text{fuel}} = 7$ (U^{238}-Pu chain plus U-235 and U-236).</u> <u>1</u> and <u>4</u> have the same meanings as described above for $M_{\max}^{\text{fuel}} = 5$; and, in addition, the value of U-235 is to</p>

DATA BLOCK 21 - Fuel Isotopic Values for Cost Calculations (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
21-1 (cont'd)	$N_{\max}^{\text{val}(i)}$	NVALMX (IN)	<p>be calculated from an "enrichment" formula -- see nos. 21-3 through 21-5 below. <u>6</u> means that a separate value is listed for each of the four Pu isotopes and also for U-235 and for U-236. A zero value is assumed for U-238.</p> <p>1, 4, or 10 if $M_{\max}^{\text{fuel}} = 11$ (U^{238}-Pu chain plus complete Th^{232}-U chain). <u>1</u> and <u>4</u> have the same meanings as above for $M_{\max}^{\text{fuel}} = 7$ but the U-233 value (Pa-233 same value as U-233) is calculated by formula in addition to the U-235 value. <u>10</u> means that a separate value is listed for each of the isotopes in the two chains, except for U-238 which is assumed to have zero value.</p>
21-2	$V_m^{(i)}$	VAL (IN,MTP)	<p>Listing of fuel isotopic values in \$/Kg ($1 < M' < N_{\max}^{\text{val}(1)}$) for reference economic assumptions. The order of the listing is as indicated in the descriptions of the different values possible for $N_{\max}^{\text{val}(1)}$ (see no. 21-1 above). If $N_{\max}^{\text{val}(1)} = 0$ (possible if $M_{\max}^{\text{fuel}} = 6$), then there is no listing of $V_m^{(1)}$ values. If</p>

DATA BLOCK 21 - Fuel Isotopic Values for Cost Calculations (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
21-2	$V_{m'}^{(i)}$	VAL (IN,MTP)	$N_{max}^{val(1)} = 4$ (for an example which is possible except for $M_{max}^{fuel} = 6$), then the values of Pu-239, Pu-240, Pu-241, and Pu-242 are listed in that order as $V_1^{(1)}$ through $V_4^{(1)}$. If $N_{max}^{val(1)} = M_{max}^{fuel} - 1$, then the listing $V_1^{(1)}$ through $V_{M_{max}^{fuel}-1}^{(1)}$ includes all of the fuel isotopes except for the one corresponding to material $M=1$ (which is U-238, except for the case of $M_{max}^{fuel} = 6$ where it is Th-232). <u>Note that the M' subscript of $V_{m'}^{(1)}$ is not the same as the isotopic material number M given in the footnote accompanying no. 1-6 above.</u>
21-3	$C_{feed}^{(i)}$	CFEED (TN)	Cost of natural uranium feed to enrichment plant in \$/Kg for reference set of economic assumptions.*
21-4	$C_{sep}^{(i)}$	CSEP (IN)	Cost of separative work in \$/Kg for reference set of economic assumptions.*
21-5	$E_{tails}^{(i)}$	ETAIL (IN)	Fissile weight percent of depleted uranium tails.*
21-7	$R_{25}^{23(i)}$	R2325 (IN)	Ratio of value of U-233 (or of Pa-233) to that of U-235.

* Used in formula to calculate U-235 value in a reactor fuel batch (if it is to be calculated by formula -- see no. 21-1 above). See statements (4-132), (4-127), and (4-128) for the formula itself which is based on material in reference 8. The fissile "enrichment" used in the formula includes the U-233 and Pa-233 contents (if present) as well as U-235; but the calculated value is assigned only to the U-235. The U-233 (and Pa-233) value is then obtained from no. 21-7 above.

DATA BLOCK 22 - Unit Costs for Fuel Fabrication and Reprocessing (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
22-1	$h_{\max}$	NHMX	Maximum number of sets of unit fabrication and reprocessing costs listed (for each set of economic assumptions) to account for the different types of fuel that may be loaded into the different reactor zones.
22-2	$U_h^{\text{fab}(i)}$	UFAB (NH, IN)	Unit fabrication cost for fresh fuel loaded at beginning of operating interval (\$/Kg loaded U+Pu+Th) for economic assumptions i and for zone range corresponding to h ($1 < h < h_{\max}$) -- see nos. 22-1.
22-3	$U_h^{\text{repr}(i)}$	UREPR (NH, IN)	Unit reprocessing cost for spent fuel discharged at end of operating interval (\$/Kg loaded U+Pu+Th) for economic assumptions i and for zone range corresponding to h ($1 < h < h_{\max}$) -- see nos. 22-1 and 22-2 above.

DATA BLOCK 23 - Indexes for Alternate Sets of Economic Assumptions (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
23-1	N_{alt}^{max}	NALTMX	Maximum number of sets of alternate economic assumptions (i.e., including the reference set). $N_{alt}^{max} < 6$.
23-2	$\delta_{alt}^{(i')}$	IALT	<p>$\delta_{alt}^{(i')}$ for $(1 < i' < N_{alt}^{max})$, is one of the following:</p> <ol style="list-style-type: none"> 1 if the i' alternate set of economic assumptions differs from the reference set only in interest rate values (Data Block 20). 2 if the i' alternate set of economic assumptions differs from the reference set only in isotopic fuel values (Data Block 21). 3 if the i' alternate set of economic assumptions differs from the reference set only in fabrication and reprocessing costs (Data Block 22). 4 if the i' alternate set of economic assumptions differs from the reference set in two or more combinations of above.

DATA BLOCK 24 - Data Printout Selectors for Whole Reactor Weight and CostOutputs (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
24-1	δ out reac	IREOUT	<p>0 means do not print Block 51 output data for current operating intervals. (Block 51 includes 51A through 51B.</p> <p>1 means print data in Blocks 51A, 51B, and 51C (with possible exception of breeding ratios and doubling time) and other Block 51 output data as indicated by selectors below.</p>
24-2	δ disch reac	IREDIS	<p>0 means do not print output data on reactor discharged fuel weights.</p> <p>1 means print summary data (Block 51E) on reactor discharged fuel weights.</p> <p>2 means same as 1 and also print reactor discharged fuel weights by each material (Block 51F).</p>
24-3	δ load reac	IRELOD	<p>0, 1 or 2 with similar meanings as no. 24-2 except for <u>loaded</u> fuel weights, Blocks 51G and 51H, instead of discharged fuel.</p>
24-4	δ mid inv reac	IREMI	<p>0, 1 or 2 with similar meanings as no. 24-2 except for <u>average fuel weight inventory</u> during operating interval, Blocks 51I, 51J, 51M, and 51N, instead of discharged fuel.</p>

DATA BLOCK 24 - Data Printout Selectors for Whole Reactor Weight and Cost
Outputs (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
24-5	δ end env react	IREEI	0, 1 or 2 with similar meanings as no. 24-2 except for <u>end-of-operating-interval fuel</u> <u>weight inventory</u> , Blocks 51K and 51L, instead of discharged fuel.
24-6	δ cost react	IRECO	0 means do not print Block 51 cost output data (Blocks 51O through 51V). 1 means print Block 51 cost output data. If δ cost comp react = 0, print only total cost data (Blocks 51O, 51P, and 51R* if δ cost meth = 1 or 3; Blocks 51S, 51T, and 51V* if δ cost meth = 2 or 3). If δ cost comp react = 1, print <u>also</u> fuel component costs (Block 51Q for δ cost meth = 1 or 3; Block 51U for δ cost meth = 2 or 3.)
24-7	δ cost comp react	IRCOCO	0 or 1 -- see no. 24-6 above.

* Omit levelized power cost data (Blocks 51R and 51V) if $P_{lev}^{int} = 0$ (see no. 20-1).

DATA BLOCK 25A - Designations of Zone Groups for Output Data Calculation and Printout (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
25A-1	JG_J	JWG(JZ)	Listing of composite zone to which zone J_z ($1 < J_z < J_{max}$) belongs. Composite zones are desirable for condensing output data from a large number of small zones.*
25A-2	g_{max}	NGMX	Number of composite zones (see statement 25A-1 above). If g_{max} is equal to 0 each zone is treated separately in the output computations.
25A-3	δ_g^{group}	IPRGP	<u>0 or 1</u> for $1 < g < g_{max}$. <u>0</u> means that group g is not a composite zone group. In this case, there is a separate printout of zonal data (Block 52) for each zone of the group. <u>1</u> means that group g is a composite zone group. In this case, there is only a single printout of the Block 52 data for the entire zone group, just as though the individual zones in the group were regions within a zone (see Figure 2 of Section 1.)*

* For example, it may be desirable to treat a core zone and its associated axial blanket zone(s) as a single composite zone group for the printout of fuel weight and cost data. The use of a composite zone may be especially attractive for combining zones that are involved in fuel transfer to or from fuel storage repositories, because such zones are limited to a single region per zone. If a composite zone group is involved in such fuel transfer to or from storage repositories.

DATA BLOCK 25B - Data Printout Selectors for Zone Breakdown of Fuel Weights and Costs (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
25B-1	δ out g	IZOUT(NG)	<p>0 means do not provide any Block 52 (52A through 52W) output data printout for group g zones (see Data Block 25A).</p> <p>1 means provide Block 52A output data printout and also printout of other Block 52 data in accordance with selectors below (see nos. 25B-2 through 25B-8).</p>
25B-2	δ disch g	IZDIS(NG)	<p>0 means do not print any weight and burnup data on fuel discharged from group of zones at end of operating interval.</p> <p>1 means printout summary of weight and burnup data (Block 52B) on fuel discharged from group g zones.</p> <p>2 means 1 plus printout of weight and burnup data broken down for each batch (Block 52C) discharged from group g zones.</p> <p>3 means 1 plus printout of weight of each material (Block 52D) discharged from group g zones.</p> <p>4 means printout Blocks 52B, 52C, and 52D, and also discharged weights broken down by batch and material (Block 52E) for group g zones.</p>

DATA BLOCK 25B - Data Printout Selectors for Zone Breakdown of Fuel Weights and Costs (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
25B-3	δ load g	IZLOD(NG)	0, 1, 2, 3, or 4 with similar meanings as for no. 25B-2 above, except for loaded fuel weights into group g zones at beginning of operating intervals (Block 52F, 52G, 52H, and 52I) instead of discharged fuel weights and burnup.
25B-4	δ mid inv g	IZMI(NG)	0, 1, 2, 3, or 4 with similar meanings as for no. 25B-2 above, except for fuel inventory weights averaged over operating interval for group g zones (Blocks 52J, 52K, 52L, and 52M) instead of discharged fuel weights and burnup.
25B-5	δ end inv g	IZEI(NG)	0, 1, 2, 3, or 4 with similar meanings as for no. 25B-2 above, except for fuel inventory weights at end of operating interval for group g zones (Blocks 52N, 52O, 52P, and 52Q) instead of discharged fuel weights and burnup.
25B-6	δ cost g	IZCO(NG)	0 means do not print any cost output data

DATA BLOCK 25B - Data Printout Selectors for Zone Breakdown of Fuel Weights and Costs (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
25B-6 (con't)	δ_g^{cost}	IZCO(NG)	<p>(Blocks 52R through 52W) for group g zones.</p> <p>1 means printout total fuel cost(s) for group g zones (Block 52R if $\delta_g^{\text{cost meth}} = 1$ or 3; Block 52V if $\delta_g^{\text{cost meth}} = 2$ or 3 -- see no. 25B - 8 below). If $\delta_g^{\text{cost comp}} > 1$ (no. 25B - 7 below), then also printout fuel cost components (Block 52S for $\delta_g^{\text{cost comp}} = 1$ or 3 and Block 52W for $\delta_g^{\text{cost meth}} = 2$ or 3).</p> <p>2 means 1 plus printout total fuel cost(s) broken down by batch (Block 52T) for fuel discharged from group g zones. If $\delta_g^{\text{cost comp}} = 2$, then also printout fuel cost components broken down by batch (Block 52U) for fuel discharged from group g zones. (<u>$\delta_g^{\text{cost}} = 2$ is applicable only for $\delta_g^{\text{cost meth}} = 1$ or 3).</u>)</p>
25B-7	$\delta_g^{\text{cost comp}}$	IZCOCO (NG)	<p>0, 1, or 2 (see no. 25B-6 above).</p> <p>1 total only.</p> <p>2 broken down by components.</p>
25B-8	$\delta_g^{\text{cost meth}}$	IZCOME (NG)	<p>0, 1, 2, or 3 (see no. 25B-6 above). Must be consistent with $\delta_g^{\text{cost meth}}$ (see no. 1-25 above).*</p>

* $\delta_g^{\text{cost meth}}$ cannot be 1 unless $\delta_g^{\text{cost meth}} = 1$ or 3, $\delta_g^{\text{cost meth}}$ cannot be 3 unless $\delta_g^{\text{cost meth}} = 3$, and $\delta_g^{\text{cost meth}}$ cannot be 2 unless $\delta_g^{\text{cost meth}} = 2$ or 3. Setting $\delta_g^{\text{cost meth}} = 1$ or 2 when $\delta_g^{\text{cost meth}} = 3$ allows the user to eliminate printout of cost data broken down by zones for one of the two methods of fuel costing (see no. 1-26 above) and still printout the cost data by both methods for the whole reactor (Data Blocks 510 through 51V.)

DATA BLOCK 26 - Selectors for Other Output Data Options and Printout (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
26-1	δ conc	ICNB	<p>0 means do not print regional material concentrations $N_{m,j}^{(o)}$ at beginning and end of operating interval (Block 55).</p> <p>1 means printout regional material concentrations at beginning and end of interval (Block 55).</p> <p>2 means the same as 1 except that printout is only for regions in zones of variable fissile enrichment.</p>
26-2	δ conc bat	ICNBBA	<p>0, 1, or 2 with similar meanings as no. 26-1, except for beginning and end of interval regional concentrations for each batch, $N_{m,j,n}^{(o)}$ (Block 57).</p>
26-3	δ rec inv	IRECYC	<p>0 means do not print records of material available in recycle repositories.</p> <p>1 means printout weights of materials available in recycle repositories at end of operating interval (Block 54).</p>
26-4	δ stor inv	ISTORE	<p>0 means do not print any output data on stored fuel material inventory weights.</p>

DATA BLOCK 26 - Selectors for Other Output Data Options and Printout (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
26-4 (con't)	δ stor inv	ISTORE	<p>1 means printout summary of stored fuel weights summed over all the stored fuel repositories (Block 53B). Stored weights are inventories during the operating interval, prior to discharge of reactor fuel at end of operating interval.</p> <p>2 means 1 plus printout of stored fuel weight inventories broken down by material (Block 53C).</p> <p>3 means 2 plus stored fuel weight inventories broken down by repository and hold-up time in each repository and by material and energy produced by stored fuel in each repository for each hold-up time (Block 53A).</p>
26-5	δ stor inv cost	ISTOIC	<p>0 means do not print stored fuel inventory costs.</p> <p>1 means printout stored fuel inventory costs summed over all stored fuel repositories for the current operating interval (Block 53D).</p> <p>2 means printout stored fuel inventory costs for each repository and hold-up time for the current operating interval (Block 52E).</p>

DATA BLOCK 26 - Selectors for Other Output Data Options and Printout (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
26-5 (con't)	δ stor inv cost	ISTOIC	<u>Note that 1 and 2 are applicable only if</u> <u>$\delta_{\text{cost}}^{\text{meth}} = 2 \text{ or } 3$ (see no. 1-26).</u>
26-6	δ BR	IBRAT	0 means do not calculate breeding ratios. 1 means printout breeding ratios (appears in output data of Blocks 51C and 51D).
26-7	δ prep restart	IPREST	0 means do not provide output data for a restart case (i.e., for continuation of the problem in a later run). 1 means provide output data in format required for a restart case (Data Blocks 29 through 38 -- see statement 4-3). This is executed only for the last operating interval of the current problem run, $I=I_{\text{max}}$.
26-8	δ dump	IDUMP	0 means do not execute a data dump on an error halt. 1 means printout all data blocks in the event of an error halt.

DATA BLOCK 27 - Indices Identifying Data to be Replaced when $I=I_s$ (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
27-1	I_s	IOPS(KS)	If I_s is equal to operating interval I for any s ($1 < s < I_{\max}$) part or all of the input data can be changed starting with operating interval I (with the exception of problem dimensions such as, number of regions $j_{\max}$, number of zones $J_{\max}$ number of materials $M_{\max}$, certain output instructions, etc.)

DATA BLOCK 28 - Energy per Fission Overlay (Optional Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
28-1	E_m^{input}	EMEV(MT)	MeV per fission for material M ($1 < M < M_{\text{max}}$). If Data Block 28 is not provided as user's input, the code will assume the values shown in statement (2-4) -- see also statements (2-8) through (2-12).

DATA BLOCK 29 - Isotopic Concentrations at Beginning of Operating Interval.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
29-1	$N_{m,j,n}^{(o)}$	CNB (MT,JR,NB)	Concentration (atoms/barn-cm) of material M in batch N of region j at beginning of an operating interval. Note that $N_{m,j,n}^{(o)}$ is only a portion (a batch portion) of the regional concentration (i.e., $N_{m,j}^{(o)} = \sum_n N_{m,j,n}^{(o)}$). The batch concentration is proportional to the weight of material M in batch N and is inversely proportional to the <u>whole</u> volume of region j.

DATA BLOCK 30A - Number of Fuel Batches to be Discharged and Batch Identification*

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
30A-1	$N_{dis}^{(J)}$	NDIS(JZ)	Number of fuel batches to be replaced in zone J ($1 < J < J_{max}$) at end of operating interval. See statements (3-85) through (3-88) and Data Block 7.
30A-2	$N'_{dis}(J)$	NLB(JZ)	Number of fuel batches which have been loaded in zone J_z . Note when $N_{dis}^{(J)}$ and $N'_{dis}(J)$ refer to the same operating interval they may be different. However, $N'_{dis}(I) = N_{dis}^J(I-1)$.

DATA BLOCK 30B - Accrued Energy Produced in Fuel Batches

30B-1	$E_{J,n}^{(o)th}$	EZTH (JZ,NB)	Thermal energy (megawatt=days) accrued in fuel batch n of zone J at beginning of the current operating interval, ($1 < J < J_{max}$; $1 < n < N_J^{bat}$).
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DATA BLOCK 30C - Fuel Batch Weights

30C-1	$W_{J,n}^{(o)}$	WF (JZ,ND)	Total weight (Kg of U+Pu+Th at time of loading) of fuel in batch n of zone J ($1 < J < J_{max}$; $1 < n < N_J^{bat}$).
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* This is usually working data (not input data provided by the user). However, Data Blocks 29, 30A, and 30B are provided as user's input for the first operating interval of the problem run if both $\delta_1^{(a)} = 0$ and $\delta_{restart} = 0$. If $\delta_1^{(a)} = 0$ and $\delta_{restart} = 1$, these Data Blocks are also input, but they are then provided by the output of a previously run problem (see nos. 1-31, 1-32, and 1-33.)

DATA BLOCK 31 - Fixed Point Recycle Control Parameters*

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
31-1	v_o	JZERO	Lowest v of the zones in J_v listing (see no. 12-4 above) having a variable isotopic content (i.e., fissile "enrichment" adjustable to satisfy reactivity requirements).
31-2	L_v	LREP(JZ)	L_v ($v_o < v < v_{max}$) is 1 if some recycle material is available in preferred recycle repository, $N_v^{rec 1}$ for zone J_v ; $L_v = 2$ if 1 is not applicable and some recycle material is available in backup recycle repository $N_v^{rec 2}$, otherwise $L = 3$ and only make-up material is used for fuel loaded into zone J_v at beginning of current operating interval.
31-3	$M_{1,v}^{rec 1}$	MTI(1)	Lowest fissile material number in preferred recycle repository for fuel to be loaded into zone J_v ($v_o < v < v_{max}$) corresponds to either Pu-239, U-233, or U-235 material numbers, depending on M_{max}^{fuel} . See statements (3-193) through (3-194a).

* Working data (needed as input data only for a restart case -- $\delta_1^{(o)} = 0$ and $\delta_{restart} = 1$). For a restart case, the data is provided as output from a previous problem run. See nos. 1-31, 1-32, and 1-33 above.

DATA BLOCK 31 - Fixed Point Recycle Control Parameters

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
31-4	$M_{2,v}^{\text{rec } 1}$	MT2(1)	Highest fissile material number in preferred recycle repository for fuel to be loaded into zone J_v . See no. 31-3 above.
31-5	$M_{1,v}^{\text{rec } 2}$	MTI(2)	Similar to 31-3 and 31-4 above, except for backup recycle repository for zone J_v
31-6	$M_{2,v}^{\text{rec } 2}$	MT2(2)	($v_o < v < v_{\text{max}}$) instead of preferred recycle repository.
31-7	$(\delta_{\text{rec } 1}^{\text{tot } U})_v$	MTU(1)	1 if $N_v^{\text{rec } 1}$, the preferred recycle repository for zone J_v ($v_o < v < v_{\text{max}}$) is in range $N_{\text{max}}^{\text{fis } U} + 1 < N_v^{\text{rec } 1} < N_{\text{max}}^{\text{tot } U}$; otherwise, (1 means that recycled uranium contains U-238 in the U isotopic mix.)
31-8	$(\delta_{\text{rec } 2}^{\text{tot } U})_v$	MTU(2)	Similar to no. 31-7, except for backup recycle repository, $N_v^{\text{rec } 2}$, for zone J_v instead of for preferred recycle repository.

DATA BLOCK 32 - Floating Point Recycle Control Parameters

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
32-1	$R_v^{(\ell)}$	SR (JZ,LR)	<p>Reactivity worth, ΔK, of 1 Kg of material from source (v, ℓ) loaded uniformly into the regions of zone J_v ($v_o < v < v_{\max}$; $1 < \ell < 4$).</p> <p>Material source (v, ℓ) is identified as follows: for $\ell = 1$, source is recycle repository $N_v^{\text{rec } 1}$ with hold-up time $I_v^{\text{rec } 1}$; for $\ell = 2$, source is recycle repository $N_v^{\text{rec } 2}$ with hold-up time $I_v^{\text{rec } 2}$; for $\ell = 3$, source is fissile make-up source N_v^{mkp} for $\ell = 4$, source is other make-up source N_v^{oth} (mainly fertile). See statements (3-199), (3-206) and (3-208a).</p>
32-2	$N_v^{(\ell)}$	SN (JZ,LR)	<p>Total fuel atom concentration (atoms of U+Pu+Th per barn-cm) contributed by 1 Kg of material from source (v, ℓ) - see no. 32-1 above - loaded uniformly into the regions of zone J_v. See statements (3-201), (3-208), and (3-208a).</p>
32-3	$P_v^{(\ell)}$	SP (JZ,LR)	<p>Power (fissions/sec) produced in 1 Kg of material from source (v, ℓ) - see no. 32-1 above - loaded uniformly into the regions of zone J_v ($v_o < v < v_{\max}$). See statements (3-201), (3-207), and (3-208a).</p>

DATA BLOCK 32 - Floating Point Recycle Control Parameters

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
32-4	$f_v^{(\ell)}$	SF (JZ,LR)	Quantity less than or equal to unity which multiplies $W_v^{(L_v)}$ - see no. 32-6 below - to give weight of material from source (v, ℓ) - see no. 32-1 above - to be loaded uniformly into the regions of zone J_v . $f_v^{(\ell)}$ (for $v_o < v < v_{\max}$) is 1 for $\ell = L_v$ - see no. 31-2 above - and is zero for $\ell < L_v$. See statements (3-195), (3-196), (3-197), (3-198), (3-204) and (3-205) for initial settings of $f_v^{(\ell)}$ values for $\ell < 3$ at the beginning of an operating interval, and statements (3-218) and (3-222) for calculation of initial $f_v^{(4)}$ values. These initial $f_v^{(\ell)}$ values are altered as needed to satisfy reactivity requirements and availability of preferred or backup recycle material.
32-5	$p_v^{(a)}$	POWA(JZ)	Power at beginning of operating interval (fissions/sec) in zone J_v ($v_o < v < v_{\max}$) contributed by fuel remaining in the zone from the preceeding operating interval (excludes power produced in the fresh fuel newly loaded into the zone).

DATA BLOCK 32 - Floating Point Recycle Control Parameters

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
32-6	$W_V^{(L_V)}$	WKG(JZ)	<p>Weight in Kg of material from source (v, l)</p> <p>for $l = L_V$ - see nos. 32-1 and 31-2 above -</p> <p>loaded uniformly into zone J_V ($v_O < v < v_{max}$).</p> <p>See statement (3-220) for relationship</p> <p>between values of $W_V^{(L_V)}$, for $v > v_O$, and</p> <p>$W_{V_O}^{(L_{V_O})}$. This relationship gives the power</p> <p>distribution between variable fissile content</p> <p>zones at the beginning of the operating</p> <p>interval that is specified by input in Data</p> <p>Block 18. The value of $W_V^{(L_{V_O})}$ is calculated</p> <p>to satisfy the estimated reactivity require-</p> <p>ments, including burnup for the new operating</p> <p>interval - see statement (3-216) $W_V^{(L_V)}$ values</p> <p>set at the beginning of a new operating</p> <p>interval are altered, along with the $f_V^{(l)}$</p> <p>values - see no. 32-4 above, as needed to</p> <p>satisfy reactivity requirements and avail-</p> <p>ability of recycle material.</p>
32-7	$R_V^{(x)}$	RX(JZ)	Reactivity (ΔK) contributed by the freshly
32-8	$R_V^{(b)}$	RB(JZ)	<p>loaded fuel into zone J_V ($v_O < v < v_{max}$) is</p> <p>$R_V^{(b)} + R_V^{(x)} W_{V_O}^{(L_{V_O})}$. See statements (3-211),</p> <p>(3-213), and (3-214).</p>

DATA BLOCK 32 - Floating Point Recycle Control Parameters

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
32-9	$R^{(x)}$	RXX	Sum of $R_V^{(x)}$ values - see no. 32-7 - over the variable fissile content zones ($v_o < v < v_{max}$). See statement (3-216) for use of $R^{(x)}$, and also of $R^{(b)}$ and $R^{(a)}$ below, in computation of $W_{V_o}^{(L_{V_o})}$ - see no. 32-6.
32-10	$R^{(b)}$	RBB	Sum of $R_V^{(b)}$ values - see no. 32-8 - over the variable fissile content zones.
32-11	$R^{(a)}$	RAA	Reactivity in excess of the reference value K_{ref} - see no. 34-7 below - contributed by fuel remaining in the reactor from the preceeding operating interval, plus reactivity contributed by newly loaded fuel taken from storage repositories (which includes fuel shuffled from one zone to another) plus reactivity contributed by freshly loaded fuel into zones of fixed initial isotopic contents - see Data Blocks 10 and 11.

DATA BLOCK 33 - Recycle Material Weights Available

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
33-1	$W_N^{(I_h)}$	WTREC (NS, IH)	Total weight (Kg) of recycle material available in recycle repository Ns that has been out of the reactor for I_h operating intervals. <u>$(N_{\max}^{\text{stor}} + 1 < N < N_{\max}^{\text{tot U}}; 0 < I_h < 3$ - see nos. 14-6 and 15.1 above for special meaning assigned to $I_h = 3$.)</u>
33-2	$W_{m,N}^{(I_h)}$	WRECM (NS, IH, MT)	Weight (Kg) of recycle material m available in recycle repository N that has been out of the reactor for I_h operating intervals: <u>$(N_{\max}^{\text{stor}} + 1 < N < N_{\max}^{\text{tot U}}; 0 < I_h < 3;$</u> <u>$2 < m < 5$ for $N_{\max}^{\text{stor}} + 1 < N < N_{\max}^{\text{Pu}};$</u> <u>$M_{\max}^{\text{fuel}} - 3 + 2 \delta 7, M_{\max}^{\text{fuel}} < M < M_{\max}^{\text{fuel}}$ for</u> <u>$N_{\max}^{\text{Pu}} + 1 < N < N_{\max}^{\text{tot U}};$ also $M = 1$ for</u> <u>$N_{\max}^{\text{fis U}} + 1 < N < N_{\max}^{\text{tot U}}.$)</u>
33-3	$W_{m_{233},N}^{(o)}$	WRECPA (NS)	Weight (Kg) of Pa-233 discharged and assigned to recycle repository N ($N_{\max}^{\text{Pu}} + 1 < N < N_{\max}^{\text{tot U}}$). Assumed to be completely converted to U-233 during the time period of one operating interval.

DATA BLOCK 34 - Parameters Interpolated from Multigroup Diffusion Cases -
Reaction Rate Cross Sections, Material Reactivity Worths,
Regional Fluxes and Volumes, Reference Fuel Isotopic
Concentrations and Reference Reactivity.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
34-1	$N_{m,j}^{(r)}$	CNR (MT,JR)	Concentration (atoms/barn-cm) of material m in region j for reference composition interpolated from multigroup diffusion cases for current operating interval - see statement (3-138). <u>$(1 < j < j_{\max}; 1 < m < m_{\max})$</u> .
34-2	$R_{m,j}^{(r)}$	RKR (MT,JR)	Reactivity worth of a unit change in concentration $(\Delta K / \Delta N_{m,j})$ of material m in region j interpolated from multigroup diffusion cases for current operating interval. <u>$1 < j < j_{\max}; 1 < m < m_{\max}$</u> - see statement (3-142).
34-3	$\sigma_{f,m,j}$	SIGF (MT,JR)	Fission cross section (one-group reaction rate cross section in barns) of material m in region j interpolated from multigroup diffusion cases for current operating interval <u>$(1 < j < j_{\max}; 1 < m < m_{\max})$</u> . See statement (3-143).
34-4	$\sigma_{c,m,j}$	SIGC (MT,JR)	Radiative capture cross section (one-group reaction rate cross section in barns) of material m in region j interpolated from multigroup diffusion cases for current operating interval. <u>$(1 < j < j_{\max}; 1 < m < m_{\max})$</u> . See statement (3-143).

DATA BLOCK 34 - Parameters Interpolated from Multigroup Diffusion Cases -
Reaction Rate Cross Sections, Material Reactivity Worths,
Regional Fluxes and Volumes, Reference Fuel Isotopic
Concentrations and Reference Reactivity.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
34-5	ϕ_j	PHI(JR)	Average flux (neutrons/cm ² -sec) in region j interpolated from multigroup diffusion cases for current operating interval ($1 < j < j_{\max}$). See statement (3-139).
34-6	V_j	VOL(JR)	Volume (cm ³) of region j interpolated from multigroup diffusion cases for current operating interval ($1 < j < j_{\max}$). See statement (3-141).
34-7	K_{ref}	REFK	Reference reactivity -- effective multiplication constant - associated with reference composition (see no. 34-1) and interpolated from multigroup diffusion cases for current operating interval. See statement (3-145).

DATA BLOCK 35 - Accumulated Operating Time and Energy Produced.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
35-1	T_{yr}^{acc}	TACYR	Accumulated reactor operating time in years (summed overall operating intervals).
35-2	E_{acc}	EACCU	Accumulated energy produced in fuel batches discharged for reprocessing (summed overall operating intervals). Unit is 10^6 BTU if $\delta_{unit}^{cost} = 0$; mill/kwh if $\delta_{unit}^{cost} = 1$. See no. 1-27.
35-3	E_{acc}^{lev}	EACLEV	Levelized accumulated energy produced in fuel batches discharged for reprocessing. (Similar to no. 35-2 except value of energy produced in the future is reduced in accordance with discount factor P_{lev}^{int} - see no. 20-1 and statement (4-237p).
35-4	E_{acc}	EACC	Accumulated energy produced by reactor (summed over all operating intervals). Units same as for no. 35-2 above. (Note difference between accumulated reactor energy produced, E_{acc} , and energy produced in spent fuel, E_{acc}' . This relates to the two different methods of fuel cost evaluation that may be selected -- see no. 1-26 above.)
35-5	E_{acc}^{lev}	EACCLV	Levelized accumulated energy produced by reactor. Bears same relationship to E_{acc} as E_{acc}^{lev} does to E_{acc}' - see nos. 35-2 through 35-4 and also statement (4-237q).

DATA BLOCK 36 - Accrued Fuel Cost Components for In-Pile Fuel Batches

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
36-1	$C_{J_z n}^{fab(i')}$	CFAB (JZ,NB,IN)	<p>Fabrication cost of fuel batch n in zone J_z for i'th set of economic assumptions</p> <p>$(0 < i' < N_{alt}^{max}$, with $i' = 0$ being the reference set of economic assumption - see Data Blocks 20, 21, and 22; $1 < z < J_{max}$ - see Data Block 25A for J_w zone listing; $1 < n < N_{J_z}^{bat}$ for each J_w). Units are 10^6 Btu if $\phi_{unit}^{cost} = 0$, mills if $\phi_{unit}^{cost} = 1$. See no. 1-27 above.</p>
36-2	$C_{J_z n}^{cred(i')}$	CRED (JZ,NB,IN)	<p>Cost of fissile material (both fissile and fertile if latter are assigned a value) for fuel batch n in zone J_z for i'th set of economic assumptions. See 36-1 above for units and range of variable.</p>
36-3	$C_{J_z n}^{inv(i')}$	CINV (JZ,NB,IN)	<p>Accrued fuel inventory cost (fissile and fertile materials only) for fuel batch n in zone J_z for i'th set of economic assumptions. See 36-1 above for units and range of variable.</p>
36-4	$C_{J_z n}^{fab inv(i')}$	CFABIN (JZ,NB,IN)	<p>Accrued fabrication inventory cost for fuel batch n in zone J_z for i'th set of economic assumptions. See 36-1 above for units and range of variable.</p>

DATA BLOCK 36 - Accrued Fuel Cost Components for In-Pile Fuel Batches*

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
36-5	$C_{J_z}^{\text{repr inv } (i')}$	CREPIN (JZ,NB,IN)	Accrued reprocessing interest credit for fuel batch n in zone J_w is i^{th} set of economic assumptions for each \$/Kg unit cost of reprocessing during operating interval when this batch is discharged for reprocessing. See 36-1 above for units and range of variable.

* Accrued fuel cost records for in-pile fuel batches (Data Block 36) are maintained only if $\delta_{\text{meth}}^{\text{cost}} = 1$ or 3 (see no. 1-26 above).

DATA BLOCK 37 - Stored Fuel Weight and Energy

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
37-1	$w_{m,N}^{(I_h)}$	WSTO (NS,IH,MT)	Weight (Kg) of material m in stored fuel repository N that has been out of the reactor for I_h operating intervals at the beginning of the current operating interval. <u>$(1 < N < N_{\max}^{\text{stor}}; 0 < I_h < I_{\max}^{\text{stor}}; 1 < m < m_{\max})$.</u>
37-2	$E_N^{(IH)\text{th}}$	ESTOTH (NS,IH)	Energy (thermal megawatt days) produced from previous reactor exposure by fuel in storage repository N with storage hold-up time of I_h operating intervals $(1 < N < N_{\max}^{\text{stor}}; 0 < I_h < I_{\max}^{\text{stor}})$.

DATA BLOCK 38 - Accrued Fuel Cost Components for Stored Fuel Batches*

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
38-1	$C_{N,I_h}^{fab(i')}$	CSFAB (NS,IH,IN)	See accrued fuel cost components for in-pile fuel batches (nos. 36-1 through 36-5 above).
38-2	$C_{N,I_h}^{cred(i')}$	CSCRED (NS,IH,IN)	These are similar cost component records for fuel which has been previously irradiated and
38-3	$C_{N,I_h}^{inv(i')}$	CPSINV (NS,IH,IN)	is now held in storage for later return to the reactor. Units are the same as indicated in
38-4	$C_{N,I_h}^{fab\ inv(i')}$	CSFAIN (NS,IH,IN)	no. 36-1. Range of variables is $0 < i' < N_{alt}^{max}$, $1 < N < N_{max}^{stor}$, $0 < I_h < I_{max}^{stor}$. (N is the fuel
38-5	$C_{N,I_h}^{repr\ inv(i')}$	CSREIN (NS,IH,IN)	storage repository number, and I_h the number of operating intervals that the stored fuel has been held out of the reactor at the beginning of the current operating interval.)
38-6	$C_N^{fab(i')}$	CFABI (NS,IN)	Cost records for fuel discharged from the reactor and sent to storage repositories at the
38-7	$C_N^{cred(i')}$	CREDI (NS,IN)	end of the current operating interval. (See nos. 38-1 through 38-5). These records will
38-8	$C_N^{inv(i')}$	CINVI (NS,IN)	become $C_{N,0}^{fab(i')}$, $C_{N,0}^{cred(i')}$, etc., and the
38-9	$C_N^{fab\ inv(i')}$	CFAINI (NS,IN)	cost records are updated for the beginning of the next operating interval.
38-10	$C_N^{repr\ inv(i')}$	CREINI (NS,IN)	

* Accrued fuel cost records for stored fuel batches (Data Block 38) are maintained only if $\delta_{meth}^{cost} = 1$ or 3 (see no. 1- above).

DATA BLOCK 39 - Parameters Supplied by Multigroup Diffusion Cases Run (Input Data).*

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
39-1	$N_{m,j}^{(a)}$	CNMA (MT,JR)	Concentration (atoms/barn-cm) of material m in region j for multigroup diffusion theory case A. <u>$(1 < j < j_{\max}; 1 < m < m_{\max})$</u> .
39-2	$N_{m,j}^{(b)}$	CNMB (MT,JR)	Similar to no. 39-1, except for multigroup diffusion theory case B.
39-3	$R_{m,j}^{(a)}$	RKA (MT,JR)	Reactivity worth of a unit concentration change ($\Delta K / \Delta N_{m,j}$) of material m in region j for multigroup diffusion theory case A. <u>$(1 < j < j_{\max}; 1 < m < m_{\max})$</u> .
39-4	$R_{m,j}^{(b)}$	RKB (MT,JR)	Similar to no. 39-3, except for multigroup diffusion theory case B.
39-5	$\sigma_{f,m,j}^{(a)}$	SIGFA (MT,JR)	Fission cross section (one-group reaction rate cross section in barns) of material m in region j for multigroup diffusion theory case A. <u>$(1 < j < j_{\max}; 1 < m < m_{\max})$</u> .

* These are the interpolation end-point parameters used to obtain the data for Block 34. (Output data from the two-dimensional multigroup diffusion synthesis code BISYN⁽³⁾ can be processed to provide the Data Block 39 input in the required format on tape or punched cards.)

DATA BLOCK 39 - Parameters Supplied by Multigroup Diffusion Cases Run (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
39-6	$\sigma_{f_{m,j}}^{(b)}$	SIGFB (MT,JR)	Similar to no. 39-5, except for multigroup diffusion theory case B.
39-7	$\sigma_{c_{m,j}}^{(a)}$	SIGCA (MT,JR)	Radiative capture cross section (one-group reaction rate cross section in barns) of material m in region j for multigroup diffusion theory case A. ($1 < j < j_{\max}$; $1 < m < m_{\max}$).
39-8	$\sigma_{c_{m,j}}^{(b)}$	SIGCB (MT,JR)	Similar to no. 38-7, except for multigroup diffusion theory case B.
39-9	$\phi_j^{(a)}$	PHIA(JR)	Flux integrated over region j (neutron-cm/sec) for multigroup diffusion theory case A. ($1 < j < j_{\max}$).
39-10	$\phi_j^{(b)}$	PHIB(JR)	Similar to no. 39-9, except for multigroup diffusion theory case B.
39-11	$V_j^{(a)}$	VOLA(JR)	Volume of region j (cm^3) for multigroup diffusion theory case A. ($1 < j < j_{\max}$).

DATA BLOCK 39 - Parameters Supplied by Multigroup Diffusion Cases Run (Input Data).

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
39-12	$V_j^{(b)}$	VOLB(JR)	Volume of region j (cm^3) for multigroup diffusion theory case B. ($1 < j < j_{\text{max}}$).
39-13	$K_{\text{ref}}^{(a)}$	REFKA	Reactivity (effective multiplication constant) for multigroup diffusion theory case A associated with compositions $N_{m,j}^{(a)}$.
39-14	$K_{\text{ref}}^{(b)}$	REFKB	Similar to no. 39-13, except for multigroup diffusion theory case B associated with compositions $N_{m,j}^{(b)}$.

