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USER'S MANUAL FOR BEMOD-I

by

C. C. Ford and J. F. Koenig

EBR-II Project
Argonne National Laboratory
Argonne, Illinois - Idaho Falls, Idaho

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ABSTRACT

Since the inception by V. Z. Jankus of BEMOD, the code for modeling the behavior of sodium-bonded fuel elements during irradiation, experimental results describing the swelling of cladding and depleted-uranium metallic fuel and the behavior of partially enriched uranium-5% fissium metallic fuel have been published. As appropriate irradiation technology for metallic and depleted-uranium fuels has developed, the BEMOD code has been modified; thus BEMOD-I has developed.

I. INTRODUCTION

The BEMOD code was developed by V. Z. Jankus[1] to model the behavior, and to estimate the lifetime, of sodium-bonded fuel elements during irradiation. Since its inception, experimental results have been collected and analyzed for the behavior of partially enriched uranium-5% fissium metallic fuel as well as depleted-uranium metallic fuel that has been used as a radial blanket around the EBR-II core. Some of these results have been published by the experimenter.[2,3,4] New fuel-swelling models have been incorporated into the BEMOD code and new subroutines have been added to BEMOD as technology has developed; thus BEMOD-I has been developed.

This report discusses modifications and additions to BEMOD and is intended to be used as a guide along with ANL-7586[1] for using BEMOD-I. The equations used in the original program can be obtained from Ref. 1.

II. GENERAL DESCRIPTION OF CODE

Most of the modifications and new options in BEMOD-I are specific to the computations discussed in this report. Two, however, are more general.

One is the increase in the number of axial nodes in the model of the fuel elements from 9 to 59. This increase gives the user a better total picture of activities taking place in the fuel or blanket element. Several of the new options are exercised by choosing appropriate values for input parameters. A parameter of general application is IOPT. If it equals 1, another complete set of input can be read in. If it is not equal to 1, the program execution terminates after all computations of the present problem have been done.

BEMOD-I is coded in Fortran-IV language. It is designed to run on the IBM-360/75 computer, or a comparable unit, and it has a 450-K requirement on compilation and 160-K requirement on execution. For full use of BEMOD-I, a Calcomp plotter, Model 564 or 565, and a standard set of Calcomp plotting subroutines are needed. The plotted information can be accumulated and plotted by hand from the printed output; consequently the plotting routine can be bypassed.

III. COMPUTATIONS WITH THE CODE

A. Swelling of Blanket Fuel

A modification to BEMOD has been the incorporation of a model for temperature- and pressure-dependent fuel swelling that has been used for depleted-uranium blanket material. This model uses the larger of the plenum-gas pressure or the fuel-cladding contact pressure of the node for the pressure dependence of fuel compressibility, provided neither exceeds the upper pressure limit, PMAX, an input parameter. This model has been used to describe the swelling of the depleted uranium used in the blanket. Data on restrained fuel swelling for depleted uranium indicated that a pressure of 1000 psi exerted on the fuel would compress the swelling below its unrestrained value by a factor of 5 at the maximum-swelling temperature of 895°F. At 100°F above or below this temperature, the swelling compresses to one-half of the unrestrained value for 1000 psi. This information is based on swelling studies by PNL[5] on fuel of similar composition. The model is:

$$\frac{\Delta V}{V} = \frac{1.2 \times Bu \times Q \times e^{-1.21 \times 10^{-4} \times \Delta t^2}}{1 + (PRS/250) \times (1 - 0.75 \times 10^{-4} \times \Delta t^2)} ,$$

where: $\Delta V/V$ is the fuel swelling, temperature- and pressure-dependent;

Bu is the average burnup;

Q is the local-to-average power or flux profile value;

Δt is the difference between the maximum fuel-swelling temperature and the calculated average fuel temperature; and

PRS is the larger of either the gas-plenum pressure or fuel-cladding contact pressure, but it is not greater than PMAX.

The model is illustrated in Fig. 1. The maximum pressure, PMAX, prevents unreasonable values for compression due to the mathematical behavior of the model for high pressures (see Fig. 1). The pressure term in the equation is used only between 780°F and 1010°F.

Data for the Q value, which is contained in an array, are taken from the ^{238}U axial flux profile (Fig. 2) because most of the heating in the blanket is due to ^{238}U fissioning. The flux profile was obtained from actuation of a fission wire that had been placed in grid position 7A4 with EBR-II operating at 50 MWt.

B. Swelling of Cladding

1. Harkness Model

The improved Harkness model for cladding swelling has replaced the former one in BEMOD-I. The model is dependent on temperature, flux, and time. Curves from the model (an iterative routine) are shown in Figs. 3 and 4. To use it in BEMOD-I, the user must code a value other than zero for the IHKNS option. (See III.C.2. Change-case Capability.) The model indicates that the maximum cladding swelling will occur at about 450°C (840°F) for fluence levels near and below 1×10^{23} n/cm^2, with a 4.5% $\Delta V/V$ at 1×10^{23} n/cm^2 for 450°C.

2. PNL Model

Pacific Northwest Laboratory has also developed a model for cladding swelling[6] from measurements taken from irradiated solution-treated Types 304 and 316 stainless steel cladding:

