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ERUPT

A two-dimensional, two-energy group fuel management programme for the IBM - 360 computer

by

W. BÖTTCHER, A. DECRESSIN AND F. LAFONTAINE

1968

ORGEL Program

Joint Nuclear Research Center
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SUMMARY

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KEYWORDS

E-CODES
FUEL CYCLE
REACTOR CORE
AUTOMATION
FORTRAN
IBM 360
NUMERICALS

CONTENTS

E R U P T

A two-dimensional, two-energy group, fuel management programme for the IBM - 360 computer

1. INTRODUCTION

ERUPT is a two-dimensional, two-energy group, fuel management code for a reactor core in r-Z geometry. This geometry has been chosen in order to be able to study also variations of axial power shapes during burn-up.

The diffusion theory calculation has been based on the code Equipoise-3 (1) being a rapid two-dimensional code suitable for survey calculations.

ERUPT is applicable to a wide range of fuel management problems. Axial shufflings are not included. Using the code, the user has to be aware that fuel managements are performed with concentric annuli. As diffusion theory is concerned, the problem has to be adapted to a homogenization in two energy groups.

ERUPT does not carry out a calculation of the variation of the isotopic composition of the fuel with irradiation. The group constants of the diffusion equations have to be provided by a separate burn-up code. The test calculations of the code have been performed with data supplied by the codes Plutharco (2) and RLT (3).

Core-life is divided in a number of time steps. During a time interval, the power distribution is regarded as unchanged. At the end of each time interval, the fuel composition has changed according to the constant flux during the time interval multiplied by the length of the time interval. The corresponding two-group parameters are obtained by interpolation in the data tables provided by the separate point burn-up code.

This report contains two parts; in the first part, the main characteristics of the code are reported; the second part describes "How to use the code".

2. THE PHYSICAL BASIS OF ERUPT

ERUPT solves the two-group diffusion equations using the same finite difference techniques as in the code Equipoise 3. It is remembered that the calculational procedure is accelerated by the use of the "extrapolated Liebmann process" which is characterized by an "over-relaxation factor" β being a number between 1 and 2. If this factor is not given in the input data, it is automatically calculated by the code. The form of the diffusion equations at each point can be written in shorthand as:

$$D_K \nabla^2 \phi_K + \Sigma_{R,3-K} \phi_{R,3-K} - \left(\Sigma_{AK} + \Sigma_{RK}\right) \phi_K + \lambda \eta_K \sum_K \nu_K \Sigma_{fK} \phi_K = 0$$

$$K = 1, 2$$

$$\sum \eta_K = 1$$

The notation of the symbols is the common one. The factor λ can be regarded as the inverse of a static multiplication factor.

As Σ_{R2} is equal to zero and normally also $\eta_2 = 0$ (only fast neutrons are created), the above system of equations reduces to:

$$D_1 \nabla^2 \phi_1 - \left(\Sigma_{A1} + \Sigma_{R1}\right) \phi_1 + \lambda \left(\nu_1 \Sigma_{f1} \phi_1 + \nu_2 \Sigma_{f2} \phi_2\right) = 0$$

$$D_2 \nabla^2 \phi_2 - \Sigma_{A2} \phi_2 + \Sigma_{R1} \phi_1 = 0$$

The code contains three convergence criteria; these are eigen value, flux and residue condition. The calculation stops automatically when these conditions are not met after the specified total number of iterations.

3. THE CORE CONFIGURATION

Regions in ERUPT are concentric annuli (maximum number 275) in which the group constants of the diffusion equations are spatially constant. Except for the reflector regions, all group constants may be given as function of the integrated flux. Every region consists of one or more mesh points with identical group constants. The maximum number of mesh points is 3200. They may be distributed according to the requirements of the problem.

All vertical regions containing fissionable materials within the same column form a cylinder of core height, named "RING". Fuel management operations are performed by means of these rings; this point is to be remembered when the size of the regions is defined.

As ERUPT treats only refuelling schemes with radial shuffling, an axial symmetry condition exists which can be used when top and bottom reflectors have identical properties.

If the core contains elements of different design, pitch or enrichment, it has to be noted that only identical cell types can be arranged to rings. For the batch cycle, this limitation is not existent. The maximum number of different cell types is four. Appendix A gives a picture of the core arrangement.

4. PROCEDURE OF THE CALCULATION

The time-integrated flux, TAU, is the independent variable of the problem. Its initial distribution in the core has to be given for all fuel regions on input cards. For all further calculations, it is found by accumulating the TAU-steps which are the product of the point-wise fluxes and the fixed time interval in which the distribution is regarded as invariant. (The time step in days has to be specified in the input data).

The TAU-distribution at every time-step of reactor life allows to find,by linear interpolation in the library table (5), the distribution of group constants with means of which the steady state flux distribution and the critical value are calculated.

The total power is summed up assuming that thermal power is equal to fission rate multiplied by an appropriate proportionality constant given as input data. Normalizing the total power to the value specified in input data, the point-wise fluxes are converted into absolute values.

The reactivity level is the only criterion for the management decision process up to now incorporated in the code. If with the new distribution of group constants, the reactivity worth falls below a prescribed value within a specified reactivity band-width, a fuel management operation is performed (see also Appendix B). In the case that the reactivity level is higher than the prescribed value, the calculation is pursued in the above-described manner.

The reactivity can get negative values during the calculation or fall below the specified reactivity band-width. In this case, the code reduces automatically the last time step in order to maintain critically the core within the reactivity band-width. The necessary reduction is found by interpolation multiplying the fixed time interval by the ratio of the reactivity step wanted to the reactivity step obtained between the last and preceding calculation. The reactivity level wanted is defined as that lying below the prescribed value and in the middle of the reactivity band.

The reactivity-band-width prevents that at every time step an interpolation becomes necessary. In Appendix B, a picture underlines the fuel management decision process.

5. THE FUEL MANAGEMENT OPERATIONS IN ERUPT

Three modes exist to run ERUPT.

Mode 1 performs a batch calculation. The core is loaded with fuel according to a given scheme in order to obtain the surplus reactivity reserved for burn-up. For this core, after each fixed time step, ERUPT gives the variation of the eigen value, fluxes and form factors. As soon as the reactivity exceeds the prescribed reactivity level, the programme stops.

With mode 2, all imaginable radial shufflings can be performed. Before applying the code to on-line refuelling schemes in which equilibrium of a core is maintained by charging and discharging only few elements every few days, it has to be remembered that fuel operations are performed by displacing or changing complete rings.