DATA BLOCK 40 - WORKING DATA VARIABLES

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
40-1	g	NG	Identification index for a composite zone ($1 \leq g \leq g_{\max}$)
40-2	h	NH	Identification index for a unit set of fabrication and reprocessing costs per Kg of fuel. ($1 \leq h \leq h_{\max}$)
40-3	i	ITER	Identification number of burnup iteration ($1 \leq i \leq I_{\max}$)
40-4	i'	IN	Identification number of alternate economic assumptions. ($1 \leq i \leq N_{\text{alt}}^{\max}$)
40-5	I_h	IH	Identification number of holdup time in stored and recycle fuel repositories. ($1 \leq I_h \leq I_h^{\max}$)
40-6	j	JR	Region indicator ($1 \leq j \leq j_{\max}$)
40-7	J	JZ	Zone indicator ($1 \leq J \leq J_{\max}$)
40-8	k	KT	Identification number of data overlay set ($1 \leq k \leq k_{\max}$)
40-9	L	LINT	Identification number of material designator used in interpolation scheme ($1 \leq L \leq L_{\max}$)
40-10	m	MX	Material designator ($1 \leq m \leq m_{\max}$)
40-11	n	NB	Batch identification ($1 \leq n \leq N_{\max}^{\text{bat}}$)
40-12	N	NS	Identification number of source ($1 \leq N \leq N_{\max}$) Also used for stored and recycle fuel repositories ($1 \leq NS \leq N_{\max}^{\text{TotU}}$)
40-13	q	MQ	Identification number of material designator found in the source ($1 \leq q \leq q_{\max}^{(N)}$)

DATA BLOCK 41 - Isotopic Fuel Concentrations at End of Operating Interval.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
41-1	$N_{m,j,n}^{(e)}$	CNE (MT,JR,NB)	Concentration (atoms/barn-cm) of material m in batch n of region j at end of operating interval. (See no. 29-1 for corresponding material concentrations at beginning of interval.)

DATA BLOCK 42 - Removal Cross Sections, Energy Produced in Fuel Batches During
Current Operating Interval, and Coefficients for Burnup
Calculations.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
42-1	$\sigma_{r,m,j}$	SIGR (MT,JR)	Removal cross section (barns) of material m in region j ($1 < j < j_{\max}$; $1 < m < m_{\max}$). Sum of fission and capture cross sections plus equivalent removal cross section due to radioactive decay - see statements (3-7), (3-8), and (3-9).
42-2	$E_{J,n}^{th}$	ETH (JZ,NB)	Energy (megawatt days) produced in fuel batch n of zone J ($1 < J < J_{\max}$; $1 < n < N_J^{bat}$) during current operating interval. (Contributes to $E_{J,n}^{(o) th}$ -- see no. 30B-1 above.)
42-3	$A_{m'',m'}$	ACO (MTPP,MTP)	Coefficients for fuel burnup calculations ($1 < m'' < 5$, $1 < m' < m_{\max}^{fuel}$) -- see statements (3-28) through (3-31).

DATA BLOCK 43 - Other Working Data Arrays

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
43-1	Z_j	ZEE(JR)	Irradiation fluence in region j ($1 < j < j_{\max}$) during operating interval - see statement (3-6).
43-2	$\frac{A_m^{\text{wt}}}{602.5}$	AWT(MT)	Atomic weight of material m ($1 < m < m_{\max}$) divided by 602.5 - gives Kg per 10^{24} atoms.
43-3	$P_{j_{\text{pk}},n}^{\text{th}}$	PTHJPK (NB)	Energy density - proportional to average power density during operating interval - in batch n region of peak power density (region j_{pk}). ($1 < n < N_{j_{\text{pk}}}^{\text{bat}}$).
43-4	$E_{m'}$	EMEVP(MT)	Energy in MeV per fission for material m' ($1 < m' < 11$) used by code if overlay values in Data Block 28 are not supplied. See statements (2-4) and (2-8) through (2-11).
43-5	$A_{m'}^{\text{wt}}$	AWTP(MT)	Atomic weight of material m' ($1 < m' < 14$) used by code to compute $A_m^{\text{wt}}/602.5$ -- see no. 43-2 above and statements (2-5), (2-6), (2-7), and (2-13) through (2-19).
43-6	V_m	VALP(MTP)	Value of fuel isotope m ($2 < m < m_{\max}^{\text{fuel}}$) in \$/Kg -- see Section 3. 4. 5. 3.

DATA BLOCK 43 - Other Working Data Arrays

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
43-7	$\Delta_f^{(\ell)}$	DELSF(LR)	Variables used in equations that adjust $f_v^{(\ell)}$ values ($1 < \ell < 4$) -- see no. 32-4 above - to obtain improved fissile "enrichments" for next iteration - see Section 3.3.15.
43-8	$N_{dis}'(J)$	NLB(JZ)	Number of fuel batches replaced in zone J ($1 < J < J_{max}$) at end of preceeding operating interval.

DATA BLOCK 44 - Other Floating Point Working Data Constants

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
44-1	T	TDA	Current operating interval time (days).
44-2	ΔT	DELTD	Maximum acceptable departure in current operating interval time T (days) to satisfy burnup and K_{eff} criteria. See no. 44-1.
44-3	T_{orig}	TORIG	Desired current operating interval time (days) -- prior to any adjustment that may have been made to satisfy burnup and K_{eff} criteria.
44-4	T_{I-1}	TIMI	Time (days) of preceeding operating interval.
44-5	$(T_{orig})_{I-1}$	TORIMI	Desired time (days) of preceeding operating interval -- prior to adjustment that may have been made to satisfy burnup and K_{eff} criteria.
44-6	f	FLOD	Load factor for current operating interval.
44-7	P^{th}	PTH	Desired rated power (thermal megawatts).
44-8	$\bar{P}^{th}$	PAVTH	Calculated rated power (thermal megawatts).
44-9	P_o^{th}	PZETH	Power (thermal megawatts) at beginning of operating interval if the flux were held constant to give an average rated power level of $\bar{P}^{th}$ during the operating interval. (In the calculation, a constant flux is assumed -- whereas flux would be varied to give the rated power level in the actual reactor.)

DATA BLOCK 44 - Other Floating Point Working Data Constants

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
44-10	P_e^{th}	PENTH	Similar to no. 44-9 above, except for end of operating interval instead of beginning.
44-11	R_p	RP	Flux normalization factor used in last burnup iteration step to give desired rated power.
44-12	$R_p^{(1)}$	RPI	First-iteration flux normalization factor - see no. 44-10 for second-iteration flux normalization factor. These are iterations in the two-step burning routine to satisfy the desired rated power level - as distinguished from the iterations performed to satisfy criteria on K_{eff} , burnup, power peaking, and burnup reactivity which involve repeats of the entire two-step burnup routine.
44-13	$\bar{P}_1^{th}$	PAVTHI	First-iteration calculated rated power (thermal megawatts). See no. 44-8 above for second-iteration calculated rated power, and see also discussion under no. 44-12 above.
44-14	a_r	ARPOW	Quantity used for calculation of R_p - see no. 44-11 above, and statements (3-44) through (3-47).
44-15	K	EK	K_{eff} at end of current operating interval.

DATA BLOCK 44 - Other Floating Point Working Data Constants

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
44-16	ΔK^-	DELKM	Largest reactivity departure from desired value $K^{(e)}$ permitted on the low side of $K^{(e)}$ at end of current operating interval.
44-17	(ΔK)	DELKBU	Reactivity change (ΔK) due to fuel burnup during current operating interval.
44-18	$(\Delta K)_{\text{control}}^{\text{burn}}$	DKBCON	Maximum acceptable magnitude of $(\Delta K)_{\text{burnup}}$ - see no. 44-17.
44-19	K_{adj}	DELKAJ	Reactivity change to be achieved by isotopic content adjustments for next iteration done to satisfy criterion on K_{adj} .
44-20	$K_{\text{adj}}^{(i-1)}$	DKAJM	Value of ΔK_{adj} for the preceeding iteration done to satisfy K_{eff} criterion - see no. 44-19.
44-21	$K_{\text{adj}}^{(i-2)}$	DKAJM2	Value of ΔK_{adj} two iterations past - see no. 44-19.
44-22	$K^{(i-1)}$	EKM1	K_{eff} at the end of the operating interval for the preceeding iteration done to satisfy K_{eff} criterion.
44-23	$K^{(i-2)}$	EKM2	K_{eff} at the end of the operating interval two iterations past.

DATA BLOCK 44 - Other Floating Point Working Data Constants

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
44-24	B_{test}	BTEST	Desired burnup (megawatt days per metric ton) for fuel discharged from designated zones at end of current operating interval.
44-25	ΔB_{test}	DBTEST	Maximum acceptable departure from desired burnup - see 44-24.
44-26	B	BU	Average burnup (megawatt-days/metric ton) of fuel discharged at end of current operating interval from zones designated by input data.
44-27	$B^{(0)}$	BUZ	Portion of burnup B - see no. 44-26 above - accrued from earlier operating intervals.
44-28	$B^{(1)}$	BUL	Portion of burnup B acquired during current operating interval - see nos. 44-26 and 44-27.
44-29	P^{pk}	PPK	Ratio of power density in region of peak power to average power density in zones designated by input data.
44-30	P^{pk}_{test}	PKTEST	Maximum acceptable value of P^{pk} - see no. 44-29.
44-31	W	WV	Total weight of material desired from a given recycle repository N with holdup time I_h in order to satisfy reload requirements - see statement

DATA BLOCK 44 - Other Floating Point Working Data Constants

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
44-32	ΔR	DELR	Portion of reactivity change for next iteration, ΔK - see no. 44-19 - to be made up by isotopic adjustments (i.e., "enrichment" changes) in a given zone J_v (one of the zones in the loop $v_o < v < v_{max}$).
44-33	λ_{241}	D241	Decay constant of Pu-241 (sec^{-1}) - see statement (2-3).
44-34	λ_{233}	D233	Decay constant of Pu-233 (sec^{-1}) - see statement (2-3).
44-35	r_{st}	RST	See special routine for time adjustment to satisfy K_{eff} when there are no variable fissile zones - Section 3.3.16. A value of either + 1 or - 1 is assigned to r_{st} in accordance with statement (4-414).
44-36	V_{enr}	VENR	Value of U-235 in \$/Kg as calculated by "enrichment" formula - see statement (4-132).
44-37	F_{feed}	FFEED	Function of feed "enrichment" (assumed to be natural U at 0.711% U-235 - see statement (2-23)
44-38	F_{tails}	FTAILS	Function of tails "enrichment" - see statement (4-127).

DATA BLOCK 44 - Other Floating Point Working Data Constants.

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
44-39	A_{enr}	AENR	Value function of ($F_{feed} - F_{tails}$) - see nos. 44-37 and 44-38 above - and of unit costs of feed.
44-40	A^{int}	AINR	End points for interpolation routine based
44-41	B^{int}	BINT	on compositions of multigroup diffusion theory cases A and B respectively - see statements (2-24) through (2-27).
44-42	R^{int}	RINT	Interpolation factor for current operating interval obtained from composition at end of preceeding operating interval - see statements (3-130) through (3-137) and also remainder of Section 3.3.7 for equations used in the interpolation routine involving A^{int} , B^{int} , and R^{int} .

DATA BLOCK 45 - Other Fixed Point Working Data Constants

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
45-1	I	IOP	Current operating interval number.
45-2	i	ITER	Iteration number in current interval (iterations to satisfy criteria on K_{eff} , burnup, etc.)
45-3	I_t	ITPOW	Iteration number in the 2-step burnup sequence (for each iteration i) to satisfy desired power level. I_t is 1 or 2.
45-4	I_{halt}	KWIT	<p>Instructs that computation be stopped if $I_{halt} > 0$. $I_{halt} = 6$ is a normal halt, indicating that the last operating interval, I_{max}, has been completed. Other values of I_{halt} (> 0 and $\neq 6$) indicate an error stop as follows:</p> <ol style="list-style-type: none"> 1 - Cannot satisfy desired power rating in 2-step burnup sequence. 2 - Too many iterations (K_{eff} criterion not satisfied with $i = i_{max}$). 3 - Burnup criterion cannot be satisfied with specified time allowance ΔT. 4 - Relative power density in region J_{pk} of peak power density exceeds allowable limit. 5 - Magnitude of reactivity change due to fuel burnups exceeds allowable limit. 6 - Normal halt on I_{max} as discussed above.

DATA BLOCK 45 - Other Fixed Point Working Data Constants

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
45-4 (con't)	T_{halt}	KWIT	<p>7 - Error that results in a zero denominator for item in eqns (3-211) and (3-214).</p> <p>8 - Error that results in a calculated zero or negative weight of recycle or fissile makeup material for the reload fuel of zone J_{v_0} in order to satisfy reactivity requirements for the new operating interval.</p> <p>9 - Error that results in a calculated negative weight of fissile makeup or fertile makeup material in the reload fuel for any zone J_v ($v_0 < v < v_{max}$) - or results in a zero denominator in several equations (occurs if $R_v^{(3)} N_v^{(4)} = R_v^{(4)} N_v^{(3)}$).</p> <p>10 - Error that results in a need for a negative fissile content in some zone J_v ($v_0 < v < v_{max}$) in order to satisfy the K_{eff} criterion.</p> <p>> 10 - See Error Message Printout in Section 6.2</p>
45-5	δ_{ur}	INUR	<p>1 indicates that U^{238}-Pu burnup chain is to be treated; 0 not to be treated. Used, along with nos. 45-9 through 45-13 below, in the burnup routine and determined separately.</p>

DATA BLOCK 45 - Other Fixed Point Working Data Constants

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
45-6	δ_{thor}	INTHOR	1 indicates that complete Th ²³² -U burnup chain is to be treated; 0 not to be treated.
45-7	δ_{235}	IN235	1 indicates only U-235 and U-236 portion of Th ²³² -U burnup chain is to be treated; 0 otherwise.
45-8	δ_{gp}	IGP	See statement (4-24f). $\delta_{\text{gp}} = 1$ if the zone being calculated in the output routine is a member of a composite zone group and if that zone is not the last member (highest zone number) of the composite zone group; otherwise $\delta_{\text{gp}} = 0$.
45-9	δ_{burn}	INBU	1 means that a previous operating interval time adjustment has been made in an attempt to satisfy the burnup criterion; otherwise $\delta_{\text{burn}} = 0$. (A second time adjustment will not be attempted).
45-10	$\delta_{\text{stor only}}$	ISTON	1 means that a previous operating interval time adjustment has been made in an attempt to satisfy the K_{eff} criterion with no variable fissile content zones (i.e., $v_{\text{stor}} = v_{\text{max}}$); otherwise $\delta_{\text{stor only}} = 0$. (A second time adjustment will not be attempted.)

DATA BLOCK 45 - Other Fixed Point Working Data Constants

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
45-11	J_{pk}	JZPK	Zone that contains region j (designated as the region of peak power density to be used in the test against the power peaking criterion).
45-12	M_{241}	MT241	Material number for isotope Pu-241.
45-13	M_{233}	MT233	Material number for isotope Pa-233.

DATA BLOCK 51A - Operating Interval, Iteration Indexes and Halt Indicator

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
51A-1	I	IOP	Current operating interval number.
51A-2	i	ITER	Number of iterations required for current operating interval to satisfy criteria on K_{eff} and burnup.
51A-3	I_t	ITPOW	Number of burnup steps (1 or 2) required to satisfy desired power level in last iteration i.
51A-4	I_{halt}	KWIT	If $I_{halt} > 0$, the problem is stopped. See no. 45-7 above for meaning of I_{halt} values greater than zero.

DATA BLOCK 51B - Time, Power, and Burnup

51B-1	T	TDA	Operating interval time (days).
51B-2	f	FLOD	Load factor for current operating interval.
51B-3	$P^{(e)}$	PEL	Calculated electrical power rating (MWe) based on input thermal efficiency factor, and $\bar{P}^{th}$ - see no. 51B-4 below.
51B-4	$\bar{P}^{th}$	PAVTH	Calculated thermal power rating (MWt) based on energy produced and fT above.
51B-5	B	BU	Fuel burnup (megawatt-days per metric ton of U+Pu+Th) averaged over fuel batches discharged from designated zones at end of operating step.

DATA BLOCK 51B - Time, Power and Burnup

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
51B-6	T_{yr}^{acc}	TACYR	Accumulated reactor operating time (yrs) from startup through end of current operating interval.

DATA BLOCK 51C - Reactivity, Power Peaking, Breeding Ratio, and Doubling Time

51C-1	K	EK	K_{eff} at end of current operating interval.
51C-2	$(\Delta K)_{burnup}$	DELKBU	Reactivity change (ΔK) due to fuel burnup during operating interval.
51C-3	p^{pk}	PPK	Ratio of power density in region of peak power (j_{pk}) to average power density in designated zones.
51C-4	$\bar{R}^{breed}$	BRAVG	Breeding ratio (average over operating interval) - rate of fissile atom creation to rate of fissile atom destruction (Pu-239, Pu-241, Pa-233, U-233, and U-235 considered to be fissile).
51C-5	T_{doub}	TDOUB	Fissile weight doubling time in years (based solely on fissile material buildup rate and inventory for current operating interval).

DATA BLOCK 51D - Supplementary Information on Power and Breeding Ratio

51D-1	R_p	RP	Flux normalization factor used to satisfy desired power level.
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DATA BLOCK 51D - Supplementary Information on Power and Breeding Ratio

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
51D-2	P_o^{th}	PZETH	Power level (MWt) at beginning of operating interval if flux were held constant to give an average rated power level $\bar{P}^{th}$ - see no. 51B-4 above - during operating interval.
51D-3	P_e^{th}	PENTH	Similar to 51D-2 above, except for end of operating interval instead of beginning.
51D-4	R_{init}^{breed}	BRINIT	Breeding ratio at beginning of operating interval - see no. 51C-3 above.
51D-5	R_{end}^{breed}	BREND	Breeding ratio at end of operating interval - see no. 51C-4 above.

DATA BLOCK 51E - Summary of Fuel Weights Discharged From Reactor

51E-1	W_{out}	WFOUT	Total weight (Kg) of fuel discharged from reactor at end of current operating interval. (Includes fuel which is to be stored for later reload or is to be shuffled from one reactor zone to another.)
51E-2	P_{out}^{tot}	PTOUT	Weight (Kg) of total plutonium discharged - see no. 51E-1 for other qualifications.
51E-3	P_{out}^{fis}	PFOUT	Weight (Kg) of Pu-239 + Pu-241 discharged - see no. 51E-1 for other qualifications.
51E-4	U_{out}^{tot}	UTOUT	Weight (Kg) of total U + Pa-233 discharged - see no. 51E-1 for other qualifications.
51E-5	U_{out}^{fis}	UFOUT	Weight (Kg) of U-233 + U-235 + Pa-233 discharged - see no. 51E-1 for other qualifications.

DATA BLOCK 51F - Fuel Weights Discharged from Reactor Broken Down by Material
(Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
51F-1	W_m^{out}	WOUT(MT)	Weight (Kg) of material m discharged $(1 < m < m_{\text{max}})$ - see no. 51E-1 for other qualifications.

DATA BLOCK 51G - Summary of Fuel Weights Loaded Into Reactor (Output Data)

51G-1	W_{in}	WFIN	Similar to nos. 51E-1 through 51E-5 above,
51G-2	$P_{\text{in}}^{\text{tot}}$	PTIN	except for fuel loaded into the reactor at
51G-3	$P_{\text{in}}^{\text{fis}}$	PFIN	the beginning of the operating interval .
51G-4	$U_{\text{in}}^{\text{tot}}$	UTIN	(instead of that discharged at end of
51G-5	$U_{\text{in}}^{\text{fis}}$	UFIN	interval). (Weights include loaded fuel that may have been previously irradiated and stored or that may be shuffled from one zone into another.)

DATA BLOCK 51H - Fuel Weights Loaded Into Reactor Broken Down by Material (Output Data)

51H-1	W_m^{in}	WIN(MT)	Weight (Kg) of material m loaded $(1 < m < m_{\text{max}})$ - see Block 51G for other qualifications.
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DATA BLOCK 51I - Summary of In-Pile Fuel Weight Inventories Averaged Over Operating
Interval (Output Data)

51I-1	$W_{\text{mid inv}}$	WFMINV	Similar to nos. 51E-1 through 51E-5 above,
51I-2	$P_{\text{mid inv}}^{\text{tot}}$	PTMINV	except for fuel inventory weights held in the
51I-3	$P_{\text{mid inv}}^{\text{fis}}$	PFMINV	reactor averaged over the current operating
51I-4	$U_{\text{mid inv}}^{\text{tot}}$	UTMINV	interval (instead of discharged fuel weights).
51I-5	$U_{\text{mid inv}}^{\text{fis}}$		

DATA BLOCK 51J - Average In-Pile Fuel Weights Broken Down by Material (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
51J-1	$W_m^{\text{mid inv}}$	WMINV(MT)	Inventory weight (Kg) of material m ($1 < m < m_{\text{max}}$) held in the reactor averaged over the current operating interval.

DATA BLOCK 51K - Summary of In-Pile Fuel Weight Inventories at End of Operating Interval (Output Data)

51K-1	$W_{\text{end inv}}$	WFEINV	Similar to nos. 51E-1 through 51E-5 above,
51K-2	$P_{\text{end inv}}^{\text{tot}}$	PTEINV	except for fuel inventory weights held in the reactor at the end of the current
51K-3	$P_{\text{end inv}}^{\text{fis}}$	PFEINV	operating interval (instead of discharged fuel weights).
51K-4	$U_{\text{end inv}}^{\text{tot}}$	UTEINV	
51K-5	$U_{\text{end inv}}^{\text{fis}}$		

DATA BLOCK 51L - In-Pile Fuel Weights at End of Operating Interval Broken Down by Material (Output Data)

51L-1	$W_m^{\text{end inv}}$	WEINV(MT)	Inventory weight (Kg) of material m ($1 < m < m_{\text{max}}$) held in the reactor at the end of the current operating interval.
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DATA BLOCK 51M - Summary of Total Fuel Weight Inventories

51M-1	W_{sys}	WFSYS	Similar to nos. 51E-1 through 51E-5 above,
51M-2	$P_{\text{sys}}^{\text{tot}}$	PTSYS	except that these are total inventory weights - in-pile plus out-of-pile (instead of dis-
51M-3	$P_{\text{sys}}^{\text{fis}}$	PFSYS	charged fuel weights). The in-pile weights are the same as for Data Block 51I (averaged

DATA BLOCK 51M - Summary of Total Fuel Weight Inventories (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
51M-4	$U_{\text{sys}}^{\text{tot}}$	UTSYS	over the current operating interval) and the
51M-5	$U_{\text{sys}}^{\text{fis}}$	UFSYS	out-of-pile weights consist of fuel held in storage repositories plus that undergoing fabrication and reprocessing (the latter computed from the amount of fresh fuel loaded and spent fuel discharged for the current operating interval and the average fabrication and reprocessing times relative to the operating interval time.

DATA BLOCK 51N - Total Fuel Weights Broken Down by Material (Output Data)

51N-1	W_m^{sys}	WSYS(MT)	Total weight (Kg) of material m ($1 < m < m_{\text{max}}$). See Data Block 51M above for further defini- tion of "total weight".
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DATA BLOCK 51O - Energy Produced in Discharged and Spent Fuel (Output Data)

51O-1	I	IOP	Current operating interval number.
51O-2	E	EDIS	Energy produced (10^6 Btu if $\delta_{\text{unit}}^{\text{cost}} = 0$; electrical kwh if $\delta_{\text{unit}}^{\text{cost}} = 1$) in spent fuel discharged from reactor at end of current operating interval for reprocessing.
51O-3	E_{acc}	EACCU	Accumulated energy produced (see no. 51Q-2) in spent fuel discharged from reactor for reprocessing since startup (summed over all operating intervals through current one).

DATA BLOCK 51O - Energy Produced in Discharged and Spent Fuel (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
51O-4	E_{acc}^{lev}	EACLEV	Levelized accumulated energy in spent fuel (similar to no. 51Q-3 except a discount factor is applied to allow for decreasing value of revenue from power with increasing time from startup.)

DATA BLOCK 51P - Total Fuel Cost of Discharged and Spent Fuel (Output Data)

51P-1	$C_{i'}^{tot}$	CTOT(IN)	Total cost ($\$/10^6$ Btu if $\delta_{unit}^{cost} = 0$; mill/ kwh if $\delta_{unit}^{cost} = 1$) of the fuel discharged from the reactor for reprocessing at the end of the current operating interval. (Com- ponents of the total fuel cost are given in Data Block 51Q.) The different total fuel costs corresponding to the subscript i' ($1 < i' < N_{alt}^{max} + 1$) are for the reference set of economic assumptions ($i' = 1$) and the alternate sets of economic assumptions ($2 < i' < N_{alt}^{max} + 1$).
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DATA BLOCK 51Q - Component Fuel Costs of Discharged and Spent Fuel (Output Data)

51Q-1	$C_{i'}^{fab}$	CFAD(IN)	Fabrication cost component of $C_{i'}^{tot}$ - see no. 51P-1 for further definition.
51Q-2	$C_{i'}^{repr}$	CREPD(IN)	Reprocessing cost component of $C_{i'}^{tot}$ - see no. 51P-1 for further definition.

DATA BLOCK 51Q - Component Fuel Costs of Discharged and Spent Fuel (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
51Q-3	$C_{i'}^{cred}$	CREDD(IN)	Fuel isotopic depletion cost component (negative for a breeder) of $C_{i'}^{tot}$ - see no. 51P-1 for further definition.
51Q-4	$C_{i'}^{inv}$	CIND(IN)	Fuel isotopic inventory cost component of $C_{i'}^{tot}$ - see no. 51P-1 for further definition.
51Q-5	$C_{i'}^{fab inv}$	CFAIND(IN)	Fuel fabrication inventory cost component of $C_{i'}^{tot}$ - see no. 51P-1 for further definition.
51Q-6	$C_{i'}^{repr inv}$	CREIND(IN)	Fuel reprocessing negative inventory cost component of $C_{i'}^{tot}$ - see no. 51P-1 for further definition.

DATA BLOCK 51R - Levelized Total Fuel Cost of Discharged and Spent Fuel (Output Data)

51R-1	$C_{i'}^{lev}$	CLEV(IN)	Levelized total fuel cost for spent fuel discharged from the reactor from startup through the current operating interval. A discount factor is applied to both costs and energy (see no. 51Q-4 above) to allow for a decreasing value of money with increasing time reckoned from the time of reactor start- up. Unit of fuel cost is $\$/10^6$ Btu if $\delta_{unit}^{cost} = 0$; mill/kwh if $\delta_{unit}^{cost} = 1$. The different levelized fuel costs corresponding to the subscript i' ($1 < i' < N_{alt}^{max} + 1$) are for the reference ($i' = 1$) and alternate sets of economic assumptions.
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DATA BLOCK 51S - Energy Produced by Reactor (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
51S-1	I	IOP	Current operating interval number.
51S-2	E_{int}	EINT	Energy produced (10^6 Btu if $\delta_{unit}^{cost} = 0$; electrical kwh if $\delta_{unit}^{cost} = 1$) by reactor during current operating interval.
51S-3	E_{acc}	EACC	Accumulated energy produced (see no. 51S-2) by reactor from startup through current operating interval.
51S-4	E_{acc}^{lev}	EACCLV	Levelized accumulated energy produced by reactor (similar to no. 51S-3 except a discount factor is applied to allow for decreasing value of revenue from power with increasing time from startup.)

DATA BLOCK 51T - Total Fuel Cost for Current Operating Interval (Output Data)

51T-1	$C_{i'}^{tot}$	CPTOT(IN)	Total fuel cost ($\text{\$/10}^6$ Btu if $\delta_{unit}^{cost} = 0$; mill/kwh if $\delta_{unit}^{cost} = 1$) for current operating interval. See cost_{meth} - no. 1-26 above - for distinction between $C_{i'}^{tot}$ and $C_{i'}^{tot}$ (no. 51P-1 above). Subscript i' ($1 < i' < N_{alt}^{max} + 1$) refers to the reference ($i' = 1$) and the alternate sets of economic assumptions.
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DATA BLOCK 51U - Component Fuel Costs for Current Operating Interval (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
51U-1	$C_i'^{fab}$	CPFAB(IN)	Fabrication cost of fresh fuel loaded into reactor at beginning of current operating interval. (Component of $C_i'^{tot}$ - see no. 51T-1 for further definition.)
51U-2	$C_r'^{repr}$	CPREP(IN)	Reprocessing cost of spent fuel discharged from reactor for reprocessing at end of current operating interval. (Component of $C_i'^{tot}$ - see no. 51T-1 for further definition.)
51U-3	$C_i'^{cred}$	CPCRED(IN)	Fuel isotopic depletion cost (negative for a breeder) - difference between cost for freshly loaded fuel at beginning of operating interval and credit for spent fuel discharged at end of operating interval. (Component of $C_i'^{tot}$ - see no. 51T-1 for further definition.)
51U-4	$C_i'^{inv}$	CPINV(IN)	Fuel isotopic inventory cost for in-pile and out-of-pile fuel for current operating interval. (Component of $C_i'^{tot}$ - see no. 51T-1 for further definition.)
51U-5	$C_i'^{fab inv}$	CPFAIN(IN)	Fuel fabrication inventory cost for in-pile and out-of-pile fuel (except excludes spent fuel reprocessing time) for current operating interval. (Component of $C_i'^{tot}$ - see no. 51T-1, for further definition.)

DATA BLOCK 51U - Component Fuel Costs for Current Operating Interval (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
51U-6	$C_i^{\text{'repr inv}}$	CPREIN(IN)	Fuel reprocessing negative inventory cost for in pile and out-of-pile fuel (except excludes fresh fuel fabrication time) for current operating interval. (Component of $C_i^{\text{'tot}}$ - see no. 51T-1 for further definition.)

DATA BLOCK 51V - Levelized Total Fuel Cost for Current Operating Interval (Output Data)

51V-1	$C_i^{\text{'lev}}$	CPLEV(IN)	<p>Levelized total fuel cost for all reactor operating intervals from startup through the current operating interval. A discount factor is applied to both costs and energy (see no. 51S-4 above) to allow for a decreasing value of money with increasing time reckoned from the time of reactor startup.</p> <p>Unit of fuel cost is $\\$/10^6$ Btu if $\delta_{\text{unit}}^{\text{cost}} = 0$; mill/kwh if $\delta_{\text{unit}}^{\text{cost}} = 1$. The different levelized fuel costs corresponding to the subscript i' ($1 < i' < N_{\text{alt}}^{\text{max}} + 1$) are for the reference ($i' = 1$) and alternate sets of economic assumptions.</p>
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DATA BLOCK 52A - Zonal Fuel Batch Identification, Power, and Energy (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
52A-1	J_w	JW	Zone number being considered in current output data calculation or printout. If output is for a composite group of zones - see no. 25A-4 above - then printout will indicate both the lowest and the highest zone numbers in the composite group (i.e., $J_{w_{g-1}} + 1$ and J_{w_g} if $\delta_{g}^{group} = 1$).
52A-2	I	IOP	Current operating interval number.
52A-3	$\bar{P}_{J_w}^{th}$	PTHW	Power (thermal megawatts) produced by zone J_w during current operating interval (at mid-burnup composition) when reactor is at calculated rated power.
52A-4	$E_{J_w}^{int}$	EINTW	Energy (10^6 Btu if $\delta_{unit}^{cost} = 0$; electrical kwh if $\delta_{unit}^{cost} = 1$) produced by zone J_w during current operating interval.

DATA BLOCK 52A - Zonal Fuel Batch Identification, Power, and Energy (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
52A-5	E_{J_w}	EDISWP	Energy produced in spent fuel discharged from zone J_w at end of current operating interval (units same as no. 52A-4 above).

DATA BLOCK 52B - Summary of Zonal Discharged Fuel Weights and Burnup (Output Data)

52B-1	B_{J_w}	BUW	Burnup (megawatt-days per metric ton of U + Pu + Th) of fuel discharged from zone J_w . *
52B-2	$W_{J_w}^{out}$	WOUTW	Total fuel weight (Kg of U + Pu + Th initially loaded) discharged from zone J_w . *
52B-3	$P_{J_w}^{tot out}$	PTOUTW	Total plutonium weight (Kg) discharged from zone J_w . *
52B-4	$P_{J_w}^{fis out}$	PFOUTW	Weight of Pu-239 + Pu-241 (Kg) discharged from zone J_w . *
52B-5	$U_{J_w}^{tot out}$	UTOUTW	Total uranium weight (Kg) discharged from zone J_w . *
52B-6	$U_{J_w}^{fis out}$	UFOUTW	Weight of U-235 + U-233 + Pa-233 (Kg) discharged from zone J_w . *

* At end of current operating interval.

DATA BLOCK 52C - Zonal Discharged Fuel Weights and Burnup Broken Down by Fuel Batch (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
52C-1	N_n'	NBP	Identification number ($n_1^{dis} < N_n' < n_2^{dis}$) of discharged fuel batch* - see statement (4-24e).
52C-2	$B_{J_w,n}$	BUB(NB)	Similar to 52B-1 through 52B-6 above, except
52C-3	$W_{J_w,n}^{out}$	WOUTB(NB)	for each discharged batch ($n_1^{dis} < N_n' < n_2^{dis}$) from zone J_w instead of all fuel discharged from
52C-4	$P_{J_w,n}^{tot out}$	PTOUTB(NB)	the zone. (If only one batch is being dis-
52C-5	$P_{J_w,n}^{fis out}$	PFOUTB(NB)	charged from the zone output data corresponding to this block is redundant and will not be
52C-6	$U_{J_w,n}^{tot out}$	UTOUTB(NB)	printed.)
52C-7	$U_{J_w,n}^{fis out}$	UFOUTB(NB)	

DATA BLOCK 52D - Zonal Discharged Fuel Weights Broken Down by Material (Output Data)

52D-1	W_{m,J_w}^{out}	WOUTM(MT)	Weight (Kg) of material m ($1 < m < m_{max}$) discharged from zone J_w at end of current operating interval.
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DATA BLOCK 52E - Zonal Discharged Fuel Weights Broken Down by Batch and Material (Output)

52E-1	N_n'	NBP	Same as no. 52C-1 above.
52E-2	$W_{m,J_w,n}^{out}$	WOUTMB (MT,NB)	Weight (Kg) of material m ($1 < m < m_{max}$) discharged from zone J_w in batch number N_n' ($n_1^{dis} < N_n' < n_2^{dis}$) at end of current operating interval. (Output data corresponding to this block will not be printed if only one batch is being discharged from the zone).

* At end of current operating interval.

DATA BLOCK 52F - Summary of Zonal Loaded Fuel Weights (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
52F-1	$W_{J_w}^{in}$	WINW	Similar to nos. 52B-2 through 52B-6 above,
52F-2	$P_{J_w}^{tot in}$	PTINW	except for fuel loaded into zone J_w at beginning of the current operating interval (instead of fuel discharged at end of interval).
52F-3	$P_{J_w}^{fis in}$	PFINW	
52F-4	$U_{J_w}^{tot in}$	UTINW	
52F-5	$U_{J_w}^{fis in}$	UFINW	

DATA BLOCK 52G - Zonal Loaded Fuel Weights Broken Down by Fuel Batch (Output Data)

52G-1	N_n'	NBP	Similar to no. 52C-1 above, except for loaded batches ($n_1^{load} < N_n' < n_2^{load}$) instead of those discharged.
52G-2	$W_{J_w,n}^{in}$	WINB(NB)	Similar to no. 52C-3 through 52C-7 above,
52G-3	$P_{J_w,n}^{tot in}$	PTINB(NB)	except for loaded fuel batches ($n_1^{load} < N_n' < n_2^{load}$) instead of those discharged. (If only
52G-4	$P_{J_w,n}^{fis in}$	PFINB(NB)	one fuel batch is loaded into zone J_w , the
52G-5	$U_{J_w,n}^{tot in}$	UTINB(NB)	output data included in this block is re-
52G-6	$U_{J_w,n}^{fis in}$	UFINB(NB)	dundant and will not be printed.)

DATA BLOCK 52H - Zonal Loaded Fuel Weights Broken Down by Material (Output Data)

52H-1	W_{m,J_w}^{in}	WINM(MT)	Weight (Kg) of material m ($1 < m < m_{max}$) loaded into zone J_w at end of current operating interval.
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DATA BLOCK 52I - Zonal Loaded Fuel Weights Broken Down by Batch and Material (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
52I-1	N_n'	NBP	Same as no. 52G-1 above.
52I-2	$W_{m,J_w,n}^{in}$	WINMB (MT,NB)	Similar to no. 52E-2 above, except for fuel batches loaded into zone J_w at beginning of current operating interval ($n_1^{load} < N_n' < n_2^{load}$) instead of batches discharged at end of interval. (Output data for this block is not printed as only one batch is loaded.)

DATA BLOCK 52J - Summary of Zonal Average Fuel Weight Inventories During Operating Interval (Output Data)

52J-1	$W_{J_w}^{mid\ inv}$	WMIVW	Total fuel inventory (Kg Pu + U + Th initially loaded) in zone J_w during current operating interval.
52J-2	$P_{J_w}^{tot\ mid\ inv}$	PTMIVW	Total plutonium inventory (Kg) in zone J_w . *
52J-3	$P_{J_w}^{fis\ mid\ inv}$	PFMIVW	Pu-239 + Pu-241 inventory (Kg) in zone J_w . *
52J-4	$U_{J_w}^{tot\ mid\ inv}$	UTMIVW	Total uranium inventory (Kg) in zone J_w . *
52J-5	$U_{J_w}^{fis\ mid\ inv}$	UFMIVW	U-235 + U-233 + Pa-233 inventory in zone J_w . *

DATA BLOCK 52K - Zonal Average Fuel Weight Inventories During Operating Interval Broken Down by Fuel Batch (Output Data)

52K-1	N_n'	NBP	Identification number of fuel batch ($n_1^{dis} < N_n' < n_2^{load}$) - see statements (4-24d) and (4-24e).
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* Averaged over current operating interval.

DATA BLOCK 52K - Zonal Average Fuel Weight Inventories During Operating Interval Broken Down by Fuel Batch (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
52K-2	$W_{J_w, n}^{\text{mid inv}}$	WMIVB(NB)	Similar to nos. 52J-1 through 52J-5 above,
52K-3	$P_{J_w, n}^{\text{tot mid inv}}$	PTMIVB(NB)	except for each fuel batch ($n_1^{\text{dis}} < N_n' < n_2^{\text{load}}$) in zone J_w (instead of being summed over all batches in the zone).
52K-4	$P_{J_w, n}^{\text{fis mid inv}}$	PFMIVB(NB)	
52K-5	$U_{J_w, n}^{\text{tot mid inv}}$	UTMIVB(NB)	
52K-6	$U_{J_w, n}^{\text{fis mid inv}}$	UFMIVB(NB)	

DATA BLOCK 52L - Zonal Average Fuel Weight Inventories During Operating Interval Broken by Material (Output Data)

52L-1	$W_{m, J_w}^{\text{mid inv}}$	WMIVM(MT)	Inventory (Kg) of material m ($1 < m < m_{\text{max}}$) in zone J_w averaged over current operating interval.
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DATA BLOCK 52M - Zonal Average Fuel Weight Inventories During Operating Interval Broken Down by Batch and Material (Output Data)

52M-1	N_n'	NBP	Same as no. 52K-1 above.
52M-2	$W_{m, J_w, n}^{\text{mid inv}}$	WMIVMB (MT, NB)	Inventory (Kg) of material m ($1 < m < m_{\text{max}}$) in fuel batch N_n' ($n_1^{\text{dis}} < N_n' < n_2^{\text{load}}$) of zone J_w averaged over current operating interval.