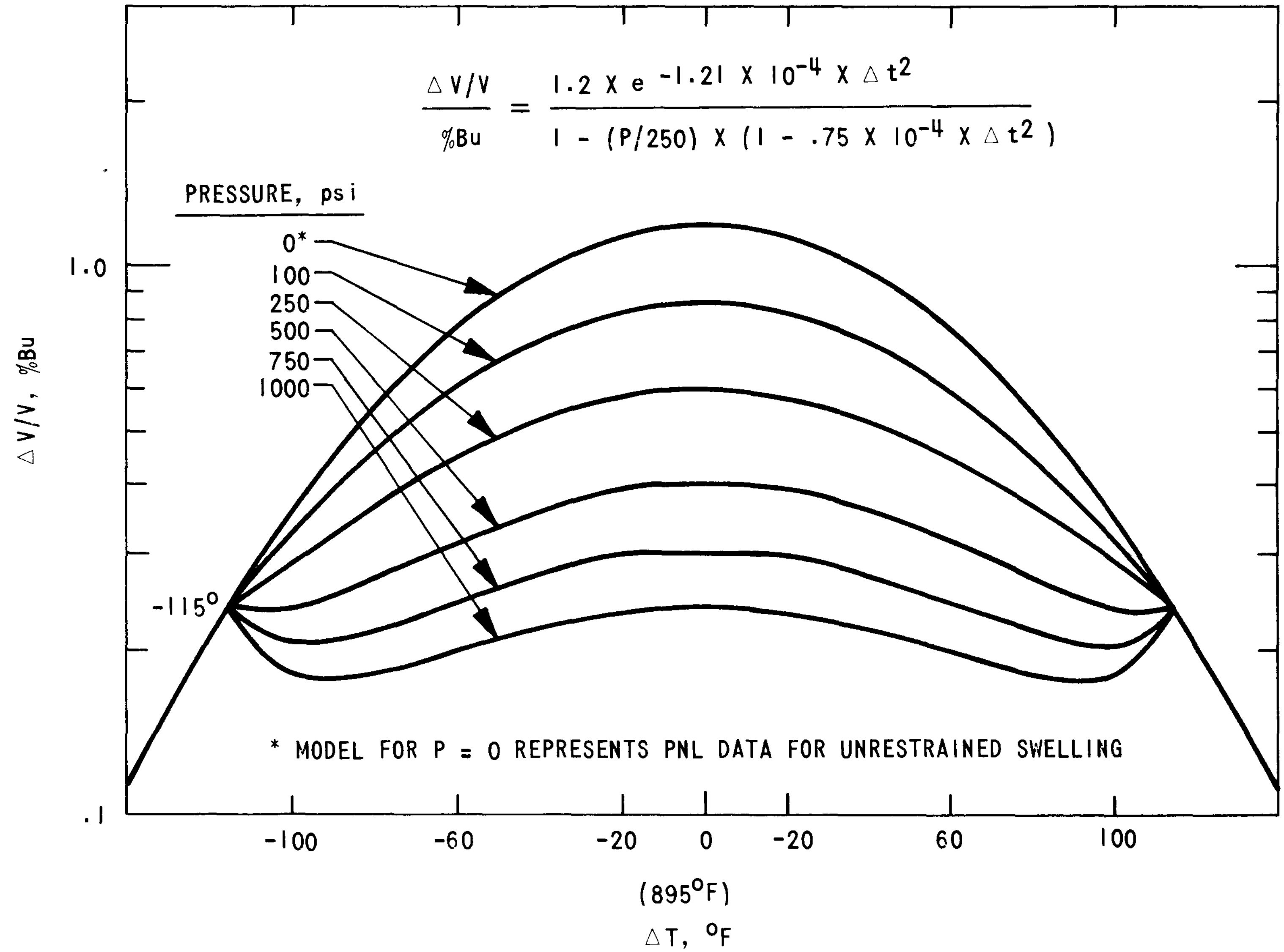

Fig. 1. Model for Swelling of EBR-II Blanket Fuel (based on PNL swelling data)

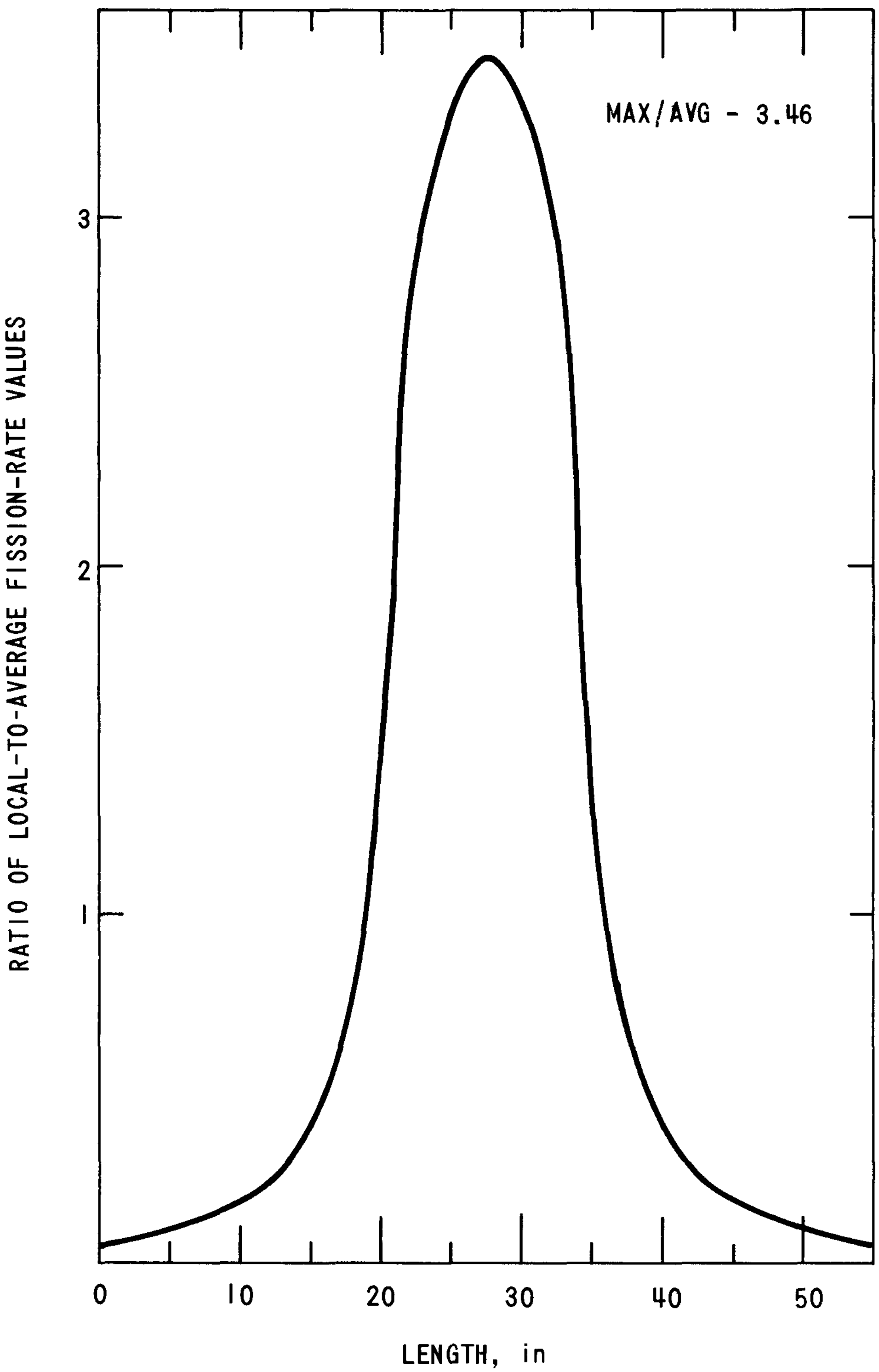

Fig. 2. Axial Distribution of Ratio of Local-to-average Linear Power Distribution