The variety of radial management operations has been made possible by means of the load vector which is described in detail in Appendix B.

The third mode to use ERUPT is a cycle without any shuffling called once-through cycle. The ring with the highest burn-up is pushed out of the core and replaced by unirradiated fuel.

6. DATA PREPARATION FOR THE CODE

For the data preparation, at first the group constants of the diffusion equations have to be calculated for every cell type, by a separate burn-up code, and tabulated as function of integrated flux. If some group constants remain unchanged as burn-up proceeds, they are tabulated only in the first step of the table. Then the preparation of input data for ERUPT is easily carried out following the "How to use the code" with the attached data punch sheet and sample problem.

Note that two possibilities exist to start the problem. The initial TAU-distribution may be zero for all regions or it may be assessed or known from preceding calculations. Both cases are treated in the same way, choosing the option RUN=1. In this option, cards are read in, which have to contain for every region the fuel type and the initial TAU-value.

An important feature of the code is the Restart possibility. Thus, an investigation which is too long for a single run may be broken down into several computer runs. The necessary data are automatically transferred from one execution to the other by means of the library tape, and it is sufficient to use the option RUN=2.

7. GENERAL EXPERIENCE WITH ERUPT

ERUPT has been applied to a number of survey calculations carried out in the frame of the ORGEL prototype, a heavy water-moderated, organic-cooled reactor of the pressure tube type. The fuel management used was an on-line refuelling scheme with radial shuffling. A comparison with a three-dimensional fuel management code based on the source-sink method has shown satisfactory results, though ERUPT is not best adapted to on-line refuelling schemes. The two group parameters for all calculations have been provided by the codes PLUTHARCO (2) and RLT-4 (3), which are appropriate for the treatment of a reactor lattice composed of individual cells.

Studies of time-dependent cores, for which large running times are necessary, can be easily carried out by ERUPT. The Restart facility allows the segmentation of the overall running time in several shorter pieces which is often advantageous from the point of view of availability of the computer. The main reason, however, for the Restart facility is to make it possible to intervene as burn-up proceeds in order to improve the management policy and to optimize the time-dependent core.

The total running time of a problem depends mainly, apart from the number of mesh points and the precision desired for the flux and reactivity value calculations, on the number of time steps which are necessary to solve the problem realistically. The length of a time step is given by the requirement that it must be short enough in order not to lead to unrealistic results because of the assumption of constant flux distribution during the time step. Calculations have shown that time steps of 10-25 days are acceptable.

For the sample problem, 1950 mesh points, convergence criteria of eigen value equal to 4×10^{-4}, of flux and residue equal to 1×10^{-3}, the execution time is about 0.7 minutes per time step.

In order not to obtain large amounts of output, it is recommended to use the option of a detailed printout in only a few selected cases.

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HOW TO USE THE CODE

1. Identification

Name	ERUPT - A two-dimensional, two-energy group fuel management programme for the IBM-360 computer
Job n°	68.8125
Codification	FORTRAN IV
System	IBM 360/65
Date	1968, September
Origin	ORGEL Project, Common Research Center, Ispra, Varese, Italy

2. Input data

The following list explains all input data items. Its arrangement on punched cards is shown in the table at the end of this chapter.

Symbol	Description
HØL	Any alphanumeric comment
ITMAX	Max. number of iterations (eg. 300)
IMAX	Total number of rows < 100 (see also APP. 1)) IMAXxJMAX ≤ 3200
JMAX	Total number of columns < 100 (see also APP. A)) IMAXxJMAX ≤ 3200
NREG	Total number of regions included reflectors ≤ 275
NMAT	Total number of compositions included reflectors ≤ NREG
NGEM	Geometry indicator (= 1)
NBUC	Transverse buckling indicator (= 0)
NSØR)	
NADJ)	Not used
NFX)	
NVG	Convergence indicator
	= 1 problem converges only on ν - critical
	= 2 problem converges on ν-critical and flux
	= 3 problem converges on ν-critical, flux and residue
NDIAG	Diagonal symmetry indicator (= 0)
NLB	Left boundary indicator (= 1)
NTB	Top boundary indicator (= 0)
NRB	Right boundary indicator (= 0)
NBB	bottom boundary indicator
	= 0 no symmetry
	= 1 axial symmetry
FACTOR	Total fission power in MW for normalization
EPI1	Convergence criteria for ν -critical (4.10^{-4})
EPI2	Convergence criteria for flux (1.10^{-3})
EPI3	Convergence criteria for residue (1.10^{-3})
BETA	Over-relaxation factor (if this number is not given, it is automatically calculated)

XI1	Fraction of fission neutrons in fast group (n°1)
XI2	Fraction of fission neutrons in thermal group (n°2)
	(XI1 + XI2 = 1)
BSG1	Buckling (= 0)
BSG2	Buckling (= 0)
$(ELY, Y)_I$	ELY is the spacing between two succeeding rows and is applied from row Y_{I-1} to Y_I. (see also APP.A)
$(ELX, X)_J$	ELX is the spacing between two succeeding columns and is applied from column X_{J-1} to X_J. (see also APP. A)
MNR	Composition number
I1	Top row number
I2	Bottom row number
J1	Left column number
J2	Right column number
TAG	Additional data (numerated from 1 to 15)
	- Blank if there are several cards with "Additional Data"
	- Set "*" if it is the last card of this set
N1) N2))	The following data items are numerated from 1 to 15; they have to be sequentially punched on cards, in which N1 and N2 are the number of the first and the last data item on a card.
Nr	
(1) NRT	Number of introduced tables (fuel compos.)
(2) RUN	= 1 for the initial run (τ_i specified by input card(s)
	= 2 if τ -distribution of a preceding calculation is available on library tape
(3) LD1	Number of fuel regions
(4) LD2	Number of vertical fuel regions) LD1 = LD2 * LD3
(5) LD3	Number of horizontal fuel regions)

(6)	CIRC	Calculation mode (see also APP. B) = 1 no fuel management (batch) = 2 radial fuel management with fixed loading scheme according to the load vector = 3 only the ring with the highest burn-up is discharged and replaced by fresh fuel the type of which is TYPE
(7)	TYPE	Type of fuel for recharge (only used if CIRC = 3)
(8)	KEF1) higher	Limit of reactivity band for management process
(9)	KEF2) lower	
(10)	DT	Time interval in which the fluxes are assumed to remain constant /days/
(11)	P/F	Power per fission /MeV/fission/
(12)	XEQ	Execution time available for the calculation /min./
(13)	PRCC	Print index = 1 if the Core Composition is to be printed = 0 if this information is not desired
(14)	PRTF	Print index = 1 if the Thermal cell Fluxes per region are to be printed = 0 if the results are not desired
(15)	PRSP	Print index = 1 if Specific Power distribution is to be printed = 0 if this result is not desired