DATA BLOCK 52N - Summary of Zonal Fuel Weight Inventories at End of Operating Interval (Output Data)

52N-1	$W_J^{\text{end inv}}$	WEIVW	Similar to nos. 52J-1 through 52J-5, except for end of current operating interval (instead of averaged over interval).
52N-2	$P_J^{\text{tot end inv}}$	PTEIVW	

DATA BLOCK 52N - Summary of Zonal Fuel Weight Inventories at End of Operating Interval (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
52N-3	$P_{J_w}^{\text{fis end inv}}$	PFEIVW	
52N-4	$U_{J_w}^{\text{tot end inv}}$	UTEIVW	
52N-5	$U_{J_w}^{\text{fis end inv}}$	UFEIVW	

DATA BLOCK 52O - Zonal Fuel Weight Inventories at End of Operating Interval Broken Down by Fuel Batch (Output Data)

52O-1	N_n	NBP	Similar to nos. 52K-1 through 52K-6, except for end of current operating interval (instead of averaged over interval).
52O-2	$W_{J_w,n}^{\text{end inv}}$	WEIVB(NB)	
52O-3	$P_{J_w,n}^{\text{tot end inv}}$	PTEIVB(NB)	
52O-4	$P_{J_w,n}^{\text{fis end inv}}$	PFEIVB(NB)	
52O-5	$U_{J_w,n}^{\text{tot end inv}}$	UTEIVB(NB)	
52O-6	$U_{J_w,n}^{\text{fis end inv}}$	UFEIVB(NB)	

DATA BLOCK 52P - Zonal Fuel Weight Inventories at End of Operating Interval Broken Down by Material (Output Data)

52P-1	$W_{m,J_w}^{\text{end inv}}$	WEIVM(MT)	Inventory (Kg) of material m ($1 < m < m_{\text{max}}$) in zone J_w at end of current operating interval.
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DATA BLOCK 52Q - Zonal Fuel Weight Inventories at End of Operating Interval Broken Down by Batch and Material (Output Data)

52Q-1	N_n	NBP	Same as no. 52K-1 above.
52Q-2	$W_{m,J_w,n}^{\text{end inv}}$	WEIVMB (MT,NB)	Similar to no. 52M-2 above, except for end of current operating interval (instead of averaged over interval.)

DATA BLOCK 52R - Zonal Total Fuel Costs for Discharged and Spent Fuel (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
52R-1	$C_{J_w}^{\text{tot}}(i')$	CTOTW(IN)	Total fuel cost ($\$/10^6$ Btu if $\delta_{\text{unit}}^{\text{cost}} = 0$; mill/kwh if $\delta_{\text{unit}}^{\text{cost}} = 1$) of spent fuel discharged from zone J_w at end of current operating interval. Superscript i' ($1 < i' < N_{\text{alt}}^{\text{max}} + 1$) denotes the reference ($i' = 1$) and the alternate sets of economic assumptions.

DATA BLOCK 52S - Zonal Component Fuel Costs for Discharged and Spent Fuel (Output Data)

52S-1	$C_{J_w}^{\text{fab}}(i')$	CFABW(IN)	Fabrication cost component of $C_{J_w}^{\text{tot}}(i')$ - see no. 52R-1 above.
52S-2	$C_{J_w}^{\text{repr}}(i')$	CREPW(IN)	Reprocessing cost component of $C_{J_w}^{\text{tot}}(i')$ - see no. 52R-1 above.
52S-3	$C_{J_w}^{\text{cred}}(i')$	CREDW(IN)	Isotopic depletion cost (negative for a breeder) component of $C_{J_w}^{\text{tot}}(i')$ - see no. 52R-1.
52S-4	$C_{J_w}^{\text{inv}}(i')$	CINPW(IN)	Isotopic inventory cost component of $C_{J_w}^{\text{tot}}(i')$ - see no. 52R-1.
52S-5	$C_{J_w}^{\text{fab inv}}(i')$	CFAINW(IN)	Fabrication inventory cost component of $C_{J_w}^{\text{tot}}(i')$ - see no. 52R-1.
52S-6	$C_{J_w}^{\text{repr inv}}(i')$	CREINW(IN)	Reprocessing negative inventory cost component of $C_{J_w}^{\text{tot}}(i')$ - see no. 52R-1.

DATA BLOCK 52T - Zonal Total Fuel Cost for Discharged and Spent Fuel Broken
Down by Fuel Batch (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
52T-1	N_n'	NBP	Batch identification number - same as no. 52C-1.
52T-2	$E_{J_{w,n}}'$	EDISWB(NB)	Energy produced (10^6 Btu if $\delta_{\text{unit}}^{\text{cost}} = 0$; electrical MWT if $\delta_{\text{unit}}^{\text{cost}} = 1$) in spent fuel batch N_n' ($n_1^{\text{dis}} < N_n' < n_2^{\text{dis}}$) discharged from zone J_w at end of current operating interval. (Output data included in this block is not printed if only one batch is discharged from the zone.
52T-3	$C_{J_{w,n}}^{\text{tot}}(i')$	CTOTB (IN,NB)	Similar to no. 52R-1 above, except for each discharged and spent fuel batch ($n_1^{\text{dis}} < N_n' < n_2^{\text{dis}}$) from zone J_w (instead of all spent fuel discharged from the zone).

DATA BLOCK 52U - Zonal Component Fuel Costs for Discharged and Spent Fuel Broken
Down by Fuel Batch (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
52U-1	$C_{J_w, n}^{fab(i')*}$	CFABB (IN,NB)	Similar to nos. 52S-1 through 52S-6 above, except for each discharged and spent fuel batch ($n_1^{dis} < N_n' < n_2^{dis}$) from zone J_w (instead of all the fuel discharged from the zone). These are components of total fuel cost $C_{J_w, n}^{tot(i')}$ - see no. 52T-3 above. (Output data in this block is not printed if only one fuel batch is discharged from the zone.)
52U-2	$C_{J_w, n}^{repr(i')*}$	CREPB (IN,NB)	
52U-3	$C_{J_w, n}^{cred(i')*}$	CREDB (IN,NB)	
52U-4	$C_{J_w, n}^{inv(i')*}$	CINVB (IN,NB)	
52U-5	$C_{J_w, n}^{fab inv(i')*}$	CFAINB (IN,NB)	
52U-6	$C_{J_w, n}^{repr inv(i')*}$	CREINB (IN,NB)	

DATA BLOCK 52V - Zonal Total Fuel Cost for Current Operating Interval (Output Data)

52V-1	$C_{J_w}^{tot(i')}$	CPTOTW (IN)	Total fuel cost ($\$/10^6$ Btu if $\delta_{unit}^{cost} = 0$; mill/kwh if $\delta_{unit}^{cost} = 1$) accrued by fuel in zone J_w during current operating interval. Only those costs incurred in connection with the current operating interval are considered; and energy is that produced by the zone during only the current operating interval. Components of $C_{J_w}^{tot(i')}$ are listed in Block 52W.
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DATA BLOCK 52W - Zonal Component Fuel Costs for Current Operating Interval. (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
52W-1	$C'_{J_w \text{ fab}} (i')$	CPFABW (IN)	Fabrication cost of fresh fuel loaded into zone J_w at beginning of current operating interval.*
52W-2	$C'_{J_w \text{ repr}} (i')$	CPREPW (IN)	Reprocessing cost of spent fuel discharged from zone J_w at end of current operating interval.*
52W-3	$C'_{J_w \text{ cred}} (i')$	CPCREW (IN)	Isotopic cost of fresh fuel loaded into zone J_w at beginning of interval minus isotopic credit for spent fuel discharged from the zone at end of interval.*
52W-4	$C'_{J_w \text{ inv}} (i')$	CPINWV (IN)	Isotopic inventory cost of fuel in zone J_w incurred during current operating interval.*
52W-5	$C'_{J_w \text{ fab inv}} (i')$	CPFINW (IN)	Fabrication inventory cost of fuel in zone J_w incurred during current operating interval.*
52W-6	$C'_{J_w \text{ repr inv}} (i')$	CPRINW (IN)	Reprocessing negative inventory cost of fuel in zone J_w credited during current operating interval.*

* Component of $C'_{J_w \text{ tot}} (i')$ - see no. 52V-1 for units and other conditions.

DATA BLOCK 53A - Material Weight Inventory and Energy Produced by Fuel in Each
Stored Fuel Repository (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
53A-1	$W_{m,N}^{(I_h)}$	WSTO (NS,IH,MT)	Weight (Kg) of material m ($1 < m < m_{\max}$) in stored fuel repository N ($1 < N < N_{\max}^{\text{stor}}$) that has been held out of the reactor for I_h operating intervals ($0 < I_h < I_{\max}^{\text{stor}}$) at the end of the current interval. ($I_h = 0$ is for fuel being shuffled immediately from one zone to another.)
53A-2	$E_N^{(I_h)^{\text{th}}}$	ESTOTH (NS,IH)	Energy produced in previous irradiation (megawatt-days) by fuel in stored fuel repository N ($1 < N < N_{\max}^{\text{stor}}$) that has been held out of the reactor for I_h operating intervals ($0 < I_h < I_{\max}^{\text{stor}}$).

DATA BLOCK 53B - Summary of Fuel Weights Held in All Stored Repositories During Current
Operating Interval (Output Data)

53B-1	W_{stor}	WFSTOR	Total fuel weight (Kg U + Pu + Th + fis. prod.) held in all stored fuel repositories during current interval.*
53B-2	$P_{\text{stor}}^{\text{tot}}$	PTSTOR	Total plutonium weight (Kg) held in all stored fuel repositories during current interval.*
53B-3	$P_{\text{stor}}^{\text{fis}}$	PFSTOR	Pu-239 + Pu-241 weight (Kg) held in all stored fuel repositories during current interval.*

* Does not include stored fuel discharged from reactor at end of current operating interval.

DATA BLOCK 53B - Summary of Fuel Weights Held in All Stored Repositories During Current Operating Interval (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
53B-4	U_{stor}^{tot}	UTSTOR	Total uranium weight (Kg) held in all stored fuel repositories during current interval.*
53B-5	U_{stor}^{fis}	UFSTOR	U-235 + U-233 + Pa-233 weight (Kg) held in all stored fuel repositories during current interval.*

DATA BLOCK 53C - Fuel Weights Held in All Stored Repositories During Current Operating Interval Broken Down by Material (Output Data)

53C-1	W_m^{stor}	WSTORM (MT)	Weight (Kg) of material m ($1 < m < m_{max}$) held in all stored fuel repositories during current interval. (Does not include stored fuel discharged from reactor at end of current operating interval.)
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DATA BLOCK 53D - Total Stored Fuel Inventory Costs for Current Operating Interval (Output)

53D-1	i'	INP	Identification of economic assumption set ($i' = 1$ for reference and $2 < i' < N_{alt}^{max} + 1$ for alternates).
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* Does not include stored fuel discharged from reactor at end of current operating interval.

DATA BLOCK 53D - Total Stored Fuel Inventory Costs for Current Operating Interval
(Output)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
53D-2	$C_{i'}^{\delta st \text{ inv}}$	CPSIT(IN)	Isotopic inventory cost* incurred on all fuel held in stored fuel repositories during current operating interval.
53D-3	$C_{i'}^{\delta st \text{ fab inv}}$	CPSFIT (IN)	Fabrication inventory cost* incurred on all fuel held in stored fuel repositories during current operating interval.
53D-4	$C_{i'}^{\delta st \text{ repr inv}}$	CPSRIT(IN)	Reprocessing negative inventory cost* credited on all fuel held in stored fuel repositories during current operating interval.
53D-5	$C_{i'}^{\delta st \text{ tot inv}}$	CPSTIT(IN)	Total inventory cost* on all stored fuel (sum of Nos. 53D-2, 53D-3, and 53D-4 above.)

DATA BLOCK 53D - Stored Fuel Inventory Costs for Current Operating Interval
Broken Down by Repository (Output Data)

53E-1	i'	INP	Same as no. 53D-1.
53E-2	$C_N^{\delta st \text{ fab inv}(i')}$	CPSIN (NS,IN)	Similar to nos. 53D-2 through 53D-4, except
53E-3	$C_N^{\delta st \text{ fab inv}(i')}$	CPSFIN (NS,IN)	broken down for each stored fuel repository
53E-4	$C_N^{\delta st \text{ repr inv}(i')}$	CPSRIN (NS,IN)	N ($1 < N < N_{\max}^{\text{stor}}$) and fuel held in the repository for I_h operating intervals at the end of the current interval ($1 < I_h < I_{\max}^{\text{stor}}$).
53E-5	N_{N, I_h}^{orig}	NSORIG (NS,IH)	Relates fuel in stored fuel repository to applicable set of fabrication and recovery cost per kg of fuel $NSORIG(NS, IH) = h$ ($1 < h < h_{\max}$)

* $\text{¢}/10^6 \text{ Btu}$ if $\delta_{\text{unit}}^{\text{cost}} = 0$; mill/kwh if $\delta_{\text{unit}}^{\text{cost}} = 1$.

DATA BLOCK 54 - Recycle Material Available (Output Data)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
54-1	$W_{m,N}^{(I_h)}$	WRECM (NS,IH,MT)	Weight (Kg) of material m available on record in recycle repository N ($N_{\max}^{\text{stor}} + 1 < N < N_{\max}^{\text{tot U}}$) that has been out of the reactor for I_h operating intervals at the end of the current operating interval. ($0 < I_h < 3$ -- but note from no. 14-6 above that $I=3$ has a special meaning; namely that it includes all recycle material that has been held in the repository for $I_h^{(N,3)}$ or more operating intervals - see no. 15-1 above.) Material numbers m cover the range of plutonium isotopes (Pu-239 through Pu-242) if $N_{\max}^{\text{stor}} + 1 < N < N_{\max}^{\text{Pu}}$; uranium isotopes excluding U-238 if $N_{\max}^{\text{Pu}} + 1 < N < N_{\max}^{\text{fis U}}$; and uranium isotopes including U-238 if $N_{\max}^{\text{fis U}} + 1 < N < N_{\max}^{\text{tot U}}$.
54-2	$W_N^{(I_h)}$	WTREC (NS,IH)	Weight (Kg) of recycle material available on record in repository N that has been held out of the reactor for I_h operating intervals at the end of the current operating interval (sum over m of $W_{m,N}^{(I_h)}$ - see no. 54-1 above - for recycle isotopes recorded in repository N).
54-3	$W_{233,N}^{(o)}$	WRECPA(NS)	Weight (Kg) of Pa-233 on record in repository N from spent fuel discharged at the end of the current operating interval.

DATA BLOCK 55 - Regional Material Concentrations at Beginning of Operating Interval (Output)

<u>NUMBER</u>	<u>PHYSICS SYMBOL</u>	<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
55-1	$N_{m,j}^{(o)}$	CNBR (MT,JR)	Concentration (atoms/barn-cm) of material m in region j ($1 < j < j_{\max}$; $1 < m < m_{\max}$) at the beginning of the current operating interval.

DATA BLOCK 56 - Regional Material Concentrations at End of Operating Interval (Output)

56-1	$N_{m,j}^{(e)}$	CNER (MT,JR)	Concentration (atoms/barn-cm) of material m in region j ($1 < j < j_{\max}$; $1 < m < m_{\max}$) at the end of the current operating interval.
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DATA BLOCK 57 - Regional Material Concentrations at Beginning of Operating Interval Broken Down by Fuel Batch (Output)

57-1	$N_{m,j,n}^{(o)}$	CNB (MT,JR,NB)	Concentration (atoms/barn-cm) component of $N_{m,j}^{(o)}$ (see no. 55-1 above) contributed by fuel batch n ($1 < n < N_J^{\text{bat}}$ for region j in zone J).
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DATA BLOCK 58 - Regional Material Concentrations at End of Operating Interval Broken By Fuel Batch (Output)

58-1	$N_{m,j,n}^{(e)}$	CNE (MT,JR,NB)	Concentration (atoms/barn-cm) component of $N_{m,j}^{(e)}$ (see no. 56-1 above) contributed by fuel batch n ($1 < n < N_J^{\text{bat}}$ for region j in zone J).
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SECTION VI

INPUT DESCRIPTION AND ERROR MESSAGES

6.1 PROBLEM DIMENSION LIMITS

Variable dimensions are used by FUMBLE to compact the input data in the computer core memory. Thus, some judgement is required in determining dimension limits for a particular problem.

A "normal" large FUMBLE problem will have the following approximate dimensions:

Alternate Economic Assumptions	NALTMX	~2
Stored Fuel Repositories	NSTOMX	~2
Recycle Fuel Repositories	NTUMX-NSTOMX	~3
Repository Hold-up Time (Operating Intervals)	ISTOMX	~4
Make-up Fuel Sources	NSMX	~3
Materials	MTMX	~8
Maximum Number of Fuel Batches (In Any Zone)	NBHI	~12
Core Zones	JZMX	~12
Core Regions	JRMX	~64

These dimension limits are adequate for nearly all anticipated fuel management studies. One exception is the case in which fuel bundles or segments of fuel bundles (i.e., the core and axial blankets) are represented by distinct zones or regions. This type of problem and other very large problems can be run with an alternate version of the FUMBLE code in which the core storage is increased.

The use of variable dimensions allows the user considerable flexibility in the preparation of a FUMBLE problems. Several of the more common examples of dimension variations are given as follows:

a) Increased number of economic assumptions - NALTMX

NALTMX 2 → 10
 . . . JRMX 64 → 36

b) Increased number of materials - MTMX

MTMX 8 → 14
 . . . JRMX 64 → 36

c) Increased number of fuel storage repositories - NSTOMX

NSTOMX 2 → 10
 . . . JRMX 64 → 54

d) 1. Reduced number of maximum fuel batches - NBHI

NBHI 12 → 4
 . . . JRMX 64 → 130

2. Increased number of maximum fuel batches - NBHI

NBHI 12 → 16
 . . . JRMX 64 → 46

e) 1. Increased number of core zones - JZMX

JZMX 12 → 24
 . . . JRMX 64 → 52

2. Core zones equal core regions

JZMX = JRMX
 . . . JRMX 64 → 36

The examples have been given in terms of the maximum number of core regions, JRMX. However, all dimensions may be varied to satisfy the limits of a particular problem. A generalized expression for selecting the dimension limits is the following:

$$\begin{aligned} & \text{JZMX} [62 + 3\text{NBHI} + 6\text{NBHI} \cdot \text{NALTMX}] \\ & + \text{JRMX} [4 + 6\text{MTMX} + 2\text{MTMX} \cdot \text{NBHI}] \\ & + \text{NALTMX} [30 + 25\text{MSTOMX}] \leq 18500 \end{aligned}$$

6.2 ERROR MESSAGES

Error messages given in the FUMBLE output are interpreted as follows:

1. Average power test was not satisfied in two step burnup sequence.
Increase ITPOW2
2. Maximum number of internal iterations were exceeded.
Increase ITERMX
3. Discharge fuel exposure test was not satisfied.
Check BTEST, DBTEST, TDA and DELTDA.
4. Peaking factor test was not satisfied.
Check JRPK, PKTEST and PFRA(JZ).
5. Burnup reactivity test was not satisfied.
Increase DKBCON
6. End-of-cycle reactivity test criterion was not satisfied.
Check ENDK, REFK, DELKE, DELKM, DELTDA.
7. Error in reload calculations. Check origin of make up and fissile fuel reload sources. Also check power parameters.

8. Error in reload calculations. Check origin of make up and fissile fuel reload sources. Also check ENDK, REFKA, PFRA, ATICON.
9. Error in reload calculations. Check origin of make up and fissile fuel reload sources. Source fraction changes are negative or too large.
10. Same as 9.
11. Possible error in problem dimensions. Check class 1 data cards.*
12. Possible error in zone specifications. Check class 2 data cards.*
13. Overlay input cards were expected and not found.
14. Problem exceeds core storage limits. Reduce the number of core regions as indicated.*
15. Error in interpolation input data. Check class 1, 9 and 10 data cards.*
16. Error in the adjustment of the number of fuel batches replaced in each zone. Check locations 21-23 of the class 2 cards.*
17. Error in the source input data. Check the class 8 data cards.*
18. Error in adjustment of storage repositories or total zones or total regions for a wrap-up problem.*
19. Error in specifications of discharge or reload fuel repositories or error in recycle hold-up times. Check class 2 data cards.*
20. Error in specifications of burnable poison or control material.*

* See also Section 3.1.

21. Error in specifications of fabrication and recovery times, fabrication and recovery fissile losses and/or plant efficiency. Check class 19 data cards.*
22. Error in convergence test criteria. Check class 6 data cards.*
23. --
24. --
25. Error in fuel cycle cost parameters. Check class 20 and class 21 data cards.*
26. Error in output instructions. Check class 13 and class 14 data cards.*

*See also Section 3.1.

6.3 OPTION CHECKOUT PROGRESS

All options of the FUMBLE code will be checked. However, there is certain to be a delay between the issuance of this report and completion of the checks. Thus, a FUMBLE status guide is included.

<u>Option</u>	<u>Status</u>	
	<u>Checked</u>	<u>Not Checked</u>
<u>Fuel Isotopic Concentrations Input</u>		
Beginning of a startup cycle	✓	
Mid-cycle of a startup cycle		✓
End of a startup cycle		✓
Beginning of an equilibrium cycle		✓
Mid-cycle of an equilibrium cycle	✓	
End of an equilibrium cycle		✓
<u>Fuel Materials</u>		
Uranium cycle (U-238 + plutonium isotopes)	✓	
Uranium cycle + U-235 + U-236	✓	
Thorium cycle		✓
Thorium cycle + uranium cycle		✓
<u>Convergence Test and Adjustment</u>		
Average rated power	✓	
Discharge fuel exposure	✓	
End-of-cycle reactivity	✓	
<u>Burnable Poison</u>		✓
<u>Restart/Wrap-up Problem</u>		✓

	<u>Status</u>	
	<u>Checked</u>	<u>Not Checked</u>
<u>Cost Calculations</u>		
Fuel cycle costs	✓	
Levelized fuel costs		✓
<u>Storage and Recycle Fuel Repositories</u>		
Recycle of discharged and reprocessed plutonium back to core.	✓	
Recycle of discharged fuel to a storage repository and then back to the reactor.		✓
<u>Interpolation Routine</u>		
Reactor parameters* are adjusted at the beginning of each operating interval by interpolation between two sets of end point input data.		✓
Reactor parameters* are changed from one set of input data to a second set of data at the beginning of a specified operating cycle.	✓	
Reactor parameters* are adjusted during the operating cycle by interpolating between two sets of end point input data.		✓

*Includes material cross sections, reactivity worths region fluxes and volumes.

6.4 INPUT DESCRIPTION

The input deck for FUMBLE consists of the following cards, in the order indicated.

- a) IDENT Card
- b) SELECT Card
- c) TAPE Cards (optional)
- d) LIMITS Cards (optional)
- e) INCODE Card
- f) CASE Card
- g) DATA Cards
- h) 999 Card
- i) LAST Card
- j) ENDJOB Card

6.4.1 Card Formats

The card formats are given as follows:

a)	<u>IDENT Card</u>
	<u>Col.</u> <u>Data</u>
	1 \$
	8-12 IDENT
	16-19 Charge Number
	20 ,
	21-23 User's Initials
	24-29 User's Address
	30 ,
	31-36 FUMBLE

b) SELECT Card

<u>Col.</u>	<u>Data</u>
1	\$
8-13	SELECT
16-21	FUMBLE

c) TAPE Cards

TAPE cards will be used to overlay the MASS cards of the FUMBLE system when a RESTART or a WRAPUP problem is used.* A TAPE card has the following format.

<u>Col.</u>	<u>Data</u>
1	\$
8-11	TAPE
16-17	File Code - 02 for a RESTART problem - 03 for a WRAPUP problem
18	,
19	Channel - x
20	Unit
21	R = tape is released after this activity S = tape is saved for the next activity C = tape is rewound, write ring removed, and then tape is remounted for next activity D = tape is dismounted.

If a specific tape reel is to be mounted, then

22-23	,,
24-27	Reel Number
30-41	12 character tape label identification

If a scratch tape is to be dismounted and saved, then

22-25	,,,,
26-37	12 character tape label identification

* The restart option is not available in Version I of FUMBLE.

d) LIMITS Card (Optional)

If the user wishes to modify the standard time limit of 0.2 hours a LIMITS card must be used.

<u>Col.</u>	<u>Data</u>
1	\$
8-13	LIMITS
16-18	Time limit in 1/100ths of an hour

e) INCODE Card

<u>Col.</u>	<u>Data</u>
1	\$
8-13	INCODE
16-19	IBMF

f) CASE Card

<u>Col.</u>	<u>Data</u>
1-5	)FUMB
6-8	USER Initials (optional)
9	*
10-14	Problem name (optional)
28-34	Data (optional)

g) DATA Cards

Described in Section 6.4.2.

h) 999 Card

<u>Col.</u>	<u>Data</u>
1-3	999

i) LAST Card

<u>Col.</u>	<u>Data</u>
1-5	)LAST
9	*

j) ENDJOB Card

<u>Col.</u>	<u>Data</u>
1	\$
8-13	ENDJOB

6.4.2 Input Data Description

Class cards have fixed fields in Columns 1-20 and variable format fields in Columns 21-80. The fixed fields are used to identify the input data and to locate the data in core memory. The variable format fields are used to specify the input data. The variable format of the data is consistent with the NIPS input format. (A description of the NIPS format is given in BISYN - A Two-Dimensional Synthesis Program, Reference 2.)

Class 1 data cards must be the first class cards read and cannot be changed during the running time of the problem. All other class cards can be overlayed at the beginning of designated operating intervals.

Table 6.1 gives a listing of the required input cards, and the FORTRAN symbols, physics symbols, and description of input data. A detailed description of each system is also given in Section V.

TABLE 6.1

FUMBLE INPUT DESCRIPTION

<u>Column</u>	<u>FORTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
<u>Class 88 Comment Cards</u>			
2-3		88	
21-80		Comments	
<u>Class 1</u>			
<u>Sub Class 1 Problem Options</u>			
3		1	
6		1	
9		Starting location	
21-80		<u>Data</u>	
(1)	INCOR1	0 - Beginning of cycle atom densities are taken from a restart case or cards 1 - Class 5 cards (Case A) give the atom densities at the beginning of a "startup" operating cycle. 2 - Class 5 cards (Case A) give the atom densities at mid-burnup of a "startup" operating cycle. 3 - Class 5 cards (Case A) give the atom densities the end of a "startup" operating cycle. 4 - Class 5 cards (Case A) give the atom densities at the beginning of an "equilibrium" operating cycle. 5 - Class 5 cards (Case A) give the atom densities at mid-burnup of an "equilibrium" operating cycle. 6 - Class 5 cards (Case A) give the atom densities at the end of an "equilibrium" operating cycle.	δ (a) 1

<u>Column</u>	<u>FORTTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
(2)	NINT	0 - Interpolation routine is not used 1 - Interpolation on routine is used between operating cycles (between End Point Cases A&B) 2 - Interpolation routine is used within the operating cycle (between End Point Cases A&B).	Nint
(3)	INPOIS	0 - Burnable poison is not included 1 - Burnable poison is included	δ pois
(4)	IPRINT	0 - Output data is printed out for all operating cycles. 1 - Output data is printed out only for the operating intervals listed in Class 10. 2 - Output data is printed out only for the last operating cycle.	I _{print}
(5)	IPUNCH	0 - Punched cards are not requested 1 - Atom densities at mid-burnup of the last operating cycle are punched out in the BISYN format. 2 - Atom densities at the beginning, mid-burnup, and end of the last operating cycle are punched out in the BISYN format.	I _{punch}
(6)	INORM	0 - Fluxes are to be normalized to the desired rated power 1 - Fluxes are not to be normalized	δ th norm
(7)	INRES1	0 - If INCOR1 = 0, beginning of cycle atom densities, by batch, are read from cards. 1 - If INCOR1 = 0, beginning of cycle atom densities, by batch, are taken from a restart tape*	δ restart
(8)	INPREP	0 - Do not prepare restart data 1 - Prepare restart data 2 - Prepare restart data and at the same time accommodate a change in the reactor zone and region layout as specified by the class cards.	δ ^{prep} restart

*See the footnote on page VI-9.

<u>Column</u>	<u>FORTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
(9)	INTWT	<ul style="list-style-type: none"> 0 - Interpolation routine is to use a constant weighting between regions 1 - Interpolation routine is to use a volume weighting between regions 2 - Interpolation routine is to use a flux-volume weighting between regions 	$\delta_{\text{interp wt}}$
(10)	INTSW1	<ul style="list-style-type: none"> 0 - Interpolation factor is to be calculated at each operating cycle 1 - Interpolation factor is to make a discontinuous jump at the beginning of operating cycle 1 (from end point A to end point B) 	I_{switch}
(11)	INOVE	<ul style="list-style-type: none"> 0 - Isotopic fission energies are to be supplied by the code 1 - Isotopic fission energies as to be supplied as input (class). 	$\delta_{\text{overlay E}}$
(12)	ICOME	<ul style="list-style-type: none"> 0 - Fuel cycle costs are not desired 1 - Fuel cycle costs are to be calculated for individual bundles 2 - Fuel cycle costs are to be calculated for the current operating cycle 3 - Fuel cycle costs are to be calculated by both methods 1 and 2 	$\delta_{\text{cost meth}}$
(13)	ICOUN	<ul style="list-style-type: none"> 0 - Unit of fuel cost is $\text{¢}/10^6 \text{ Btu}$ 1 - Unit of fuel cost is mill/kwh 	$\delta_{\text{cost unit}}$
(14)	KTMX	Number of distinct changes from one operating cycle to the next. (If input data is not to be overlaid, KTMX must be set equal to zero.)	k_{max}
(15)	NALTMX	Maximum number of alternate economic assumptions (including the reference set listed in Classes 20 and 21).	$N_{\text{alt}}^{\text{max}}$
(16)	NHMX	Maximum number of unit fabrication and reprocessing costs listed in Class 21.	h_{max}

Column	FORTTRAN Symbol	Description	Physics Symbol
<u>Sub Class 2 Region Dimensions</u>			
3		1	
6		2	
9		Starting location	
21-80		<u>Data</u>	
(1)	JRMX	Maximum number of regions	$J_{\max}$
(2)	JZMX	Maximum number of zones	$J_{\max}$
(3)	NGMX	Maximum number of composite zones	$g_{\max}$
(4)	NSTOMX	Maximum number of stored fuel repositories	$N_{\max}^{\text{stor}}$
(5)	NPUMX	NSTOMX + maximum number of plutonium recycle repositories	$N_{\max}^{\text{Pu}}$
(6)	NFUMX	NPUMX + maximum number of <u>fissile</u> uranium recycle repositories	$N_{\max}^{\text{fisU}}$
(7)	NTUMX	NFUMX + maximum number of total uranium recycle repositories	$N_{\max}^{\text{totU}}$
(8)	NSMX	Maximum number of fuel sources (for core loading, blanket fuel, core makeup, etc.)	$N_{\max}$
(9)	JRPK	Region of peak power (used only if peak power is to be tested)	j_{PK}

Sub Class 3 Operating Intervals and Maximum Batches

3		1	
6		3	
9		Starting location	
21-80		<u>Data</u>	
(1)	IOPMX	Maximum number of operating intervals	$I_{\max}$
(2)	ITERMX	Maximum number of iterations within an operating interval	$i_{\max}$
(3)	INIT	Identification number of first operating cycle (does not have to be 1)	I_{init}
(4)	ISTOMX	Maximum number of operating intervals that fuel will be held in the stored fuel repositories	$I_{\max}^{\text{stor}}$
(5)	NBHI	Maximum number of fuel batches for any reactor zone	$n_{\text{batch}}^{\text{ni}}$
(6)	IOPT(K)	Listing of operating cycles for which the input data is overlaid ($1 \leq K \leq \text{KTMX} \leq 30$)	I_k

Column	FORTTRAN Symbol	Description	Physics Symbol																																																												
<u>Sub Class 4 Material Specification</u>																																																															
3		1																																																													
6		4																																																													
9		Starting location																																																													
21-80		<u>Data</u>																																																													
(1)	MFUMX	Maximum number of fuel materials (excluding fission products). Can only be 5, 6, 7 or 11.	$m_{\text{fuel max}}$																																																												
		<table><tr><td></td><td><u>5</u></td><td><u>6</u></td><td><u>7</u></td><td><u>11</u></td></tr><tr><td>1</td><td>U-238</td><td>Th-232</td><td>U-238</td><td>U-238</td></tr><tr><td>2</td><td>Pu-239</td><td>Pa-233</td><td>Pu-239</td><td>Pu-239</td></tr><tr><td>3</td><td>Pu-240</td><td>U-233</td><td>Pu-240</td><td>Pu-240</td></tr><tr><td>4</td><td>Pu-241</td><td>U-234</td><td>Pu-241</td><td>Pu-241</td></tr><tr><td>5</td><td>Pu-242</td><td>U-235</td><td>Pu-242</td><td>Pu-242</td></tr><tr><td>6</td><td></td><td>U-236</td><td>U-235</td><td>Th-232</td></tr><tr><td>7</td><td></td><td></td><td>U-236</td><td>Pa-232</td></tr><tr><td>8</td><td></td><td></td><td></td><td>U-233</td></tr><tr><td>9</td><td></td><td></td><td></td><td>U-234</td></tr><tr><td>10</td><td></td><td></td><td></td><td>U-235</td></tr><tr><td>11</td><td></td><td></td><td></td><td>U-236</td></tr></table>		<u>5</u>	<u>6</u>	<u>7</u>	<u>11</u>	1	U-238	Th-232	U-238	U-238	2	Pu-239	Pa-233	Pu-239	Pu-239	3	Pu-240	U-233	Pu-240	Pu-240	4	Pu-241	U-234	Pu-241	Pu-241	5	Pu-242	U-235	Pu-242	Pu-242	6		U-236	U-235	Th-232	7			U-236	Pa-232	8				U-233	9				U-234	10				U-235	11				U-236	
	<u>5</u>	<u>6</u>	<u>7</u>	<u>11</u>																																																											
1	U-238	Th-232	U-238	U-238																																																											
2	Pu-239	Pa-233	Pu-239	Pu-239																																																											
3	Pu-240	U-233	Pu-240	Pu-240																																																											
4	Pu-241	U-234	Pu-241	Pu-241																																																											
5	Pu-242	U-235	Pu-242	Pu-242																																																											
6		U-236	U-235	Th-232																																																											
7			U-236	Pa-232																																																											
8				U-233																																																											
9				U-234																																																											
10				U-235																																																											
11				U-236																																																											
(2)	MTMX	Maximum number of materials (fuel + fission products + poison)	M_{max}																																																												
(3)	NFPMX	Maximum number of fission product aggregates (can only be 1 or 2)	$N_{\text{FP}}^{\text{max}}$																																																												
(4)	LINTMX	Maximum number of materials used in Interpolation Routine	L_{max}																																																												
(5)	MQMX(Q)	Maximum number of materials in source Q 1 < Q < NSMX	$q_{\text{max}}^{(N)}$																																																												

<u>Column</u>	<u>FORTTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
<u>Class 2 Zone Specifications</u>			
3		2	
9		Starting Location	
12	JZ	Zone indicator	J
21-80		<u>Data</u>	
(1)	JRZ(JZ)	Highest region number in zone JZ	J _J
(2)	JWG(JZ)	Number of the composite group to which zone JZ belongs (zones may be combined into composite groups for output)	JW _J
(3)	JZB(JZ)	0 - Zone JZ is not used to test average burnup criterion. 1 - Zone JZ is used to test average burnup criterion	JB _J
(4)	JZP(JZ)	0 - Not used to test power criteria 1 - Used to test power criteria	JP _J
(5)	JZL(JZ)	0 - Not used to determine the interpolation factor 1 - Used to determine the interpolation factor	JL _J
(6)	JAZ(JZ)*	Source of fuel for blanket regions (See Class). If zone JZ is a zone of variable fissile enrichment (a core zone) or receives fuel from a stored fuel repository than JAZ(JZ) = 0.	JA _J
(7)	JZV(JZ)*	Listing of core zones in order of execution of loading instructions (The order is not important unless two or more zones receive fuel from the same recycle repository). For blanket zones, JZV(JZ) = 0.	JV _J

* JAZ(JZ) and JZV(JZ) must not both be equal to zero, nor may they both be greater than zero.

<u>Column</u>	<u>FORTTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
<u>Class 2 Zone Specifications</u>			
(8)	NBMX(JZ)	Number of fuel batches in Zone JZ	N_J^{bat}
(9)	NDIS(JZ)	Number of fuel batches to be replaced in Zone JZ	$N_{dis}^{(J)}$
(10)	JWH(JZ)	If ICOME greater than 0, JWH(JZ) gives the set of unit fabrication and recovery costs (Class) to be used in Zone JZ	JH_J
(11)	NSDS(JZ)	Principal discharge repository (stored or recycle)	N_d^{stor}
(12)	NSDS2(JZ)	Secondary discharge repository if desired (recycle only)	N_d^{stor2}
(13)	NSVS(JZ)	Preferred repository for loading (stored or recycle) ore Zone JZ. Not applicable to blanket zones (i.e. JZV(JZ) = 0.	N_v^{recl}
(14)	IHVS(JZ)	Hold up time (number of operating cycles) of loaded fuel from the preferred repository. Hold up time may be 0.	I_v^{reel}
(15)	NSV2(JZ)	Alternate repository for loading (recycle only) core Zone JZ. Not applicable to blanket zones (i.e., JZV(JZ) = 0).	N_v^{rec2}
(16)	IHV2(JZ)	Hold up time (number of operating cycles) of loaded fuel from the alternate repository.	I_v^{rec2}
(17)	NSV3(JZ)	External fissile makeup source for core zone JZ. Not applicable to blanket zones (i.e., JZV(JZ) = 0.	N_v^{rec3}
(18)	NSV4(JZ)	Other makeup source (fertile) for core zone JZ. Not applicable to blanket zones (i.e., JZV(JZ) = 0.	N_v^{rec4}

<u>Column</u>	<u>FORTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
<u>Class 2 Zone Specifications</u>			
(19)	NSV5(JZ)	0 - Not used 1 - Preferred and alternate recycle repositories are equally preferred	N_v^{rec}
(20)	IHN3(JZ) *	Minimum holdup time (operating intervals) if IHVS(JZ) or IHV2(JZ) are equal to 3. for those operating intervals I that satisfy the condition $I > INU(JZ)$, the refueling for zone JZ is a uniform process defined by NBMX(JZ) and NOIS(JZ). For $I < INU(JZ)$ number of batches that are discharged can be varied as described in Data Block 7 $1 \leq NP \leq ICY(JZ) \leq 4$	$I_h^{(N,3)}$
(21)	INU(JZ) *		I_J^{nu}
(22)	ICY(JZ) *		I_J^{cy}
(23)	NUB(JZ, NP) *		$N_n^{(J)}$

Class 3(a) Region Indicator (Precedes End Case B volumes only)

3	3
9	0 Data to follow will be for End Case B

Class 3 Region Volumes

3	3
6	1
9	Starting location of volumes
21-80	$\left\{ \begin{array}{l} VOLA(JR) \\ VOLB(JR) \end{array} \right\}$ Volumes for $1 \leq JR \leq JRMX$ (end case A or end case B)

 $\left\{ \begin{array}{l} V_j^{(a)} \\ V_j^{(b)} \end{array} \right\}$
Class 4(a) Integrated Fluxes Indicator (Precedes End Case B integrated fluxes only)

3	4
9	0 Data to follow will be for End Case B

* This information is required only for an irregular loading pattern. See the discussion in Section 5.2, Data Block 7.