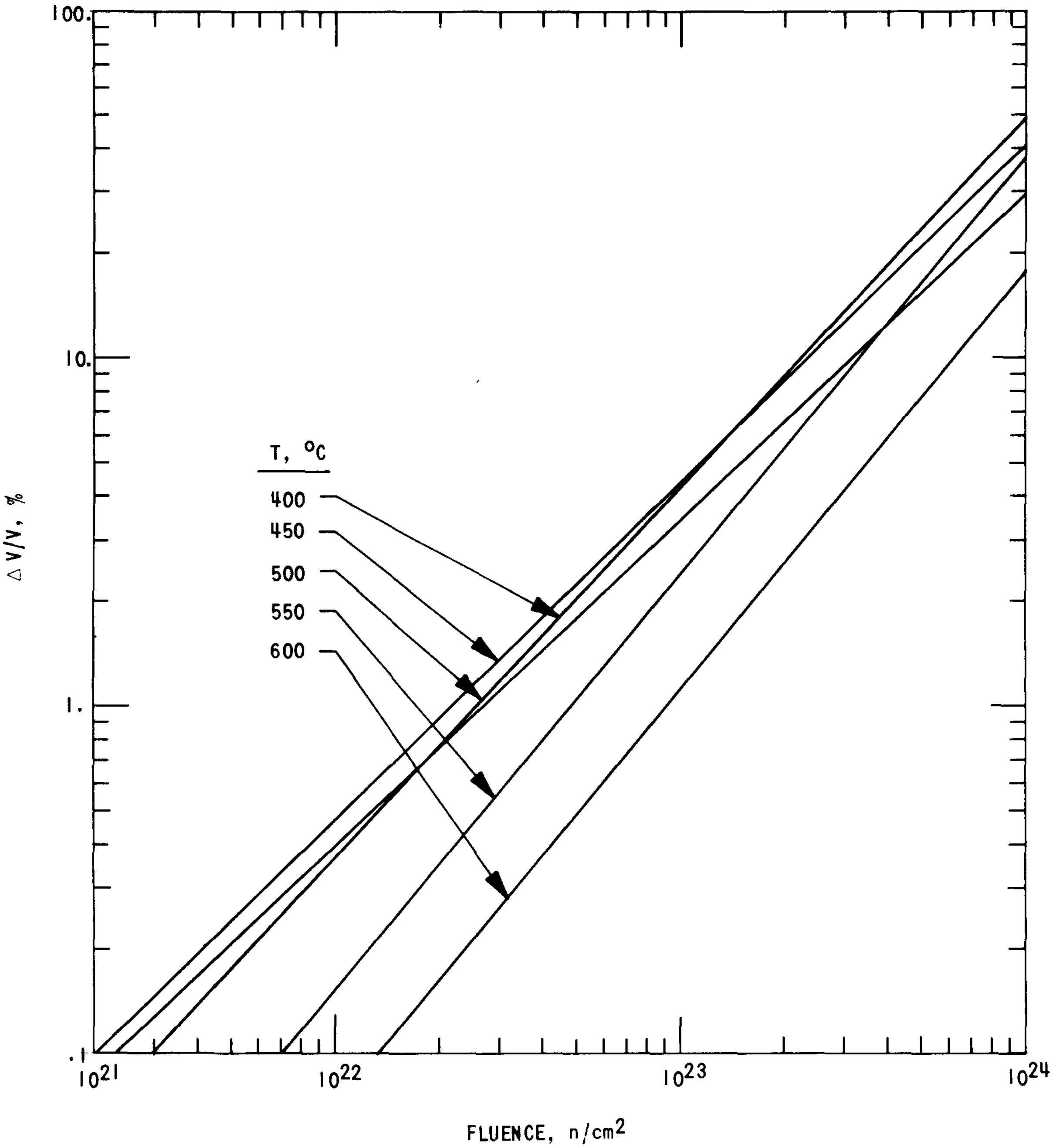

Fig. 3. Model by Harkness for Change in Cladding Swelling with Fluence (flux, 2×10^{15} n/cm^2-sec)