LDCØ	Number of positions occupied in the LOAD vector	
LØAD	Load vector which contains the radial fuel movement scheme (see APP.B)	
NM	Region number of reflectors	) For the
NG	Group number	) two groups
D	Diffusion coefficient	) of axial
SIGR	Macroscopic removal cross-section	) and
SIGA	Macroscopic absorption cross-section	) radial
NUSF	ν*macroscopic fission cross-section (=0)	) reflectors
K	Table number	
J	Number of burn-up steps in table k	

IND1	Interpolation index vector Contains 11 positions corresponding to the 11 program variables (BU, D1, SR1, SA1, NSF1, SF1, D2, SR2, SA2, NSF2, SF2) A number 1 means that the variable corresponding to the position is given as a function of irradiations TAUI ; the number 0 means that the parameter is kept constant during irradiation and equal to the initial value (specified in the 1rst TAU-step in the table)	
TAU	Cell irradiation (time-integrated flux)	/n/kb/
BU	Burn-up	/MWD/T/
D1	Fast diffusion length	/cm/
SR1	Macroscopic removal cross-section (fast)	/cm^{-1}/
SA1	Macroscopic absorption cross-section (fast)	/cm^{-1}/
NSF1	ν * times macroscopic fission cross-section (fast)	/cm^{-1}/
D2	Thermal diffusion length	/cm/
SR2	Macroscopic removal cross-section (therm)	/cm^{-1}/
SA2	Macroscopic absorption cross-section (therm)	/cm^{-1}/
NSF2	ν * times macroscopic fission cross-section (therm)	/cm^{-1}/
SF2	Macroscopic fission cross-section (therm)	/cm^{-1}/
LIFE	Reactor life at initial definition of the core	/days/
NM, NG	Lower and upper delimiting point for succeeding regions in the reactor with the same reactor state	
CØMP	Composition number	Applicated to all regions NM to NG
CHAR	Charge number	Applicated to all regions NM to NG
TAU	Irradiation	Applicated to all regions NM to NG

DATA CARDS

Card(s)	Format	Symbols
1	20A6	HØL
1	16I3	ITMAX, IMAX, JMAX, NREG, NMAT, NGEM, NBUC, NSØR, NADJ, NFX, NVG, NDIAG, NLB, NTB, NRB, NBB
1	5E10.5	FACTØR, EPI1, EPI2, EPI3, BETA
1	4E10.5	XI1, XI2, BSG1, BSG2
variable	8(E8.5.I2)	$(ELY,Y)_I$ — I sets, the last one containing Y = IMAX
variable	8(E8.5,I2)	$(ELY,X)_J$ — J sets, the last one containing X = JMAX
NREG/6	6(I3,4I2,1x)	$(MNR,I1,I2,J1,J2)_K$ — K = 1, NREG
variable	A1,2I2,7E10.5	TAG, N1, N2, DATA (N1), ..., ..., ..., DATA (N2)
1	I3	LDCØ } only if CIRC = 2
LDCØ/20	20I3	$LØAD_L$ L=1,LDCØ } only if CIRC = 2
4 or 6	2I3,5E10.5	NM, NG, D, SIGR, SIGA, NUSF, BS
1	2I3	K, J } NRT sets (K = 1, ..., NRT)
1	11I3	$IND1_M$ M = 1,11 } NRT sets (K = 1, ..., NRT)
J	2E10.5	TAU, BU } NRT sets (K = 1, ..., NRT)
	5E10.5	D1, SR1, SA1, NSF1, SF1 } NRT sets (K = 1, ..., NRT)
	5E10.5	D2, SR2, SA2, NSF2, SF2 } NRT sets (K = 1, ..., NRT)
1	E10.5	LIFE } Only of RUN = 1; a value NG = LD1 stops input sequence
variable	4I3, E10.5	NM, NG, CØMP, CHAR, TAU } Only of RUN = 1; a value NG = LD1 stops input sequence

3. Output data

The output printed is largely self-explaining; at first, all input data are reprinted, then the program prints the following results (some of them only on request):

- a table with the cell volumes (cm3);
- f_t, Λ_t, ϱ_t, R_{max}, ν -critical printed every ten iterations;
- the final value of reactivity keff = $1/\nu$-critical;
- the form factors for fast and thermal fluxes and for the power distribution;
- total fission power (MW);
- a table with thermal cell fluxes (on request);
- a table with power distribution (on request);
- execution time per each cycle;
- core composition for each region (on request);
  this table contains the region number (REG), the fuel type (CØMP), the charge number (CHAR), and the variables TAU, BU, D1, SR1, NSF1, SF1, D2, SR2, NSF2, SF2 for each fuel region;
  in any case, this information is printed before and after each fuel movement;
- for the discharged fuel, the mean irradiation in n/kb (TAUM), the mean burn-up (BUM), the max. burn-up (BUMAX) and the form factor of burn-up is printed.

4. Remarks

4.1. Program limitations :

The actual program dimensions allow the treatment of problems with:

IMAX	< 100
JMAX	< 100
IMAX*JMAX	$\leqslant 3200$
NREG	$\leqslant 275$
NREG $\geqslant$ NMAT	$\leqslant 275$
LDCO	$\leqslant 1000$
NRT	$\leqslant 4$
J $\leqslant$ 50	(number of burn-up steps in the tables)

4.2. Memory occupation

The program, included library functions, occupies about 230k bytes.

4.3. Magnetic tapes

The program uses 1 library tape (symbolic tape unit 9) for writing the τ -distribution at each time step: thus a calculation which cannot be finished in the given execution time can be restarted with the last registered τ-distribution. If this option will not be used, define a scratch tape as dummy library.

4.4. Execution time

The execution time is dependent on the number of mesh points, the iteration number according to the precision required and the output desired at each time-step. For example, a problem with 1950 mesh points will take about 0.7 minutes per time step.