Column	FORTTRAN Symbol	Description	Physics Symbol
<u>Class 4 Integrated Fluxes</u>			
3		4	
6		1	
9		Starting location of integrated fluxes	
21-80	$\left\{ \begin{array}{l} \text{PHIA(JR)} \\ \text{PHIB(JR)} \end{array} \right\}$	Integrated fluxes for $1 \leq \text{JR} \leq \text{JRMX}$ (either end Case A or end Case B)	$\left\{ \begin{array}{l} \phi_j^{(a)} \\ \phi_j^{(b)} \end{array} \right\}$
<u>Class 5(a) Atom Densities, One Group Cross Sections and Reactivity Worth Indicators</u>			
(Procedes End Case B Data Only)			
3		5	
9		0 Data to follow will be for end Case B	
<u>Class 5 Atom Densities, One Group Cross Sections and Reactivity Worths</u>			
3		5	
4-6	MM1(MT,JR)	Material designator	ND_j^m
7-9	JR	Region	j
10-12	MT	Material corresponding to the material numbers listed on page VI-16.	
21-80		<u>Data</u>	
(1)	$\left\{ \begin{array}{l} \text{CNMA(MT,JR)} \\ \text{CNMB(MT,JR)} \end{array} \right\}$	Batch average atom density for material MT in region JR (either end Case A or end Case B)	$\left\{ \begin{array}{l} N_{m,j}^{(a)} \\ N_{m,j}^{(b)} \end{array} \right\}$
(2)	$\left\{ \begin{array}{l} \text{SIGCA(MT,JR)} \\ \text{SIGCB(MT,JR)} \end{array} \right\}$	One group capture cross section for material MT in region JR (either end Case A or end Case B)	$\left\{ \begin{array}{l} \sigma_{c,m,j}^{(a)} \\ \sigma_{c,m,j}^{(b)} \end{array} \right\}$

<u>Column</u>	<u>FORTTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
(3)	$\left\{ \begin{array}{l} \text{SIGFA}(\text{MT}, \text{JR}) \\ \text{SIGFB}(\text{MT}, \text{JR}) \end{array} \right\}$	One group fission cross section for material MT in region JR (either end Case A or end Case B).	$\left\{ \begin{array}{l} \sigma_{f,m,j}^{(a)} \\ \sigma_{f,m,j}^{(b)} \end{array} \right\}$
(4)	$\left\{ \begin{array}{l} \text{RKA}(\text{MT}, \text{JR}) \\ \text{RKB}(\text{MT}, \text{JR}) \end{array} \right\}$	Reactivity worth of a unit concentration change of material MT in region JR (either end Case A or end Case B).	$\left\{ \begin{array}{l} R_{m,j}^{(a)} \\ R_{m,j}^{(b)} \end{array} \right\}$

Class 6 Convergence Tests

3	6		
9		Starting location of Data	
<u>21-80</u>		<u>Data</u>	
(1)	ENDK	Effective multiplication constant desired at the end of the operating interval.	$K^{(e)}$
(2)	DELKE	Excess reactivity permitted on high side of ENDK to satisfy convergence criterion. ⁽¹⁾	$\Delta K^{(e)}$
(3)	DELKM	Excess reactivity permitted on low side of ENDK to satisfy convergence criterion. ⁽¹⁾	ΔK^{-}
(4)	EPØW1	Fractional deriation in power which is permitted after the first flux normalization. If set equal to zero the code sets EPØW1 = 0.001. ⁽¹⁾	$E_p^{(1)}$
(5)	EPØW2	Fractional deriation in power which is permitted after the second flux normalization. If set equal to zero the code sets EPØW2 = 0.01. ⁽²⁾	$E_p^{(2)}$
(6)	DBTEST	Maximum acceptable departure from the desired burnup (MWD/MT). ⁽¹⁾	ΔB_{test}

<u>Column</u>	<u>FORTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
(7)	DKBCØN	Maximum acceptable magnitude of the reactivity change due to fuel burnup. ⁽²⁾	(ΔK) ^{burn} control
(8)	PKTEST	Maximum acceptable ratio of power density in region of peak power (see input 9, sub class 2) to average power density in zones designated by input data (see class 2 input). ⁽²⁾	P ^{PK} test
(9)	DELTDΔ	Maximum departure in operating time permitted to satisfy burnup criterion (days). ⁽²⁾	ΔT

-
- (1). The code will adjust the fissile enrichment, neutron flux level and/or the operating time to satisfy this convergence criterion. If the maximum number of internal iterations (ITERMX) is exceeded the problem will terminate.
- (2). If this convergence is not satisfied the problem will terminate. For this reason, this convergence criterion should be made sufficiently large to satisfy the conditions of the problem being run.

<u>Column</u>	<u>FORTTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
<u>Class 7 Operating Time, Total Power and Average Fuel Exposure</u>			
3		7	
9		Starting location of data	
<u>21-80</u>		<u>Data</u>	
(1)	TDA	Estimated operating time (days)	T
(2)	FLOD	Load factor - fraction of operating time spent at operating power.	f
(4)	PTH	Desired rated power (MW_T) for test zones (location 4, class 2).	p^{th}
(5)	BTEST	Average fuel discharge exposure (MWD/MT) over test zones (location 3, class 2).	B
<u>Class 8 Source Data</u>			
3		8	
7-9		Starting location of data	
10-12	N	Source set identification number	
<u>21-80</u>		<u>Data</u>	
(1)	MTS(N,MS)*	Identification number of material MS ($1 \leq M \leq MZMX(N)$) in source N (based upon the numbering sequence for various values of MFUMX-Class 1, sub class 4).	$M_{S,N}$
(2)	WS(N,MS)	Fraction of total atoms in source N belong to material MS.	$W_{S,N}$
(3)	MTS(N,MS+1)	.	
(4)	WS(N,MS+1)		
	MTS(N,MQMX(N))		
	WS(N,MQMX(N))		

*For example, if MFUMX = 7 and MTS(N,MS) = 2 then WS(N,MS) would be the atom fraction of Pu-239 in source N. Similarly, if MTS(N,MS) = 8, WS(N,MS) would be the atom fraction of U-235 in source N.

<u>Column</u>	<u>FORTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
<u>Class 9 Interpolation Data (Required Only if NINT = 1 and INTSW = 0)</u>			
3		9	
9		Starting location of interpolation data	
<u>21-80</u>		<u>Data</u>	
(1)	MTL(ML)*	Identification number of material ML(1<ML<LINTMX) to be used in the calculation of the Interpolation Factor (based upon the numbering sequence for various values of MFUMX-Class 1, sub class 4).	M_L
(2)	GM(ML)	{ Material coefficients used in the calculation of the interpolation factor. }	G_L
(3)	HM(ML)		H_L
(4)	MTL(ML+1)		
(5)	GM(ML+1)		
(6)	GM(ML+1)		
	.		
	.		
	.		
1	MTL(LINTMX)		
	GM(LINTMX)		
	HM(LINTMX)		

* See the footnote below the Class 8 card description.

<u>Column</u>	<u>FORTTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
<u>Class 10 Miscellaneous Parameters</u>			
2-3		10	
9		Starting locations	
<u>21-80</u>		<u>Data</u>	
(1)	REFKA	Effective multiplication constant of end Case A (set equal to 1.0 if not supplied).	$K_{ref}^{(a)}$
(2)	REFKB	Effective multiplication constant of end Case B (set equal to 1.0 if not supplied).	$K_{ref}^{(b)}$
(3)	AWPØIS	Atomic weight of burnable poison if INPØIS = 1 (set equal to 1.0 if not supplied).	A_{Mmax}^{wt}
(4)	ATICØN	Factor used to estimate fuel burnup reactivity change for the next operating interval. $0 \leq ATICØN \leq 1$ (set equal to 0.0 if not supplied).	A_T^{cont}
(5)	PLEV	Percent discount per year on future fuel costs and revenues (required only if ICØME < 0 and levelized fuel cycle cost are requested see Class .	P_{int}^{lev}
(6)	GZER	Constants used in the calculation of the Inter- polation Factor. Required only if NINT = 1. and the interpolation between end Case A and end Case B is desired for each operating cycle. (Not required for a discontinuous jump from end Case A to end Case B.)	G_o
(7)	HZER		H_o

<u>Column</u>	<u>FORTTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
(8)	FAOUT	Used to adjust the Interpolation Factor only if	F_a^{out}
(9)	FAIN	NINT = 1 and the interpolation between end Case A	F_a^{in}
(10)	FBOUT	and end Case B is desired for each operating	F_b^{out}
(11)	FBIN	cycle. Set equal to 1.0 if adjustments are not desired.	F_b^{in}

Class 11 Available Recycle Fraction (Required Only if Different from 1.0)

2-3		11	
9		Starting location of recycle fractions.	
21-80	FRMULT(NS)	Fraction of fuel in stored or recycle fuel repositories available for reloading the core. $1 \leq NS \leq NTUMX$ (set equal to 1.0 if not supplied).	$F_{MULT}^{(N)}$

Class 12 Output for Selected Operating Intervals (Required Only if IPRINT = 1)

2-3		12	
9		Starting locations of operating intervals.	
21-80	IOPS(I)	Listing of operating intervals for which printed output is requested ($INIT \leq IOPS \leq IOPMX$).	I_s

Class 13 Output Options - Reactor

2-3		13	
9		Starting location of data	
<u>21-80</u>		<u>Data</u>	
(1)	IREOUT	0 - Do not print output data for current operating interval. 1 - Print output data as indicated by the selectors that follow.	δ_{reac}^{out}

<u>Column</u>	<u>FORTTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
(2)	IREDIS	0 - Do not print output data for discharged fuel. 1 - Print total discharge fuel weights. 2 - Print discharge fuel weights by material in addition to total weights.	δ disch reac
(3)	IRELØD	0 - Do not print output data for loaded fuel. 1 - Print total loaded fuel weights. 2 - Print loaded fuel weights by material in addition to total weights.	δ load reac
(4)	IREMI	0 - Do not print output data for average fuel weights. 1 - Print average total fuel weights. 2 - Print average fuel weights by material in addition to total weights.	δ midinv reac
(5)	IREEI	0 - Do not print output data for total fuel weights at the end of the operating interval. 1 - Print total weights of fuel at the end of the operating interval. 2 - Print weights of fuel, by material, at the end of the operating interval, in addition to total weights.	δ endinv reac
(6)	IRECØ	0 - Do not print cost output data. 1 - Print cost output data.	δ cost reac
(7)	IRCØCØ	0 - Print only total fuel cost. 1 - Print total fuel cost and also fuel component costs (fabrication recovery etc.)	δ cost comp reac

<u>Column</u>	<u>FORTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
(8)	ICNE	<p>0 - Do not print regional material concentrations.</p> <p>1 - Print regional material concentrations for the beginning, average, and end of the operating interval.</p> <p>2 - Print regional material concentrations for only regions of variable fissile enrichment (core zones).</p>	δ^{conc}
(9)	ICNEBA	<p>0 - Do not print regional material concentrations by batch.</p> <p>1 - Print regional material concentrations, by batch at the beginning and end of the operating interval.</p> <p>2 - Print regional material concentrations, by batch, for only regions of variable fissile enrichment (core zones).</p>	$\delta^{conc\ bat}$
(10)	ISTØRE	<p>0 - Do not print output data for stored or recycle fuel repositories.</p> <p>1 - Print stored and recycle fuel weights for all repositories and hold up times.</p> <p>2 - In addition to 1 print stored and recycle fuel weights by material.</p> <p>3 - In addition to 1 and 2 print energy in stored fuel repositories.</p>	$\delta^{stor\ inv}$
(11)	ISTØIC	<p>0 - Do not print stored fuel inventory costs.</p> <p>1 - Print total stored fuel inventory costs.</p> <p>2 - In addition to 1 print stored fuel inventory costs for all stored fuel repositories and hold up times.</p>	$\delta^{stor\ inv\ cot}$

<u>Column</u>	<u>FORTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
(12)	IBRAT	0 - Do not print out the breeding ratio and doubling time. 1 - Print out the breeding ratio and doubling time.	δ_{BR}
(13)	IDUMP	0 - Do not execute a dump on an error halt. 1 - Dump core in the event of an error exit. 2 - Ignore all error exits.	δ_{dump}
<u>Class 14 Output Options - Zones</u>			
2-3		14	
9		Starting location of data	
12	K	Zone indicator	
<u>21-80</u>		<u>Data</u>	
(1)	IZOUT(K)	0 - Do not print output data for Zone K. 1 - Print output data for Zone K in accordance with selectors that follow.	δ_g^{out}
(2)	IZDIS(K)	0 - Do not print fuel discharge weights or burnup for Zone K. 1 - Print fuel discharge weights and burnup for Zone K. 2 - Print fuel discharge weights and burnup by batch for Zone K. 3 - Print fuel discharge weights by material for Zone K. 4 - Print discharge weights by material and batch for Zone K.	δ_g^{disch}

<u>Column</u>	<u>FORTTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
(3)	IZLØD(K)	Loaded fuel weights with the same options as IZDIS(K).	δ load g
(4)	IZMI(K)	Average fuel weights for the operating interval - with the same options as IZDIS(K).	δ mid inv g
(5)	IZEI(K)	End-of-cycle weights for the operating interval - with the same options as IZDIS(K).	δ end inv g
(6)	IZCØ(K)	0 - Do not print cost output data for Zone K. 1 - Print cost output data for Zone K. 2 - Print cost output data broken down by batch for Zone K.	δ cost g
(7)	IZCØCØ(K)	0 - Total fuel cost only 1 - Total fuel cost and fuel cost components (fabrication, recovery, etc.)	δ cost comp g

Class 15 Exposure Parameters for End point Cases A and B*

2-3	15	
9	Starting location of data	
<u>21-80</u>		
(1)	BURNA	Average Exposure corresponding to end point Case A
(2)	BURNB	Average Exposure associated with End point Case B

*Required only if the specified burnup (BTEST) is different than the
burnup associated with the end point data.

Class 16 Fuel Atom Densities

2-3 16

9 Starting location of fuel atom densities by zone.

21-80 CNF(JZ) Fuel atom densities ($1 \leq JZ \leq JZMX$). If set equal to 0.0 or not supplied the code will calculate the fuel atom densities based upon the information on the Class 5 cards.

N_J^{fuel}

Class 17 Poison Atom Density (Not required if INPOIS = 0)

2-3 17

9 Starting location for data

21-80 CNBPV(JZ) Initial atom density (atoms/cm³ batch) of poison in zone JZ. ($1 \leq JZ \leq JZMX$) (if set equal to 0.0 or not supplied the code will calculate the poison atom densities based upon the information on the Class 5 cards).

$N_{M_{\text{max}},V}^{(0)}$

<u>Column</u>	<u>FORTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
<u>Class 18 Relative Total Power</u>			
2-3		18	
9		Starting location of data	
21-80	PFRA(JZ)	Relative power (can be input as a ratio) in Zone JZ. Required only for zones of variable fissile enrichment (core zones). If set equal to zero or not supplied. The code will calculate the relative power ratios from the information contained on the Class 3, 4, and 5 cards.	P_V
<u>Class 19 Out-of-Pile Delay Times and Losses, Overall Reactor Efficiency</u>			
2-3		19	
9		Starting location of data.	
21-80		<u>Data</u>	
(1)	REPRT	Reprocessing time (days)	T_{repr}
(2)	FABT	Fabrication time (days)	T_{fab}
(3)	REPRL	Fraction of fuel lost in reprocessing	L_{repr}
(4)	FABL	Fraction of fuel lost in fabrication	L_{fab}
(5)	EFFIC	Thermal efficiency (fraction)	e_{th}
<u>Class 20 Interest Rates and Fuel Isotopic Values for Cost Calculations</u>			
(Not Required if ICOME = 0)			
2-3		20	
9		Starting location of data.	
12	K	Economic assumption (K=1 for the reference economic assumption).	

<u>Column</u>	<u>FORTTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
<u>21-80</u>		<u>Data</u>	
(1)	PFU(K)	Yearly interest rate for fuel inventory cost (%)	$P_{fuel}^{int(i)}$
(2)	PFAB(K)	Yearly interest rate for fabrication inventory cost (%)	$P_{fab}^{int(i)}$
(3)	CFEED(K)	Cost of natural uranium feed to enrichment plant (\$/kg).	$C_{feed}^{(i)}$
(4)	CSEP(K)	Cost of separative work for natural uranium (\$/kg).	$C_{sep}^{(i)}$
(5)	ETAIL(K)	Fissile weight percent of depleted uranium tails (%).	$E_{tails}^{(i)}$
(6)	R2325(K)	Ratio of value of U-235 (or of Po-233) to that of U-235.	$R_{25}^{23(i)}$
(7)	NVALM(K)	Number of isotope fuel values listed for economic assumption K restricted as follows: MFUMX = 5, NVALM(K) = 1 or 4 MFUMX = 6, NVALM(K) = 0, 1 or 5 MFUMX = 7, NVALM(K) = 1, 4 or 6 MFUMX = 11, NVALM(K) = 1, 4 or 10 (See Data Block 21 for a detailed description of the isotopic fuel values.)	$N_{max}^{val(i)}$
(8)	VAL(1,K)	Isotopic fuel values	$V_m^{(i)}$
(9)	VAL(MT+1,K)	(1 ≤ MT ≤ NVALM(K))	
⋮	⋮		
	VAL(NVALM(K),K)		

<u>Column</u>	<u>FORTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
<u>Class 21 Unit Costs for Fuel Fabrication and Reprocessing (Not required if ICØME = 0)</u>			
2-3		21	
9		Starting location of data.	
12	K	Economic assumption (K=1 for the reference economic assumption).	
<u>21-80</u>		<u>Data</u>	
(1)	UFAB(1,K)	Unit fabrication cost (\$/kg loaded U+Pu+TH)	$U_h^{fab(i)}$
(2)	UREPR(1,K)	Unit reprocessing cost for spent fuel discharged at the end of the operating interval (\$/kg loaded U+Pu+TH). Set NH	$U_h^{repr(i)}$
(3)	UFAB(NH,K)	(1 ≤ NH ≤ NHMX)	
(4)	UREPR(NH,K)		
	⋮	⋮	
	UFAB(NHMX,K)		
	UREPR(NHMX,K)		
<u>Class 22 Fission Energy Overlays (Required only if INOVE = 1)</u>			
2-3		22	
9		Starting location of data	
<u>21-80</u>		<u>Data</u>	
(1)	EMEV(1)	Energy per fission (MeV) for material 1. (See Class 1, sub-class 4 for a description of the material numbering sequence).	E_m^{input}
(MT)	EMEV(MT)	1 ≤ MT ≤ MFUMX	
⋮	⋮		
MFUMX	EMEV(MFUMX)		

<u>Column</u>	<u>FORTTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
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Class 23 Beginning-of-Cycle Material Concentrations by Batch (Required only ifINCOR1 = 0 and INRES1 = 1)

2-3		23	
6	NB	Region	
9		Starting location	
12	JR	Batch	
<u>21-80</u>		<u>Data</u>	
(1)	CNB(1,JR,NB)	Concentration of material, MT=1, in region JR	$N_{mid,n}^{(o)}$
	⋮	batch NB.	
(2)	⋮		
(MT)	CNB(MT,JR,NB)	$1 \leq MT \leq MTMX$	
⋮			
(MTMX)	CNB(MTMX,JR,NB)		

Class 24 Zone Weights (Required only if ICOR1 = 0 and INRES1 = 1)

2-3		24	
9		Starting location of data	
12	JZ	Batch	
<u>21-80</u>		<u>Data</u>	
(1)	WF(JZ,1)	Weight of fuel in zone JZ=1 for batch NB.	$W_{J,n}^{(o)}$
⋮			
(NB)	WF(JZ,NB)	$1 \leq JZ \leq JZMX$	
⋮			
(NBMX)	WF(JZ,NBMX)		

<u>Column</u>	<u>FORTTRAN Symbol</u>	<u>Description</u>	<u>Physics Symbol</u>
<u>Class 25 Thermal Energies by Zone (Required only if INCOR1 = 0 and INRES1 = 1)</u>			
2-3		25	
9		Starting location of data	
12	JZ	Batch	
<u>21-80</u>		<u>Data</u>	
(1)	EZTH (JZ,1)	Thermal energy in zone JZ=1 accrued in batch NB.	$E_{J,n}^{(o)th}$
⋮			
(NB)	EZTH (JZ,NB)	$1 \leq JZ \leq JZMX$	
⋮			
(NBMX)	EZTH (JZ,NBMX)		

REFERENCES

1. Research and Development Requirements for a 1000 MWe Sodium-Cooled Fast Reactor, Task IV Report of 1000 MWe LMFBR Follow-on Work, GEAP-5769, April, 1969.
2. Greebler, P., and Cowan, C., "RAPFU, A Computer Code for Rapid Calculation of Fuel Cycle Physics Parameters in Fast Breeder Reactors with Variable Fissile Recycle Schemes," GEAP-5494, May, 1967.
3. Vaughan, P. C., et al, "BICYCL - A Computer Code for Two-Dimensional Analysis of Equilibrium Fuel Cycles," GEAP-13556, December, 1969.
4. Greebler, P., et al, "BISYN, A Two-Dimensional Synthesis Program", GEAP-4922, July 15, 1965.
5. Lane, J. A., "Economics of Nuclear Power", Annual Revision of Nuclear Science, Volume 16, 1966.

SECTION VII

SAMPLE INPUT AND OUTPUT

7.1 INPUT DESCRIPTION

The input information for a sample problem is given below. The information is used to specify reactor operations from a startup operating cycle to equilibrium operating conditions including the transition from a large core with low power fuel to a small core with high power fuel. The transition from the large to small core is accomplished during operating interval seven by a discontinuous switch from the data for end point case A to the data for end point case B.

The geometry for the startup reactor system is described by five core zones, two axial blanket zones and one radial blanket zone. The extra core zones are included to show the changes in the core loading pattern during the transition from startup to equilibrium. After the first operating cycle a two batch loading scheme is used in the core and axial blankets and a three batch loading scheme is used in the radial blankets. The supply source for the fissile fuel is external to the reactor system and is similar to the fuel discharged from a BWR. Depleted uranium is used as a fertile makeup source in the core and the primary fuel source for all blankets.

The core fuel discharge exposure for the first operating interval is 20,000 MWD/MT and is increased gradually in subsequent operating intervals until an equilibrium exposure of 100,000 MWD/MT is achieved.

Printed output is given in Section 7.2 and includes the regional power and atom concentrations for each material, core fuel discharge exposures, breeding ratios, doubling times, loaded and discharge fuel weights and fuel cycle costs for the discharged fuel.