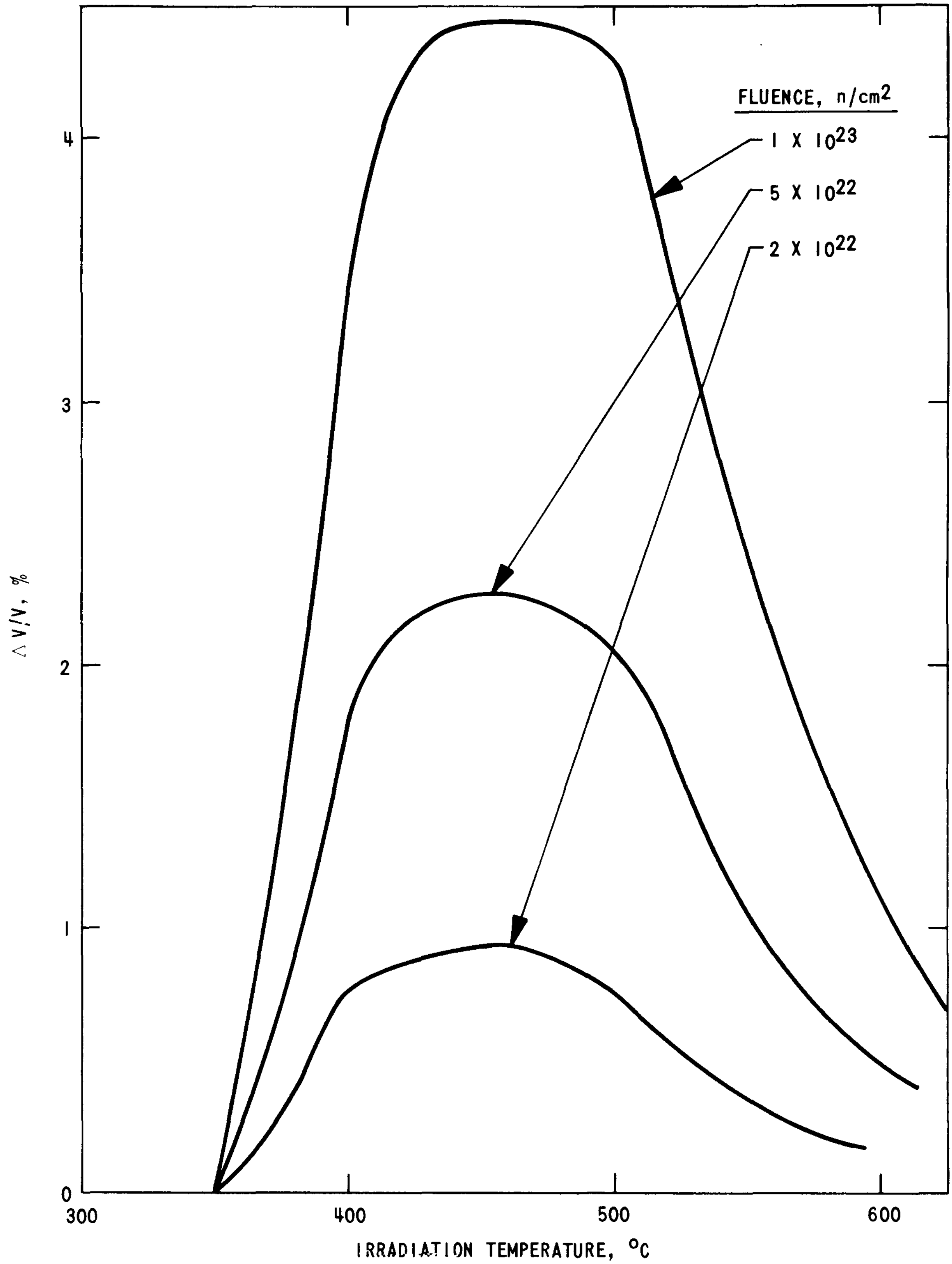

Fig. 4. Model by Harkness of Change in Cladding Swelling with Irradiation Temperature

$$\frac{\Delta V}{V} = 4.9 \times 10^{-49} \times (\phi t)^{1.71} \times 10^{\left(\frac{1.55 \times 10^4}{T} - \frac{5.99 \times 10^6}{T^2}\right)},$$

where: $\Delta V/V$ is the % cladding swelling;
ϕ is the flux in n/cm^2-sec;
t is time in sec; and
T is temperature in °K.

Figures 5 and 6 show graphs of this model.

3. Damage Function (QFFLX Array)

The relative axial profile, QFFLX, is used to calculate the cladding swelling and flux-enhanced creep; it may differ from the relative profile for heat generation, Q. The QFFLX array is used to obtain a better comparison between measured and calculated values for cladding $\Delta D/D$ resulting from swelling and creep. Damage-function curves being used for the Mark-IA and Mark-II driver-fuel elements, shown in Figs. 7 and 8, are based on previously measured damage data.[7]

The number of values in this array is one more than the number of nodes (NT + 1), with the last (NT + 1st) value for the plenum region.

The damage-function array is used when the cladding swelling due to neutron fluence is calculated with either of the two models; therefore the fluence values, calculated with the Q array, that are printed out (see V. Code Output) are not necessarily the values used to calculate cladding $\Delta D/D$.

C. Program Computation Options with Change-case Capability

1. BEMOD-I Options

Several new options are used in BEMOD-I. These are exercised by choosing appropriate values for the following input parameters.

Symbol	Description
IOPT*	If =1, another complete set of input can be read in; if not =1, program execution terminates after all computations of present problem have been done.

*Options when doing both initial and change-case calculations.