4.5. Printed lines

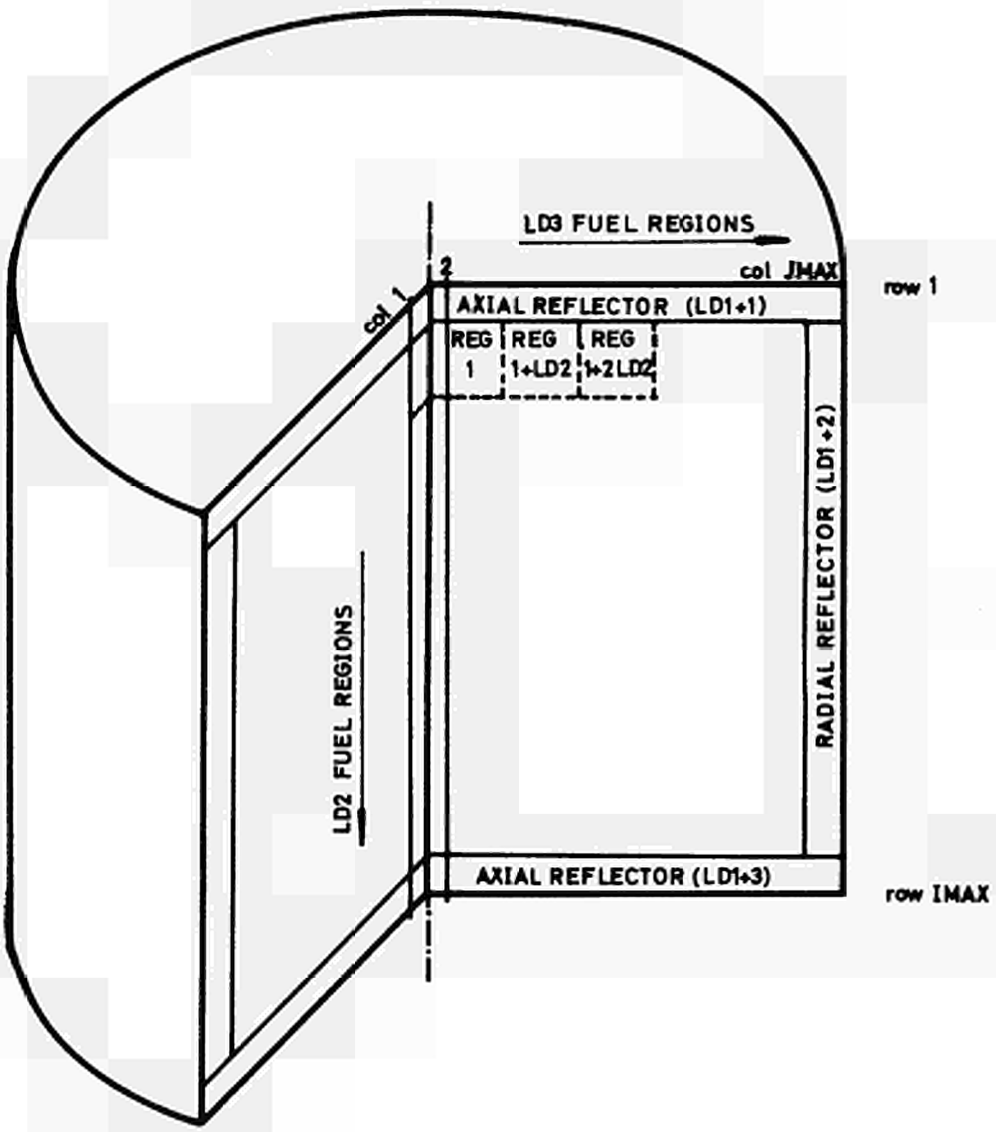
The number of printed lines depends on the output options. Printing of available information takes about 1250 lines max/400/lines min. output per 1 minute of execution time.

4.6. Clock overflow

A clock overflow may happen if the available execution time is too short for a complete investigation. The program checks however that such a clock overflow cannot happen during the "write-tape" operation of the TAU-distribution.

APPENDIX A

Reactor geometry



Explanation

1) The reactor axis is always situated between columns 1 and 2. For instance, if a equidistant mesh is used, take attention that the distance between Col. 1 and 2 is the double of one 2-3 a.s.o.

2) Is axial symmetry is used, the symmetry axis is situated between row IMAX-1 and IMAX.

3) Regions are defined by top/bottom row and left/right column numbers, and are numbered in vertical sense. We name a RING LD2 vertical regions.

4) The reflector regions are numbered LD1+1, LD1+2, LD1+3.

APPENDIX B

(Management)

1. Decision process

k_{eff2}

$k_{eff} > k_{eff2}$, burn-up proceeds.

$k_{eff1} < k_{eff} < k_{eff2}$, refuelling occurs.

k_{eff1}

$k_{eff} < k_{eff1}$, last time step is reduced.

$k_{eff} = 1$

2. Load vector

The load vector contains references to RING-numbers (1 to LD3), TABLE-numbers (1 to 4) and STOP-sequence-numbers (o or 1), as shown:

Pos. 1 … Pøs. LDCØ

Ri	Rj	Rk	-T	STOP	RL	RM	RN	Ro	-T	STOP						a.s.o.

Sequence 1 (Ri … STOP); Sequence 2 (RL … STOP); a.s.o.

Explanation

The ring, the number of which is Ri, is discharged and replaced by the ring Rj, which is at the same time replaced by Rk. Then ring Rk is replaced by fresh fuel of type T. If STØP is 0, the program treats also immediately the following sequence in the same way as sequence 1. If stop is 1, the shuffling stops and, at the next loading process, the program enters in the load vector at this point.

Note that the number of rings to be moved (in the first sequence Rj, Rk) is variable (from o to LD3-1) and may also vary from one sequence to the other.

Logically, at least in the position LDCO, the STOP-sequence-number must be 1. After having executed all management information within the LØAD vector, the program returns automatically at the beginning of the load vector.