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JFMBL *NIM
C CLASS 1 - MISCELLANEOUS PARAMETERS INCLUDING INPUT REACTOR OPERATING
C CONDITIONS (E.G., EQUILIBRIUM OR STARTUP CORE), PROBLEM
C DIMENSIONS AND GENERAL TYPES OF OUTPUT DESIRED
1 1 1 1 1 0 0 0 2 0 0 7 0 1 1 10 1 3
1 2 1 8 8 8 0 1 1 2 2 1
1 3 1 11 10 1 3 12 2 3 4 6 7 8 9 10 11
1 4 1 7 8 1 1 4 2
C CLASS 2 - ZONE DESCRIPTION (TESTS ON POWER AND BURNUP, LOADING SEQUENCE,
C LOADING AND DISCHARGE REPOSITIONS, NUMBER OF BATCHES, ETC)
2 1 1 1 1 1 0 0 51 2 1 1 1 2 0 1 0 1 1 2
2 1 2 2 2 1 1 0 0 1 2 1 1 1 2 0 1 0 1 1 2
2 1 3 3 3 1 1 0 0 52 2 1 1 1 2 0 1 0 1 1 2
2 1 4 4 4 1 1 0 0 2 2 1 1 1 2 0 1 0 1 1 2
2 1 5 5 5 1 1 0 0 2 2 1 1 1 2 0 1 0 1 1 2
2 1 6 6 6 0 2 0 2 0 2 1 2 1 2 0 1 0
2 1 7 7 7 0 2 0 2 0 2 1 2 1 2 0 1 0
2 1 8 8 8 0 2 0 2 0 3 1 3 1 2 0 1 0
C CLASS 3 - VOLUMES (BY REGION)
C DATA FOR END POINT CASE A - PUNCHED CARDS FROM BISYN
3 1 5.72688E 05 9.54480E 04 2.14758E 05 1.84078E 05 2.24985E 05
3 6 1.0782E+06 0.22734E+06 1.3159E+06
C DATA FOR END POINT CASE B - PUNCHED CARDS FROM BISYN
3 1 5.72688E 05 9.54480E 04 2.14758E 05 1.84078E 05 2.24985E 05
3 6 1.0782E+06 0.22734E+06 1.3159E+06
C CLASS 4 - INTEGRATED FLUXES (BY REGION)
C DATA FOR END POINT CASE A - PUNCHED CARDS FROM BISYN
4 1 2.77607E 21 4.09921E 20 8.28609E 20 6.29316E 20 6.06255E 20
4 6 1.28345E+21 0.14696E+21 1.01752E+21
C DATA FOR END POINT CASE B - PUNCHED CARDS FROM BISYN
4 1 3.01001E 21 4.30243E 20 8.48519E 20 5.55938E 20 4.62340E 20
4 6 1.44309E+21 0.14511E+21 0.75163E+21
C CLASS 5 - ATOM CONCENTRATIONS, ONE GROUP CROSS SECTIONS AND REACTIVITY
C NORTH (PARAMETERS GIVEN FOR EACH MATERIAL AND EACH REGION)
C DATA FOR END POINT CASE A - PUNCHED CARDS FROM BISYN
5282 1 1 5.20063E-03 3.22908E-01 4.44225E-02 -1.54521E 01
5490 1 2 7.40045E-04 6.03205E-01 1.92641E 00 2.73342E 02
5402 1 3 3.22906E-04 4.61402E-01 3.65692E-01 2.98832E 01
5420 1 4 1.53286E-04 5.20397E-01 2.85870E 00 4.41621E 02
5430 1 5 4.02061E-05 6.86389E-01 2.85171E-01 6.02599E 00
5250 1 6 1.56480E-05 8.11250E-01 2.22968E 00 2.22661E 02
5260 1 7 1.00013E-20 5.80811E-01 1.22013E-01 -2.48689E 01
5 1 1 8 1.00013E-20 5.35635E-01 0. -3.80436E 01
5282 2 1 5.20063E-03 3.10546E-01 4.72837E-02 -1.77749E 00
5490 2 2 7.40045E-04 5.67495E-01 1.90386E 00 3.58317E 01
5402 2 3 3.22906E-04 4.40909E-01 3.79228E-01 4.53432E 00
5420 2 4 1.53286E-04 4.96556E-01 2.78253E 00 5.65671E 01
5430 2 5 4.02061E-05 6.60539E-01 3.00637E-01 1.62456E 00
5250 2 6 1.56480E-05 7.69346E-01 2.16639E 00 2.90156E 01
5260 2 7 1.00013E-20 5.57467E-01 1.28985E-01 -2.65031E 00
5 1 2 8 1.00013E-20 5.10540E-01 0. -4.47422E 00
5290 3 1 4.66724E-03 2.80149E-01 5.34677E-02 -2.90459E 00
5490 3 2 1.05513E-03 4.51858E-01 1.80319E 00 6.32043E 01
5410 3 3 4.60384E-04 3.65264E-01 4.07226E-01 1.03719E 01
5422 3 4 2.18547E-04 4.10248E-01 2.53440E 00 9.44680E 01
5432 3 5 5.73241E-05 5.57123E-01 3.33481E-01 5.51630E 00

```

5250	3	6	1.40436E-05	6.34588E-01	1.96279E 00	4.77048E 01	0059
5260	3	7	9.28689E-21	4.65831E-01	1.43659E-01	-3.60177E 00	0060
5261	3	8	9.28689E-21	4.17451E-01	0.	-7.47230E 00	0061
5290	4	1	5.44518E-03	2.68883E-01	5.55575E-02	-1.79710E 00	0062
5498	4	2	1.23098E-03	4.16159E-01	1.77419E 00	4.04226E 01	0063
5410	4	3	5.37114E-04	3.43362E-01	4.15895E-01	7.09144E 00	0064
5422	4	4	2.54972E-04	3.83026E-01	2.45470E 00	5.91126E 01	0065
5432	4	5	6.68781E-05	5.25094E-01	3.43606E-01	3.94420E 00	0066
5250	4	6	1.63842E-05	5.90726E-01	1.89637E 00	2.96029E 01	0067
5260	4	7	1.08347E-20	4.37304E-01	1.48371E-01	-2.16014E 00	0068
5601	4	8	1.08347E-20	3.88373E-01	0.	-4.77487E 00	0069
5290	5	1	5.44518E-03	2.88108E-01	5.08096E-02	-1.39531E 00	0070
5498	5	2	1.23098E-03	4.86213E-01	1.84458E 00	3.22994E 01	0071
5410	5	3	5.37115E-04	3.92155E-01	3.93180E-01	4.84561E 00	0072
5422	5	4	2.54973E-04	4.50603E-01	2.62778E 00	4.89353E 01	0073
5432	5	5	6.68781E-05	6.20875E-01	3.18128E-01	2.17724E 00	0074
5250	5	6	1.63841E-05	6.84878E-01	2.03676E 00	2.52308E 01	0075
5260	5	7	1.00013E-20	5.08673E-01	1.56848E-01	-1.91489E 00	0076
5601	5	8	1.00013E-20	4.57096E-01	0.	-3.69247E 00	0077
5384	6	1	6.72705E-03	4.93509E-01	1.41471E-02	-2.84450E-02	0078
5502	6	2	1.00010E-20	1.75743E 00	3.22616E 00	1.40816E 00	0079
5400	6	3	1.00106E-20	2.68104E 00	2.30365E-01	-8.69312E-03	0080
5423	6	4	1.00106E-20	1.66131E 00	5.12819E 00	2.37154E 00	0081
5433	6	5	1.00106E-20	2.73061E 00	1.23834E-01	-6.70214E-02	0082
5251	6	6	2.02419E-05	1.98481E 00	3.98789E 00	1.40772E 00	0083
5261	6	7	1.00106E-20	1.45869E 00	4.89741E-02	-6.74549E-02	0084
5602	6	8	1.00106E-20	1.48522E 00	0.	-7.99816E-02	0085
5384	7	1	7.84823E-03	4.24537E-01	1.22543E-02	-2.36782E-02	0086
5502	7	2	1.16791E-20	9.78354E-01	2.18411E 00	6.58835E-01	0087
5400	7	3	1.16791E-20	8.09650E-01	2.11936E-01	1.77798E-02	0088
5423	7	4	1.16791E-20	7.90563E-01	3.58967E 00	1.15265E 00	0089
5433	7	5	1.16791E-20	1.02459E 00	1.13095E-01	-2.68251E-02	0090
5251	7	6	2.36156E-05	1.20757E 00	2.82443E 00	6.70130E-01	0091
5261	7	7	1.16791E-20	8.01636E-01	4.40893E-02	-3.99994E-02	0092
5602	7	8	1.16791E-20	7.80617E-01	0.	-4.71017E-02	0093
5382	8	1	1.06602E-02	5.15196E-01	3.71308E-03	-1.70118E-03	0094
5503	8	2	9.60326E-21	1.54384E 00	2.74758E 00	9.15171E-02	0095
5400	8	3	9.60326E-21	1.56795E 00	1.64844E-01	1.30539E-03	0096
5423	8	4	9.60326E-21	1.28971E 00	4.76683E 00	1.67374E-01	0097
5433	8	5	9.60326E-21	1.77944E 00	4.70840E-02	-3.65815E-03	0098
5251	8	6	3.20767E-05	1.83182E 00	3.76750E 00	1.03019E-01	0099
5261	8	7	9.60326E-21	1.23320E 00	1.73628E-02	-3.508	

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5250	2	6	8.78582E-06	6.98867E-01	2.06020E 00	2.82541E 01	0117
5250	2	7	1.15585E-06	5.03689E-01	1.36810E-01	-2.33170E 00	0118
5601	2	8	3.46023E-04	4.57968E-01	0.	-4.38401E 00	0119
5290	3	1	4.25048E-03	2.94202E-01	5.21213E-02	-2.97648E 00	0120
5410	3	3	5.37040E-04	3.91258E-01	3.99724E-01	9.54618E 00	0121
5422	3	4	1.73613E-04	4.41730E-01	2.63088E 00	9.57110E 01	0122
5432	3	5	6.72051E-05	5.92498E-01	3.23829E-01	4.66804E 00	0123
5498	3	2	1.09395E-03	4.95955E-01	1.83803E 00	6.24564E 01	0124
5250	3	6	8.78582E-06	6.87045E-01	2.04250E 00	4.87470E 01	0125
5260	3	7	1.15585E-06	4.98083E-01	1.39627E-01	-3.78536E 00	0126
5601	3	8	3.46023E-04	4.51570E-01	0.	-7.42953E 00	0127
5290	4	1	4.96441E-03	2.88914E-01	4.95806E-02	-1.46388E 00	0128
5498	4	2	1.25627E-03	4.69112E-01	1.80496E 00	3.13543E 01	0129
5410	4	3	5.10982E-04	3.74550E-01	3.86855E-01	4.75687E 00	0130
5422	4	4	1.94373E-04	4.22519E-01	2.57392E 00	4.76645E 01	0131
5432	4	5	7.71768E-05	5.70230E-01	3.11496E-01	2.31428E 00	0132
5250	4	6	1.07615E-05	6.56575E-01	1.99510E 00	2.43510E 01	0133
5260	4	7	1.34999E-06	4.74079E-01	1.33850E-01	-1.83017E 00	0134
5	1	4	4.31709E-04	4.27564E-01	0.	-3.59583E 00	0135
5382	5	1	1.07360E-02	3.05829E-01	3.45714E-02	-8.48044E-01	0136
5503	5	2	2.94570E-04	5.78620E-01	1.87155E 00	1.87689E 01	0137
5400	5	3	1.63895E-05	4.56047E-01	3.20054E-01	1.62164E 00	0138
5423	5	4	5.58482E-07	4.94819E-01	2.77915E 00	3.01704E 01	0139
5433	5	5	1.57632E-08	6.53371E-01	2.39125E-01	2.72707E-01	0140
5251	5	6	2.43163E-05	7.70393E-01	2.16536E 00	1.58854E 01	0141
5261	5	7	2.59703E-06	5.38571E-01	1.00267E-01	-1.43250E 00	0142
5602	5	8	7.13577E-05	4.95019E-01	0.	-2.15000E 00	0143
5384	6	1	6.59929E-03	4.70002E-01	1.71532E-02	-5.02874E-02	0144
5502	6	2	1.10040E-04	1.47803E 00	2.83327E 00	1.20643E 00	0145
5400	6	3	4.26289E-06	1.52344E 00	2.43515E-01	-9.47520E-02	0146
5423	6	4	1.28417E-07	1.27460E 00	4.56450E 00	2.14942E 00	0147
5433	6	5	2.57728E-09	1.79092E 00	1.38399E-01	-1.60883E-01	0148
5251	6	6	1.65162E-05	1.72294E 00	3.59985E 00	1.20170E 00	0149
5261	6	7	1.16289E-06	1.24539E 00	5.57798E-02	-1.38314E-01	0150
5602	6	8	1.58894E-05	1.23279E 00	0.	-1.55664E-01	0151
5382	7	1	1.09610E-02	4.96522E-01	9.06283E-03	-2.90419E-02	0152
5503	7	2	1.35705E-04	1.80576E 00	3.19433E 00	6.88291E-01	0153
5400	7	3	3.47738E-06	2.03470E 00	2.00016E-01	-1.92087E-01	0154
5423	7	4	6.27754E-08	1.60567E 00	5.31653E 00	1.28418E 00	0155
5433	7	5	8.11733E-10	2.20281E 00	8.50006E-02	-2.27059E-01	0156
5251	7	6	2.90602E-05	2.13055E 00	4.21296E 00	7.21829E-01	0157
5261	7	7	1.35759E-06	1.56272E 00	3.29438E-02	-1.15308E-01	0158
5602	7	8	1.51992E-05	1.55018E 00	0.	-1.24601E-01	0159
5382	8	1	1.10444E-02	5.39667E-01	4.54192E-03	-1.86576E-03	0160
5503	8	2	6.29689E-05	1.82988E 00	3.12849E 00	8.02976E-02	0161
5400	8	3	6.08237E-07	2.19444E 00	1.69363E-01	-3.45900E-03	0162
5423	8	4	4.34181E-09	1.63127E 00	5.36111E 00	1.46478E-01	0163
5433	8	5	3.27042E-11	2.38049E 00	4.83408E-02	-7.42006E-03	0164
5251	8	6	3.14807E-05	2.13686E 00	4.22197E 00	8.79459E-02	0165
5261	8	7	6.13513E-07	1.48219E 00	1.81150E-02	-4.97323E-03	0166
5602	8	8	3.68858E-06	1.51577E 00	0.	-5.32705E-03	0167
C	CLASS 6	- CONVERGENCE CRITERIA (POWER, EXPOSURE, REACTIVITY, ETC)					0168
6	1	1.0 0.002 0.002 0.01 0.10 20000.0 0.5 2.0 5.0					0169
C	CLASS 7	- OPERATING TIME, TOTAL POWER, LOAD FACTOR AND BURNUP					0170
7	1	401.0 0.4091 467.5 20000.0					0171
C	CLASS 8	- SOURCE CONCENTRATIONS FOR CORE AND BLANKETS (THE SUM OF THE					0172
C		CONCENTRATIONS SHOULD BE 1.0)					0173
8	1 1	2 0.589 3 0.257 4 0.122 5 0.032					0174

8	1 2	1 0.997 6 0.003	0175
C	CLASS 9 - INTERPOLATION FACTORS FOR END POINT CASES A AND B		0176
9	1	2 1.0 1.0	0177
C	CLASS 10 - MISCELLANEOUS PARAMETERS		0178
10	1	1.001 1.0014 54.0 1.0 10.0 1.0 1.0 1.0 1.0 1.0	0179
C	CLASS 11 - RECYCLE FRACTION AVAILABLE (1.0 FOR ALL FUEL REPOSITORIES.		0180
11	1	1.0 R12	0181
C	CLASS 13 - OUTPUT DESCRIPTION FOR THE REACTOR		0182
13	1	1 2 2 2 2 1 2 2 2 1 0 1 1	0183
C	CLASS 14 - OUTPUT DESCRIPTION FOR EACH ZONE		0184
14	1 1	1 4 4 4 4 1 2	0185
14	1 2	1 4 4 4 4 1 2	0186
14	1 3	1 4 4 4 4 1 2	0187
14	1 4	1 4 4 4 4 1 2	0188
14	1 5	1 4 4 4 4 1 2	0189
14	1 6	1 1 1 1 1 1 2	0190
14	1 7	1 1 1 1 1 1 2	0191
14	1 8	1 1 1 1 1 1 2	0192
C	CLASS 16 - TOTAL FUEL ATOM CONCENTRATIONS PER BATCH (IF SET EQUAL TO		0193
C	ZERO THESE PARAMETERS WILL BE CALCULATED FROM CLASS 5 DATA)		0194
16	1 1	0.0 R8	0195
C	CLASS 18 - RELATIVE POWER FOR THE CORE ZONES (IF SET EQUAL TO ZERO THESE		0196
C	PARAMETERS WILL BE CALCULATED FROM CLASS 4 DATA - THE RELATIVE		0197
C	POWER IS REQUIRED ONLY FOR CORE ZONES TO DETERMINE RELOAD		0198
C	REQUIREMENTS)		0199
18	1 1	0.0 R8	0200
C	CLASS 19 - OUT-OF-PILE PARAMETERS (FABRICATION AND RECOVERY TIMES,		0201
C	FISSILE LOSSES AND EFFICIENCY)		0202
19	1	270.0 180.0 0.01 0.01 0.375	0203
C	CLASS 20 - ECONOMIC ASSUMPTIONS (INTEREST RATES, FUEL WORTHS, ETC)		0204
20	1 1	10.0 0.0 0.0 0.0 0.0 0.0 1 10000.0	0205
C	CLASS 21 - FABRICATION AND RECOVERY COSTS (SEIS)		0206
21	1 1	175.0 70.0 35.0 70.0 30.0 60.0	0207
888			0208
C	OPERATING CYCLE 2 - ADJUST THE ESTIMATED OPERATING INTERVAL, LOAD FACTOR,		0209
C	AND DISCHARGE EXPOSURE		0210
7	1	292.0 0.6 467.5 40000.0	0211
C	- OUTPUT BY ZONE IS NO LONGER REQUESTED		0212
14	1 1	0	0213
14	1 2	0	0214
14	1 3	0	0215
14	1 4	0	0216
14	1 5	0	0217
14	1 6	0	0218
14	1 7	0	0219
14	1 8	0	0220
888			0221
C	OPERATING CYCLE 3 - ADJUST THE ESTIMATED OPERATING INTERVAL, LOAD FACTOR		0222
C	AND DISCHARGE EXPOSURE		0223
7	1	219.0 0.72 467.5 40000.0	0224
888			0225
C	OPERATING CYCLE 4 - ADJUST THE LOAD FACTOR		0226
7	1	219.0 0.80 467.5 40000.0	0227
888			0228
C	OPERATING CYCLE 6 - CORE ZONE 2 IS LOADED WITH FUEL HAVING THE SAME		0229
C	FISSILE ENRICHMENT AS CORE ZONE 3		0230
2	1 2	2 2 1 1 0 0 2 2 1 1 1 2 0 1 0 1 1 2	0231
C	- FUEL DISCHARGED FROM CORE ZONE 5 IS REPLACED WITH		0232

7.2 OUTPUT DESCRIPTION

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[illegible]

FUEL MATERIAL CONCENTRATIONS AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 1 (ATOMS/CC*E-24)

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
1	U-238	2.60031E-03	2.53660E-03	2.60031E-03	2.53660E-03
1	PU-239	3.70022E-04	3.63379E-04	3.70022E-04	3.63379E-04
1	PU-240	1.61453E-04	1.67212E-04	1.61453E-04	1.67212E-04
1	PU-241	7.66430E-05	6.20338E-05	7.66430E-05	6.20338E-05
1	PU-242	2.01030E-05	2.11699E-05	2.01030E-05	2.11699E-05
1	U-235	7.82400E-06	6.37148E-06	7.82400E-06	6.37148E-06
1	U-236	5.00065E-21	3.78140E-07	5.00065E-21	3.78140E-07
1	FP-1	0.	7.42555E-05	0.	7.42555E-05

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
2	U-238	2.60031E-03	2.54523E-03	2.60031E-03	2.54523E-03
2	PU-239	3.70022E-04	3.63585E-04	3.70022E-04	3.63585E-04
2	PU-240	1.61453E-04	1.65875E-04	1.61453E-04	1.65875E-04
2	PU-241	7.66430E-05	6.32638E-05	7.66430E-05	6.32638E-05
2	PU-242	2.01030E-05	2.09890E-05	2.01030E-05	2.09890E-05
2	U-235	7.82400E-06	6.56362E-06	7.82400E-06	6.56362E-06
2	U-236	5.00065E-21	3.23413E-07	5.00065E-21	3.23413E-07
2	FP-1	0.	6.56767E-05	0.	6.56767E-05

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
3	U-238	2.33364E-03	2.29217E-03	2.33364E-03	2.29217E-03
3	PU-239	5.27565E-04	5.00134E-04	5.27565E-04	5.00134E-04
3	PU-240	2.30192E-04	2.33047E-04	2.30192E-04	2.33047E-04
3	PU-241	1.09273E-04	9.21246E-05	1.09273E-04	9.21246E-05
3	PU-242	2.86620E-05	2.94823E-05	2.86620E-05	2.94823E-05
3	U-235	7.02180E-06	6.10679E-06	7.02180E-06	6.10679E-06
3	U-236	4.64344E-21	2.19848E-07	4.64344E-21	2.19848E-07
3	FP-1	0.	7.63934E-05	0.	7.63934E-05

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
4	U-238	2.72259E-03	2.68084E-03	2.72259E-03	2.68084E-03
4	PU-239	6.15490E-04	5.87366E-04	6.15490E-04	5.87366E-04
4	PU-240	2.68557E-04	2.70721E-04	2.68557E-04	2.70721E-04
4	PU-241	1.27486E-04	1.09120E-04	1.27486E-04	1.09120E-04
4	PU-242	3.34390E-05	3.41915E-05	3.34390E-05	3.41915E-05
4	U-235	8.19210E-06	7.27695E-06	8.19210E-06	7.27695E-06
4	U-236	5.41735E-21	2.14301E-07	5.41735E-21	2.14301E-07
4	FP-1	0.	7.83462E-05	0.	7.83462E-05

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
5	U-238	2.72259E-03	2.68817E-03	2.72259E-03	2.68817E-03
5	PU-239	6.15490E-04	5.91938E-04	6.15490E-04	5.91938E-04
5	PU-240	2.68557E-04	2.71611E-04	2.68557E-04	2.71611E-04
5	PU-241	1.27486E-04	1.10840E-04	1.27486E-04	1.10840E-04

5	PU-242	3.34390E-05	3.42566E-05	3.34390E-05	3.42566E-05
5	U-235	8.19205E-06	7.39660E-06	8.19205E-06	7.39660E-06
5	U-236	5.00065E-21	1.97549E-07	5.00065E-21	1.97549E-07
5	FP-1	0.	6.36756E-05	0.	6.36756E-05

FRACTION OF REACTOR POWER AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 1

TOTAL REACTOR POWER (MWT) AT BEGINNING OF CYCLE 0.47422E 03
 TOTAL REACTOR POWER (MWT) AT END OF CYCLE 0.46149E 03

REGION	POWER FRACTION (BOC)	POWER FRACTION (EOC)
1	0.43917E 00	0.42808E 00
2	0.64577E-01	0.63247E-01
3	0.17063E 00	0.16396E 00
4	0.14941E 00	0.14467E 00
5	0.14789E 00	0.14421E 00
6	0.15541E-01	0.30929E-01
7	0.16734E-02	0.23919E-02
8	0.11110E-01	0.22515E-01

BATCH AVERAGED MATERIAL CONCENTRATIONS FOR OPERATING CYCLE 1 (ATOMS/CC-E-24)

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
1	U-238	5.20063E-03	5.13666E-03	5.07321E-03
1	PU-239	7.40045E-04	7.33444E-04	7.26758E-04
1	PU-240	3.22906E-04	3.28763E-04	3.34423E-04
1	PU-241	1.53286E-04	1.37951E-04	1.24068E-04
1	PU-242	4.02061E-05	4.13701E-05	4.23399E-05
1	U-235	1.56480E-05	1.41458E-05	1.27430E-05
1	U-236	1.00013E-20	3.94383E-07	7.56281E-07
1	FP-1	0.	7.42555E-05	1.48511E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
2	U-238	5.20063E-03	5.14535E-03	5.09047E-03
2	PU-239	7.40045E-04	7.33620E-04	7.27171E-04
2	PU-240	3.22906E-04	3.27401E-04	3.31790E-04
2	PU-241	1.53286E-04	1.39321E-04	1.26528E-04
2	PU-242	4.02061E-05	4.11667E-05	4.19779E-05
2	U-235	1.56480E-05	1.43507E-05	1.31272E-05
2	U-236	1.00013E-20	3.35290E-07	6.46826E-07
2	FP-1	0.	6.56767E-05	1.31353E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
3	U-238	4.66729E-03	4.62569E-03	4.58434E-03
3	PU-239	1.05513E-03	1.02725E-03	1.00027E-03
3	PU-240	4.60384E-04	4.63370E-04	4.66094E-04
3	PU-241	2.18547E-04	2.00771E-04	1.84249E-04
3	PU-242	5.73241E-05	5.82139E-05	5.89647E-05
3	U-235	1.40436E-05	1.31073E-05	1.22136E-05
3	U-236	9.28689E-21	2.26248E-07	4.39696E-07
3	FP-1	0.	7.63934E-05	1.52787E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
4	U-238	5.44518E-03	5.40332E-03	5.36168E-03
4	PU-239	1.23098E-03	1.20246E-03	1.17473E-03
4	PU-240	5.37114E-04	5.39384E-04	5.41443E-04
4	PU-241	2.54972E-04	2.36009E-04	2.18239E-04
4	PU-242	6.68781E-05	6.76915E-05	6.83829E-05
4	U-235	1.63842E-05	1.54510E-05	1.45539E-05
4	U-236	1.09347E-20	2.19587E-07	4.28601E-07
4	FP-1	0.	7.83462E-05	1.56692E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
5	U-238	5.44518E-03	5.41069E-03	5.37634E-03
5	PU-239	1.23098E-03	1.20715E-03	1.18388E-03
5	PU-240	5.37115E-04	5.40255E-04	5.43221E-04
5	PU-241	2.54973E-04	2.37838E-04	2.21679E-04
5	PU-242	6.68781E-05	6.77474E-05	6.85132E-05
5	U-235	1.63841E-05	1.55751E-05	1.47932E-05
5	U-236	1.00013E-20	2.01751E-07	3.95098E-07
5	FP-1	0.	6.36756E-05	1.27351E-04

OUTPUT FOR COMPOSITE ZONES

COMPOSITE ZONE 1 OPERATING INTERVAL 1 AVERAGE ZONE POWER (MW) 2.02812E 02

REACTOR ZONE 1 TOTAL BATCHES 2 BATCHES LOADED 2 BATCHES DISCHARGED 1

DISCHARGE FUEL EXPOSURE (MWD/MT) AND WEIGHTS (KG)

	BURNUP	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
BATCH 1	2.2691E 04	7.3315E 02	1.3978E 02	9.6761E 01	5.7542E 02	1.4232E 00
	2.2691E 04	7.3315E 02	1.3978E 02	9.6761E 01	5.7542E 02	1.4232E 00

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
BATCH 1	5.7391E 02	8.2550E 01	3.8145E 01	1.4210E 01	4.8696E 00	1.4232E 00	8.4825E-02	1.6798E 01
	5.7391E 02	8.2550E 01	3.8145E 01	1.4210E 01	4.8696E 00	1.4232E 00	8.4825E-02	1.6798E 01

LOADED FUEL WEIGHTS (KG)

	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
BATCH 1	1.4663E 03	2.8614E 02	2.0383E 02	1.1801E 03	3.4953E 00
BATCH 2	7.3315E 02	1.4307E 02	1.0102E 02	5.9007E 02	1.7477E 00
	7.3315E 02	1.4307E 02	1.0102E 02	5.9007E 02	1.7477E 00

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
BATCH 1	1.1767E 03	1.6812E 02	7.3663E 01	3.5114E 01	9.2484E 00	3.4953E 00	2.2435E-15	0.
BATCH 2	5.8833E 02	8.4060E 01	3.6831E 01	1.7557E 01	4.6242E 00	1.7477E 00	1.1218E-15	0.
	5.8833E 02	8.4060E 01	3.6831E 01	1.7557E 01	4.6242E 00	1.7477E 00	1.1218E-15	0.

AVERAGE FUEL WEIGHTS (KG) AT MID-CYCLE

	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
BATCH 1	1.4663E 03	2.8285E 02	1.9838E 02	1.1655E 03	3.1709E 00
BATCH 2	7.3315E 02	1.4142E 02	9.9189E 01	5.8275E 02	1.5854E 00
	7.3315E 02	1.4142E 02	9.9189E 01	5.8275E 02	1.5854E 00

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
BATCH 1	1.1622E 03	1.6661E 02	7.4977E 01	3.1767E 01	9.4939E 00	3.1789E 00	8.4825E-02	1.6798E 01
BATCH 2	5.8112E 02	8.3305E 01	3.7488E 01	1.5884E 01	4.7469E 00	1.5854E 00	4.2413E-02	8.3992E 00
	5.8112E 02	8.3305E 01	3.7488E 01	1.5884E 01	4.7469E 00	1.5854E 00	4.2413E-02	8.3992E 00

TOTAL FUEL WEIGHTS (KG) AT THE END-OF-CYCLE

	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
BATCH 1	1.4663E 03	2.7955E 02	1.9392E 02	1.1508E 03	2.8464E 00
BATCH 2	7.3315E 02	1.3978E 02	9.6761E 01	5.7542E 02	1.4232E 00
	7.3315E 02	1.3978E 02	9.6761E 01	5.7542E 02	1.4232E 00

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
BATCH 1	1.1478E 03	1.6510E 02	7.6250E 01	2.8421E 01	9.7393E 00	2.8464E 00	1.6965E-01	3.3597E 01
BATCH 2	5.7391E 02	8.2550E 01	3.8145E 01	1.4210E 01	4.8696E 00	1.4232E 00	8.4825E-02	1.6798E 01
	5.7391E 02	8.2550E 01	3.8145E 01	1.4210E 01	4.8696E 00	1.4232E 00	8.4825E-02	1.6798E 01

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES FUEL CYCLE COSTS (MILLS/KWHR)

REFERENCE SET	TOTAL COST	FAB COST	REP COST	DEPLETION	INVENTORY	FAB INV	REP INV
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1

1.4343E 00 3.7363E-01 1.4945E-01 2.2872E-01 6.7068E-01 2.3354E-02 -1.1551E-02

OUTPUT FOR COMPOSITE ZONES

COMPOSITE ZONE 2 OPERATING INTERVAL 1 AVERAGE ZONE POWER (MWT) 2.98970E 01

REACTOR ZONE 2 TOTAL BATCHES 2 BATCHES LOADED 2 BATCHES DISCHARGED 1

DISCHARGE FUEL EXPOSURE (MWD/MT) AND WEIGHTS (KG)

	BURNUP	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
BATCH 1	2.0069E 04 2.0069E 04	1.2219E 02 1.2219E 02	2.3293E 01 2.3293E 01	1.6182E 01 1.6182E 01	9.6234E 01 9.6234E 01	2.4435E-01 2.4435E-01

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
BATCH 1	9.5977E 01	1.3766E 01	6.3067E 00	2.4154E 00	8.0467E-01	2.4435E-01	1.2091E-02	2.4763E 00

LOADED FUEL WEIGHTS (KG)

	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
BATCH 1	2.4438E 02	4.7691E 01	3.3872E 01	1.9669E 02	5.8255E-01
BATCH 2	1.2219E 02	2.3845E 01	1.6936E 01	9.8346E 01	2.9128E-01

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
BATCH 1	1.9611E 02	2.8020E 01	1.2277E 01	5.8523E 00	1.5414E 00	5.8255E-01	3.7392E-16	0.
BATCH 2	9.8054E 01	1.4010E 01	6.1386E 00	2.9262E 00	7.7070E-01	2.9188E-01	1.8696E-16	0.

AVERAGE FUEL WEIGHTS (KG) AT MID-CYCLE

	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
BATCH 1	2.4438E 02	4.7138E 01	3.3118E 01	1.9458E 02	5.3563E-01
BATCH 2	1.2219E 02	2.3569E 01	1.6559E 01	9.7290E 01	2.6782E-01

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
BATCH 1	1.9403E 02	2.7776E 01	1.2445E 01	5.3415E 00	1.5754E 00	5.3563E-01	1.2091E-02	2.4763E 00
BATCH 2	9.7016E 01	1.3888E 01	6.2226E 00	2.6708E 00	7.8768E-01	2.6782E-01	6.0457E-03	1.2381E 00

TOTAL FUEL WEIGHTS (KG) AT THE END-OF-CYCLE

	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
BATCH 1	2.4438E 02	4.6586E 01	3.2363E 01	1.9247E 02	4.8871E-01
BATCH 2	1.2219E 02	2.3293E 01	1.6182E 01	9.6234E 01	2.4435E-01

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
BATCH 1	1.9195E 02	2.7532E 01	1.2613E 01	4.8307E 00	1.6093E 00	4.8871E-01	2.4183E-02	4.9525E 00
BATCH 2	9.5977E 01	1.3766E 01	6.3067E 00	2.4154E 00	8.0467E-01	2.4435E-01	1.2091E-02	2.4763E 00

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES FUEL CYCLE COSTS (MILLS/KWHR)

REFERENCE SET	TOTAL COST	FAB COST	REP COST	DEPLETION	INVENTORY	FAB INV	REP INV
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1

2,3772E-01 6,2271E-02 2,4908E-02 3,6592E-02 1,1198E-01 3,8923E-03 -1,9252E-03

OUTPUT FOR COMPOSITE ZONES

COMPOSITE ZONE 3 OPERATING INTERVAL 1 AVERAGE ZONE POWER (MWT) 7.82597E 01

REACTOR ZONE 3 TOTAL BATCHES 2 BATCHES LOADED 2 BATCHES DISCHARGED 1

DISCHARGE FUEL EXPOSURE (MWD/MT) AND WEIGHTS (KG)

	BURNUP	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
BATCH 1	2,3336E 04	2.7508E 02	7.3000E 01	5.0520E 01	1.9501E 02	5.1153E-01
	2,3336E 04	2.7508E 02	7.3000E 01	5.0520E 01	1.9501E 02	5.1153E-01

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
BATCH 1	1.9448E 02	4.2607E 01	1.9936E 01	7.9138E 00	2.5431E 00	5.1153E-01	1.8494E-02	6.4807E 00
	1.9448E 02	4.2607E 01	1.9936E 01	7.9138E 00	2.5431E 00	5.1153E-01	1.8494E-02	6.4807E 00

LOADED FUEL WEIGHTS (KG)

	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
BATCH 1	5.5016E 02	1.9299E 02	1.0886E 02	3.9717E 02	1.1764E 00
BATCH 2	2.7508E 02	7.6495E 01	5.4350E 01	1.9859E 02	5.8818E-01
	2.7508E 02	7.6495E 01	5.4350E 01	1.9859E 02	5.8818E-01

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
BATCH 1	3.9599E 02	8.9887E 01	3.9384E 01	1.8774E 01	4.9448E 00	1.1764E 00	7.8122E-16	0.
BATCH 2	1.9800E 02	4.4943E 01	1.5692E 01	9.3869E 00	2.4724E 00	5.8818E-01	3.9061E-16	0.
	1.9800E 02	4.4943E 01	1.5692E 01	9.3869E 00	2.4724E 00	5.8818E-01	3.9061E-16	0.

AVERAGE FUEL WEIGHTS (KG) AT MID-CYCLE

	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
BATCH 1	5.5016E 02	1.4949E 02	1.0485E 02	3.9359E 02	1.0997E 00
BATCH 2	2.7508E 02	7.4747E 01	5.2425E 01	1.9680E 02	5.4986E-01
	2.7508E 02	7.4747E 01	5.2425E 01	1.9680E 02	5.4986E-01

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
BATCH 1	3.9248E 02	8.7550E 01	3.9629E 01	1.7301E 01	5.0155E 00	1.0997E 00	1.8494E-02	6.4807E 00
BATCH 2	1.9624E 02	4.3775E 01	1.9814E 01	8.6504E 00	2.5078E 00	5.4986E-01	9.2469E-03	3.2404E 00
	1.9624E 02	4.3775E 01	1.9814E 01	8.6504E 00	2.5078E 00	5.4986E-01	9.2469E-03	3.2404E 00

TOTAL FUEL WEIGHTS (KG) AT THE END-OF-CYCLE

	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
BATCH 1	5.5016E 02	1.4600E 02	1.0104E 02	3.9002E 02	1.0231E 00
BATCH 2	2.7508E 02	7.3000E 01	5.0520E 01	1.9501E 02	5.1153E-01
	2.7508E 02	7.3000E 01	5.0520E 01	1.9501E 02	5.1153E-01

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
BATCH 1	3.8896E 02	8.5213E 01	3.9873E 01	1.5828E 01	5.0863E 00	1.0231E 00	3.6988E-02	1.2961E 01
BATCH 2	1.9448E 02	4.2607E 01	1.9936E 01	7.9138E 00	2.5431E 00	5.1153E-01	1.8494E-02	6.4807E 00
	1.9448E 02	4.2607E 01	1.9936E 01	7.9138E 00	2.5431E 00	5.1153E-01	1.8494E-02	6.4807E 00

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES FUEL CYCLE COSTS (MILLS/KWHR)

REFERENCE SET	TOTAL COST	FAB COST	REP COST	DEPLETION	INVENTORY	FAB INV	REP INV
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1

7,1235E-01 1,4019E-01 5,6074E-02 1,5763E-01 3,5404E-01 8,7624E-03 -4,3340E-03

OUTPUT FOR COMPOSITE ZONES

COMPOSITE ZONE 4 OPERATING INTERVAL 1 AVERAGE ZONE POWER (MWT) 6.87948E 01

REACTOR ZONE 4 TOTAL BATCHES 2 BATCHES LOADED 2 BATCHES DISCHARGED 1

DISCHARGE FUEL EXPOSURE (MWD/MT) AND WEIGHTS (KG)

	BURNUP	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
	2.0514E 04	2.7508E 02	7.3303E 01	5.0924E 01	1.9550E 02	5.2247E-01
BATCH 1	2.0514E 04	2.7508E 02	7.3303E 01	5.0924E 01	1.9550E 02	5.2247E-01

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	Fp-1
	1.9496E 02	4.2890E 01	1.9851E 01	8.0346E 00	2.5280E 00	5.2247E-01	1.5452E-02	5.6969E 00
BATCH 1	1.9496E 02	4.2890E 01	1.9851E 01	8.0346E 00	2.5280E 00	5.2247E-01	1.5452E-02	5.6969E 00

LOADED FUEL WEIGHTS (KG)

	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
	5.5016E 02	1.5299E 02	1.0806E 02	3.9717E 02	1.1764E 00
BATCH 1	2.7508E 02	7.6495E 01	5.4350E 01	1.9859E 02	5.8818E-01
BATCH 2	2.7508E 02	7.6495E 01	5.4350E 01	1.9859E 02	5.8818E-01

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	Fp-1
	3.9599E 02	8.9886E 01	3.9384E 01	1.8774E 01	4.9447E 00	1.1704E 00	7.8122E-16	0.
BATCH 1	1.9800E 02	4.4943E 01	1.9692E 01	9.3869E 00	2.4724E 00	5.8818E-01	3.9061E-16	0.
BATCH 2	1.9800E 02	4.4943E 01	1.9692E 01	9.3869E 00	2.4724E 00	5.8818E-01	3.9061E-16	0.

AVERAGE FUEL WEIGHTS (KG) AT MID-CYCLE

	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
	5.5016E 02	1.4980E 02	1.0585E 02	3.9408E 02	1.1106E 00
BATCH 1	2.7508E 02	7.4899E 01	5.2627E 01	1.9704E 02	5.5532E-01
BATCH 2	2.7508E 02	7.4899E 01	5.2627E 01	1.9704E 02	5.5532E-01

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	Fp-1
	3.9298E 02	8.7833E 01	3.9543E 01	1.7422E 01	5.0004E 00	1.1186E 00	1.5452E-02	5.6969E 00
BATCH 1	1.9648E 02	4.3916E 01	1.9771E 01	8.7108E 00	2.5002E 00	5.5532E-01	7.7259E-03	2.8485E 00
BATCH 2	1.9648E 02	4.3916E 01	1.9771E 01	8.7108E 00	2.5002E 00	5.5532E-01	7.7259E-03	2.8485E 00

TOTAL FUEL WEIGHTS (KG) AT THE END-OF-CYCLE

	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
	5.5016E 02	1.4661E 02	1.0185E 02	3.9100E 02	1.0449E 00
BATCH 1	2.7508E 02	7.3303E 01	5.0924E 01	1.9550E 02	5.2247E-01
BATCH 2	2.7508E 02	7.3303E 01	5.0924E 01	1.9550E 02	5.2247E-01

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	Fp-1
	3.8992E 02	8.5779E 01	3.9702E 01	1.6069E 01	5.0560E 00	1.0449E 00	3.0904E-02	1.1394E 01
BATCH 1	1.9496E 02	4.2890E 01	1.9851E 01	8.0346E 00	2.5280E 00	5.2247E-01	1.5452E-02	5.6969E 00
BATCH 2	1.9496E 02	4.2890E 01	1.9851E 01	8.0346E 00	2.5280E 00	5.2247E-01	1.5452E-02	5.6969E 00

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES FUEL CYCLE COSTS (MILLS/KWHR)

REFERENCE SET	TOTAL COST	FAB COST	REP COST	DEPLETION	INVENTORY	FAB INV	REP INV
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1

7,0234E-01 1,4019E-01 5,6074E-02 1,4611E-01 3,5554E-01 8,7623E-03 -4,3340E-03

OUTPUT FOR COMPOSITE ZONES

COMPOSITE ZONE 5 OPERATING INTERVAL 1 AVERAGE ZONE POWER (MWT) 6.83369E 01

REACTOR ZONE 5 TOTAL BATCHES 2 BATCHES LOADED 2 BATCHES DISCHARGED 1

DISCHARGE FUEL EXPOSURE (MWD/MT) AND WEIGHTS (KG)

	BURNUP	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
	1.6672E 04	3.3621E 02	9.0241E 01	6.2804E 01	2.3960E 02	6.4908E-01
BATCH 1	1.6672E 04	3.3621E 02	9.0241E 01	6.2804E 01	2.3960E 02	6.4908E-01

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
	2.3894E 02	5.2829E 01	2.4342E 01	9.9749E 00	3.0957E 00	6.4908E-01	1.7409E-02	5.6591E 00
BATCH 1	2.3894E 02	5.2829E 01	2.4342E 01	9.9749E 00	3.0957E 00	6.4908E-01	1.7409E-02	5.6591E 00

LOADED FUEL WEIGHTS (KG)

	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
	6.7242E 02	1.8699E 02	1.3281E 02	4.8543E 02	1.4378E 00
BATCH 1	3.3621E 02	9.3494E 01	6.6484E 01	2.4272E 02	7.1888E-01
BATCH 2	3.3621E 02	9.3494E 01	6.6484E 01	2.4272E 02	7.1888E-01

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
	4.8399E 02	1.7098E 02	4.8137E 01	2.2946E 01	6.0436E 00	1.4378E 00	8.8138E-16	0.
BATCH 1	2.4200E 02	5.4931E 01	2.4068E 01	1.1473E 01	3.0218E 00	7.1888E-01	4.74069E-16	0.
BATCH 2	2.4200E 02	5.4931E 01	2.4068E 01	1.1473E 01	3.0218E 00	7.1888E-01	4.74069E-16	0.

AVERAGE FUEL WEIGHTS (KG) AT MID-CYCLE

	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
	6.7242E 02	1.8374E 02	1.2921E 02	4.8232E 02	1.3680E 00
BATCH 1	3.3621E 02	9.1868E 01	6.4684E 01	2.4116E 02	6.8398E-01
BATCH 2	3.3621E 02	9.1868E 01	6.4684E 01	2.4116E 02	6.8398E-01

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
	4.6094E 02	1.7076E 02	4.8410E 01	2.1448E 01	6.1175E 00	1.3680E 00	1.7409E-02	5.6591E 00
BATCH 1	2.4047E 02	5.3880E 01	2.4205E 01	1.0724E 01	3.0587E 00	6.8398E-01	8.77047E-03	2.8295E 00
BATCH 2	2.4047E 02	5.3880E 01	2.4205E 01	1.0724E 01	3.0587E 00	6.8398E-01	8.77047E-03	2.8295E 00

TOTAL FUEL WEIGHTS (KG) AT THE END-OF-CYCLE

	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
	6.7242E 02	1.8048E 02	1.2961E 02	4.7921E 02	1.2982E 00
BATCH 1	3.3621E 02	9.0241E 01	6.2804E 01	2.3960E 02	6.4908E-01
BATCH 2	3.3621E 02	9.0241E 01	6.2804E 01	2.3960E 02	6.4908E-01

	U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
	4.7788E 02	1.0566E 02	4.8684E 01	1.9950E 01	6.1914E 00	1.2962E 00	3.4819E-02	1.1318E 01
BATCH 1	2.3894E 02	5.2829E 01	2.4342E 01	9.9749E 00	3.0957E 00	6.4908E-01	1.7409E-02	5.6591E 00
BATCH 2	2.3894E 02	5.2829E 01	2.4342E 01	9.9749E 00	3.0957E 00	6.4908E-01	1.7409E-02	5.6591E 00

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES FUEL CYCLE COSTS (MILLS/KWHR)

REFERENCE SET	TOTAL COST	FAB COST	REP COST	DEPLETION	INVENTORY	FAB INV	REP INV
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1

8.4446E-01 1.7134E-01 6.6536E-02 1.6253E-01 4.3665E-01 1.0710E-02 -5.2971E-03

OUTPUT FOR COMPOSITE ZONES

COMPOSITE ZONE 6 OPERATING INTERVAL 1 AVERAGE ZONE POWER (MWT) 1.08773E 01

REACTOR ZONE 6 TOTAL BATCHES 2 BATCHES LOADED 2 BATCHES DISCHARGED 1

DISCHARGE FUEL EXPOSURE (MWD/MT) AND WEIGHTS (KG)

BURNUP	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
6.2088E 02	1.4370E 03	1.1419E 01	1.1259E 01	1.4247E 03	3.8549E 00

LOADED FUEL WEIGHTS (KG)

TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
2.8740E 03	1.7234E-14	8.5989E-15	2.8740E 03	8.5126E 00

AVERAGE FUEL WEIGHTS (KG) AT MID-CYCLE

TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
2.8740E 03	1.1419E 01	1.1259E 01	2.8617E 03	8.1112E 00

TOTAL FUEL WEIGHTS (KG) AT THE END-OF-CYCLE

TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
2.8740E 03	2.2838E 01	2.2589E 01	2.8494E 03	7.7098E 00

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES FUEL CYCLE COSTS (MILLS/KWHR)

REFERENCE SET	TOTAL COST	FAB COST	REP COST	DEPLETION	INVENTORY	FAB INV	REP INV
1	1.4354E-01	1.4646E-01	2.9293E-01	-3.2447E-01	4.2098E-02	9.1548E-03	-2.2640E-02

OUTPUT FOR COMPOSITE ZONES

COMPOSITE ZONE 7 OPERATING INTERVAL 1 AVERAGE ZONE POWER (MW_T) 9.49960E-01

REACTOR ZONE 7 TOTAL BATCHES 2 BATCHES LOADED 2 BATCHES DISCHARGED 1