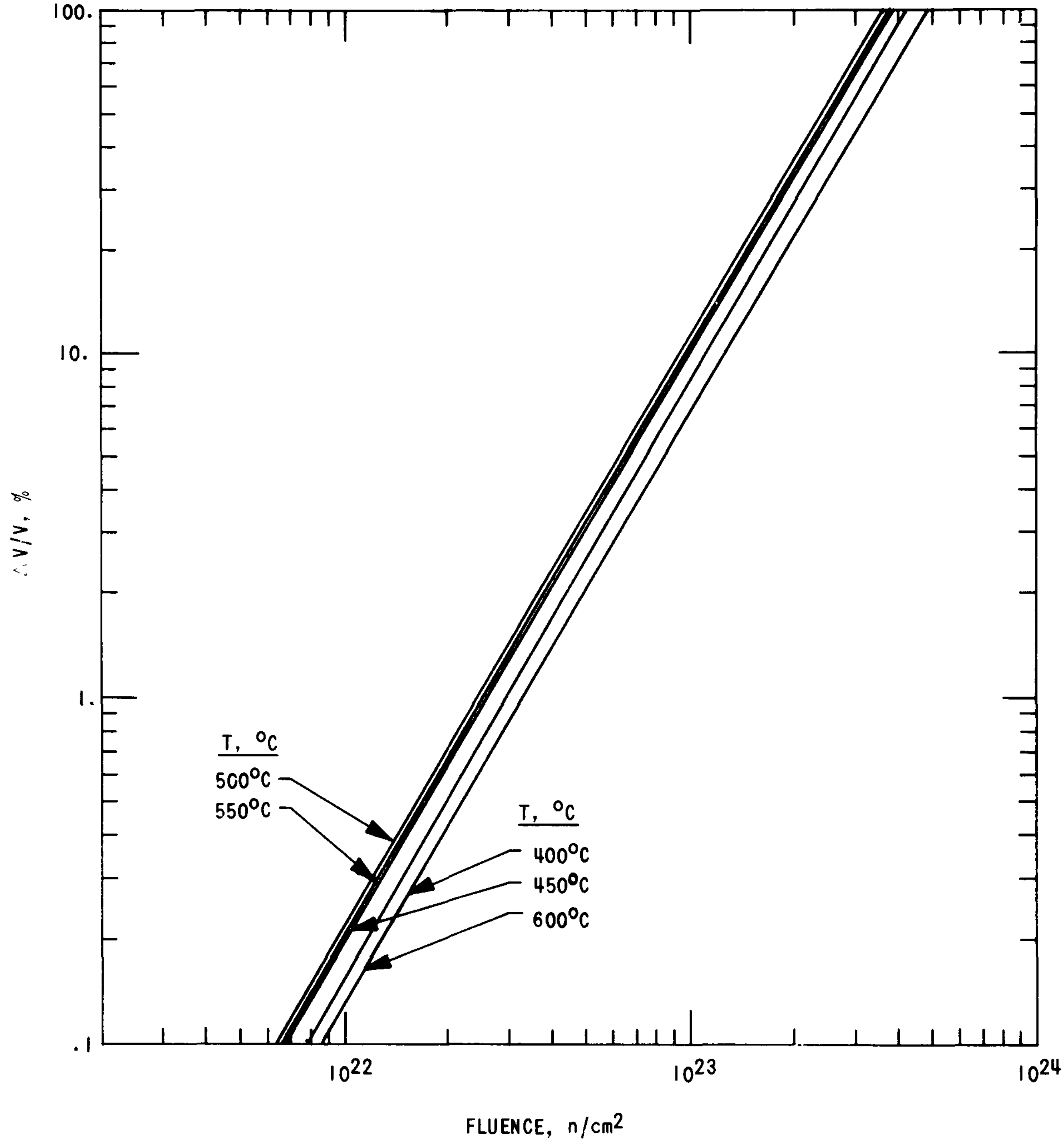

Fig. 5. PNL Model for Change in Cladding Swelling with Fluence

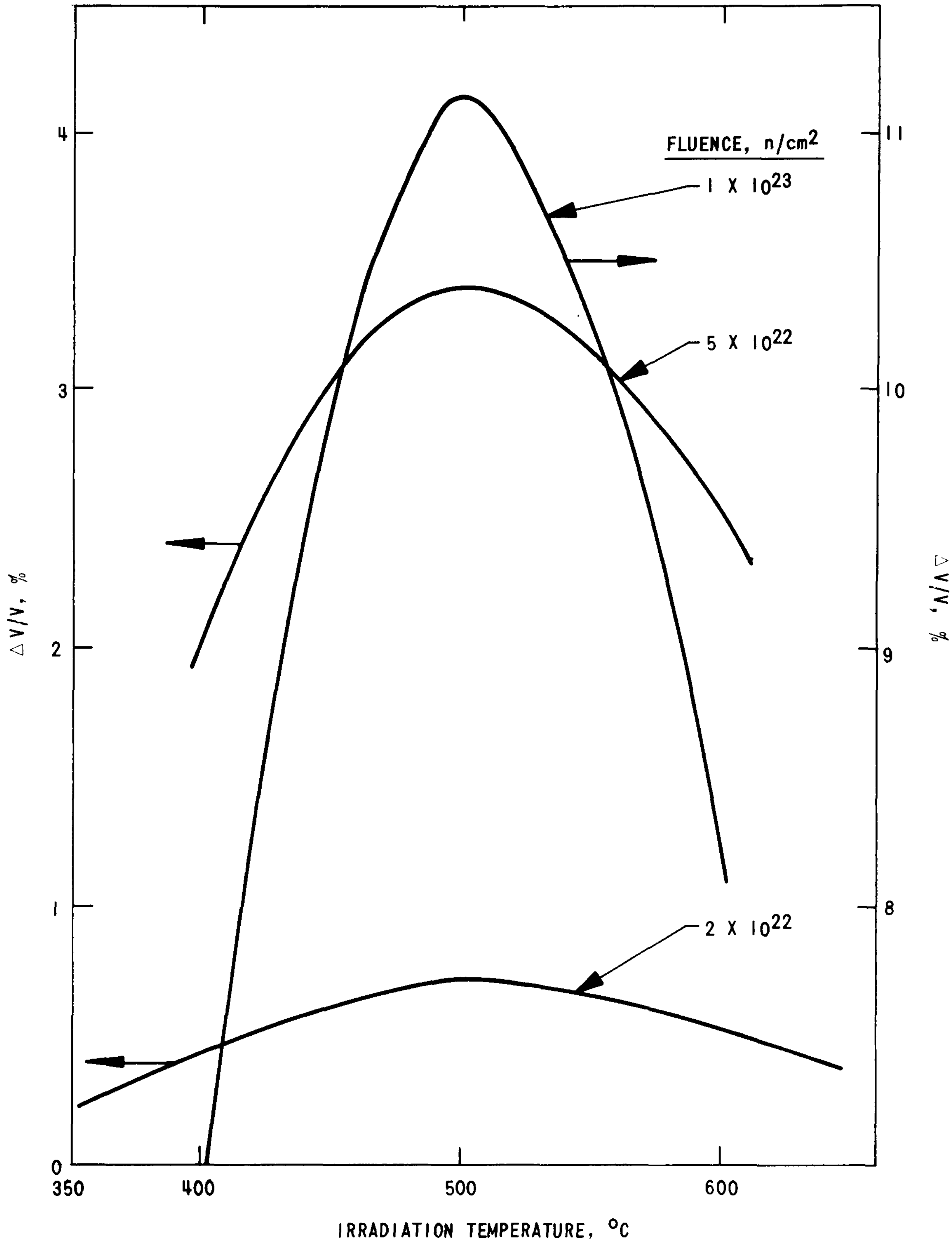

Fig. 6. PNL Model for Change in Cladding Swelling with Irradiation Temperature

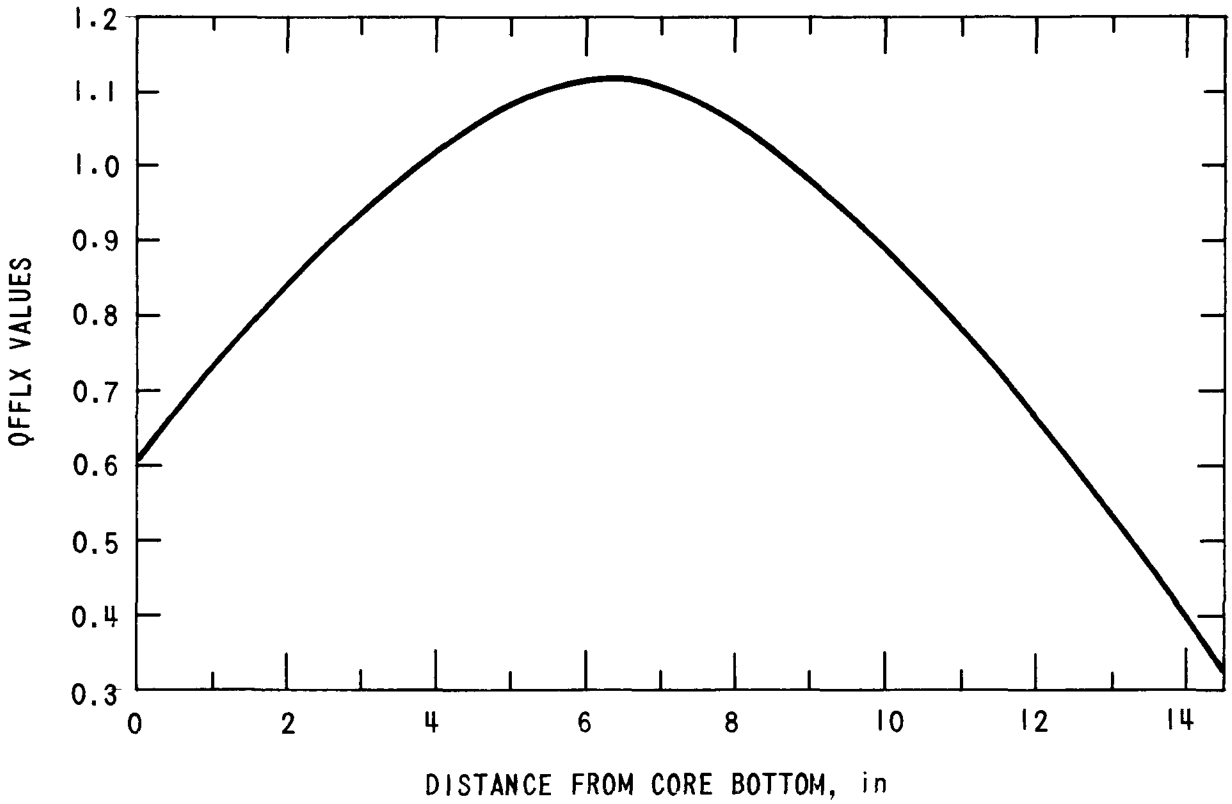

Fig. 7. Damage Function (QFFLX) for Mark-IA Driver-fuel Element

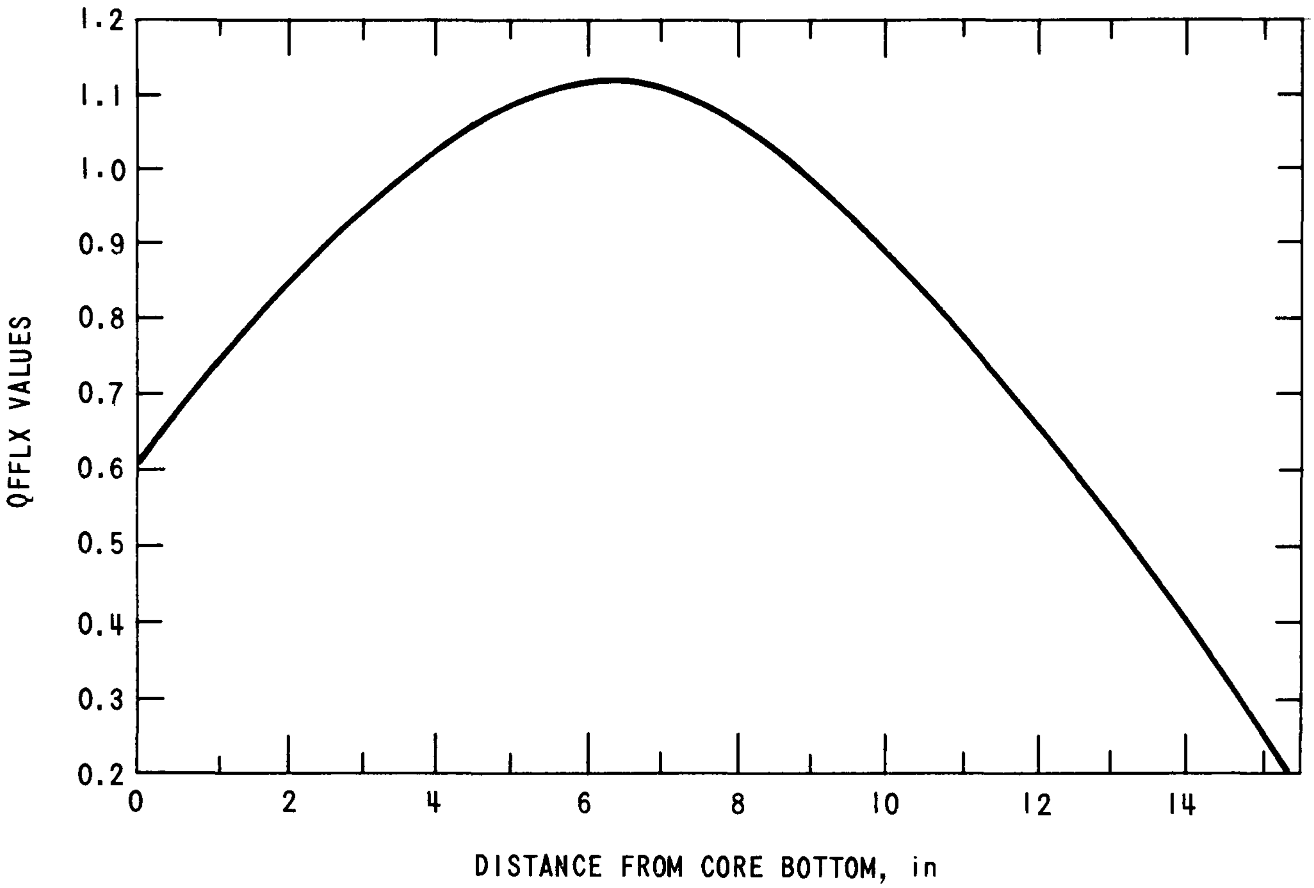

Fig. 8. Damage Function (QFFLX) for Mark-II Driver-fuel Element

Symbol	Description
ICALC*	If =1, change-case data may be read in after terminal conditions have been reached, if the problem is not previously terminated by the total ΔD/D limit; if not =1 or 2, no change-case data will be read in.
IPLT1*	If =1, all plots will be made after processing an entire input data set; if =2, plots will be made at the maximum burnup value (BUMX) of an input parameter (PLTBU) if PLTBU is less than the terminal BU (burnup) as well as after the entire problem data set has been processed; if =3, plots will be made for specific parameters as a function of burnup (maximum). (See III.E.1. Plotting Subroutine.)
IRSWL*	If =0, the fuel swelling will be compressible; if not =0, the fuel swelling will be incompressible; Comment: this option eliminates fuel shrinkage caused by an increase in plenum pressure or fuel-cladding contact pressure.
IHKNS	If =0, PNL's model for swelling of Type 304 annealed stainless steel will be used for calculating cladding swelling; if not =0, Harkness' swelling routine will be used (see III.B. Swelling of Cladding).
IFUEL	If =0, original fuel-swelling model (see Ref. 1) for driver fuel 13.5-in. long is used; if =1, a temperature-dependent fuel-swelling model is used for calculations (see III.A. Swelling of Blanket Fuel); values of 2 or 3 are not now used; if used, the model for blanket-fuel swelling would be used rather than the model for core swelling; if =4, the original fuel-swelling model is used for calculations for fuel 14.2 in. long.
IPRNT*	If =1, all calculations are printed every fifth burnup step (usually for 35 nodes); if =2, all calculations are printed every burnup step (usually for 6 nodes);

*Options when doing both initial and change-case calculations.
No * indicates options only for initial calculations.

Symbol	Description
	if =3, all calculations are printed every other burnup step (usually for 35 nodes);