APPENDIX C

Sample problem

```
*** SAMPLE PROBLEM ERUPT ***
300 34 30 92 92  1  0  0  0  0  3  0  1  0  0  1
 350     +02 4        -04 1        -03 1        -03
 1       +00
 18.5      3   6.0    33   0.000134
 44.444    2  22.222   4   9.205   7   7.063 10   5.954313   5.246 16   4.742719   4.361322
  4.059325    3.813 28  26.0     30
  103060104   206090104   3 9120104   412150104   515180104   618210104
  721240104   824270104   927300104  1030340104  11 3 60407  1206090407
 13 9120407  1412150407  1515180407  1618210407  1721240407  1824270407
 1927300407  2030340407  21 3 60710  22 6 90710  23 9120710  2412150710
 2515180710  2618210710  2721240710  2824270710  2927300710  3030340710
 3103061013  3206091013  3309121013  3412151013  3515181013  3618211013
 3721241013  3824271013  3927301013  4030341013  4103061316  4206091316
 4309121316  4412151316  4515181316  4618211316  4721241316  4824271316
 4927301316  5030341316  5103061619  5206091619  5309121619  5412151619
 5515181619  5618211619  5721241619  5824271619  5927301619  6030341619
 6103061922  6206091922  6309121922  6412151922  6515181922  6618211922
 6721241922  6824271922  6927301922  7030341922  7103062225  7206092225
 7309122225  7412152225  7515182225  7618212225  7721242225  7824272225
 7927302225  8030342225  8103062528  8206092528  8309122528  8412152528
 8515182528  8618212528  8721242528  8824272528  8927302528  9030342528
 91 1 3 128  92 1342830
  1 7      1          1         90        10         9         2         1
  814      1001      1000        30       185                   1         1
 1515      1
*1212     10
 15
  1  4  7 -1  0  2  5  8 -1  0  3  6  9 -1 -1
 91  1 1.1540    0.011524
 91  2 0.6355                   0.0022325
 92  1 1.2841    0.012823
 92  2 0.8413                   0.0000625
  1 21
  1  0  0  0  0  0  0  0  1  1  1
 0        +00 0        +00
 1282     +00 1128     -02 3        -03 0        +00 0        +00
 7268     -01 0        +00 528      -03 819      -03 333      -03
 6        -02 1091     +02

                           5405     -03 8211     -03 3328     -03
 15       -01 2004     +02

                           545      -03 822      -03 3325     -03
 28       -01 3511     +02

                           55       -03 8235     -03 332      -03
 46       -01 5302     +02

                           5545     -03 8252     -03 3317     -03
```

55	-01	6321	+02	5561	-03	8261	-03	3314	-03			
82	-01	9062	+02	5605	-03	8276	-03	3304	-03			
145	+00	1531	+03	5693	-03	8299	-03	3283	-03			
202	+00	2039	+03	5749	-03	8287	-03	3265	-03			
249	+00	2552	+03	5795	-03	8272	-03	3237	-03			
303	+00	3074	+03	5846	-03	8246	-03	3206	-03			
348	+00	3521	+03	5882	-03	8219	-03	3184	-03			
396	+00	4002	+03	5920	-03	8190	-03	3160	-03			
455	+00	4565	+03	5954	-03	8145	-03	3126	-03			
501	+00	5015	+03	5981	-03	8109	-03	3099	-03			
556	+00	5569	+03	6014	-03	8059	-03	3066	-03			
600	+00	6019	+03	6041	-03	8018	-03	3039	-03			
652	+00	6552	+03	6068	-03	7970	-03	3004	-03			
696	+00	7009	+03	6090	-03	7929	-03	2974	-03			
750	+00	7548	+03	6117	-03	7881	-03	2939	-03			
786	+00	7913	+03	6136	-03	7848	-03	2916	-03			
0	+00											
1 30	1	1	0.0									

```
//ERUPT     JOB ('68.0125.37171930130',12,007,005,090,0000,5,0,0,1),     CJOB    55
//             '023-BOETTCHER     ',                                       C
//             MSGLEVEL=1
//JOBLIB   DD  DSNAME=SYS1.CMPLIB,DISP=SHR
//        EXEC  FTLG
//FTLG     PROC XR=MAP,XC=LET,OV=SCTR,PRJ=,VLB=2,CLU=TRK,VU=0,DSL=NEW,  C00032000
//             STEL=,SL=4,SO=SO                                          00032010
//LKED     EXEC PGM=IEWL,PARM='+XR,LIST,+XC,+OV'                         00032020
//SYSPRINT  DD SYSOUT=A                                                  00032030
//SYSLIB    DD DSNAME=SYS1.FORTLIB,DISP=SHR                              00032040
//          DD DSNAME=SYS1.LIB+PRJ,UNIT=SYSSQ,DISP=SHR,                 C00032050
//             VOLUME=SER=EURSY+VLB                                      00032060
//          DD DSNAME=SYS1.SSPLIB,DISP=SHR                               00032070
//SYSUT1    DD UNIT=SYSSQ,SPACE=(+CLU,(15,4)),VOLUME=SER=EURSY+VU        00032080
//SYSLMOD   DD DSNAME=++SOSET(+SO),DISP=(+DSL,PASS,DELETE),UNIT=SYSSQ, C00032090
//             SPACE=(TRK,(40,30,1),RLSE),VOLUME=SER=EURSY3              00032100
//SYSLIN    DD DDNAME=SYSIN                                              00032110
//LKED.SYSIN    DD *
IEF236I ALLOC. FOR ERUPT     LKED
IEF237I JOBLIB    ON 130
IEF237I SYSLIB    ON 130
IEF237I           ON 231
IEF237I           ON 231
IEF237I SYSUT1    ON 130
IEF237I SYSLMOD   ON 232
IEF237I SYSLIN    ON 330
```

F-LEVEL LINKAGE EDITOR OPTIONS SPECIFIED MAP,LIST,LET,SCTR
****GO DOES NOT EXIST BUT HAS BEEN ADDED TO DATA SET

MODULE MAP

CONTROL SECTION NAME		ORIGIN	LENGTH
MAIN		00	D0
SUB1		00	2116
SUB2		21E8	CC6
SUB3		2E30	E00
SUB4		3C30	12E0
STCLOK	*	4F90	D4
AREA1		5068	2553
AREA2		7620	686C
AREA3		E230	C30
AREA4		EE30	113
AREA5		EFC8	12C
AREA6		F0F8	25300
AREA7		343F8	1C
AREA8		34918	7D4
INTER		350F0	37C
PRINT2		35470	436
IHCUOPT	*	358A8	8
IHCFCOMH	*	35830	F00
PRINT1		36730	346
IHCTRCH	*	36AF8	2C8
IHCSSQRT	*	36DC0	AC
IHCFINTH	*	36E70	3A6
IHCFIOSH	*	37218	DAA
IHCUATBL	*	37FC8	638
IHCFCVTH	*	38600	10A5

ENTRY NAME	LOCATION	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION
TIME	4F98						
IBCOM=	35830	FDIOCS=	3596C	INTSW	36690		
SQRT	36DC0						
ARITH=	36E70	ADJSW	37135				
FIOCS=	37218						
ADCON=	38600	FCVZO	3874C	FCVAO	387F2	FCVLO	38882
FCVIO	38B38	FCVEO	390BA	FCVCO	392D4	INT6SW	39690