DISCHARGE FUEL EXPOSURE (MWD/MT) AND WEIGHTS (KG)

BURNUP 2.2043E 02	TOTAL FUEL 3.5349E 02	TOTAL PU 1.3552E 00	FISSILE PU 1.3491E 00	TOTAL U 3.5206E 02	FISSILE U 1.0092E 00
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LOADED FUEL WEIGHTS (KG)

TOTAL FUEL 7.0699E 02	TOTAL PU 4.2394E-15	FISSILE PU 2.1153E-15	TOTAL U 7.0699E 02	FISSILE U 2.0940E 00
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AVERAGE FUEL WEIGHTS (KG) AT MID-CYCLE

TOTAL FUEL 7.0699E 02	TOTAL PU 1.3552E 00	FISSILE PU 1.3491E 00	TOTAL U 7.0556E 02	FISSILE U 2.0562E 00
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TOTAL FUEL WEIGHTS (KG) AT THE END-OF-CYCLE

TOTAL FUEL 7.0699E 02	TOTAL PU 2.7104E 00	FISSILE PU 2.6982E 00	TOTAL U 7.0413E 02	FISSILE U 2.0184E 00
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FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES
FUEL CYCLE COSTS (MILLS/KWHR)

REFERENCE SET
1

TOTAL COST 7.0922E-02	FAB COST 3.6029E-02	REP COST 7.2059E-02	DEPLETION -3.8895E-02	INVENTORY 5.0464E-03	FAB INV 2.2520E-03	REP INV -5.5694E-03
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OUTPUT FOR COMPOSITE ZONES

COMPOSITE ZONE 6 OPERATING INTERVAL 1 AVERAGE ZONE POWER (MWT) 7.85461E 00
 REACTOR ZONE 6 TOTAL BATCHES 3 BATCHES LOADED 3 BATCHES DISCHARGED 1

DISCHARGE FUEL EXPOSURE (MWD/MT) AND WEIGHTS (KG)

BURNUP	TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
2.3182E 02	1.8528E 03	1.0116E 01	1.0032E 01	1.8423E 03	5.1666E 00

LOADED FUEL WEIGHTS (KG)

TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
5.5584E 03	2.0177E-14	1.0068E-14	5.5584E 03	1.6464E 01

AVERAGE FUEL WEIGHTS (KG) AT MID-CYCLE

TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
5.5584E 03	1.5175E 01	1.5049E 01	5.5426E 03	1.5982E 01

TOTAL FUEL WEIGHTS (KG) AT THE END-OF-CYCLE

TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
5.5584E 03	3.0349E 01	3.0097E 01	5.5269E 03	1.5500E 01

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES
 FUEL CYCLE COSTS (MILLS/KWHR)

REFERENCE SET	TOTAL COST	FAB COST	REP COST	DEPLETION	INVENTORY	FAB INV	REP INV
	2.1899E-01	1.6187E-01	3.2373E-01	-2.8923E-01	3.7526E-02	1.0118E-02	-2.5021E-02

OPERATING INTERVAL	1
NUMBER OF INTERNAL ITERATIONS	1
OPERATING INTERVAL TIME (DAYS)	401.000E 00
LOADING FACTOR	0.40910E 00
AVERAGE ELECTRICAL POWER (MWE)	1.75418E 02
AVERAGE THERMAL POWER (MWT)	4.67782E 02
AVERAGE BURNUP FOR DESIGNATED ZONES (MWD/MT)	2.11080E 04
ACCUMULATED OPERATING TIME (YRS)	1.09788E 00
EFFECTIVE MULTIPLICATION CONSTANT AT EOC	0.10020E 01
BURNUP REACTIVITY	-0.39049E-01
RATIO OF POWER DENSITY PEAK TO AVERAGE	1.02105E 00
AVERAGE BREEDING RATIO	1.22234E 00
BEG-OF-CYCLE BREEDING RATIO	1.20979E 00
END-OF-CYCLE BREEDING RATIO	1.23490E 00
DOUBLING TIME (YR)	0.

DISCHARGE FUEL WEIGHTS (KG) FOR THE REACTOR									
TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38501E 03		4.22903E 02		2.99827E 02		4.92884E 03		1.33813E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.9071E 03	2.9727E 02	1.0884E 02	4.2552E 01	1.3841E 01	1.3381E 01	3.9670E-01	3.8544E 01		

LOADED FUEL WEIGHTS (KG) FOR THE REACTOR									
TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26228E 04		8.26802E 02		5.87234E 02		1.17960E 04		3.49385E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1761E 04	4.8977E 02	2.1285E 02	1.0146E 02	2.8723E 01	3.4939E 01	1.5279E-14	0.		

AVERAGE FUEL WEIGHTS (KG) FOR THE REACTOR									
TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26228E 04		8.40962E 02		5.98460E 02		1.17400E 04		3.34339E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1706E 04	5.0518E 02	2.1530E 02	9.3282E 01	2.7203E 01	3.3484E 01	4.4911E-01	3.8764E 01		

END-OF-CYCLE FUEL WEIGHTS (KG) FOR THE REACTOR									
TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26228E 04		8.55123E 02		6.09686E 02		1.16840E 04		3.19293E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1651E 04	5.2498E 02	2.1776E 02	8.5104E 01	2.7682E 01	3.1929E 01	8.9823E-01	7.7529E 01		

ACCUMULATED IN-PILE AND OUT-OF-PILE FUEL WEIGHTS (KG) FOR THE REACTOR									
TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
2.19538E 04		1.49890E 03		1.06425E 03		2.03983E 04		5.81607E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
2.0299E 04	8.9669E 02	3.8424E 02	1.6761E 02	4.8531E 01	5.8161E 01	7.1488E-01	6.5044E 01		

FUEL CYCLE COSTS (MILLS/KWHR)

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES							
OPERATING INTERVAL 1 ENERGY OF DISCHARGED FUEL 3.43394E 08				ACCUMULATED ENERGY OF DISCHARGED FUEL 3.43394E 08			
REFERENCE SET	TOTAL COST	INVENTORY	CREDIT	FABRICATION	REPROCESSING	FAB INV	REPR INV
1	4.36461E 00	2.01356E 00	7.89833E-02	1.23197E 00	1.04377E 00	7.70044E-02	-8.06722E-02

LEVELIZED FUEL CYCLE COSTS

REFERENCE SET	LEVELIZED COST FOR DISCHARGED FUEL	LEVELIZED COST FOR OPERATING CYCLE
1	4.36461E 00	0.

STORED AND RECYCLE FUEL REPOSITORIES EDIT (OPERATING CYCLE 1)

FUEL REPOSITORY 1

MATERIAL /	0	DELAY TIME (ACCUMULATED OPERATING INTERVALS)				5	6
		1	2	3	4		
U-238	0.	0.	0.	0.			
PU-239	2.52155E 02	0.	0.	0.			
PU-240	1.06370E 02	0.	0.	0.			
PU-241	4.17051E 01	0.	0.	0.			
PU-242	1.35697E 01	0.	0.	0.			
U-235	0.	0.	0.	0.			
U-236	0.	0.	0.	0.			
FP-1	0.	0.	0.	0.			
TOTAL	4.14995E 02	0.	0.	0.			

MATERIAL /	0	FUEL REPOSITORY 2 DELAY TIME (ACCUMULATED OPERATING INTERVALS)				5	6
		1	2	3	4		
U-238	4.80941E 03	0.	0.	0.			
PU-239	0.	0.	0.	0.			
PU-240	0.	0.	0.	0.			
PU-241	0.	0.	0.	0.			
PU-242	0.	0.	0.	0.			
U-235	1.31151E 01	0.	0.	0.			
U-236	3.88602E 01	0.	0.	0.			
FP-1	0.	0.	0.	0.			
TOTAL	4.82292E 03	0.	0.	0.			

FUEL MATERIAL CONCENTRATIONS AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 2 (ATOMS/CC*E-24)

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
1	U-238	2.53660E-03	2.47300E-03	2.52461E-03	2.46130E-03
1	PU-239	3.63379E-04	3.56353E-04	4.15722E-04	4.00056E-04
1	PU-240	1.67212E-04	1.72505E-04	1.80638E-04	1.67125E-04
1	PU-241	6.20338E-05	5.18247E-05	8.53943E-05	6.99484E-05
1	PU-242	2.11699E-05	2.17649E-05	2.23060E-05	2.35435E-05
1	U-235	6.37148E-06	5.16348E-06	7.69455E-06	6.23570E-06
1	U-236	3.78140E-07	6.74503E-07	0.	3.79561E-07
1	FP-1	7.42555E-05	1.46685E-04	0.	8.34122E-05

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
2	U-238	2.54523E-03	2.49006E-03	2.52461E-03	2.46988E-03
2	PU-239	3.63585E-04	3.56938E-04	4.15722E-04	4.01392E-04
2	PU-240	1.65875E-04	1.69960E-04	1.80638E-04	1.65633E-04
2	PU-241	6.32638E-05	5.36461E-05	8.53943E-05	7.13688E-05
2	PU-242	2.09890E-05	2.15081E-05	2.23060E-05	2.33350E-05
2	U-235	6.56362E-06	5.48345E-06	7.69455E-06	6.42827E-06
2	U-236	3.23413E-07	5.87126E-07	0.	3.24762E-07
2	FP-1	6.56767E-05	1.29998E-04	0.	7.37813E-05

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
3	U-238	2.29217E-03	2.25047E-03	2.20309E-03	2.16381E-03
3	PU-239	3.00134E-04	4.74692E-04	6.06146E-04	5.67093E-04
3	PU-240	2.33047E-04	2.35206E-04	2.63379E-04	2.66686E-04
3	PU-241	9.21266E-05	7.93702E-05	1.24509E-04	1.06337E-04
3	PU-242	2.94823E-05	2.99554E-05	3.25233E-05	3.35021E-05
3	U-235	6.10679E-06	5.29351E-06	6.71462E-06	5.82039E-06
3	U-236	2.19848E-07	4.07924E-07	0.	2.14769E-07
3	FP-1	7.63934E-05	1.49754E-04	0.	8.78663E-05

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
4	U-238	2.68084E-03	2.63877E-03	2.57027E-03	2.52993E-03
4	PU-239	5.87366E-04	5.60940E-04	7.07170E-04	6.67245E-04
4	PU-240	2.70721E-04	2.72314E-04	3.07226E-04	3.09789E-04
4	PU-241	1.09120E-04	9.52599E-05	1.45261E-04	1.26001E-04
4	PU-242	3.41915E-05	3.46373E-05	3.79438E-05	3.88437E-05
4	U-235	7.27675E-06	6.44595E-06	7.83323E-06	6.93915E-06
4	U-236	2.14301E-07	4.02797E-07	0.	2.09413E-07
4	FP-1	7.83482E-05	1.54124E-04	0.	9.01068E-05

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
5	U-238	2.68817E-03	2.65338E-03	2.57027E-03	2.53701E-03
5	PU-239	5.91938E-04	5.69504E-04	7.07170E-04	6.73624E-04
5	PU-240	2.71611E-04	2.74221E-04	3.07276E-04	3.10843E-04
5	PU-241	1.10840E-04	9.82116E-05	1.45261E-04	1.28035E-04

5	PU-242	3.42566E-05	3.48167E-05	3.79438E-05	3.89182E-05
5	U-235	7.39880E-06	6.66228E-06	7.83373E-06	7.05601E-06
5	U-236	1.97549E-07	3.75023E-07	0.	1.93089E-07
5	FP-1	6.36756E-09	1.25681E-04	0.	7.34086E-05

BATCH AVERAGED MATERIAL CONCENTRATIONS FOR OPERATING CYCLE 2 (ATOMS/CC-E-24)

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
1	U-238	5.06121E-03	4.99749E-03	4.93431E-03
1	PU-239	7.79101E-04	7.67661E-04	7.56410E-04
1	PU-240	3.47849E-04	3.53875E-04	3.59630E-04
1	PU-241	1.47428E-04	1.33981E-04	1.21773E-04
1	PU-242	4.34759E-05	4.44792E-05	4.53085E-05
1	U-235	1.40660E-05	1.26859E-05	1.13992E-05
1	U-236	3.78140E-07	7.31291E-07	1.05406E-06
1	FP-1	7.42555E-05	1.92176E-04	2.30097E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
2	U-238	5.06984E-03	5.01469E-03	4.95994E-03
2	PU-239	7.79308E-04	7.68729E-04	7.58330E-04
2	PU-240	3.46513E-04	3.51152E-04	3.55593E-04
2	PU-241	1.48658E-04	1.36338E-04	1.25015E-04
2	PU-242	4.32949E-05	4.41364E-05	4.48430E-05
2	U-235	1.42582E-05	1.30498E-05	1.19117E-05
2	U-236	3.23413E-07	6.28920E-07	9.11888E-07
2	FP-1	6.56767E-05	1.34728E-04	2.03780E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
3	U-238	4.49526E-03	4.45425E-03	4.41349E-03
3	PU-239	1.10628E-03	1.07345E-03	1.04175E-03
3	PU-240	4.96426E-04	4.99312E-04	5.01892E-04
3	PU-241	2.18634E-04	2.00636E-04	1.85708E-04
3	PU-242	6.20056E-05	6.27956E-05	6.34574E-05
3	U-235	1.28214E-05	1.19473E-05	1.11139E-05
3	U-236	2.19868E-07	4.27363E-07	6.22693E-07
3	FP-1	7.63934E-05	1.57007E-04	2.37620E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
4	U-238	5.25111E-03	5.20980E-03	5.16870E-03
4	PU-239	1.29454E-03	1.26086E-03	1.22819E-03
4	PU-240	5.77997E-04	5.80175E-04	5.82103E-04
4	PU-241	2.54381E-04	2.37317E-04	2.21261E-04
4	PU-242	7.21353E-05	7.28644E-05	7.34810E-05
4	U-235	1.51107E-05	1.42305E-05	1.33851E-05
4	U-236	2.14301E-07	4.18342E-07	6.12209E-07
4	FP-1	7.83462E-05	1.61289E-04	2.44231E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
5	U-238	5.25844E-03	5.22434E-03	5.19040E-03
5	PU-239	1.29911E-03	1.27076E-03	1.24313E-03
5	PU-240	5.78886E-04	5.82078E-04	5.85063E-04
5	PU-241	2.56101E-04	2.40767E-04	2.26246E-04
5	PU-242	7.22005E-05	7.30153E-05	7.37349E-05
5	U-235	1.52303E-05	1.44611E-05	1.37183E-05
5	U-236	1.97549E-07	3.86908E-07	5.68112E-07
5	FP-1	6.36756E-05	1.31383E-04	1.99090E-04

FRACTION OF REACTOR POWER AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 2

TOTAL REACTOR POWER (MWT) AT BEGINNING OF CYCLE 0.47469E 03
 TOTAL REACTOR POWER (MWT) AT END OF CYCLE 0.46101E 03

REGION	POWER FRACTION (BOC)	POWER FRACTION (EOC)
1	0.43151E 00	0.42063E 00
2	0.63561E-01	0.62280E-01
3	0.16851E 00	0.16208E 00
4	0.14801E 00	0.14351E 00
5	0.14711E 00	0.14372E 00
6	0.21851E-01	0.36562E-01
7	0.19156E-02	0.26221E-02
8	0.17533E-01	0.28591E-01

OPERATING INTERVAL	2
NUMBER OF INTERNAL ITERATIONS	2
OPERATING INTERVAL TIME (DAYS)	292.000E 00
LOADING FACTOR	0.60000E 00
AVERAGE ELECTRICAL POWER (MWE)	1.75425E 02
AVERAGE THERMAL POWER (MHT)	4.67800E 02
AVERAGE BURNUP FOR DESIGNATED ZONES (MWD/MT)	4.16061E 04
ACCUMULATED OPERATING TIME (YRS)	1.89733E 00
EFFECTIVE MULTIPLICATION CONSTANT AT EOC	0.99990E 00
BURNUP REACTIVITY	-0.41157E-01
RATIO OF POWER DENSITY PEAK TO AVERAGE	1.01650E 00
AVERAGE BREEDING RATIO	1.17042E 00
BEG-OF-CYCLE BREEDING RATIO	1.15879E 00
END-OF-CYCLE BREEDING RATIO	1.18204E 00
DOUBLING TIME (YR)	0.

DISCHARGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38501E 03	4.33120E 02			3.07515E 02		4.86971E 03		1.21607E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.8568E 03	2.7098E 02	1.1148E 02	3.6612E 01	1.4122E 01	1.2161E 01	7.4779E-01	7.6941E 01		

LOADED FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38520E 03	4.69559E 02			3.33856E 02		4.91981E 03		1.46087E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.9012E 03	2.7657E 02	1.2068E 02	5.7286E 01	1.5026E 01	1.4609E 01	0.	0.		

AVERAGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26230E 04	9.14732E 02			6.53036E 02		1.16226E 04		3.17126E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1590E 04	5.6047E 02	2.3241E 02	9.2570E 01	2.9289E 01	3.1713E 01	9.2756E-01	8.0382E 01		

END-OF-CYCLE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26230E 04	9.27286E 02			6.62357E 02		1.15662E 04		3.02685E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1535E 04	5.7705E 02	2.3522E 02	8.5302E 01	2.7712E 01	3.0269E 01	1.3536E 00	1.2178E 02		

ACCUMULATED IN-PILE AND OUT-OF-PILE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
2.09306E 04	1.60560E 03			1.14280E 03		1.91484E 04		5.19515E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.9095E 04	9.78105E 02	4.0974E 02	1.6156E 02	5.1591E 01	5.1951E 01	1.6155E 00	1.5163E 02		

FUEL CYCLE COSTS (MILLS/KWHR)

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES

REFERENCE SET	TOTAL COST	INVENTORY	CREDIT	FABRICATION	REPROCESSING	FAB INV	REPR INV
1	2.43683E 00	1.37116E 00	-7.47406E-02	6.17128E-01	5.22852E-01	5.33746E-02	-5.29508E-02

LEVELIZED FUEL CYCLE COSTS

REFERENCE SET	LEVELIZED COST FOR DISCHARGED FUEL	LEVELIZED COST FOR OPERATING CYCLE
1	3.1219E 00	0.

STORED AND RECYCLE FUEL REPOSITORIES EDIT (OPERATING CYCLE 2)

FUEL REPOSITORY 1

MATERIAL /	0	DELAY TIME (ACCUMULATED OPERATING INTERVALS)				5	6
		1	2	3	4		
U-238	0.	0.	0.	0.	0.		
PU-239	2.65511E 02	2.52155E 02	0.	0.	0.		
PU-240	1.09264E 02	1.06670E 02	0.	0.	0.		
PU-241	3.58836E 01	3.99845E 01	0.	0.	0.		
PU-242	1.38414E 01	1.35657E 01	0.	0.	0.		
U-235	0.	0.	0.	0.	0.		
U-236	0.	0.	0.	0.	0.		
FP-1	0.	0.	0.	0.	0.		
TOTAL	4.24501E 02	4.12375E 02	0.	0.	0.		

MATERIAL /	0	FUEL REPOSITORY 2 DELAY TIME (ACCUMULATED OPERATING INTERVALS)				5	6
		1	2	3	4		
U-238	4.76015E 03	4.80941E 03	0.	0.	0.		
PU-239	0.	0.	0.	0.	0.		
PU-240	0.	0.	0.	0.	0.		
PU-241	0.	0.	0.	0.	0.		
PU-242	0.	0.	0.	0.	0.		
U-235	1.19187E 01	1.31151E 01	0.	0.	0.		
U-236	7.32906E-01	3.88805E-01	0.	0.	0.		
FP-1	0.	0.	0.	0.	0.		
TOTAL	4.77280E 03	4.82292E 03	0.	0.	0.		

FUEL MATERIAL CONCENTRATIONS AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 3 (ATOMS/CC*E-24)

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
1	U-238	2.46130E-03	2.40585E-03	2.59226E-03	2.53386E-03
1	PU-239	4.00056E-04	3.87053E-04	3.75651E-04	3.68592E-04
1	PU-240	1.87123E-04	1.92118E-04	1.63226E-04	1.68636E-04
1	PU-241	6.99484E-05	5.97827E-05	7.71631E-05	6.48483E-05
1	PU-242	2.35435E-05	2.41903E-05	2.01559E-05	2.11914E-05
1	U-235	6.23570E-06	5.16365E-06	7.90077E-06	6.94245E-06
1	U-236	3.79561E-07	6.43030E-07	0.	3.54338E-07
1	FP-1	8.34122E-05	1.54123E-04	0.	6.92101E-05

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
2	U-238	2.46988E-03	2.42178E-03	2.59226E-03	2.54178E-03
2	PU-239	4.01392E-04	3.89436E-04	3.75651E-04	3.68898E-04
2	PU-240	1.85633E-04	1.89907E-04	1.63226E-04	1.67384E-04
2	PU-241	7.13688E-05	6.18437E-05	7.71631E-05	6.60455E-05
2	PU-242	2.33390E-05	2.38991E-05	2.01559E-05	2.10155E-05
2	U-235	6.42827E-06	5.47039E-06	7.90077E-06	6.72347E-06
2	U-236	3.24762E-07	5.58960E-07	0.	3.02624E-07
2	FP-1	7.37813E-05	1.36678E-04	0.	6.12019E-05

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
3	U-238	2.16301E-03	2.12767E-03	2.32582E-03	2.28782E-03
3	PU-239	5.67053E-04	5.35380E-04	5.33458E-04	5.07438E-04
3	PU-240	2.66686E-04	2.68764E-04	2.31795E-04	2.34508E-04
3	PU-241	1.06337E-04	9.35144E-05	1.09579E-04	9.56584E-05
3	PU-242	3.35021E-05	3.40363E-05	2.86232E-05	2.94203E-05
3	U-235	5.82039E-06	5.11979E-06	7.08868E-06	6.23542E-06
3	U-236	2.14769E-07	3.76966E-07	0.	2.05295E-07
3	FP-1	8.78663E-05	1.61541E-04	0.	7.10412E-05

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
4	U-238	2.52993E-03	2.49427E-03	2.71345E-03	2.67521E-03
4	PU-239	6.67245E-04	6.34447E-04	6.22368E-04	5.95715E-04
4	PU-240	3.09789E-04	3.11317E-04	2.70428E-04	2.72495E-04
4	PU-241	1.26001E-04	1.12149E-04	1.27842E-04	1.13180E-04
4	PU-242	3.88437E-05	3.93494E-05	3.33937E-05	3.41260E-05
4	U-235	6.93915E-06	6.22369E-06	8.27013E-06	7.41744E-06
4	U-236	2.09413E-07	3.71850E-07	0.	1.99908E-07
4	FP-1	9.01068E-05	1.66273E-04	0.	7.28333E-05

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
5	U-238	2.53701E-03	2.50753E-03	2.71345E-03	2.68192E-03
5	PU-239	6.73624E-04	6.45675E-04	6.22368E-04	6.00053E-04
5	PU-240	3.10843E-04	3.13445E-04	2.70428E-04	2.73311E-04
5	PU-241	1.28035E-04	1.15502E-04	1.27842E-04	1.14825E-04

5	PU-242	3.89182E-05	3.95373E-05	3.33937E-05	3.41820E-05
5	U-235	7.05601E-06	6.42406E-06	8.27013E-05	7.32944E-06
5	U-236	1.93089E-07	3.45941E-07	0.	1.84135E-07
5	FP-1	7.34086E-05	1.35938E-04	0.	5.91926E-05

BATCH AVERAGED MATERIAL CONCENTRATIONS FOR OPERATING CYCLE 3 (ATOMS/CC-E-24)

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
1	U-238	5.05357E-03	4.99643E-03	4.93971E-03
1	PU-239	7.75707E-04	7.65604E-04	7.55646E-04
1	PU-240	3.50351E-04	3.55659E-04	3.60754E-04
1	PU-241	1.47111E-04	1.35395E-04	1.24631E-04
1	PU-242	4.36994E-05	4.46094E-05	4.53817E-05
1	U-235	1.41365E-05	1.28831E-05	1.17061E-05
1	U-236	3.79561E-07	7.00894E-07	9.97368E-07
1	FP-1	8.34122E-05	1.53372E-04	2.23333E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
2	U-238	5.06214E-03	5.01269E-03	4.96356E-03
2	PU-239	7.77043E-04	7.67617E-04	7.58334E-04
2	PU-240	3.48858E-04	3.52954E-04	3.56891E-04
2	PU-241	1.48532E-04	1.37830E-04	1.27889E-04
2	PU-242	4.34908E-05	4.42559E-05	4.49145E-05
2	U-235	1.43290E-05	1.32327E-05	1.21939E-05
2	U-236	3.24762E-07	6.02380E-07	8.61583E-07
2	FP-1	7.37813E-05	1.35830E-04	1.97879E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
3	U-238	4.48883E-03	4.45206E-03	4.41549E-03
3	PU-239	1.10051E-03	1.07121E-03	1.04282E-03
3	PU-240	4.98481E-04	5.00999E-04	5.03272E-04
3	PU-241	2.15919E-04	2.02143E-04	1.89173E-04
3	PU-242	6.21252E-05	6.28409E-05	6.34566E-05
3	U-235	1.29091E-05	1.21155E-05	1.13552E-05
3	U-236	2.14769E-07	4.03493E-07	5.82261E-07
3	FP-1	8.78663E-05	1.60224E-04	2.32582E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
4	U-238	5.24338E-03	5.20635E-03	5.16948E-03
4	PU-239	1.28961E-03	1.25949E-03	1.23016E-03
4	PU-240	5.80217E-04	5.82115E-04	5.83812E-04
4	PU-241	2.53842E-04	2.39211E-04	2.25329E-04
4	PU-242	7.22374E-05	7.29001E-05	7.34754E-05
4	U-235	1.52093E-05	1.44110E-05	1.36411E-05
4	U-236	2.09413E-07	3.94736E-07	5.71757E-07
4	FP-1	9.01068E-05	1.64607E-04	2.39107E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
5	U-238	5.25046E-03	5.21990E-03	5.18946E-03
5	PU-239	1.29599E-03	1.27057E-03	1.24573E-03
5	PU-240	5.81271E-04	5.84096E-04	5.86756E-04
5	PU-241	2.55876E-04	2.42803E-04	2.30328E-04
5	PU-242	7.23119E-05	7.30525E-05	7.37193E-05
5	U-235	1.53261E-05	1.46291E-05	1.39535E-05
5	U-236	1.43089E-07	3.64906E-07	5.30076E-07
5	FP-1	7.34086E-05	1.34270E-04	1.95130E-04

FRACTION OF REACTOR POWER AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 3

TOTAL REACTOR POWER (MWT) AT BEGINNING OF CYCLE 0.47378E 03
 TOTAL REACTOR POWER (MWT) AT END OF CYCLE 0.46189E 03

REGION	POWER FRACTION (BOC)	POWER FRACTION (EOC)
1	0.42985E 00	0.42014E 00
2	0.63390E-01	0.62241E-01
3	0.16770E 00	0.16198E 00
4	0.14747E 00	0.14345E 00
5	0.14674E 00	0.14372E 00
6	0.21987E-01	0.35156E-01
7	0.19210E-02	0.25514E-02
8	0.20945E-01	0.30762E-01

OPERATING INTERVAL	3
NUMBER OF INTERNAL ITERATIONS	2
OPERATING INTERVAL TIME (DAYS)	219.000E 00
LOADING FACTOR	0.72000E 00
AVERAGE ELECTRICAL POWER (MWE)	1.75442E 02
AVERAGE THERMAL POWER (MWT)	4.67846E 02
AVERAGE BURNUP FOR DESIGNATED ZONES (MWD/MT)	4.42926E 04
ACCUMULATED OPERATING TIME (YRS)	2.49692E 00
EFFECTIVE MULTIPLICATION CONSTANT AT EOC	0.99927E 00
BURNUP REACTIVITY	-0.36355E-01
RATIO OF POWER DENSITY PEAK TO AVERAGE	1.01624E 00
AVERAGE BREEDING RATIO	1.17356E 00
BEG-OF-CYCLE BREEDING RATIO	1.16419E 00
END-OF-CYCLE BREEDING RATIO	1.18293E 00
DOUBLING TIME (YR)	1.44129E 01

DISCHARGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38520E 03	4.88770E 02	3.46616E 02	4.80955E 03	1.18781E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.7969E 03	3.0385E 02	1.2625E 02	4.2768E 01	1.5899E 01	1.1878E 01	8.0547E-01	8.2417E 01		

LOADED FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38489E 03	4.17651E 02	2.96950E 02	4.96738E 03	1.47634E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.9526E 03	2.4600E 02	1.0734E 02	5.0953E 01	1.3365E 01	1.4763E 01	0.	0.		

AVERAGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26229E 04	9.23216E 02	6.60263E 02	1.16133E 04	3.15741E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1581E 04	5.6692E 02	2.3361E 02	9.3339E 01	2.9342E 01	3.1574E 01	9.8790E-01	8.2098E 01		

END-OF-CYCLE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26229E 04	9.34614E 02	6.68734E 02	1.15628E 04	3.02770E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1531E 04	5.8170E 02	2.3615E 02	8.7035E 01	2.9729E 01	3.0277E 01	1.3700E 00	1.1936E 02		

ACCUMULATED IN-PILE AND OUT-OF-PILE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
2.36994E 04	1.86954E 03	1.33076E 03	2.16166E 04	5.83404E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
2.1556E 04	1.1429E 03	4.7715E 02	1.8743E 02	5.9885E 01	5.8340E 01	1.9760E 00	1.8366E 02		

FUEL CYCLE COSTS (MILLS/KWHR)

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES

OPERATING INTERVAL	3	ENERGY OF DISCHARGED FUEL	7.34313E 08	ACCUMULATED ENERGY OF DISCHARGED FUEL	1.76322E 09		
REFERENCE SET	TOTAL COST	INVENTORY	CREDIT	FABRICATION	REPROCESSING	FAB INV	REPR INV
1	2.25952E 00	1.23651E 00	-3.78735E-02	5.76164E-01	4.88125E-01	4.37119E-02	-4.71234E-02

LEVELIZED FUEL CYCLE COSTS

REFERENCE SET	LEVELIZED COST FOR DISCHARGED FUEL	LEVELIZED COST FOR OPERATING CYCLE
1	2.78382E 00	0.

STORED AND RECYCLE FUEL REPOSITORIES EDIT (OPERATING CYCLE 3)

FUEL REPOSITORY 1

MATERIAL /	0	DELAY TIME (ACCUMULATED OPERATING INTERVALS)				5	6
		1	2	3	4		
U-238	0.	0.	0.	0.			
PU-239	2.97801E 02	2.65511E 02	2.52155E 02	0.			
PU-240	1.23742E 02	1.09264E 02	1.06670E 02	0.			
PU-241	4.19170E 01	8.47675E 01	3.87407E 01	0.			
PU-242	1.55827E 01	1.38414E 01	1.35657E 01	0.			
U-235	0.	0.	0.	0.			
U-236	0.	0.	0.	0.			
FP-1	0.	0.	0.	0.			
TOTAL	4.79043E 02	4.23385E 02	4.11131E 02	0.			

MATERIAL /	0	FUEL REPOSITORY 2 DELAY TIME (ACCUMULATED OPERATING INTERVALS)				5	6
		1	2	3	4		
U-238	4.70141E 03	4.75015E 03	4.80941E 03	0.			
PU-239	0.	0.	0.	0.			
PU-240	0.	0.	0.	0.			
PU-241	0.	0.	0.	0.			
PU-242	0.	0.	0.	0.			
U-235	1.16417E 01	1.19187E 01	1.31151E 01	0.			
U-236	7.69446E-01	7.32906E-01	3.88805E-01	0.			
FP-1	0.	0.	0.	0.			
TOTAL	4.71384E 03	4.77280E 03	4.82292E 03	0.			

FUEL MATERIAL CONCENTRATIONS AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 4 (ATOMS/CC-E-24)

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
1	U-238	2.53386E-03	2.47047E-03	2.53816E-03	2.47466E-03
1	PU-239	3.68592E-04	3.60692E-04	4.07692E-04	3.93618E-04
1	PU-240	1.68636E-04	1.74032E-04	1.77148E-04	1.83524E-04
1	PU-241	6.48483E-05	5.45634E-05	8.37448E-05	6.93185E-05
1	PU-242	2.11914E-05	2.18804E-05	2.18751E-05	2.30999E-05
1	U-235	6.54245E-06	5.30446E-06	7.73588E-06	6.27206E-06
1	U-236	3.54338E-07	6.59685E-07	0.	3.80874E-07
1	FP-1	6.92101E-05	1.42718E-04	0.	8.20040E-05

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
2	U-238	2.54178E-03	2.48680E-03	2.53816E-03	2.48326E-03
2	PU-239	3.68898E-04	3.61461E-04	4.07692E-04	3.94753E-04
2	PU-240	1.67384E-04	1.71553E-04	1.77148E-04	1.82056E-04
2	PU-241	6.60455E-05	5.64489E-05	8.37448E-05	7.07280E-05
2	PU-242	2.10195E-05	2.16145E-05	2.18751E-05	2.28939E-05
2	U-235	6.72347E-06	5.61919E-06	7.73588E-06	6.46532E-06
2	U-236	3.02624E-07	5.73416E-07	0.	3.25873E-07
2	FP-1	6.12019E-05	1.26478E-04	0.	7.25343E-05

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
3	U-238	2.28782E-03	2.24629E-03	2.22076E-03	2.18045E-03
3	PU-239	5.07438E-04	4.81136E-04	5.95627E-04	5.58138E-04
3	PU-240	2.34508E-04	2.36768E-04	2.58831E-04	2.62084E-04
3	PU-241	9.56584E-05	8.31458E-05	1.22359E-04	1.05607E-04
3	PU-242	2.94203E-05	2.99759E-05	3.19616E-05	3.29344E-05
3	U-235	6.23542E-06	5.40669E-06	6.76849E-06	5.86891E-06
3	U-236	2.05295E-07	3.97584E-07	0.	2.16062E-07
3	FP-1	7.10412E-05	1.45466E-04	0.	6.64666E-05

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
4	U-238	2.67521E-03	2.63331E-03	2.59089E-03	2.55032E-03
4	PU-239	5.95715E-04	5.68431E-04	6.94957E-04	6.56603E-04
4	PU-240	2.72495E-04	2.74177E-04	3.01969E-04	3.04443E-04
4	PU-241	1.13180E-04	9.97202E-05	1.42752E-04	1.25137E-04
4	PU-242	3.41260E-05	3.46517E-05	3.72885E-05	3.61837E-05
4	U-235	7.41744E-06	6.57213E-06	7.89658E-06	6.99667E-06
4	U-236	1.99908E-07	3.92177E-07	0.	2.10667E-07
4	FP-1	7.28333E-05	1.49674E-04	0.	8.86712E-05

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
5	U-238	2.68192E-03	2.64729E-03	2.59089E-03	2.55744E-03
5	PU-239	6.00053E-04	5.76907E-04	6.94957E-04	6.62742E-04
5	PU-240	2.73311E-04	2.76007E-04	3.01969E-04	3.05474E-04
5	PU-241	1.14825E-04	1.02704E-04	1.42752E-04	1.27156E-04

5	PU-242	3.41820E-05	3.48158E-05	3.72885E-05	3.82559E-05
5	U-235	7.52944E-06	6.78347E-06	7.89658E-06	7.11424E-06
5	U-236	1.84185E-07	3.64844E-07	0.	1.94242E-07
5	FP-1	5.91926E-05	1.22064E-04	0.	7.22218E-05

BATCH AVERAGED MATERIAL CONCENTRATIONS FOR OPERATING CYCLE 4 (ATOMS/CC-E-24)

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
1	U-238	5.07203E-03	5.00831E-03	4.94513E-03
1	PU-239	7.76285E-04	7.65214E-04	7.54310E-04
1	PU-240	3.45785E-04	3.51803E-04	3.57596E-04
1	PU-241	1.48593E-04	1.35662E-04	1.23882E-04
1	PU-242	4.30665E-05	4.41079E-05	4.49883E-05
1	U-235	1.42783E-05	1.28802E-05	1.15765E-05
1	U-236	3.54338E-07	7.12809E-07	1.04056E-06
1	FP-1	6.92101E-05	1.46966E-04	2.24722E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
2	U-238	5.07994E-03	5.02480E-03	4.97006E-03
2	PU-239	7.76591E-04	7.66320E-04	7.56214E-04
2	PU-240	3.44533E-04	3.49168E-04	3.53609E-04
2	PU-241	1.49790E-04	1.38027E-04	1.27177E-04
2	PU-242	4.28906E-05	4.37645E-05	4.45084E-05
2	U-235	1.44593E-05	1.32364E-05	1.20845E-05
2	U-236	3.02624E-07	6.12341E-07	8.99289E-07
2	FP-1	6.12019E-05	1.30107E-04	1.99012E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
3	U-238	4.50858E-03	4.46754E-03	4.42674E-03
3	PU-239	1.10312E-03	1.07064E-03	1.03927E-03
3	PU-240	4.93338E-04	4.96247E-04	4.98852E-04
3	PU-241	2.18010E-04	2.02905E-04	1.88753E-04
3	PU-242	6.13818E-05	6.22072E-05	6.29104E-05
3	U-235	1.30039E-05	1.21192E-05	1.12756E-05
3	U-236	2.05295E-07	4.15625E-07	6.13645E-07
3	FP-1	7.10412E-05	1.51487E-04	2.31932E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
4	U-238	5.26610E-03	5.22476E-03	5.18363E-03
4	PU-239	1.29067E-03	1.25736E-03	1.22503E-03
4	PU-240	5.74464E-04	5.76666E-04	5.78620E-04
4	PU-241	2.55933E-04	2.39950E-04	2.24857E-04
4	PU-242	7.14146E-05	7.21782E-05	7.28354E-05
4	U-235	1.53140E-05	1.44238E-05	1.35688E-05
4	U-236	1.99908E-07	4.06511E-07	6.02844E-07
4	FP-1	7.28333E-05	1.55589E-04	2.38345E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
5	U-238	5.27281E-03	5.23870E-03	5.20473E-03
5	PU-239	1.29501E-03	1.26698E-03	1.23965E-03
5	PU-240	5.75280E-04	5.78482E-04	5.81481E-04
5	PU-241	2.57578E-04	2.43365E-04	2.29859E-04
5	PU-242	7.14706E-05	7.23159E-05	7.30717E-05
5	U-235	1.54260E-05	1.46486E-05	1.38977E-05
5	U-236	1.84135E-07	3.75724E-07	5.59085E-07
5	FP-1	5.91926E-05	1.26739E-04	1.94286E-04

FRACTION OF REACTOR POWER AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 4

TOTAL REACTOR POWER (MWT) AT BEGINNING OF CYCLE 0.47430E 03
 TOTAL REACTOR POWER (MWT) AT END OF CYCLE 0.46139E 03

REGION	POWER FRACTION (BOC)	POWER FRACTION (EOC)
1	0.43056E 00	0.41976E 00
2	0.63420E-01	0.62150E-01
3	0.16814E 00	0.16176E 00
4	0.14766E 00	0.14320E 00
5	0.14674E 00	0.14340E 00
6	0.21278E-01	0.35912E-01
7	0.18880E-02	0.25880E-02
8	0.20325E-01	0.31233E-01

OPERATING INTERVAL	4
NUMBER OF INTERNAL ITERATIONS	2
OPERATING INTERVAL TIME (DAYS)	219.000E 00
LOADING FACTOR	0.80000E 00
AVERAGE ELECTRICAL POWER (MWE)	1.75430E 02
AVERAGE THERMAL POWER (MWT)	4.67814E 02
AVERAGE BURNUP FOR DESIGNATED ZONES (MWD/MT)	4.04494E 04
ACCUMULATED OPERATING TIME (YRS)	3.09651E 00
EFFECTIVE MULTIPLICATION CONSTANT AT EOC	0.99996E 00
BURNUP REACTIVITY	-0.39978E-01
RATIO OF POWER DENSITY PEAK TO AVERAGE	1.01655E 00
AVERAGE BREEDING RATIO	1.17894E 00
BEG-OF-CYCLE BREEDING RATIO	1.16918E 00
END-OF-CYCLE BREEDING RATIO	1.18859E 00
DOUBLING TIME (YR)	1.44129E 01

DISCHARGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38489E 03	4.46589E 02	3.19794E 02	4.85915E 03	1.19906E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.8463E 03	2.8139E 02	1.1264E 02	3.8409E 01	1.4156E 01	1.1991E 01	8.1622E-01	7.5668E 01		

LOADED FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38515E 03	4.61066E 02	3.27818E 02	4.92425E 03	1.46340E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.9096E 03	2.7157E 02	1.1849E 02	5.6250E 01	1.4754E 01	1.4634E 01	0.	0.		

AVERAGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26228E 04	9.19858E 02	6.59376E 02	1.16212E 04	3.15902E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1589E 04	5.76596E 02	2.3126E 02	9.3620E 01	2.9026E 01	3.1590E 01	9.8941E-01	7.8339E 01		

END-OF-CYCLE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26228E 04	9.32806E 02	6.69215E 02	1.15849E 04	3.01475E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1533E 04	5.8249E 02	2.3412E 02	8.6724E 01	2.9468E 01	3.0147E 01	1.4143E 00	1.1974E 02		

ACCUMULATED IN-PILE AND OUT-OF-PILE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
2.36994E 04	1.85048E 03	1.32266E 03	2.16496E 04	5.83877E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
2.1589E 04	1.1355E 03	4.6731E 02	1.8690E 02	5.8579E 01	5.8388E 01	1.9907E 00	1.7162E 02		

FUEL CYCLE COSTS (MILLS/KWHR)

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES

OPERATING INTERVAL	4	ENERGY OF DISCHARGED FUEL	6.74118E 08	ACCUMULATED ENERGY OF DISCHARGED FUEL	2.43734E 09		
REFERENCE SET	TOTAL COST	INVENTORY	CREDIT	FABRICATION	REPROCESSING	FAB INV	REPR INV
1	2.08035E 00	1.13000E 00	-2.05300E-01	6.27530E-01	5.31678E-01	4.31085E-02	-4.66640E-02

LEVELIZED FUEL CYCLE COSTS

REFERENCE SET	LEVELIZED COST FOR DISCHARGED FUEL	LEVELIZED COST FOR OPERATING CYCLE
1	2.50583E 00	0.

STORED AND RECYCLE FUEL REPOSITORIES EDIT (OPERATING CYCLE 4)

FUEL REPOSITORY 1

MATERIAL /	0	DELAY TIME (ACCUMULATED OPERATING INTERVALS)				5	6
		1	2	3	4		
U-238	0.	0.	0.	0.	0.		
PU-239	2.75786E 02	2.97801E 02	2.65511E 02	2.52155E 02			
PU-240	1.10397E 02	1.23742E 02	1.09264E 02	1.06670E 02			
PU-241	3.76448E 01	4.06132E 01	3.36860E 01	3.79357E 01			
PU-242	1.38743E 01	1.55827E 01	1.36414E 01	1.35657E 01			
U-235	0.	0.	0.	0.			
U-236	0.	0.	0.	0.			
FP-1	0.	0.	0.	0.			
TOTAL	4.37702E 02	4.77739E 02	4.22303E 02	4.09926E 02			

MATERIAL /	0	FUEL REPOSITORY 2 DELAY TIME (ACCUMULATED OPERATING INTERVALS)				5	6
		1	2	3	4		
U-238	4.74990E 03	4.70141E 03	4.76015E 03	4.60941E 03			
PU-239	0.	0.	0.	0.			
PU-240	0.	0.	0.	0.			
PU-241	0.	0.	0.	0.			
PU-242	0.	0.	0.	0.			
U-235	1.17520E 01	1.16417E 01	1.19187E 01	1.31151E 01			
U-236	7.99973E-01	7.89446E-01	7.32906E-01	3.88805E-01			
FP-1	0.	0.	0.	0.			
TOTAL	4.76245E 03	4.71384E 03	4.77280E 03	4.82292E 03			

FUEL MATERIAL CONCENTRATIONS AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 5 (ATOMS/CC-E-24)

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
1	U-238	2.47466E-03	2.41284E-03	2.57905E-03	2.51462E-03
1	PU-239	3.93618E-04	3.80537E-04	3.83478E-04	3.74121E-04
1	PU-240	1.83524E-04	1.88989E-04	1.66627E-04	1.72696E-04
1	PU-241	6.93185E-05	5.84243E-05	7.87709E-05	6.52179E-05
1	PU-242	2.30999E-05	2.38082E-05	2.05758E-05	2.17264E-05
1	U-235	6.27206E-06	5.08695E-06	7.86049E-06	6.37524E-06