	if =4, all calculations are printed every burnup step (usually for 35 nodes);
	Comment: The IPRNT value is used for page spacing of the output and does not hamper program operation.
IQF*	If not =0, Q and QFFLX arrays are not input data when reading in change-case data.
IT*	If not =0, used to prohibit possible erroneous values for cladding swelling and shrinkage during change-case calculations;
	if =0, IT not =0 condition ignored.
	Comment: during change-case calculations when the irradiation environment might change, the value for cladding swelling (or shrinkage) calculated with the PNL model may be greater than it actually should be. Therefore, this option has been added to the code to take the incremental change in swelling (or shrinkage) between the present and previous burnup step and add it to the previous value of swelling, so that a new swelling value is arrived at. If IRSWL and IT are not coded as zero, the "worst-case" plenum pressures and fuel-cladding contact pressures will be calculated during the change-case computations.
IT2*	If =1, ten complete burnup-step computations are done when processing change-case data, provided BUINC (see III.C.2. Change-case Capability) is large enough;
	if not =1, change-case data are processed until a preset termination limit is reached.

*Options only when doing change-case calculations.

2. Change-case Capability

BEMOD-I can continue burnup calculations under a new environment after a desired steady-state limit, i.e., burnup, has been reached. This calculation is done by assigning 1 to the option parameter ICALC. With ICALC = 1, the following section is executed to read in change-case parameters after terminal conditions for the previous environment have been printed:

```
READ 3001, TITLE1
READ 1100, ICALC, IRSWL, IPLT1, IQF, IT2, IT, IPRNT, PLTBU
READ 1001, DELTCN, HC, BUINC, FFLX, QPB, A26
IF (IQF.NE.0) GO TO 650
READ 2000, [Q(I), I=1, NT]
READ 2000, [QFFLX(I), I=1, NT1]
```

Where 650 is the label number for the next statement after the two READ statements for the two arrays, Q and QFFLX, the necessary formats are:

```
3001 FORMAT (10A8)
1100 FORMAT [7I5, 25X (2E10.4)]
1001 FORMAT (6E10.4)
2000 FORMAT (8E10.4)
```

Quantities read in at this time that have not been described before or in Ref. 1 are:

Symbol	Description
PLTBU	Maximum burnup value at which plots can be made if IPLT1 = 2. (See III.E.1. Plotting Subroutines.)