ENTRY ADDRESS 00
TOTAL LENGTH 396A5

```
IEF285I   SYS1.CMPLIB                                          KEPT
IEF285I   VOL SER NOS= EURSY0.
IEF285I   SYSOUT                                               SYSOUT
IEF285I   VOL SER NOS=          .
IEF285I   SYS1.FORTLIB                                         KEPT
IEF285I   VOL SER NOS= EURSY0.
IEF285I   SYS1.LIB                                             KEPT
IEF285I   VOL SER NOS= EURSY2.
IEF285I   SYS1.SSPLIB                                          KEPT
IEF285I   VOL SER NOS= EURSY2.
IEF285I   SYS68275.T034007.RP001.ERUPT.R0000440                DELETED
IEF285I   VOL SER NOS= EURSY0.
IEF285I   SYS68275.T034007.RP001.ERUPT.GOSET                   PASSED
IEF285I   VOL SER NOS= EURSY3.
    LKED       DATE=68.10.01   BEG.T.=10.333   DURATION=0.003   N.OPER=463
//GO        EXEC PGM=*.+STEL.LKED.SYSLMOD,COND=(+GL,LT,+STEL.LKED)              00032120
//FT05F001   DD DDNAME=SYSIN                                                    00032130
//FT06F001   DD SYSOUT=A                                                        00032140
//FT07F001   DD UNIT=SYSCP,LABEL=(,NL),DISP=(MOD,PASS),DSNAME=PUNCH1,         C00032150
//              VOLUME=SER=PUNCH1                                               00032160
//SYSUDUMP   DD SYSOUT=A                                                        00032170
//GO.FT09F001   DD UNIT=L91,VOLUME=(PRIVATE,SER=TP0458),                      C
//              LABEL=(1,SL),DSNAME=ERUPT,                                     C
//              DISP=(OLD,DELETE)
//GO.SYSIN      DD *
IEF236I ALLOC. FOR ERUPT     GO
IEF237I JOBLIB   ON 100
IEF237I PGM=*.DD ON 232
IEF237I FT05F001 ON 00C
IEF237I FT07F001 ON 00D
IEF237I FT09F001 ON 332
```

```
 *** SAMPLE PROBLEM ERUPT ***

REACTOR SPECIFICATIONS
  34 ROWS   30 COLUMNS    92 REGIONS    92 COMPS    2 GROUPS   RZ GEOM   B.C.(L,T,R,B)=1,0,0,1   N.F.= 3.50000E 02
  CHI1= 1.0000   CHI2= 0.0

MESH SPECIFICATIONS
    I  DELTA
    1 18.500    3  6.000  33  0.000  34

    J  DELTA
    1 44.444    2 22.222    4  9.205    7  7.063   10  5.954   13  5.246   16  4.743   19  4.361   22  4.059   25  3.813   28
26.000  30

DIMENSION SPECIFICATIONS
     I   DIST.
     2   18.500     3   37.000     4   43.000     5   49.000     6   55.000     7   61.000     8   67.000     9   73.000    10   79.000
    11   85.000    12   91.000    13   97.000    14  103.000    15  109.000    16  115.000    17  121.000    18  127.000    19  133.000
    20  139.000    21  145.000    22  151.000    23  157.000    24  163.000    25  169.000    26  175.000    27  181.000    28  187.000
    29  193.000    30  199.000    31  205.000    32  211.000    33  217.000    34  217.000

     J   DIST.
     2   22.222     3   44.444     4   66.666     5   75.871     6   85.076     7   94.281     8  101.344     9  108.407    10  115.470
    11  121.424    12  127.373    13  133.333    14  138.579    15  143.825    16  149.071    17  153.913    18  158.556    19  163.299
    20  167.660    21  172.021    22  176.383    23  180.442    24  184.501    25  188.561    26  192.374    27  196.187    28  200.000
    29  226.000    30  252.000

ADDITIONAL DATA
      NRT          RUN          LD1          LD2          LD3          CIRC         TYPE         KEF1         KEF2
   1.0000E 00   1.0000E 00   9.0000E 01   1.0000E 01   9.0000E 00   2.0000E 00   1.0000E 00   1.0010E 00   1.0000E 00
      DT           P/F          KEQ          PRCC         PRTF         PRSP
   3.0000E 01   1.8300E 02   1.0000E 01   1.0000E 00   1.0000E 00   1.0000E 00

MOVE-SEQUENCES FOR RADIAL FUEL MANAGEMENT
     1  4  7 -1  0  2  5  8 -1  0  3  6  9 -1 -1
```

TABLE 1

TAU	BU	D	SIGR	SIGA	NUSF	SIGF
0.0	0.0	1.2820E 00 7.2630E-01	1.1280E-02 0.0	3.0000E-03 5.2800E-03	0.0 8.1900E-03	0.0 3.3300E-03
6.0000E-02	1.0910E 02	0.0 0.0	0.0 0.0	0.0 5.4050E-03	0.0 8.2110E-03	0.0 3.3280E-03
1.5000E-01	2.0040E 02	0.0 0.0	0.0 0.0	0.0 5.4500E-03	0.0 8.2200E-03	0.0 3.3250E-03
2.8000E-01	3.5110E 02	0.0 0.0	0.0 0.0	0.0 5.5000E-03	0.0 8.2350E-03	0.0 3.3200E-03
4.6000E-01	5.3020E 02	0.0 0.0	0.0 0.0	0.0 5.5450E-03	0.0 8.2520E-03	0.0 3.3170E-03
5.5000E-01	6.3210E 02	0.0 0.0	0.0 0.0	0.0 5.5610E-03	0.0 8.2610E-03	0.0 3.3140E-03
8.2000E-01	9.0620E 02	0.0 0.0	0.0 0.0	0.0 5.6050E-03	0.0 8.2760E-03	0.0 3.3040E-03
1.4500E 00	1.5310E 03	0.0 0.0	0.0 0.0	0.0 5.6930E-03	0.0 8.2990E-03	0.0 3.2830E-03
2.0200E 00	2.0890E 03	0.0 0.0	0.0 0.0	0.0 5.7490E-03	0.0 8.2870E-03	0.0 3.2650E-03
2.4900E 00	2.5520E 03	0.0 0.0	0.0 0.0	0.0 5.7950E-03	0.0 8.2720E-03	0.0 3.2370E-03
3.0300E 00	3.0740E 03	0.0 0.0	0.0 0.0	0.0 5.8460E-03	0.0 8.2460E-03	0.0 3.2060E-03
3.4800E 00	3.5210E 03	0.0 0.0	0.0 0.0	0.0 5.8820E-03	0.0 8.2190E-03	0.0 3.1840E-03
3.9600E 00	4.0020E 03	0.0 0.0	0.0 0.0	0.0 5.9200E-03	0.0 8.1900E-03	0.0 3.1600E-03
4.5500E 00	4.5650E 03	0.0 0.0	0.0 0.0	0.0 5.9540E-03	0.0 8.1450E-03	0.0 3.1260E-03
5.0100E 00	5.0150E 03	0.0 0.0	0.0 0.0	0.0 5.9810E-03	0.0 8.1090E-03	0.0 3.0990E-03
5.5600E 00	5.5690E 03	0.0 0.0	0.0 0.0	0.0 6.0140E-03	0.0 8.0590E-03	0.0 3.0660E-03
6.0000E 00	6.0190E 03	0.0 0.0	0.0 0.0	0.0 6.0410E-03	0.0 8.0180E-03	0.0 3.0390E-03
6.5200E 00	6.5520E 03	0.0 0.0	0.0 0.0	0.0 6.0680E-03	0.0 7.9700E-03	0.0 3.0040E-03
6.9600E 00	7.0090E 03	0.0 0.0	0.0 0.0	0.0 6.0900E-03	0.0 7.9290E-03	0.0 2.9740E-03