1	U-236	3.80874E-07	6.71249E-07	0.	3.86467E-07
1	FP-1	8.20040E-05	1.59376E-04	0.	7.79384E-05

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
2	U-238	2.48326E-03	2.42963E-03	2.57905E-03	2.52335E-03
2	PU-239	3.94723E-04	3.82891E-04	3.83478E-04	3.74660E-04
2	PU-240	1.82056E-04	1.86295E-04	1.66627E-04	1.71295E-04
2	PU-241	7.07280E-05	6.05276E-05	7.87709E-05	6.65418E-05
2	PU-242	2.28939E-05	2.35135E-05	2.05758E-05	2.15329E-05
2	U-235	6.46532E-06	5.40500E-06	7.86049E-06	6.57136E-06
2	U-236	3.25873E-07	5.84468E-07	0.	3.30649E-07
2	FP-1	7.25343E-05	1.41352E-04	0.	6.89367E-05

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
3	U-238	2.18045E-03	2.14094E-03	2.30688E-03	2.26507E-03
3	PU-239	5.58138E-04	5.24444E-04	5.44675E-04	5.14355E-04
3	PU-240	2.62084E-04	2.64335E-04	2.36669E-04	2.39690E-04
3	PU-241	1.05607E-04	9.18648E-05	1.11883E-04	9.65829E-05
3	PU-242	3.29344E-05	3.35261E-05	2.92250E-05	3.01134E-05
3	U-235	5.86891E-06	5.09006E-06	7.03096E-06	6.09789E-06
3	U-236	2.16062E-07	3.96033E-07	0.	2.24111E-07
3	FP-1	8.64666E-05	1.67036E-04	0.	8.00278E-05

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
4	U-238	2.55032E-03	2.51044E-03	2.69136E-03	2.64928E-03
4	PU-239	6.56603E-04	6.21680E-04	6.35454E-04	6.04399E-04
4	PU-240	3.04443E-04	3.06096E-04	2.76114E-04	2.78413E-04
4	PU-241	1.25137E-04	1.10318E-04	1.30530E-04	1.14441E-04
4	PU-242	3.81837E-05	3.87459E-05	3.40958E-05	3.49132E-05
4	U-235	6.99667E-06	6.20051E-06	8.20279E-06	7.26939E-06
4	U-236	2.10667E-07	3.91141E-07	0.	2.18511E-07
4	FP-1	8.86712E-05	1.71985E-04	0.	8.20753E-05

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
5	U-238	2.55744E-03	2.52447E-03	2.69136E-03	2.65066E-03
5	PU-239	6.62742E-04	6.32975E-04	6.35454E-04	6.09421E-04
5	PU-240	3.05474E-04	3.08301E-04	2.76114E-04	2.79346E-04
5	PU-241	1.27156E-04	1.13785E-04	1.30530E-04	1.16284E-04

5	PU-242	3.82589E-05	3.89429E-05	3.40958E-05	3.49782E-05
5	U-235	7.11424E-06	6.41048E-06	8.20279E-06	7.39135E-06
5	U-236	1.94242E-07	3.64235E-07	0.	2.01471E-07
5	FP-1	7.22218E-05	1.40622E-04	0.	6.67519E-05

BATCH AVERAGED MATERIAL CONCENTRATIONS FOR OPERATING CYCLE 5 (ATOMS/CC-E-24)

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
1	U-238	5.05371E-03	4.99032E-03	4.92747E-03
1	PU-239	7.77096E-04	7.65785E-04	7.54658E-04
1	PU-240	3.50151E-04	3.56051E-04	3.61685E-04
1	PU-241	1.48089E-04	1.35297E-04	1.23642E-04
1	PU-242	4.36758E-05	4.46884E-05	4.55346E-05
1	U-235	1.41326E-05	1.27508E-05	1.14622E-05
1	U-236	3.80874E-07	7.34447E-07	1.05772E-06
1	FP-1	8.20040E-05	1.59659E-04	2.37314E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
2	U-238	5.06231E-03	5.00745E-03	4.95298E-03
2	PU-239	7.78231E-04	7.67701E-04	7.57350E-04
2	PU-240	3.48683E-04	3.53233E-04	3.57589E-04
2	PU-241	1.49499E-04	1.37832E-04	1.27069E-04
2	PU-242	4.34697E-05	4.43223E-05	4.50464E-05
2	U-235	1.43258E-05	1.31160E-05	1.19764E-05
2	U-236	3.25873E-07	6.31736E-07	9.15116E-07
2	FP-1	7.25343E-05	1.41412E-04	2.10289E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
3	U-238	4.48733E-03	4.44655E-03	4.40601E-03
3	PU-239	1.10281E-03	1.07025E-03	1.03880E-03
3	PU-240	4.98753E-04	5.01540E-04	5.04025E-04
3	PU-241	2.17490E-04	2.02493E-04	1.88448E-04
3	PU-242	6.21594E-05	6.29598E-05	6.36395E-05
3	U-235	1.28999E-05	1.20236E-05	1.11879E-05
3	U-236	2.16062E-07	4.24188E-07	6.20144E-07
3	FP-1	8.64666E-05	1.66765E-04	2.47064E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
4	U-238	5.24168E-03	5.20059E-03	5.15972E-03
4	PU-239	1.29206E-03	1.25857E-03	1.22608E-03
4	PU-240	5.80537E-04	5.82656E-04	5.84509E-04
4	PU-241	2.55667E-04	2.39771E-04	2.24759E-04
4	PU-242	7.22795E-05	7.30221E-05	7.36591E-05
4	U-235	1.51995E-05	1.43173E-05	1.34699E-05
4	U-236	2.10667E-07	4.15240E-07	6.09652E-07
4	FP-1	8.86712E-05	1.71366E-04	2.54061E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
5	U-238	5.24880E-03	5.21489E-03	5.18113E-03
5	PU-239	1.29820E-03	1.26994E-03	1.24240E-03
5	PU-240	5.81588E-04	5.84719E-04	5.87647E-04
5	PU-241	2.57685E-04	2.43526E-04	2.30069E-04
5	PU-242	7.23518E-05	7.31813E-05	7.39220E-05
5	U-235	1.53170E-05	1.45463E-05	1.38018E-05
5	U-236	1.94242E-07	3.84045E-07	5.65706E-07
5	FP-1	7.22218E-05	1.39798E-04	2.07374E-04

FRACTION OF REACTOR POWER AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 5

TOTAL REACTOR POWER (MWT) AT BEGINNING OF CYCLE 0.47433E 03
 TOTAL REACTOR POWER (MWT) AT END OF CYCLE 0.46136E 03

REGION	POWER FRACTION (BOC)	POWER FRACTION (EOC)
1	0.42998E 00	0.41923E 00
2	0.63395E-01	0.62125E-01
3	0.16781E 00	0.16148E 00
4	0.14754E 00	0.14310E 00
5	0.14680E 00	0.14346E 00
6	0.21928E-01	0.36480E-01
7	0.19164E-02	0.26144E-02
8	0.20629E-01	0.31499E-01

OPERATING INTERVAL	5
NUMBER OF INTERNAL ITERATIONS	2
OPERATING INTERVAL TIME (DAYS)	219.080E 00
LOADING FACTOR	0.80000E 00
AVERAGE ELECTRICAL POWER (MWE)	1.75431E 02
AVERAGE THERMAL POWER (MWT)	4.67815E 02
AVERAGE BURNUP FOR DESIGNATED ZONES (MWD/MT)	4.58077E 04
ACCUMULATED OPERATING TIME (YRS)	3.69610E 00
EFFECTIVE MULTIPLICATION CONSTANT AT EOC	0.99910E 00
BURNUP REACTIVITY	-0.40007E-01
RATIO OF POWER DENSITY PEAK TO AVERAGE	1.01623E 00
AVERAGE BREEDING RATIO	1.17553E 00
BEG-OF-CYCLE BREEDING RATIO	1.16569E 00
END-OF-CYCLE BREEDING RATIO	1.18537E 00
DOUBLING TIME (YR)	1.95900E 01

DISCHARGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38515E 03	4.82265E 02	3.42345E 02	4.81370E 03	1.18106E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.8011E 03	3.70037E 02	1.2427E 02	4.1978E 01	1.5634E 01	1.181E 01	8.3076E-01	8.5280E 01		

LOADED FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38493E 03	4.26401E 02	3.03171E 02	4.95869E 03	1.47373E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.9439E 03	2.5115E 02	1.0959E 02	5.2021E 01	1.3645E 01	1.4737E 01	0.	0.		

AVERAGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26229E 04	9.25354E 02	6.62069E 02	1.16884E 04	3.14616E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1576E 04	5.6857E 02	2.3390E 02	9.3495E 01	2.9387E 01	3.1462E 01	1.0197E 00	8.5466E 01		

END-OF-CYCLE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26229E 04	9.38091E 02	6.71539E 02	1.15523E 04	3.00290E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1521E 04	5.78489E 02	2.3674E 02	8.6654E 01	2.9817E 01	3.0029E 01	1.4412E 00	1.2688E 02		

ACCUMULATED IN-PILE AND OUT-OF-PILE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
2.36996E 04	1.87096E 03	1.33246E 03	2.16895E 04	5.81235E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
2.1549E 04	1.1445E 03	4.7686E 02	1.8753E 02	5.9862E 01	5.8123E 01	2.0388E 00	1.9054E 02		

FUEL CYCLE COSTS (MILLS/KWHR)

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES

REFERENCE SET	TOTAL COST	INVENTORY	CREDIT	FABRICATION	REPROCESSING	FAB INV	REPR INV
1	2.04800E 00	1.08415E 00	-6.19835E-02	5.56812E-01	4.71735E-01	3.78117E-02	-4.05255E-02

LEVELIZED FUEL CYCLE COSTS

REFERENCE SET	LEVELIZED COST FOR DISCHARGED FUEL	LEVELIZED COST FOR OPERATING CYCLE
1	2.46773E 00	0.

STORED AND RECYCLE FUEL REPOSITORIES EDIT (OPERATING CYCLE 5)

FUEL REPOSITORY 1

MATERIAL /	DELAY TIME (ACCUMULATED OPERATING INTERVALS)				
	0	1	2	3	4
U-238	0.	0.	0.	0.	0.
PU-239	2.94390E 02	2.75786E 02	2.97801E 02	5.17666E 02	
PU-240	1.21793E 02	1.10397E 02	1.23742E 02	2.12934E 02	
PU-241	4.11430E 01	3.64739E 01	3.93499E 01	6.90064E 01	
PU-242	1.53426E 01	1.38743E 01	1.55827E 01	2.74071E 01	
U-235	0.	0.	0.	0.	
U-236	0.	0.	0.	0.	
FP-1	0.	0.	0.	0.	
TOTAL	4.72668E 02	4.36531E 02	4.76476E 02	8.30014E 02	

MATERIAL /	FUEL REPOSITORY 2 DELAY TIME (ACCUMULATED OPERATING INTERVALS)				
	0	1	2	3	4
U-238	4.70552E 03	4.74990E 03	4.70141E 03	9.56956E 03	
PU-239	0.	0.	0.	0.	
PU-240	0.	0.	0.	0.	
PU-241	0.	0.	0.	0.	
PU-242	0.	0.	0.	0.	
U-235	1.15755E 01	1.17520E 01	1.16417E 01	2.50337E 01	
U-236	8.14230E-01	7.99973E-01	7.89446E-01	1.12171E 00	
FP-1	0.	0.	0.	0.	
TOTAL	4.71791E 03	4.76245E 03	4.71384E 03	9.59572E 03	

FUEL MATERIAL CONCENTRATIONS AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 6 (ATOMS/CC-E-24)

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
1	U-238	2.51462E-03	2.45031E-03	2.48434E-03	2.42079E-03
1	PU-239	3.74121E-04	3.64742E-04	4.39572E-04	4.18874E-04
1	PU-240	1.72698E-04	1.78177E-04	1.91001E-04	1.97906E-04
1	PU-241	6.52179E-05	5.47975E-05	9.02933E-05	7.44851E-05
1	PU-242	2.17264E-05	2.24054E-05	2.35856E-05	2.49300E-05
1	U-235	6.37524E-06	5.14445E-06	7.57182E-06	6.11082E-06
1	U-236	3.86467E-07	6.87831E-07	0.	3.80129E-07
1	FP-1	7.79384E-05	1.53844E-04	0.	8.91046E-05

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
2	U-238	2.52335E-03	2.46755E-03	2.15034E-03	2.10278E-03
2	PU-239	3.74660E-04	3.65903E-04	6.37389E-04	5.84401E-04
2	PU-240	1.71295E-04	1.75535E-04	2.76955E-04	2.84209E-04
2	PU-241	6.65418E-05	5.67842E-05	1.30927E-04	1.10243E-04
2	PU-242	2.15329E-05	2.21272E-05	3.41997E-05	3.58218E-05
2	U-235	6.57136E-06	5.46984E-06	6.55384E-06	5.45527E-06
2	U-236	3.30649E-07	5.99139E-07	0.	2.81623E-07
2	FP-1	6.89367E-05	1.36391E-04	0.	1.07918E-04

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
3	U-238	2.26507E-03	2.22304E-03	2.15033E-03	2.11043E-03
3	PU-239	5.14355E-04	4.86333E-04	6.37389E-04	5.93056E-04
3	PU-240	2.39690E-04	2.41930E-04	2.76955E-04	2.80460E-04
3	PU-241	9.65829E-05	8.38033E-05	1.30927E-04	1.12715E-04
3	PU-242	3.01134E-05	3.06650E-05	3.41997E-05	3.52601E-05
3	U-235	6.09789E-06	5.27043E-06	6.55384E-06	5.66491E-06
3	U-236	2.24111E-07	4.15233E-07	0.	2.13516E-07
3	FP-1	8.00278E-05	1.56904E-04	0.	9.36289E-05

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
4	U-238	2.64928E-03	2.60686E-03	2.50872E-03	2.46856E-03
4	PU-239	6.04399E-04	5.75302E-04	7.43621E-04	6.98384E-04
4	PU-240	2.78413E-04	2.80071E-04	3.23114E-04	3.25776E-04
4	PU-241	1.14441E-04	1.00664E-04	1.52749E-04	1.33604E-04
4	PU-242	3.49132E-05	3.54376E-05	3.98996E-05	4.08757E-05
4	U-235	7.26939E-06	6.42336E-06	7.64615E-06	6.75628E-06
4	U-236	2.18511E-07	4.10222E-07	0.	2.08247E-07
4	FP-1	8.20793E-05	1.61520E-04	0.	9.60195E-05

BATCH AVERAGED MATERIAL CONCENTRATIONS FOR OPERATING CYCLE 6 (ATOMS/CC*E-24)

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
1	U-238	4.99896E-03	4.93475E-03	4.87110E-03
1	PU-239	8.13693E-04	7.98450E-04	7.83616E-04
1	PU-240	3.63697E-04	3.70057E-04	3.76084E-04
1	PU-241	1.55311E-04	1.41774E-04	1.29283E-04
1	PU-242	4.53121E-05	4.64154E-05	4.73354E-05
1	U-235	1.39471E-05	1.25527E-05	1.12345E-05
1	U-236	3.86467E-07	7.42857E-07	1.06796E-06
1	FP-1	7.79384E-05	1.60444E-04	2.42949E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
2	U-238	4.67368E-03	4.62181E-03	4.57033E-03
2	PU-239	1.01205E-03	9.80549E-04	9.50304E-04
2	PU-240	4.48250E-04	4.54228E-04	4.59744E-04
2	PU-241	1.97469E-04	1.81622E-04	1.67027E-04
2	PU-242	5.57325E-05	5.69305E-05	5.79490E-05
2	U-235	1.31252E-05	1.19915E-05	1.09251E-05
2	U-236	3.30649E-07	6.16481E-07	8.80782E-07
2	FP-1	6.69367E-05	1.56623E-04	2.44309E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
3	U-238	4.41541E-03	4.37431E-03	4.33347E-03
3	PU-239	1.13174E-03	1.11491E-03	1.07939E-03
3	PU-240	5.16645E-04	5.19691E-04	5.22390E-04
3	PU-241	2.27510E-04	2.11496E-04	1.96518E-04
3	PU-242	6.43130E-05	6.51852E-05	6.59251E-05
3	U-235	1.20517E-05	1.17725E-05	1.09349E-05
3	U-236	2.24111E-07	4.32679E-07	6.28750E-07
3	FP-1	8.00278E-05	1.65280E-04	2.50533E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
4	U-238	5.15800E-03	5.11660E-03	5.07542E-03
4	PU-239	1.34802E-03	1.31027E-03	1.27369E-03
4	PU-240	6.01527E-04	6.03829E-04	6.05847E-04
4	PU-241	2.67189E-04	2.50249E-04	2.34268E-04
4	PU-242	7.49129E-05	7.56207E-05	7.63133E-05
4	U-235	1.49155E-05	1.40297E-05	1.31796E-05
4	U-236	2.18511E-07	4.23711E-07	6.18469E-07
4	FP-1	8.20753E-05	1.69807E-04	2.57539E-04

FRACTION OF REACTOR POWER AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 6

TOTAL REACTOR POWER (MWT) AT BEGINNING OF CYCLE 0.47470E 03
 TOTAL REACTOR POWER (MWT) AT END OF CYCLE 0.46099E 03

REGION	POWER FRACTION (BOC)	POWER FRACTION (EOC)
1	0.45798E 00	0.44436E 00
2	0.81695E-01	0.78153E-01
3	0.17840E 00	0.17122E 00
4	0.15669E 00	0.15167E 00
5	0.79415E-01	0.81334E-01
6	0.22430E-01	0.37714E-01
7	0.19608E-02	0.26951E-02
8	0.21437E-01	0.32854E-01

OPERATING INTERVAL	6
NUMBER OF INTERNAL ITERATIONS	2
OPERATING INTERVAL TIME (DAYS)	219.000E 00
LOADING FACTOR	0.80000E 00
AVERAGE ELECTRICAL POWER (MWE)	1.75418E 02
AVERAGE THERMAL POWER (MMT)	4.67783E 02
AVERAGE BURNUP FOR DESIGNATED ZONES (MWD/MT)	4.36285E 04
ACCUMULATED OPERATING TIME (YRS)	4.29589E 00
EFFECTIVE MULTIPLICATION CONSTANT AT EOC	0.99986E 00
BURNUP REACTIVITY	-0.43289E-01
RATIO OF POWER DENSITY PEAK TO AVERAGE	1.08210E 00
AVERAGE BREEDING RATIO	1.21164E 00
BEG-OF-CYCLE BREEDING RATIO	1.20064E 00
END-OF-CYCLE BREEDING RATIO	1.22263E 00
DOUBLING TIME (YR)	1.54846E 01

DISCHARGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38493E 03	4.55047E 02	3.25272E 02	4.84468E 03	1.18339E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.8320E 03	2.8656E 02	1.1529E 02	3.9710E 01	1.4487E 01	1.1834E 01	8.5325E-01	8.1623E 01		

LOADED FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38480E 03	3.94892E 02	2.80768E 02	4.98999E 03	1.48185E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.9752E 03	2.3259E 02	1.0149E 02	4.8177E 01	1.2637E 01	1.4818E 01	0.	0.		

AVERAGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26225E 04	8.65195E 02	6.21098E 02	1.16709E 04	3.15678E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1638E 04	5.3492E 02	2.1687E 02	8.6181E 01	2.7229E 01	3.1568E 01	1.0423E 00	8.2979E 01		

END-OF-CYCLE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26225E 04	8.79672E 02	6.32230E 02	1.16132E 04	3.00984E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1582E 04	5.5272E 02	2.1978E 02	7.9509E 01	2.7659E 01	3.0098E 01	1.4741E 00	1.2438E 02		

ACCUMULATED IN-PILE AND OUT-OF-PILE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
2.36989E 04	1.75125E 03	1.25204E 03	2.17359E 04	5.83252E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
2.1675E 04	1.0788E 03	4.4213E 02	1.7307E 02	5.5439E 01	5.8325E 01	2.0890E 00	1.8356E 02		

FUEL CYCLE COSTS (MILLS/KWHR)

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES

REFERENCE SET	TOTAL COST	INVENTORY	CREDIT	FABRICATION	REPROCESSING	FAB INV	REPR INV
1	1.95958E 00	1.06573E 00	-1.77931E-01	5.81743E-01	4.92881E-01	3.95048E-02	-4.23423E-02

LEVELIZED FUEL CYCLE COSTS

REFERENCE SET	LEVELIZED COST FOR DISCHARGED FUEL	LEVELIZED COST FOR OPERATING CYCLE
1	2.40309E 00	0.

STORED AND RECYCLE FUEL REPOSITORIES EDIT (OPERATING CYCLE 6)

MATERIAL /	DELAY TIME (ACCUMULATED OPERATING INTERVALS)					5	6
	0	1	2	3	4		
U-238	0.	0.	0.	0.			
PU-239	2.80859E 02	2.94390E 02	2.75786E 02	8.15468E 02			
PU-240	1.12994E 02	1.21793E 02	1.10397E 02	3.39676E 02			
PU-241	3.79399E 01	5.98632E 01	3.53394E 01	1.04986E 02			
PU-242	1.41985E 01	1.53426E 01	1.38743E 01	4.29898E 01			
U-235	0.	0.	0.	0.			
U-236	0.	0.	0.	0.			
FP-1	0.	0.	0.	0.			
TOTAL	4.45992E 02	4.71388E 02	4.35397E 02	1.30312E 03			

MATERIAL /	FUEL REPOSITORY 2 DELAY TIME (ACCUMULATED OPERATING INTERVALS)					5	6
	0	1	2	3	4		
U-238	4.73583E 03	4.70552E 03	4.74990E 03	1.42710E 04			
PU-239	0.	0.	0.	0.			
PU-240	0.	0.	0.	0.			
PU-241	0.	0.	0.	0.			
PU-242	0.	0.	0.	0.			
U-235	1.15984E 01	1.15755E 01	1.17520E 01	3.66755E 01			
U-236	8.36273E-01	8.14230E-01	7.99973E-01	1.91116E 00			
FP-1	0.	0.	0.	0.			
TOTAL	4.74827E 03	4.71791E 03	4.76245E 03	1.43096E 04			

FUEL MATERIAL CONCENTRATIONS AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 7 (ATOMS/CC*E-24)

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
1	U-238	2.42079E-03	2.30608E-03	2.54168E-03	2.42123E-03
1	PU-239	4.18874E-04	3.85738E-04	4.05612E-04	3.80472E-04
1	PU-240	1.97906E-04	2.06667E-04	1.76244E-04	1.86593E-04
1	PU-241	7.44851E-05	5.49223E-05	8.33174E-05	5.93401E-05
1	PU-242	2.49300E-05	2.59229E-05	2.17634E-05	2.35321E-05
1	U-235	6.11002E-06	4.11310E-06	7.74659E-06	5.21479E-06
1	U-236	3.80129E-07	8.46118E-07	0.	6.32683E-07
1	FP-1	8.91046E-05	2.42650E-04	0.	1.53620E-04

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
2	U-238	2.10278E-03	2.01971E-03	2.36491E-03	2.27148E-03
2	PU-239	5.84401E-04	5.07649E-04	5.10304E-04	4.58903E-04
2	PU-240	2.84209E-04	2.89796E-04	2.21735E-04	2.29388E-04
2	PU-241	1.10243E-04	8.39203E-05	1.04822E-04	7.80156E-05
2	PU-242	3.58218E-05	3.69330E-05	2.73808E-05	2.90604E-05
2	U-235	5.45527E-06	3.96667E-06	7.20783E-06	5.24101E-06
2	U-236	2.81623E-07	6.24281E-07	0.	4.79272E-07
2	FP-1	1.07918E-04	2.80900E-04	0.	1.57054E-04

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
3	U-238	2.11043E-03	2.03772E-03	2.36491E-03	2.28343E-03
3	PU-239	5.93096E-04	5.23228E-04	5.10304E-04	4.64518E-04
3	PU-240	2.80460E-04	2.85728E-04	2.21734E-04	2.28141E-04
3	PU-241	1.12715E-04	8.77632E-05	1.04822E-04	8.03440E-05
3	PU-242	3.52601E-05	3.63760E-05	2.73808E-05	2.88684E-05
3	U-235	5.66451E-06	4.29692E-06	7.20783E-06	5.46764E-06
3	U-236	2.13516E-07	5.33028E-07	0.	4.23549E-07
3	FP-1	9.36289E-05	2.48369E-04	0.	1.38622E-04

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
4	U-238	2.46856E-03	2.41474E-03	2.75906E-03	2.68773E-03
4	PU-239	6.98384E-04	6.35624E-04	5.95355E-04	5.55095E-04
4	PU-240	3.25776E-04	3.30610E-04	2.58693E-04	2.64144E-04
4	PU-241	1.33604E-04	1.08805E-04	1.22293E-04	9.86100E-05
4	PU-242	4.08757E-05	4.19870E-05	3.19443E-05	3.33058E-05
4	U-235	6.75628E-06	5.50303E-06	8.40914E-06	6.84929E-06
4	U-236	2.08247E-07	5.01495E-07	0.	3.76899E-07
4	FP-1	9.60195E-05	2.34216E-04	0.	1.22404E-04

BATCH AVERAGED MATERIAL CONCENTRATIONS FOR OPERATING CYCLE 7 (ATOMS/CC-E-24)

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
1	U-238	4.96247E-03	4.84394E-03	4.72731E-03
1	PU-239	8.24485E-04	7.94569E-04	7.66211E-04
1	PU-240	3.74151E-04	3.84252E-04	3.93261E-04
1	PU-241	1.57802E-04	1.34154E-04	1.14262E-04
1	PU-242	4.66934E-05	4.83427E-05	4.94549E-05
1	U-235	1.38566E-05	1.14433E-05	9.32789E-06
1	U-236	3.80129E-07	9.76818E-07	1.47880E-06
1	FP-1	8.91046E-05	2.42687E-04	3.96270E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
2	U-238	4.46769E-03	4.37885E-03	4.29119E-03
2	PU-239	1.09470E-03	1.02824E-03	9.66552E-04
2	PU-240	5.05943E-04	5.13288E-04	5.19184E-04
2	PU-241	2.15065E-04	1.86637E-04	1.66193E-04
2	PU-242	6.32026E-05	6.48508E-05	6.59935E-05
2	U-235	1.26631E-05	1.08438E-05	9.20767E-06
2	U-236	2.81623E-07	7.20846E-07	1.10355E-06
2	FP-1	1.07918E-04	2.72936E-04	4.37954E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
3	U-238	4.47534E-03	4.39780E-03	4.32116E-03
3	PU-239	1.10336E-03	1.04366E-03	9.87746E-04
3	PU-240	5.02194E-04	5.08293E-04	5.13869E-04
3	PU-241	2.17538E-04	1.91289E-04	1.68107E-04
3	PU-242	6.26408E-05	6.41464E-05	6.52445E-05
3	U-235	1.28723E-05	1.12470E-05	9.76456E-06
3	U-236	2.13516E-07	6.07027E-07	9.56577E-07
3	FP-1	9.36289E-05	2.40310E-04	3.86992E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
4	U-238	5.22762E-03	5.15975E-03	5.09247E-03
4	PU-239	1.29374E-03	1.24097E-03	1.19072E-03
4	PU-240	5.84466E-04	5.89972E-04	5.94754E-04
4	PU-241	2.55896E-04	2.30483E-04	2.07415E-04
4	PU-242	7.28199E-05	7.42023E-05	7.52928E-05
4	U-235	1.51654E-05	1.37108E-05	1.23523E-05
4	U-236	2.08247E-07	5.57843E-07	8.78394E-07
4	FP-1	9.60195E-05	2.26320E-04	3.56620E-04

FRACTION OF REACTOR POWER AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 7

TOTAL REACTOR POWER (MWT) AT BEGINNING OF CYCLE 0.48025E 03
 TOTAL REACTOR POWER (MWT) AT END OF CYCLE 0.45574E 03

REGION	POWER FRACTION (BOC)	POWER FRACTION (EOC)
1	0.51823E 00	0.49086E 00
2	0.94086E-01	0.86616E-01
3	0.18681E 00	0.17442E 00
4	0.14032E 00	0.13455E 00
5	0.12528E-01	0.19835E-01
6	0.26758E-01	0.56417E-01
7	0.22280E-02	0.43250E-02
8	0.19040E-01	0.32986E-01

OPERATING INTERVAL	7
NUMBER OF INTERNAL ITERATIONS	3
OPERATING INTERVAL TIME (DAYS)	365.000E 00
LOADING FACTOR	0.80000E 00
AVERAGE ELECTRICAL POWER (MWE)	1.75238E 02
AVERAGE THERMAL POWER (MWT)	4.67302E 02
AVERAGE BURNUP FOR DESIGNATED ZONES (MWD/MT)	7.29798E 04
ACCUMULATED OPERATING TIME (YRS)	5.29580E 00
EFFECTIVE MULTIPLICATION CONSTANT AT EOC	0.10080E 01
BURNUP REACTIVITY	-0.74688E-01
RATIO OF POWER DENSITY PEAK TO AVERAGE	1.02932E 00
AVERAGE BREEDING RATIO	1.23482E 00
BEG-OF-CYCLE BREEDING RATIO	1.21586E 00
END-OF-CYCLE BREEDING RATIO	1.25428E 00
DOUBLING TIME (YR)	1.17830E 01

DISCHARGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38480E 03		4.28407E 02		3.09353E 02		4.83859E 03		1.11078E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.8264E 03	2.7395E 02	1.0943E 02	3.1398E 01	1.3622E 01	1.1188E 01	1.0786E 00	1.1326E 02		

LOADED FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38423E 03		3.36862E 02		2.39509E 02		5.04964E 03		1.49914E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
5.0326E 03	1.9841E 02	8.6573E 01	4.1097E 01	1.0780E 01	1.4991E 01	0.	0.		

AVERAGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26218E 04		7.87282E 02		5.66719E 02		1.17188E 04		3.08550E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1687E 04	4.9469E 02	1.9604E 02	7.2025E 01	2.4527E 01	3.0835E 01	1.3207E 00	1.1167E 02		

END-OF-CYCLE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26218E 04		8.13078E 02		5.86971E 02		1.16214E 04		2.84540E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1591E 04	5.2482E 02	2.0100E 02	6.2155E 01	2.5102E 01	2.8454E 01	2.0206E 00	1.8059E 02		

ACCUMULATED IN-PILE AND OUT-OF-PILE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.92673E 04		1.27040E 03		9.10174E 02		1.77819E 04		4.64606E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.7733E 04	7.9467E 02	3.1949E 02	1.1532E 02	3.9896E 01	4.6461E 01	2.1146E 00	1.9553E 02		

FUEL CYCLE COSTS (MILLS/KWHR)

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES

OPERATING INTERVAL	7	ENERGY OF DISCHARGED FUEL	1.00910E 09	ACCUMULATED ENERGY OF DISCHARGED FUEL	4.93345E 09		
REFERENCE SET	TOTAL COST	INVENTORY	CREDIT	FABRICATION	REPROCESSING	FAB INV	REPR INV
1	1.44811E 00	8.35822E-01	-1.60806E-01	4.19199E-01	3.55176E-01	3.34938E-02	-3.47716E-02

LEVELIZED FUEL CYCLE COSTS

REFERENCE SET	LEVELIZED COST FOR DISCHARGED FUEL	LEVELIZED COST FOR OPERATING CYCLE
1	2.24043E 00	0.

STORED AND RECYCLE FUEL REPOSITORIES EDIT (OPERATING CYCLE 7)

FUEL REPOSITORY 1

MATERIAL /	DELAY TIME (ACCUMULATED OPERATING INTERVALS)					5	6
	0	1	2	3	4		
U-238	0.	0.	0.	0.	0.		
PU-239	2.68503E 02	2.80859E 02	2.94390E 02	1.09125E 03			
PU-240	1.07255E 02	1.12994E 02	1.21793E 02	4.50073E 02			
PU-241	3.07733E 01	3.59935E 01	3.78182E 01	1.33126E 02			
PU-242	1.33510E 01	1.41985E 01	1.53426E 01	5.68641E 01			
U-235	0.	0.	0.	0.			
U-236	0.	0.	0.	0.			
FP-1	0.	0.	0.	0.			
TOTAL	4.19882E 02	4.44045E 02	4.69343E 02	1.73132E 03			

MATERIAL /	FUEL REPOSITORY 2 DELAY TIME (ACCUMULATED OPERATING INTERVALS)					5	6
	0	1	2	3	4		
U-238	4.73036E 03	4.73583E 03	4.70552E 03	1.90209E 04			
PU-239	0.	0.	0.	0.			
PU-240	0.	0.	0.	0.			
PU-241	0.	0.	0.	0.			
PU-242	0.	0.	0.	0.			
U-235	1.08865E 01	1.15984E 01	1.15755E 01	4.84275E 01			
U-236	1.09714E 00	6.36273E-01	8.14230E-01	2.71113E 00			
FP-1	0.	0.	0.	0.			
TOTAL	4.74230E 03	4.74827E 03	4.71791E 03	1.90720E 04			

FUEL MATERIAL CONCENTRATIONS AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 8 (ATOMS/CC*E=24).

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
1	U-238	2.42123E-03	2.30918E-03	2.44259E-03	2.32955E-03
1	PU-239	3.80472E-04	3.58701E-04	4.64298E-04	4.20074E-04
1	PU-240	1.86593E-04	1.94000E-04	2.01744E-04	2.12728E-04
1	PU-241	9.93401E-05	4.53276E-05	9.53723E-05	6.83397E-05
1	PU-242	2.35321E-05	2.39311E-05	2.49123E-05	2.69073E-05
1	U-235	9.21479E-06	3.54392E-06	7.44458E-06	5.05926E-06
1	U-236	6.32683E-07	9.97015E-07	0.	5.96803E-07
1	FP-1	1.53620E-04	2.90136E-04	0.	1.66603E-04

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
2	U-238	2.27148E-03	2.18385E-03	2.08783E-03	2.00729E-03
2	PU-239	4.58903E-04	4.17869E-04	6.74406E-04	5.77921E-04
2	PU-240	2.29388E-04	2.33706E-04	2.93039E-04	3.02092E-04
2	PU-241	7.80196E-05	6.07259E-05	1.38531E-04	1.03654E-04
2	PU-242	2.90604E-05	2.95003E-05	3.61858E-05	3.83712E-05
2	U-235	9.24101E-06	3.84010E-06	6.36335E-06	4.66245E-06
2	U-236	4.79272E-07	7.87589E-07	0.	4.14875E-07
2	FP-1	1.57054E-04	2.93703E-04	0.	1.93103E-04

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
3	U-238	2.28343E-03	2.20662E-03	2.08783E-03	2.01760E-03
3	PU-239	4.64518E-04	4.27088E-04	6.74406E-04	5.88760E-04
3	PU-240	2.28141E-04	2.31967E-04	2.93039E-04	3.00689E-04
3	PU-241	8.03440E-05	6.37556E-05	1.38531E-04	1.06687E-04
3	PU-242	2.88684E-05	2.93498E-05	3.61858E-05	3.81194E-05
3	U-235	5.46764E-06	4.17515E-06	6.36335E-06	4.85913E-06
3	U-236	4.23549E-07	7.12530E-07	0.	3.66423E-07
3	FP-1	1.38622E-04	2.60648E-04	0.	1.70686E-04

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
4	U-238	2.68773E-03	2.61989E-03	2.43581E-03	2.37432E-03
4	PU-239	5.55095E-04	5.20679E-04	7.86807E-04	7.10840E-04
4	PU-240	2.64144E-04	2.67884E-04	3.41879E-04	3.48510E-04
4	PU-241	9.86100E-05	8.11760E-05	1.61619E-04	1.30806E-04
4	PU-242	3.33058E-05	3.38195E-05	4.22168E-05	4.39831E-05
4	U-235	6.84929E-06	5.60629E-06	7.42391E-06	6.07663E-06
4	U-236	3.76899E-07	6.60505E-07	0.	3.25731E-07
4	FP-1	1.22404E-04	2.32520E-04	0.	1.51360E-04

BATCH AVERAGED MATERIAL CONCENTRATIONS FOR OPERATING CYCLE 8 (ATOMS/CC=E-24)

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
1	U-238	4.86382E-03	4.75038E-03	4.63872E-03
1	PU-239	8.44770E-04	8.10770E-04	7.78775E-04
1	PU-240	3.88338E-04	3.98108E-04	4.06728E-04
1	PU-241	1.54712E-04	1.32455E-04	1.13667E-04
1	PU-242	4.84444E-05	4.98863E-05	5.08384E-05
1	U-235	1.26594E-05	1.05010E-05	8.60318E-06
1	U-236	6.32683E-07	1.15448E-06	1.59382E-06
1	FP-1	1.53620E-04	3.05179E-04	4.56739E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
2	U-238	4.35932E-03	4.27468E-03	4.19114E-03
2	PU-239	1.13331E-03	1.06199E-03	9.95790E-04
2	PU-240	5.22427E-04	5.29865E-04	5.35798E-04
2	PU-241	2.16547E-04	1.88670E-04	1.64379E-04
2	PU-242	6.52463E-05	6.68002E-05	6.78715E-05
2	U-235	1.16044E-05	9.97319E-06	8.58254E-06
2	U-236	4.79272E-07	8.65541E-07	1.20286E-06
2	FP-1	1.57054E-04	3.21930E-04	4.86806E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
3	U-238	4.37127E-03	4.29732E-03	4.22422E-03
3	PU-239	1.13892E-03	1.07538E-03	1.01585E-03
3	PU-240	5.21180E-04	5.27492E-04	5.32652E-04
3	PU-241	2.18875E-04	1.93187E-04	1.70443E-04
3	PU-242	6.50543E-05	6.64556E-05	6.74693E-05
3	U-235	1.18310E-05	1.03699E-05	9.03428E-06
3	U-236	4.23549E-07	7.70488E-07	1.07895E-06
3	FP-1	1.38622E-04	2.84978E-04	4.31333E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
4	U-238	5.12354E-03	5.05860E-03	4.99482E-03
4	PU-239	1.34190E-03	1.28537E-03	1.23192E-03
4	PU-240	6.06023E-04	6.11584E-04	6.16394E-04
4	PU-241	2.60229E-04	2.34961E-04	2.11982E-04
4	PU-242	7.55226E-05	7.68539E-05	7.79026E-05
4	U-235	1.42732E-05	1.29349E-05	1.16829E-05
4	U-236	3.76899E-07	6.94590E-07	9.86235E-07
4	FP-1	1.22404E-04	2.53142E-04	3.83879E-04

FRACTION OF REACTOR POWER AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 8

TOTAL REACTOR POWER (MWT) AT BEGINNING OF CYCLE 0.48120E 03
 TOTAL REACTOR POWER (MWT) AT END OF CYCLE 0.45483E 03

REGION	POWER FRACTION (BOC)	POWER FRACTION (EOC)
1	0.51081E 00	0.48492E 00
2	0.93885E-01	0.86643E-01
3	0.18609E 00	0.17430E 00
4	0.14057E 00	0.13521E 00
5	0.13121E-01	0.20099E-01
6	0.32225E-01	0.60149E-01
7	0.26199E-02	0.46228E-02
8	0.20680E-01	0.34062E-01

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      0
      3
365.000E 00
0.80000E 00
1.75247E 02
4.67326E 02
8.15648E 04
6.29482E 04
0.10080E 01
-0.76749E-01
1.023374E 00
1.16988E 00
1.616724E 00
1.21175E 00
1.17830E 01

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TOTAL FUEL	TOTAL PU	FISSILE PU	TOTAL U	FISSILE U
5.38423E 03	3.93163E 02	2.85158E 02	4.85816E 03	1.05269E 01

U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1
4.8464E 03	2.6089E 02	9.6347E 01	2.4265E 01	1.1677E 01	1.0527E 01	1.2813E 00	1.2844E 02

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38468E 03		4.17516E 02		2.96854E 02		4.96751E 03		1.47510E 01	
U-238	PU-239	PU-240	PU-241	PU-242		U-235	U-236	FP-1	
4.9528E 03	2.4598E 02	1.0730E 02	5.0937E 01	1.3361E 01		1.4751E 01	0.	0.	

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26217E 04		8.24601E 02		5.95220E 02		1.16963E 04		2.98557E 01	
U-238	PU-239	PU-240	PU-241	PU-242		U-235	U-236	FP-1	
1.1625E 04	5.2302E 02	2.0402E 02	7.2196E 01	2.5359E 01		2.9856E 01	1.5904E 00	1.3626E 02	

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26217E 04		8.47015E 02		6.11909E 02		1.15023E 04		2.76140E 01	
U-238	PU-239	PU-240		PU-241	PU-242	U-235		U-236	FP-1
1.1532E 04	5.4927E 02	2.0917E 02		6.2700E 01	2.5878E 01	2.7614E 01		2.2387E 00	2.0518E 02

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.92669E 04		1.32197E 03		9.52234E 02		1.76941E 04		4.49148E 01	
U-238	PU-239	PU-240	PU-241	PU-242		U-235	U-236	FP-1	
1.7647E 04	8.3688E 02	3.2812E 02	1.1529E 02	4.0576E 01		4.4915E 01	2.5334E 00	2.3129E 02	

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES

REFERENCE SET	TOTAL COST	INVENTORY	CREDIT	FABRICATION	REPROCESSING	FAB INV	REPR INV
1	1.05921E 00	7.96934E-01	33.35294E-01	3.28522E-01	3.13174E-01	3.02856E-02	3.44153E-02

REFERENCE SET	LEVELIZED COST FOR DISCHARGED FUEL	LEVELIZED COST FOR OPERATING CYCLE
1	2.254735 88	8.

STORED AND RECYCLE FUEL REPOSITORIES EDIT (OPERATING CYCLE 8)

FUEL REPOSITORY 1

MATERIAL /	0	DELAY TIME (ACCUMULATED OPERATING INTERVALS)				5	6
		1	2	3	4		
U-238	0.	0.	0.	0.			
PU-239	2.55701E 02	2.68503E 02	2.80859E 02	1.38564E 03			
PU-240	9.44301E 01	1.07255E 02	1.12994E 02	5.71866E 02			
PU-241	2.37819E 01	2.91946E 01	3.41469E 01	1.62175E 02			
PU-242	1.14451E 01	1.33510E 01	1.41985E 01	7.22067E 01			
U-235	0.	0.	0.	0.			
U-236	0.	0.	0.	0.			
FP-1	0.	0.	0.	0.			
TOTAL	3.85388E 02	4.18303E 02	4.42199E 02	2.19189E 03			

MATERIAL /	0	FUEL REPOSITORY 2 DELAY TIME (ACCUMULATED OPERATING INTERVALS)				5	6
		1	2	3	4		
U-238	4.74991E 03	4.73036E 03	4.73583E 03	2.37264E 04			
PU-239	0.	0.	0.	0.			
PU-240	0.	0.	0.	0.			
PU-241	0.	0.	0.	0.			
PU-242	0.	0.	0.	0.			
U-235	1.03174E 01	1.08865E 01	1.15984E 01	6.08030E 01			
U-236	1.25579E 00	1.05714E 00	8.36273E-01	3.52536E 00			
FP-1	0.	0.	0.	0.			
TOTAL	4.76148E 03	4.74230E 03	4.74627E 03	2.37899E 04			

FUEL MATERIAL CONCENTRATIONS AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 9 (ATOMS/CC-E-24)

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
1	U-238	2.32955E-03	2.22699E-03	2.50739E-03	2.39700E-03
1	PU-239	4.20074E-04	3.85812E-04	4.25920E-04	3.95988E-04
1	PU-240	2.12728E-04	2.19499E-04	1.85068E-04	1.95097E-04
1	PU-241	6.83397E-05	5.26962E-05	8.74890E-05	6.36538E-05
1	PU-242	2.69073E-05	2.73854E-05	2.28531E-05	2.46317E-05
1	U-235	5.05926E-06	3.50502E-06	7.64208E-06	5.29437E-06
1	U-236	5.96803E-07	9.38377E-07	0.	5.88836E-07
1	FP-1	1.66603E-04	3.07765E-04	0.	1.48447E-04

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
2	U-238	2.00729E-03	1.93364E-03	2.31718E-03	2.23216E-03
2	PU-239	5.77921E-04	5.04956E-04	5.38574E-04	4.82946E-04
2	PU-240	3.02092E-04	3.05611E-04	2.34018E-04	2.41499E-04
2	PU-241	1.03694E-04	8.14625E-05	1.10630E-04	8.39115E-05
2	PU-242	3.83712E-05	3.89726E-05	2.88977E-05	3.05908E-05
2	U-235	4.66245E-06	3.46952E-06	7.06235E-06	5.25540E-06
2	U-236	4.14875E-07	6.78909E-07	0.	4.41606E-07
2	FP-1	1.93103E-04	3.51584E-04	0.	1.52805E-04

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