DELTCN	Value for coolant ΔT.
BUINC	Burnup increment to be added to the terminal maximum burnup from previous calculation to obtain new burnup limit. (See III.D.1. Burnup-limit Termination.)
QFFLX(I)	See III.B.3. Damage Function (QFFLX Array).

With this change-case capability, the user can change some or all of the above input quantities to simulate abnormal conditions such as overpower or flow-coastdown conditions, or a change in irradiation environment, and obtain resulting temperatures, pressures, etc.

Because the model for blanket-fuel swelling is temperature-dependent, a change-case option in which the value for coolant Δt is changed may change the fuel expansion. Therefore, the first burnup-step calculations are done with the new fuel temperature at the terminal-conditions burnup to get a base for calculating swelling. The difference between the fuel swelling at an increased burnup increment and the base is added to the swelling at the terminal burnup to obtain the total fuel swelling.

D. Other Modifications to BEMOD

1. Burnup-limit Termination

In addition to problem termination by a calculated total ΔD/D for cladding, ET(I), exceeding a preset input limit, EMAX1, a problem can also be terminated in BEMOD-I when burnup has reached a preset maximum-burnup criterion, BUMAX, which is a new input parameter. When a change-case problem is run the calculated maximum burnup, BUMX, is increased by BUINC, an input parameter, to arrive at a new BUMAX, and computations are continued.

2. Power-change Value, QPBD

The QPBD input value has a slightly different meaning in BEMOD-I than in BEMOD. QPBD has been changed to a fractional change in original power (QPB), coolant Δt (DELTC), and average fast flux (FFLX). As in BEMOD, the program sets BU to zero and recalculates burnup conditions with the different power conditions dictated by QPBD if the new QPB is less than or equal to the maximum power value, QPBM.

3. Irradiation-time Correction (Blanket)

Because appreciable heating in the blanket (∿20%) is due to gamma heating, an adjustment has been made in calculating irradiation time. In BEMOD-I, time is calculated by

AA9 = k/(QPB x (1 - GAMFR));

TM = AA9 x BU,

where:

k is a constant;

QPB is the average linear power (Btu/hr-ft);

GAMFR is the fraction of power due to gamma heating;

TM is time; and

BU is burnup.