TABLE 1

TAU	BU	D	SIGR	SIGA	NUSF	SIGF
7.5000E 00	7.5430E 03	0.0	0.0	0.0	0.0	0.0
		0.0	0.0	6.1170E-03	7.8810E-03	2.9390E-03
7.8600E 00	7.9130E 03	0.0	0.0	0.0	0.0	0.0
		0.0	0.0	6.1360E-03	7.8480E-03	2.9160E-03

*** SAMPLE PROBLEM ERUPT ***

REGION SPECIFICATIONS

REG	I1	I2	J1	J2	COMP	GROUP	D	SIGR	SIGA	NUSF	B SQ
1	3	6	1	4	1	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
2	6	9	1	4	2	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
3	9	12	1	4	3	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
4	12	15	1	4	4	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
5	15	18	1	4	5	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
6	18	21	1	4	6	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
7	21	24	1	4	7	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
8	24	27	1	4	8	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
9	27	30	1	4	9	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
10	30	34	1	4	10	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
11	3	6	4	7	11	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
12	6	9	4	7	12	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
13	9	12	4	7	13	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
14	12	15	4	7	14	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
15	15	18	4	7	15	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0

*** SAMPLE PROBLEM ERUPT ***

REGION SPECIFICATIONS

REG	I1	I2	J1	J2	COMP	GROUP	D	SIGR	SIGA	NUSF	B SQ
16	18	21	4	7	16	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
17	21	24	4	7	17	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
18	24	27	4	7	18	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
19	27	30	4	7	19	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
20	30	34	4	7	20	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
21	3	6	7	10	21	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
22	6	9	7	10	22	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
23	9	12	7	10	23	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
24	12	15	7	10	24	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
25	15	18	7	10	25	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
26	18	21	7	10	26	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
27	21	24	7	10	27	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
28	24	27	7	10	28	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
29	27	30	7	10	29	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
30	30	34	7	10	30	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0

*** SAMPLE PROBLEM ERUPT ***

REGION SPECIFICATIONS

REG	I1	I2	J1	J2	COMP	GROUP	D	SIGR	SIGA	NUSF	B SQ
31	3	6	10	13	31	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
32	6	9	10	13	32	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
33	9	12	10	13	33	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
34	12	15	10	13	34	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
35	15	18	10	13	35	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
36	18	21	10	13	36	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
37	21	24	10	13	37	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
38	24	27	10	13	38	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
39	27	30	10	13	39	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
40	30	34	10	13	40	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
41	3	6	13	16	41	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
42	6	9	13	16	42	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
43	9	12	13	16	43	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
44	12	15	13	16	44	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
45	15	18	13	16	45	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0

*** SAMPLE PROBLEM ERUPT ***

REGION SPECIFICATIONS

REG	I1	I2	J1	J2	COMP	GROUP	D	SIGR	SIGA	NUSF	B SQ
46	18	21	13	16	46	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
47	21	24	13	16	47	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
48	24	27	13	16	48	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
49	27	30	13	16	49	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
50	30	34	13	16	50	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
51	3	6	16	19	51	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
52	6	9	16	19	52	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
53	9	12	16	19	53	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
54	12	15	16	19	54	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
55	15	18	16	19	55	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
56	18	21	16	19	56	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
57	21	24	16	19	57	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
58	24	27	16	19	58	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
59	27	30	16	19	59	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
60	30	34	16	19	60	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0

*** SAMPLE PROBLEM ERUPT ***

REGION SPECIFICATIONS

REG	I1	I2	J1	J2	COMP	GROUP	D	SIGR	SIGA	NUSF	B SQ
61	3	6	19	22	61	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
62	6	9	19	22	62	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
63	9	12	19	22	63	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
64	12	15	19	22	64	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
65	15	18	19	22	65	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
66	18	21	19	22	66	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
67	21	24	19	22	67	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
68	24	27	19	22	68	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
69	27	30	19	22	69	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
70	30	34	19	22	70	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
71	3	6	22	25	71	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
72	6	9	22	25	72	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
73	9	12	22	25	73	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
74	12	15	22	25	74	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
75	15	18	22	25	75	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0

*** SAMPLE PROBLEM ERUPT ***

REGION SPECIFICATIONS

REG	I1	I2	J1	J2	COMP	GROUP	D	SIGR	SIGA	NUSF	B SQ
76	18	21	22	25	76	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
77	21	24	22	25	77	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
78	24	27	22	25	78	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
79	27	30	22	25	79	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
80	30	34	22	25	80	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
81	3	6	25	28	81	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
82	6	9	25	28	82	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
83	9	12	25	28	83	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
84	12	15	25	28	84	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
85	15	18	25	28	85	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
86	18	21	25	28	86	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
87	21	24	25	28	87	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
88	24	27	25	28	88	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
89	27	30	25	28	89	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0
90	30	34	25	28	90	1	1.232E 00	1.128E-02	3.000E-03	0.0	0.0
						2	7.268E-01	0.0	5.280E-03	8.190E-03	0.0