3	U-238	2.01760E-03	1.95305E-03	2.31718E-03	2.24305E-03
3	PU-239	5.88760E-04	5.22115E-04	5.38574E-04	4.89112E-04
3	PU-240	3.00682E-04	3.04024E-04	2.34018E-04	2.40282E-04
3	PU-241	1.06687E-04	8.54792E-05	1.10629E-04	8.62586E-05
3	PU-242	3.81194E-05	3.87551E-05	2.88977E-05	3.03926E-05
3	U-235	4.85913E-06	3.76367E-06	7.06235E-06	5.46583E-06
3	U-236	3.66423E-07	6.13161E-07	0.	3.89564E-07
3	FP-1	1.70686E-04	3.13002E-04	0.	1.34852E-04

REGION	MATERIAL	BATCH 1		BATCH 2	
		(BOC)	(EOC)	(BOC)	(EOC)
4	U-238	2.37432E-03	2.31734E-03	2.70337E-03	2.63650E-03
4	PU-239	7.10840E-04	6.48664E-04	6.28337E-04	5.84801E-04
4	PU-240	3.48510E-04	3.52214E-04	2.73022E-04	2.78354E-04
4	PU-241	1.30806E-04	1.08621E-04	1.29068E-04	1.05524E-04
4	PU-242	4.39831E-05	4.47856E-05	3.37140E-05	3.50739E-05
4	U-235	6.07663E-06	5.02372E-06	8.23941E-06	6.81175E-06
4	U-236	3.25731E-07	5.66697E-07	0.	3.45583E-07
4	FP-1	1.51360E-04	2.81202E-04	0.	1.19083E-04

BATCH AVERAGED MATERIAL CONCENTRATIONS FOR OPERATING CYCLE 9 (ATOMS/CC-E-24)

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
1	U-238	4.83694E-03	4.72966E-03	4.62399E-03
1	PU-239	8.45994E-04	8.12950E-04	7.81880E-04
1	PU-240	3.97796E-04	4.06699E-04	4.14597E-04
1	PU-241	1.55829E-04	1.34508E-04	1.16390E-04
1	PU-242	4.97604E-05	5.11123E-05	5.20171E-05
1	U-235	1.27013E-05	1.06313E-05	8.79939E-06
1	U-236	5.96803E-07	1.09975E-06	1.52721E-06
1	FP-1	1.66603E-04	3.11408E-04	4.56213E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
2	U-238	4.32447E-03	4.24464E-03	4.16579E-03
2	PU-239	1.11650E-03	1.04993E-03	9.87902E-04
2	PU-240	5.36111E-04	5.42269E-04	5.47110E-04
2	PU-241	2.14283E-04	1.88247E-04	1.65394E-04
2	PU-242	6.72689E-05	6.86297E-05	6.95634E-05
2	U-235	1.17248E-05	1.01511E-05	8.72492E-06
2	U-236	4.14675E-07	7.90407E-07	1.12051E-06
2	FP-1	1.93103E-04	3.48746E-04	5.04389E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
3	U-238	4.33478E-03	4.26506E-03	4.19610E-03
3	PU-239	1.12733E-03	1.06748E-03	1.01123E-03
3	PU-240	5.34703E-04	5.40014E-04	5.44386E-04
3	PU-241	2.17316E-04	1.93215E-04	1.71738E-04
3	PU-242	6.70171E-05	6.82598E-05	6.91577E-05
3	U-235	1.19215E-05	1.05165E-05	9.22690E-06
3	U-236	3.66423E-07	7.02214E-07	1.00273E-06
3	FP-1	1.70686E-04	3.09270E-04	4.47894E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
4	U-238	5.07770E-03	5.01652E-03	4.95584E-03
4	PU-239	1.33918E-03	1.28509E-03	1.23346E-03
4	PU-240	6.21932E-04	6.26388E-04	6.30568E-04
4	PU-241	2.59874E-04	2.35980E-04	2.14146E-04
4	PU-242	7.76970E-05	7.89050E-05	7.98595E-05
4	U-235	1.43160E-05	1.30364E-05	1.18395E-05
4	U-236	3.25731E-07	6.80867E-07	9.12280E-07
4	FP-1	1.51360E-04	2.75822E-04	4.00284E-04

FRACTION OF REACTOR POWER AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 9

TOTAL REACTOR POWER (MWT) AT BEGINNING OF CYCLE 0.48065E 03
 TOTAL REACTOR POWER (MWT) AT END OF CYCLE 0.45533E 03

REGION	POWER FRACTION (BOC)	POWER FRACTION (EOC)
1	0.51260E 00	0.48749E 00
2	0.92926E-01	0.86218E-01
3	0.18488E 00	0.17387E 00
4	0.14054E 00	0.13548E 00
5	0.13051E-01	0.19702E-01
6	0.31929E-01	0.58546E-01
7	0.25988E-02	0.45038E-02
8	0.21486E-01	0.34196E-01

OPERATING INTERVAL	9
NUMBER OF INTERNAL ITERATIONS	5
OPERATING INTERVAL TIME (DAYS)	347.140E 00
LOADING FACTOR	0.80080E 00
AVERAGE ELECTRICAL POWER (MWE)	1.75270E 02
AVERAGE THERMAL POWER (MWT)	4.67386E 02
AVERAGE BURNUP FOR DESIGNATED ZONES (MWD/MT)	9.15168E 04
ACCUMULATED OPERATING TIME (YRS)	7.24479E 00
EFFECTIVE MULTIPLICATION CONSTANT AT EOC	0.10083E 01
BURNUP REACTIVITY	-0.73567E-01
RATIO OF POWER DENSITY PEAK TO AVERAGE	1.02684E 00
AVERAGE BREEDING RATIO	1.18868E 00
BEG-OF-CYCLE BREEDING RATIO	1.16715E 00
END-OF-CYCLE BREEDING RATIO	1.21022E 00
DOUBLING TIME (YR)	1.19323E 01

DISCHARGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38468E 03	4.50695E 02	3.18970E 02	4.78597E 03	1.03834E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.7743E 03	2.8834E 02	1.1727E 02	3.0633E 01	1.4451E 01	1.0383E 01	1.2672E 00	1.4253E 02		

LOADED FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38428E 03	3.54690E 02	2.52184E 02	5.02993E 03	1.49383E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
5.0150E 03	2.7089E 02	9.1155E 01	4.3272E 01	1.1350E 01	1.4938E 01	0.	0.		

AVERAGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26218E 04	8.29518E 02	5.94841E 02	1.16449E 04	2.98854E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1613E 04	5.7221E 02	2.0865E 02	7.2664E 01	2.6028E 01	2.9885E 01	1.5771E 00	1.4230E 02		

END-OF-CYCLE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26218E 04	8.50513E 02	6.10687E 02	1.15558E 04	2.77453E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1526E 04	5.4707E 02	2.1332E 02	6.3621E 01	2.6505E 01	2.7745E 01	2.1967E 00	2.0786E 02		

ACCUMULATED IN-PILE AND OUT-OF-PILE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.96086E 04	1.36405E 03	9.73089E 02	1.79696E 04	4.57049E 01					
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.7921E 04	8.5417E 02	3.4690E 02	1.1876E 02	4.3125E 01	4.5705E 01	2.5577E 00	2.5309E 02		

FUEL CYCLE COSTS (MILLS/KWHR)

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES

OPERATING INTERVAL	9	ENERGY OF DISCHARGED FUEL	1.26996E 09	ACCUMULATED ENERGY OF DISCHARGED FUEL	7.34774E 09		
REFERENCE SET	TOTAL COST	INVENTORY	CREDIT	FABRICATION	REPROCESSING	FAB INV	REPR INV
1	1.25636E 00	7.87975E-01	-1.05634E-01	2.96075E-01	2.82209E-01	2.73852E-02	-3.16486E-02

LEVELIZED FUEL CYCLE COSTS

REFERENCE SET	LEVELIZED COST FOR DISCHARGED FUEL	LEVELIZED COST FOR OPERATING CYCLE
1	1.25740E 00	0.

STORED AND RECYCLE FUEL REPOSITORIES EDIT (OPERATING CYCLE 9)

FUEL REPOSITORY 1

MATERIAL /	0	DELAY TIME (ACCUMULATED OPERATING INTERVALS)				5	6
		1	2	3	4		
U-238	0.	0.	0.	0.	0.		
PU-239	2.82599E 02	2.55701E 02	2.68503E 02	1.66650E 03			
PU-240	1.14941E 02	9.44301E 01	1.07255E 02	6.84660E 02			
PU-241	3.00235E 01	2.26200E 01	2.77682E 01	1.86730E 02			
PU-242	1.41632E 01	1.14451E 01	1.33510E 01	8.64052E 01			
U-235	0.	0.	0.	0.			
U-236	0.	0.	0.	0.			
FP-1	0.	0.	0.	0.			
TOTAL	4.41726E 02	8.84196E 02	4.16877E 02	2.62450E 03			

MATERIAL /	0	FUEL REPOSITORY 2 DELAY TIME (ACCUMULATED OPERATING INTERVALS)				5	6
		1	2	3	4		
U-238	4.67931E 03	4.74991E 03	4.73036E 03	2.84622E 04			
PU-239	0.	0.	0.	0.			
PU-240	0.	0.	0.	0.			
PU-241	0.	0.	0.	0.			
PU-242	0.	0.	0.	0.			
U-235	1.01767E 01	1.03174E 01	1.09865E 01	7.16014E 01			
U-236	1.24195E 00	1.25579E 00	1.05714E 00	4.36163E 00			
FP-1	0.	0.	0.	0.			
TOTAL	4.69073E 03	4.76148E 03	4.74230E 03	2.85382E 04			

FUEL MATERIAL CONCENTRATIONS AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 10 (ATOMS/CC*E-24)

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
1	U-238	2.39700E-03	2.27653E-03	2.45396E-03	2.33062E-03
1	PU-239	3.95988E-04	3.66902E-04	4.57563E-04	4.12292E-04
1	PU-240	1.95057E-04	2.03046E-04	1.98818E-04	2.10469E-04
1	PU-241	6.36538E-05	4.73519E-05	9.39888E-05	6.55601E-05
1	PU-242	2.46317E-05	2.51210E-05	2.45509E-05	2.66053E-05
1	U-235	5.29437E-06	3.47739E-06	7.47924E-06	4.91244E-06
1	U-236	5.88836E-07	9.87256E-07	0.	6.39404E-07
1	FP-1	1.48447E-04	3.01701E-04	0.	1.78303E-04

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
2	U-238	2.23216E-03	2.13860E-03	2.10294E-03	2.01481E-03
2	PU-239	4.82946E-04	4.31409E-04	6.65458E-04	5.64209E-04
2	PU-240	2.41499E-04	2.46149E-04	2.89151E-04	2.98633E-04
2	PU-241	8.39115E-05	6.37786E-05	1.36693E-04	9.98320E-05
2	PU-242	3.05908E-05	3.11269E-05	3.57058E-05	3.79657E-05
2	U-235	5.25540E-06	3.74637E-06	6.40940E-06	4.56901E-06
2	U-236	4.41606E-07	7.75026E-07	0.	4.47332E-07
2	FP-1	1.52805E-04	3.07487E-04	0.	2.06421E-04

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
3	U-238	2.24305E-03	2.16105E-03	2.10294E-03	2.02607E-03
3	PU-239	4.89112E-04	4.42105E-04	6.65458E-04	5.75466E-04
3	PU-240	2.40282E-04	2.44438E-04	2.89151E-04	2.97177E-04
3	PU-241	8.62586E-05	6.69763E-05	1.36693E-04	1.02971E-04
3	PU-242	3.03926E-05	3.09705E-05	3.57057E-05	3.77128E-05
3	U-235	5.46583E-06	4.07558E-06	6.40940E-06	4.77915E-06
3	U-236	3.89564E-07	7.01387E-07	0.	3.95927E-07
3	FP-1	1.34852E-04	2.73104E-04	0.	1.82576E-04

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
4	U-238	2.63850E-03	2.56610E-03	2.45343E-03	2.38611E-03
4	PU-239	5.84801E-04	5.41438E-04	7.76368E-04	6.96395E-04
4	PU-240	2.78354E-04	2.82487E-04	3.37343E-04	3.44345E-04
4	PU-241	1.05524E-04	8.53134E-05	1.59475E-04	1.26731E-04
4	PU-242	3.50739E-05	3.57969E-05	4.16567E-05	4.35035E-05
4	U-235	6.81175E-06	5.47787E-06	7.47763E-06	6.01336E-06
4	U-236	3.45583E-07	6.50537E-07	0.	3.53254E-07
4	FP-1	1.19083E-04	2.44065E-04	0.	1.62080E-04

BATCH AVERAGED MATERIAL CONCENTRATIONS FOR OPERATING CYCLE 10 (ATOMS/CC-E-24)

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
1	U-238	4.85096E-03	4.72801E-03	4.60715E-03
1	PU-239	8.53551E-04	8.15106E-04	7.79194E-04
1	PU-240	3.93875E-04	4.04389E-04	4.13515E-04
1	PU-241	1.57643E-04	1.33223E-04	1.12912E-04
1	PU-242	4.91826E-05	5.07440E-05	5.17243E-05
1	U-235	1.27736E-05	1.04286E-05	8.38983E-06
1	U-236	5.88836E-07	1.15621E-06	1.62666E-06
1	FP-1	1.48447E-04	3.14226E-04	4.80004E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
2	U-238	4.33510E-03	4.24360E-03	4.15341E-03
2	PU-239	1.14840E-03	1.06890E-03	9.95618E-04
2	PU-240	5.30651E-04	5.38620E-04	5.44782E-04
2	PU-241	2.20605E-04	1.89977E-04	1.63611E-04
2	PU-242	6.62965E-05	6.79806E-05	6.90926E-05
2	U-235	1.16648E-05	9.89579E-06	8.31538E-06
2	U-236	4.41606E-07	8.60965E-07	1.22236E-06
2	FP-1	1.52805E-04	3.3357E-04	5.13908E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
3	U-238	4.34599E-03	4.26606E-03	4.18712E-03
3	PU-239	1.15457E-03	1.08363E-03	1.01757E-03
3	PU-240	5.29433E-04	5.36219E-04	5.41615E-04
3	PU-241	2.22952E-04	1.94697E-04	1.69948E-04
3	PU-242	6.60983E-05	6.76211E-05	6.86833E-05
3	U-235	1.18752E-05	1.02912E-05	8.85473E-06
3	U-236	3.89564E-07	7.66044E-07	1.09731E-06
3	FP-1	1.34852E-04	2.95266E-04	4.55681E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
4	U-238	5.09193E-03	5.02175E-03	4.95282E-03
4	PU-239	1.36117E-03	1.29766E-03	1.23783E-03
4	PU-240	6.15697E-04	6.21718E-04	6.26831E-04
4	PU-241	2.65000E-04	2.37154E-04	2.12044E-04
4	PU-242	7.67306E-05	7.81840E-05	7.93004E-05
4	U-235	1.42894E-05	1.28395E-05	1.14912E-05
4	U-236	3.45583E-07	8.89995E-07	1.00379E-06
4	FP-1	1.19083E-04	2.62614E-04	4.06145E-04

FRACTION OF REACTOR POWER AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 10

TOTAL REACTOR POWER (MWT) AT BEGINNING OF CYCLE 0.48280E 03
 TOTAL REACTOR POWER (MWT) AT END OF CYCLE 0.45334E 03

REGION	POWER FRACTION (BOC)	POWER FRACTION (EOC)
1	0,51111E 00	0,48303E 00
2	0,94140E-01	0,86300E-01
3	0,18664E 00	0,17387E 00
4	0,14103E 00	0,13526E 00
5	0,12771E-01	0,20333E-01
6	0,30989E-01	0,61215E-01
7	0,25286E-02	0,46984E-02
8	0,20797E-01	0,35287E-01

OPERATING INTERVAL 10
 NUMBER OF INTERNAL ITERATIONS 4
 OPERATING INTERVAL TIME (DAYS) 400.000E 00
 LOADING FACTOR 0.80090E 00
 AVERAGE ELECTRICAL POWER (MWE) 1.75281E 02
 AVERAGE THERMAL POWER (MWT) 4.67284E 02
 AVERAGE BURNUP FOR DESIGNATED ZONES (HWD,MT) 8.51105E 04
 ACCUMULATED OPERATING TIME (YRS) 8.33993E 00
 EFFECTIVE MULTIPLICATION CONSTANT AT EOC 0.10001E 01
 BURNUP REACTIVITY -0.84950E-01
 RATIO OF POWER DENSITY PEAK TO AVERAGE 1.02684E 00
 AVERAGE BREEDING RATIO 1.17847E 00
 BEG-OF-CYCLE BREEDING RATIO 1.15320E 00
 END-OF-CYCLE BREEDING RATIO 1.20373E 00
 DOUBLING TIME (YR) 1.1323E 01

DISCHARGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38428E 03		4.08362E 02		2.94765E 02		4.83704E 03		1.03580E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.8254E 03	2.6935E 02	1.0130E 02	2.5439E 01	1.2293E 01	1.0358E 01	1.3213E 00	1.3414E 02		

LOADED FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38457E 03		4.11754E 02		2.92757E 02		4.97324E 03		1.47682E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.9585E 03	2.4252E 02	1.0502E 02	5.0234E 01	1.3176E 01	1.4768E 01	0.	0.		

AVERAGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26217E 04		8.35143E 02		6.01911E 02		1.16410E 04		2.97033E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1610E 04	5.2906E 02	2.0745E 02	7.2649E 01	2.5784E 01	2.9703E 01	1.6307E 00	1.4083E 02		

END-OF-CYCLE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26217E 04		8.58714E 02		6.19348E 02		1.15389E 04		2.72765E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1509E 04	5.5687E 02	2.1303E 02	6.2475E 01	2.6338E 01	2.7276E 01	2.3319E 00	2.1634E 02		

ACCUMULATED IN-PILE AND OUT-OF-PILE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.86854E 04		1.29657E 03		9.32285E 02		1.71388E 04		4.33391E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.7093E 04	8.1963E 02	3.2335E 02	1.1262E 02	3.9999E 01	4.3339E 01	2.5181E 00	2.3142E 02		

FUEL CYCLE COSTS (MILLS/KWHR)

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES

OPERATING INTERVAL	10	ENERGY OF DISCHARGED FUEL	1.19509E 09	ACCUMULATED ENERGY OF DISCHARGED FUEL	8.54282E 09		
REFERENCE SET	TOTAL COST	INVENTORY	CREDIT	FABRICATION	REPROCESSING	FAB INV	REPR INV
1	1.08819E 00	7.70880E-01	-2.92641E-01	3.14571E-01	2.99871E-01	3.00006E-02	-3.44916E-02

LEVELIZED FUEL CYCLE COSTS

REFERENCE SET	LEVELIZED COST FOR DISCHARGED FUEL	LEVELIZED COST FOR OPERATING CYCLE
1	1.87259E 00	0.

STORED AND RECYCLE FUEL REPOSITORIES EDIT (OPERATING CYCLE 10)

FUEL REPOSITORY 1

MATERIAL /	0	DELAY TIME (ACCUMULATED OPERATING INTERVALS)				5	6
		1	2	3	4		
U-238	0.	0.	0.	0.			
PU-239	2.63967E 02	2.82599E 02	2.55701E 02	1.93501E 03			
PU-240	9.92889E 01	1.14941E 02	9.44301E 01	7.92115E 02			
PU-241	2.49324E 01	2.83397E 01	2.13514E 01	2.02469E 02			
PU-242	1.20479E 01	1.41632E 01	1.14451E 01	9.97562E 01			
U-235	0.	0.	0.	0.			
U-236	0.	0.	0.	0.			
FP-1	0.	0.	0.	0.			
TOTAL	4.00236E 02	4.40042E 02	3.82928E 02	3.02935E 03			

MATERIAL /	0	FUEL REPOSITORY 2 DELAY TIME (ACCUMULATED OPERATING INTERVALS)				5	6
		1	2	3	4		
U-238	4.72933E 03	4.67931E 03	4.74991E 03	3.31926E 04			
PU-239	0.	0.	0.	0.			
PU-240	0.	0.	0.	0.			
PU-241	0.	0.	0.	0.			
PU-242	0.	0.	0.	0.			
U-235	1.01518E 01	1.01767E 01	1.03174E 01	8.24880E 01			
U-236	1.29503E 00	1.24199E 00	1.25579E 00	5.41877E 00			
FP-1	0.	0.	0.	0.			
TOTAL	4.74078E 03	4.69073E 03	4.76148E 03	3.32805E 04			

FUEL MATERIAL CONCENTRATIONS AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 11 (ATOMS/CC*E-24)

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
1	U-238	2.33062E-03	2.21404E-03	2.46783E-03	2.34435E-03
1	PU-239	4.12292E-04	3.76071E-04	4.49367E-04	4.07226E-04
1	PU-240	2.10469E-04	2.17696E-04	1.95257E-04	2.06744E-04
1	PU-241	6.55601E-05	4.92601E-05	9.23054E-05	6.44725E-05
1	PU-242	2.66033E-05	2.69702E-05	2.41112E-05	2.61233E-05
1	U-235	4.91244E-06	3.23311E-06	7.52142E-06	4.95021E-06
1	U-236	6.39404E-07	9.99261E-07	0.	6.40670E-07
1	FP-1	1.78303E-04	3.35309E-04	0.	1.75031E-04

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
2	U-238	2.01481E-03	1.93076E-03	2.25964E-03	2.16538E-03
2	PU-239	5.64209E-04	4.85906E-04	5.72655E-04	4.99825E-04
2	PU-240	2.98633E-04	3.01950E-04	2.48827E-04	2.97400E-04
2	PU-241	9.98320E-05	7.63523E-05	1.17630E-04	6.60154E-05
2	PU-242	3.79697E-05	3.84484E-05	3.07263E-05	3.26654E-05
2	U-235	4.56901E-06	3.26242E-06	6.88697E-06	4.91751E-06
2	U-236	4.47332E-07	7.31340E-07	0.	4.78806E-07
2	FP-1	2.06421E-04	3.81598E-04	0.	1.81526E-04

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
3	U-238	2.02607E-03	1.95236E-03	2.25963E-03	2.17743E-03
3	PU-239	5.75466E-04	5.03651E-04	5.72655E-04	5.07844E-04
3	PU-240	2.97177E-04	3.00424E-04	2.48827E-04	2.96043E-04
3	PU-241	1.02971E-04	8.03528E-05	1.17630E-04	6.87065E-05
3	PU-242	3.77128E-05	3.82760E-05	3.07263E-05	3.24480E-05
3	U-235	4.77915E-06	3.56863E-06	6.88697E-06	5.14256E-06
3	U-236	3.95927E-07	6.63855E-07	0.	4.23731E-07
3	FP-1	1.82576E-04	3.40162E-04	0.	1.60402E-04

		BATCH 1		BATCH 2	
REGION	MATERIAL	(BOC)	(EOC)	(BOC)	(EOC)
4	U-238	2.38611E-03	2.32096E-03	2.63624E-03	2.56425E-03
4	PU-239	6.96395E-04	6.28921E-04	6.68097E-04	6.10744E-04
4	PU-240	3.44345E-04	3.48157E-04	2.90298E-04	2.96518E-04
4	PU-241	1.26731E-04	1.02782E-04	1.37235E-04	1.09147E-04
4	PU-242	4.35035E-05	4.42776E-05	3.58473E-05	3.74308E-05
4	U-235	6.01336E-06	4.84093E-06	8.03480E-06	6.46825E-06
4	U-236	3.53254E-07	6.19004E-07	0.	3.77978E-07
4	FP-1	1.62080E-04	3.06324E-04	0.	1.42027E-04

BATCH AVERAGED MATERIAL CONCENTRATIONS FOR OPERATING CYCLE 11 (ATOMS/CC=E-24)

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
1	U-238	4.79842E-03	4.67738E-03	4.55839E-03
1	PU-239	8.61659E-04	8.21087E-04	7.83297E-04
1	PU-240	4.05725E-04	4.15792E-04	4.24440E-04
1	PU-241	1.57865E-04	1.33784E-04	1.13733E-04
1	PU-242	5.07165E-05	5.21878E-05	5.30935E-05
1	U-235	1.24339E-05	1.01808E-05	8.18332E-06
1	U-236	6.39404E-07	1.18639E-06	1.63993E-06
1	FP-1	1.78303E-04	3.44322E-04	5.10340E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
2	U-238	4.27444E-03	4.18466E-03	4.09614E-03
2	PU-239	1.13686E-03	1.05823E-03	9.85731E-04
2	PU-240	5.47460E-04	5.54278E-04	5.59350E-04
2	PU-241	2.17462E-04	1.87872E-04	1.62368E-04
2	PU-242	6.86920E-05	7.01754E-05	7.11138E-05
2	U-235	1.14560E-05	9.72617E-06	8.17993E-06
2	U-236	4.47332E-07	8.56945E-07	1.21015E-06
2	FP-1	2.06421E-04	3.84773E-04	5.63124E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
3	U-238	4.28570E-03	4.20726E-03	4.12979E-03
3	PU-239	1.14812E-03	1.07738E-03	1.01149E-03
3	PU-240	5.46004E-04	5.51913E-04	5.56467E-04
3	PU-241	2.20601E-04	1.93138E-04	1.69059E-04
3	PU-242	6.84391E-05	6.98026E-05	7.07240E-05
3	U-235	1.16661E-05	1.01168E-05	8.71119E-06
3	U-236	3.99927E-07	7.63760E-07	1.08759E-06
3	FP-1	1.82576E-04	3.41570E-04	5.00564E-04

REGION	MATERIAL	BEGINNING OF CYCLE	MID CYCLE	END OF CYCLE
4	U-238	5.02236E-03	4.95347E-03	4.88521E-03
4	PU-239	1.36449E-03	1.30041E-03	1.23966E-03
4	PU-240	6.34643E-04	6.40110E-04	6.44675E-04
4	PU-241	2.63966E-04	2.36611E-04	2.11929E-04
4	PU-242	7.93508E-05	8.06934E-05	8.17084E-05
4	U-235	1.40482E-05	1.26292E-05	1.13092E-05
4	U-236	3.53254E-07	6.90027E-07	9.96982E-07
4	FP-1	1.62080E-04	3.05215E-04	4.48351E-04

FRACTION OF REACTOR POWER AT THE BEGINNING (BOC) AND END (EOC) OF OPERATING CYCLE 11

TOTAL REACTOR POWER (MWT) AT BEGINNING OF CYCLE 0.48307E 03
 TOTAL REACTOR POWER (MWT) AT END OF CYCLE 0.45309E 03

REGION	POWER FRACTION (BOC)	POWER FRACTION (EOC)
1	0.51201E 00	0.48357E 00
2	0.92874E-01	0.85354E-01
3	0.18480E 00	0.1725CE 00
4	0.14056E 00	0.13496E 00
5	0.13099E-01	0.20579E-01
6	0.32486E-01	0.62331E-01
7	0.26336E-02	0.47846E-02
8	0.21541E-01	0.35917E-01

OPERATING INTERVAL	11
NUMBER OF INTERNAL ITERATIONS	3
OPERATING INTERVAL TIME (DAYS)	400.000E 00
LOADING FACTOR	0.80080E 00
AVERAGE ELECTRICAL POWER (MWE)	1.75284E 02
AVERAGE THERMAL POWER (MWT)	4.67210E 02
AVERAGE BURNUP FOR DESIGNATED ZONES (MWD/MT)	9.96228E 04
ACCUMULATED OPERATING TIME (YRS)	9.43587E 00
EFFECTIVE MULTIPLICATION CONSTANT AT EOC	0.10081E 01
BURNUP REACTIVITY	-0.85692E-01
RATIO OF POWER DENSITY PEAK TO AVERAGE	1.02628E 00
AVERAGE BREEDING RATIO	1.16843E 00
BEG-OF-CYCLE BREEDING RATIO	1.14252E 00
END-OF-CYCLE BREEDING RATIO	1.19439E 00
DOUBLING TIME (YR)	1.88472E 01

DISCHARGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38497E 03		4.48813E 02		3.17798E 02		4.77899E 03		1.00708E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.7626E 03	2.8899E 02	1.1676E 02	2.8809E 01	1.4256E 01	1.0071E 01	1.3540E 00	1.5585E 02		

LOADED FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
5.38434E 03		3.75783E 02		2.67181E 02		5.00997E 03		1.48754E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
4.9941E 03	2.2134E 02	9.6576E 01	4.5845E 01	1.2025E 01	1.4875E 01	0.	0.		

AVERAGE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26217E 04		8.48813E 02		6.08324E 02		1.16899E 04		2.94100E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1579E 04	5.33961E 02	2.1371E 02	7.2717E 01	2.6577E 01	2.9420E 01	1.6980E 00	1.5771E 02		

END-OF-CYCLE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.26217E 04		8.71091E 02		6.24884E 02		1.15889E 04		2.70260E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.1479E 04	5.6233E 02	2.1912E 02	6.2552E 01	2.7084E 01	2.7026E 01	2.3855E 00	2.3322E 02		

ACCUMULATED IN-PILE AND OUT-OF-PILE FUEL WEIGHTS (KG) FOR THE REACTOR

TOTAL FUEL		TOTAL PU		FISSILE PU		TOTAL U		FISSILE U	
1.86896E 04		1.32086E 03		9.42601E 02		1.70816E 04		4.29014E 01	
U-238	PU-239	PU-240	PU-241	PU-242	U-235	U-236	FP-1		
1.7036E 04	8.2980E 02	3.3581E 02	1.1270E 02	4.1591E 01	4.2901E 01	2.6074E 00	2.6288E 02		

FUEL CYCLE COSTS (MILLS/KWHR)

FUEL CYCLE COSTS BASED UPON THE ACCRUED COST COMPONENTS AND TOTAL ENERGY PRODUCED IN INDIVIDUAL BUNDLES

REFERENCE SET	TOTAL COST	INVENTORY	CREDIT	FABRICATION	REPROCESSING	FAB INV	REPR INV
1	1.17369E 00	7.67282E-01	-1.18675E-01	2.70755E-01	2.58082E-01	2.69381E-02	-3.06875E-02

LEVELIZED FUEL CYCLE COSTS

REFERENCE SET	LEVELIZED COST FOR DISCHARGED FUEL	LEVELIZED COST FOR OPERATING CYCLE
1	1.80688E 00	0.

STORED AND RECYCLE FUEL REPOSITORIES EDIT (OPERATING CYCLE.11)

FUEL REPOSITORY 1

MATERIAL /	DELAY TIME (ACCUMULATED OPERATING INTERVALS)				
	0	1	2	3	4
U-238	0.	0.	0.	0.	0.
PU-239	2.83237E 02	2.63967E 02	2.82599E 02	2.19071E 03	
PU-240	1.14435E 02	9.92889E 01	1.14941E 02	8.86545E 02	
PU-241	2.82359E 01	2.35342E 01	2.67504E 01	2.11248E 02	
PU-242	1.39726E 01	1.20479E 01	1.41632E 01	1.11211E 02	
U-235	0.	0.	0.	0.	
U-236	0.	0.	0.	0.	
FP-1	0.	0.	0.	0.	
TOTAL	4.39881E 02	3.98838E 02	4.38453E 02	3.39972E 03	

MATERIAL /	FUEL REPOSITORY 2 DELAY TIME (ACCUMULATED OPERATING INTERVALS)				
	0	1	2	3	4
U-238	4.66779E 03	4.72933E 03	4.67931E 03	3.79425E 04	
PU-239	0.	0.	0.	0.	
PU-240	0.	0.	0.	0.	
PU-241	0.	0.	0.	0.	
PU-242	0.	0.	0.	0.	
U-235	9.87041E 00	1.01518E 01	1.01767E 01	9.28053E 01	
U-236	1.32704E 00	1.29503E 00	1.24195E 00	6.67457E 00	
FP-1	0.	0.	0.	0.	
TOTAL	4.67899E 03	4.74078E 03	4.69073E 03	3.80420E 04	

APPENDIX AMODEL FOR CALCULATING BEGINNING-OF-CYCLE ATOM CONCENTRATIONS

Beginning-of-cycle atom concentrations, by batch, for the first operating interval must be calculated from the input total atom concentrations (unless they are read from tape for a RESTART problem or unless the batch values are read from cards.). The input data may correspond to one of the following operating conditions:

1. Beginning-of-cycle concentrations for a startup core¹.
2. Average concentrations for a startup core¹.
3. End-of-cycle concentrations for a startup core¹.
4. Beginning-of-cycle concentrations for an equilibrium core².
5. Average concentrations for an equilibrium core².
6. End-of-cycle concentrations for an equilibrium core².

Beginning-of-cycle atom concentrations, by batch, for Case 1 are determined by simply dividing the input total concentrations by the number of fuel batches. However, for the remaining cases, the beginning-of-cycle concentrations must be computed by a fuel cycle calculation which is backwards in time. The same general expression may be used for each calculation. It is,

$$N_{m,j,n}^{(o)} = \frac{N_{m,j}^{(r)} - \sum_{m'=1}^{m-1} A_{m,m'}(e_{m',j} - e_{m,j})}{e_{m,j}} \quad A.1$$

where $N_{m,j,n}^{(o)}$ = The beginning-of-cycle atom concentrations for material m , in region j , corresponding to a fresh fuel batch - batch n .

-
1. A startup core is defined as a reactor system in which all fuel batches in a given region, at a given time during the operating interval, have the same atom concentration.
 2. An equilibrium core is defined as a reactor system in which the operating parameters for successive operating intervals remain the same (e.g., the operating time, discharge fuel burnup, loaded and discharge fuel weights, etc.). Note that an equilibrium core will be the same as a startup core when only one fuel batch is utilized.

$N_{m,j}^{(r)}$ = Input total atom concentration for material m in region j . One of the six cases given above.

$A_{m,m'}$ = Coefficients used in burnup calculation.

m' = One of the fuel isotopes, in a reaction chain, that contributes to the buildup of material m .

$e_{m,j}$ = $F(\sigma_{r,m,j}, f, \phi_j, t, i)$ = function which is different for each of the six cases

$\sigma_{r,m,j}$ = One group removal cross section for material m in region j

f = load factor

ϕ_j = Total neutron flux in region j

t = operating time for one operating interval

i = Total number of operating intervals that fuel batch n has remained in the reactor

$$(0 \leq i \leq NP = N_J^{bat} / N_{dis}^{(J)})$$

N_J^{bat} = Number of batches of fuel in Zone J

$$(j_{J-1} + 1 \leq j \leq j_J)$$

N_{dis}^J = Number of fuel batches discharged from Zone J at the end of each (current) operating interval

$$(j_{J-1} + 1 \leq j \leq j_J)$$

The basis for the form of statement A-1 will become apparent in the calculations to follow.

BEGINNING-OF-CYCLE CONCENTRATIONS FOR A STARTUP CORE

Atom concentrations by batch are given by,

$$N_{m,j,n}^{(o)} = N_{m,j}^{(r)} / N_J^{bat} \quad A.2$$

Therefore, in expression A.1 the term $e_{m,j}$ is,

$$e_{m,j} = N_J^{bat} \quad (j_{J-1} + 1 \leq j \leq j_J) \quad A.3$$

AVERAGE CONCENTRATIONS FOR A STARTUP CORE

The average atom concentration over the first operating interval is the following:

$$\bar{N}_{m,j,n} = N_{m,j}^{(r)} / N_J^{bat} = \left(\int_0^{t'=t} N_{m,j,n}^{(t')} dt' \right) / t \quad A.4$$

where $N_{m,j,n}^{(t')}$ is given by,*

$$N_{m,j,n}^{t'} = \sum_{m'=1}^{m-1} A_{m,m'} (e'_{m',j} - e'_{m,j}) + N_{m,j,n}^{(o)} e'_{m',j}$$

$$\text{and } e'_{m,j} = \exp(-10^{-24} \sigma_{r,m,j} f \phi_j t')$$

Carrying out the indicated integration and transposing terms gives statement A.1 with $e_{m,j}$ defined as

$$e_{m,j} = N_J^{bat} \left[\frac{1.0 - \exp(-10^{-24} \sigma_{r,m,j} f \phi_j t)}{10^{-24} \sigma_{r,m,j} f \phi_j t} \right] \quad A.5$$

$$(j_{J-1} + 1 \leq j \leq j_J)$$

*This common expression for the atom concentration as a function of time will be used on numerous occasions in this Appendix. See Section 3.3.1 of the main report for the terms of the burnup coefficient $A_{m,m'}$.

END-OF-CYCLE CONCENTRATIONS FOR A STARTUP CORE

The atom concentration at the end of a startup cycle is,*

$$N_{m,j,n}^{(1)} = N_{m,j}^{(r)} / N_J^{bat} = \sum_{m'=1}^{m-1} A_{m,m'} (e'_{m',j} - e'_{m,j}) + N_{m,j,n}^{(o)} e'_{m,j} \quad A.6$$

where $e'_{m,j} = \exp(-10^{-24} \sigma_{r,m,j} f \phi_j t)$

Statement A.6 can be rearranged in the form of Statement A.1 with,

$$e_{m,j} = N_J^{bat} e'_{m,j} = N_J^{bat} \exp(-10^{-24} \sigma_{r,m,j} f \phi_j t) \quad A.7$$

$$(j_{J-1}+1 \leq j \leq j_J)$$

BEGINNING-OF-CYCLE CONCENTRATIONS FOR AN EQUILIBRIUM CORE

The atom concentration at the end of operating interval i is the following:*

$$N_{m,j,n}^i = \sum_{m'=1}^{m-1} A_{m,m'} (e_{m',j}^i - e_{m,j}^i) + N_{m,j,n}^{(o)} e_{m,j}^i \quad A.8$$

with $e_{m,j}^i = \exp(-10^{-24} \sigma_{r,m,j} f \phi_j t_i) =$

$$= [\exp(-10^{-24} \sigma_{r,m,j} f \phi_j t)]^i$$

for $(0 \leq i \leq NP = N_J^{bat} / N_{dis}^{(J)})$

Then, the average atom concentration at the beginning of an equilibrium operating interval is,

$$N_{m,j,n}^+ = N_{m,j}^r / N_J^{bat} = \left(\sum_{i=0}^{NP-1} N_{m,j,n}^i \right) / NP$$

*This common expression for the atom concentration as a function of time will be used on numerous occasions in this Appendix. See Section 3.3.1 of the main report for the terms of the burnup coefficient $A_{m,m'}$.

Substituting for $N_{m,j,n}^i$ and NP and transposing terms gives Statement A.1.

$$N_{m,j,n}^{(o)} = N_{m,j}^{(r)} - \frac{\sum_{m'=1}^{m-1} A_{m,m'}(e_{m',j} - e_{m,j})}{e_{m,j}}$$

In this case $e_{m,j}$ has the following form:

$$e_{m,j} = N_{dis}^{(J)} \sum_{i=0}^{NP-1} [\exp(-10^{-24} \sigma_{r_{m,j}} f \phi t)]^i$$

$e_{m,j}$ is recognized as a binomial expansion of the type,

$$\sum_{i=0}^{N-1} x^i = \frac{1-x^N}{1-x}$$

Therefore, $e_{m,j}$ can be expressed as

$$e_{m,j} = N_{dis}^{(J)} \left(\frac{1 - \exp(-10^{-24} \sigma_{r_{m,j}} f \phi t N_J^{bat} / N_{dis}^{(J)})}{1 - \exp(-10^{-24} \sigma_{r_{m,j}} f \phi t)} \right)$$

and $(j_{J-1} + 1 \leq j \leq j_J)$

AVERAGE ATOM CONCENTRATIONS FOR AN EQUILIBRIUM CORE

The computations for an equilibrium core are very similar to the computations for a startup core (Case 2). The average atom concentration over the life of the fuel is,

$$\bar{N}_{m,j,n} = N_{m,j}^{(r)} / N_J^{bat} = \left(\int_0^{t' = (N_J^{bat} t / N_{dis}^{(J)})} N_{m,j,n}^{(t')} dt' \right) / \left(N_J^{bat} t / N_{dis}^{(J)} \right) \quad A.10$$

$$\text{where } N_{m,j,n}^{t'} = \sum_{m'=1}^{m-1} A_{m,m'} (e'_{m',j} - e'_{m,j}) + N_{m,j,n}^{(o)} e'_{m,j}$$

$$\text{and } e'_{m,j} = \exp(-10^{-24} \sigma_{r_{m,j}} f \phi t')$$

Again, carrying out the integration and transposing terms gives Statement A.1 with $e_{m,j}$ in this case being,

$$e_{m,j} = \frac{N_{dis}^{(J)} (1.0 - \exp(-10^{-24} \sigma_{r_{m,j}} f \phi_j t N_J^{bat} / N_{dis}^{(J)}))}{10^{-24} \sigma_{r_{m,j}} f \phi_j t} \quad A.11$$

$$(j_{J-1} + 1 \leq j \leq j_J)$$

END-OF-CYCLE CONCENTRATIONS FOR AN EQUILIBRIUM CORE

The atom concentration at the end of operating interval i is the same as given by Statement A.8.

$$N_{m,j,n}^i = \sum_{m'=1}^{m-1} A_{m,m'} (e_{m',j}^i - e_{m,j}^i) + N_{m,j,n}^{(o)} e_{m,j}^i$$

$$\text{with } e_{m,j}^i = [\exp(-10^{-24} \sigma_{r_{m,j}} f \phi_j t)]^i$$

$$\text{for } (0 \leq i \leq NP = N_J^{bat} / N_{dis}^{(J)})$$

The average atom concentration at the end of an equilibrium operating interval is,

$$N_{m,j,n} = N_{m,j}^{(r)} / N_J^{bat} = \left(\sum_{i=1}^{NP} N_{m,j,n}^{(i)} \right) / NP$$

Substituting for $N_{m,j,n}^{(i)}$ and NP and transposing terms gives Statement A.1.

$$N_{m,j,n}^{(o)} = \frac{N_{m,j}^{(r)} - \sum_{m'=1}^{m-1} A_{m,m'} (e_{m',j} - e_{m,j})}{e_{m,j}}$$

$$\text{with } e_{m,j} = N_{dis}^{(J)} \sum_{i=1}^{NP} \{ \exp(-10^{-24} \sigma_{r,m,j} f \phi_j t) \}^i$$

$e_{m,j}$ is recognized as a binomial expansion of the form

$$\sum_{i=1}^N X^i = \left(\sum_{i=0}^{N-1} X^i \right) + (X^N - 1) = \frac{1-X^N}{1-X} + X^N - 1 = (1-X^N)/(1/X-1)$$

Therefore, $e_{m,j}$ can be expressed as,

$$e_{m,j} = N_{dis}^{(J)} \left(\frac{1 - \exp(-10^{-24} \sigma_{r,m,j} f \phi_j t N_J^{bat} / N_{dis}^{(J)})}{(\exp(+10^{-24} \sigma_{r,m,j} f \phi_j t) - 1)} \right) \quad A.12$$

BEGINNING-OF-CYCLE ATOM CONCENTRATION FOR ALL FUEL BATCHES

All fuel batches for a startup core ($1 \leq \delta_1^a \leq 3$)

have the same beginning-of-cycle atom concentrations. Thus,

$$N_{m,j,n'}^{(o)} = N_{m,j,n}^{(o)} \quad \text{for } 1 \leq m \leq m_{\max}$$

$$1 \leq j \leq j_{\max}$$

$$1 \leq n' \leq n'_{\max}$$

The beginning-of-cycle atom concentrations for an equilibrium core ($4 \leq \delta_1^a \leq 6$) includes partially burned fuel if more than one fuel batch

is used. The atom concentrations for the burned fuel must be computed from the burnup equation as follows:

$$N_{m,j,n'}^{(o)} = \sum_{m'=1}^{m-1} A_{m,m'} (e_{m',j} - e_{m,j}) + N_{m,j,n}^{(o)} e_{m,j}$$

where $e_{m,j} = \exp(-10^{-24} \sigma_{m,j} f \phi_j t (n-n'))$

for $(1 \leq n' \leq n = N_J^{\text{bat}}/N_{\text{dis}}^{(J)})$

and $(j_{J-1}+1 \leq j \leq j_J)$

Note that in this expression that the batch number is given in the reverse order of the loading in the reactor (i.e., batch n has been loaded prior to the loading of batch $n+1$) and if N_{dis}^J is greater than 1 more than 1 fuel batch will have the same atom concentration.

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