*** SAMPLE PROBLEM ERUPT ***

REGION SPECIFICATIONS

REG	I1	I2	J1	J2	COMP	GROUP	D	SIGR	SIGA	NUSF	B SQ
91	1	3	1	23	91	1	1.134E 00	1.152E-02	0.0	0.0	0.0
						2	6.335E-01	0.0	2.232E-03	0.0	0.0
92	1	34	28	30	92	1	1.284E 00	1.282E-02	0.0	0.0	0.0
						2	8.413E-01	0.0	6.250E-05	0.0	0.0

VOLUMES PER REGION

RING 1	RING 2	RING 3	RING 4	RING 5	RING 6	RING 7	RING 8	RING 9
2.5132E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5133E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5134E 05
2.5132E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5133E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5134E 05
2.5132E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5133E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5134E 05
2.5132E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5133E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5134E 05
2.5132E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5133E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5134E 05
2.5132E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5133E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5134E 05
2.5132E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5133E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5134E 05
2.5132E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5133E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5134E 05
2.5132E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5133E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5134E 05
2.5132E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5133E 05	2.5133E 05	2.5132E 05	2.5132E 05	2.5134E 05

XEQ TIME= 0.03 MINUTES

*** SAMPLE PROBLEM ERUPT ***

FLUX CALCULATION BEGINS FOR REACTOR STATE AT LIFE=   0.0 *   BETA= 1.8648E 00   *

IT NO	FLUX CONVR	NU-CRIT CONVR	TOT RESIDUE	MAX RESIDUE	NU-CRITICAL
10	4.6555E-01	1.0000E 00	2.2271E-02	1.0903E-02	8.68663E-01
20	4.9368E-01	2.2462E-02	9.6933E-03	5.3382E-03	8.49579E-01
30	3.7153E-01	5.4474E-03	3.3762E-03	2.1232E-03	8.44976E-01
40	1.5369E-01	1.5068E-03	1.1805E-03	2.6473E-04	8.43704E-01
50	1.1089E-01	2.0027E-05	4.5992E-04	8.3443E-05	8.43687E-01
60	7.8807E-02	4.0656E-04	1.8812E-04	5.6340E-05	8.44030E-01
70	2.0490E-02	5.3055E-05	3.8651E-05	1.0472E-05	8.44079E-01
80	2.0666E-03	1.3351E-05	1.2634E-05	1.8732E-06	8.44068E-01
90	5.8895E-04	9.5367E-06	4.5956E-06	4.8721E-07	8.44059E-01

REACTIVITY KEFF   = 1.1848E 00

FORMFACTOR FAST FLUX   = 4.3030E-01

FORMFACTOR THERMAL FLUX= 4.4516E-01

FORMFACTOR SPEC. POWER = 4.4516E-01

TOTAL POWER (MW)   = 3.5000E 02

THERMAL CELL FLUXES

RING 1	RING 2	RING 3	RING 4	RING 5	RING 6	RING 7	RING 8	RING 9
8.4325E 13	7.6236E 13	6.3371E 13	6.0901E 13	5.3826E 13	4.7168E 13	4.1030E 13	3.5895E 13	3.3765E 13
1.2554E 14	1.1349E 14	1.0177E 14	9.0637E 13	8.0086E 13	7.0134E 13	6.0920E 13	5.3167E 13	5.0057E 13
1.6782E 14	1.5171E 14	1.3503E 14	1.2113E 14	1.0700E 14	9.3659E 13	8.1278E 13	7.0814E 13	6.6506E 13
2.0713E 14	1.8723E 14	1.6787E 14	1.4947E 14	1.3201E 14	1.1550E 14	1.0019E 14	8.7221E 13	8.1831E 13
2.4240E 14	2.1909E 14	1.9643E 14	1.7489E 14	1.5443E 14	1.3510E 14	1.1715E 14	1.0196E 14	9.5612E 13
2.7290E 14	2.4666E 14	2.2114E 14	1.9686E 14	1.7383E 14	1.5205E 14	1.3183E 14	1.1471E 14	1.0755E 14
2.9805E 14	2.6939E 14	2.4151E 14	2.1499E 14	1.8982E 14	1.6603E 14	1.4394E 14	1.2524E 14	1.1741E 14
3.1736E 14	2.8683E 14	2.5714E 14	2.2891E 14	2.0210E 14	1.7677E 14	1.5324E 14	1.3332E 14	1.2498E 14
3.3044E 14	2.9866E 14	2.6774E 14	2.3834E 14	2.1042E 14	1.8404E 14	1.5954E 14	1.3880E 14	1.3012E 14
3.3704E 14	3.0462E 14	2.7309E 14	2.4310E 14	2.1462E 14	1.8771E 14	1.6272E 14	1.4156E 14	1.3271E 14

SPECIFIC POWERS PER REGION

RING 1	RING 2	RING 3	RING 4	RING 5	RING 6	RING 7	RING 8	RING 9
1.3479E 00	1.2136E 00	1.0023E 00	0.7344E-01	8.6036E-01	7.5393E-01	6.5582E-01	5.7374E-01	5.3970E-01
2.0065E 00	1.8140E 00	1.6267E 00	1.4487E 00	1.2801E 00	1.1210E 00	9.7375E-01	8.4981E-01	8.0012E-01
2.6325E 00	2.4249E 00	2.1743E 00	1.9362E 00	1.7103E 00	1.4970E 00	1.2991E 00	1.1319E 00	1.0630E 00
3.3108E 00	2.9926E 00	2.6332E 00	2.3890E 00	2.1100E 00	1.9462E 00	1.6014E 00	1.3941E 00	1.3080E 00
3.8744E 00	3.5026E 00	3.1097E 00	2.7953E 00	2.4684E 00	2.1594E 00	1.8725E 00	1.6296E 00	1.5283E 00
4.3621E 00	3.9426E 00	3.5346E 00	3.1467E 00	2.7785E 00	2.4304E 00	2.1072E 00	1.8335E 00	1.7192E 00
4.7641E 00	4.3359E 00	3.3602E 00	3.4364E 00	3.0341E 00	2.6539E 00	2.3007E 00	2.0018E 00	1.8767E 00
5.0726E 00	4.5347E 00	4.1102E 00	3.6588E 00	3.2304E 00	2.8254E 00	2.4494E 00	2.1310E 00	1.9977E 00
5.2317E 00	4.7737E 00	4.2736E 00	3.3095E 00	3.3634E 00	2.9417E 00	2.5501E 00	2.2185E 00	2.0798E 00
5.3372E 00	4.3691E 00	4.3551E 00	3.3856E 00	3.4306E 00	3.0004E 00	2.6009E 00	2.2628E 00	2.1212E 00

XEQ TIME= 0.60 MINUTES

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Alfred Nobel

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