GAMFR is a new input parameter.

4. Calculation of Gas-plenum Length (XLP)

BEMOD-I has been modified to recalculate the gas-plenum length (labeled XLP on the printout) after the plenum pressure (PP) has been calculated. Before this modification, in some cases the XLP value oscillated unnecessarily. This oscillation was attributed to how the plenum pressure was calculated, in which the final plenum-pressure value might differ significantly from the pressure value used to calculate XLP; consequently XLP is now calculated after the PP value for the burnup step has been set.

E. Subroutine Additions

1. Plotting Subroutines

A plotting subroutine that can use either the Calcomp Digital Plotter Model 564 or Model 565 has been included in BEMOD-I. The set of plots include:

fuel-cladding contact pressure vs fuel-pin length (FPL);
cladding creep ΔD/D, %, vs FPL;
total cladding ΔD/D, %, vs FPL;
cladding swelling ΔD/D, %, vs FPL;
total cladding stress vs FPL;
average hoop stress vs FPL;
thermal stress vs FPL;
% fuel swelling vs FPL;
volume of fission gas released to the plenum, liters, vs FPL;
plenum pressure vs % maximum burnup (MBP)*;
maximum fuel-cladding contact pressure vs MBP*;
maximum total cladding ΔD/D, %, vs MBP; and
gas-plenum length vs MBP.*

All of these plots can be obtained if IPLT1 = 1 or 2 and the user has 35 nodes (NT = 35) with fuel length = 13.5, 14.2, or 55 in. When IPLT1 = 3, only the plots indicated by an asterisk can be output; these plots have no restriction on fuel-pin length or number of nodes. Plots are drawn after all data have been processed for the problem. Plots without the asterisk can be made at a desired maximum burnup value, PLTBU, a new input parameter, if NT = 35 and IPLT1 = 2. The IFUEL value indicates the fuel-pin length; i.e., IFUEL = 0 for a 13.5-in.-long fuel pin, IFUEL = 1 for one 55 in. long, and IFUEL = 4 for one 14.2 in. long

The graphs are titled with the information contained on the third general-information input card, TITLE3 (see IV. Code Input).

The plotting can be bypassed during execution of coding a value of zero for IPLT1.

In addition to the plotting subroutine, DPLOT, a subroutine, PLINE, has been added to aid in drawing the axes and to check the domain and range of the ΔD/D and maximum burnup plots.

2. IO Subroutine (Input/Output)

All of BEMOD-I's input and output control has been incorporated into a single subroutine, IO.

3. BLOCK DATA Subprogram

Most of the important non-local variables, including all of the input, have been put into three labeled COMMON blocks, with the advantage that the quantities do not have to be in the argument list of either the SUBROUTINE or corresponding CALL statements. Consequently, a BLOCK DATA subprogram has been added to BEMOD to initialize all of the common data for which initialization is necessary. This is done only before execution of the first problem data set.

IV. CODE INPUT

Following is a listing of only the statements needed for input of a complete problem data set, excluding change-case information.

(1) READ 3001, TITLE1

(2) READ 3001, TITLE2

(3) READ 3001, TITLE3

(4) READ 1100, IOPT, ICALC, IPLT1, IRSWL, IHKNS, IFUEL, IPRNT, GAMFR, PLTBU

(5) READ 2000, TFBL, TFBH, TFB1, TFB2, TFB3, TFB4, TFB5, PMAX

(6) READ 1000, NT, TCIN, DELTC, DOPP, HC, XLFPP, DPPP

(7) READ 2000, AF, FCB, XLPPP, A1, A2, A3, A4, A5

(8) READ 2000, A6, A9, A12, A13, A14, A15, A16, A26

(9) READ 2000, A27, A28, A29, A30, A31, A32, A33, A34

(10) READ 2000, A35, A36, A37, A38, A39, A40, A41, A42

(11) READ 2000, A43, A44, A45, A46, A47, A48, A49, A50

(12) READ 2000, A51, A53, A54, A55, A56, A57, A58, A300

(13) READ 2000, AA20, AA21, AB20, AB21, TFMAX, FFLX, BUMAX, DOF

(14) READ 2000, [Q(I), I=1, NT]

(15) READ 2000, [QFFLX(I), I=1, NT1]

(16) READ 2000, [PO(I), I=1, NT]

(17) READ 2000, QPB, QPBD, QPBM, X, XLCL, XMNA, XMF, RHTHF

(18) READ 3000, N0, M1, NDL, NO1, NO2, DFDI, XNU, PPO, XLNAO, ALPNA, A401, A402

(19) READ 2000, TB, GT, CORR, G1, BUST, GB, G2, PG

(20) READ 2000, GMO GM1, V1, V2, FGR2, EMAX1, EPS1, EPS2

(21) READ 2000, [TDL(I), DL(I), I=1, NDL]

(22) 3001 FORMAT (10A8)

(23) 1100 FORMAT [7I5, 25X2 (E10.4)]

(24) 2000 FORMAT (2E10.4)

(25) 3000 FORMAT (5I2, 7E10.4)

These changes from the original BEMOD input, in order, are:

Card	Description
(1)-(3)	The first three input cards contain general information of use to the user (see III.E.1., Plotting Subroutines, for additional information on TITLE3).
(4)	Input options and data previously explained.
(5)	Input values for the model for blanket-fuel swelling (see Appendix A, Sample Input).
(6)	The input value DODI, now computed in the code, which was between DELTC and DOPP in BEMOD, has been removed.
(13)	The parameters BUMAX and DOFF, the fuel-pin diameter, have been added to the input card.

Card	Description
(15)	Used to read in the NT + 1 values for cladding-damage functions
(17)	See III.D.2. Power-change Value; the following values -- X, not used; XLCL, length of cladding ID, (in.); XMNA, mass (g) of the sodium within the cladding; XMF, fuel mass (g); and RHTHF, fuel density (g/in.^{3}) at room temperature -- replace BEMOD input values VO, VOD, and VOM on this card. If XMF and RHTHF are not zero, the diameter of the fuel is computed and the initial gas-plenum length, XLPPP, and initial height of sodium above the fuel, XLNAO, are computed and printed.

V. CODE OUTPUT

Output Values

All of the input is printed at the beginning of each problem.

At each burnup step the following computed values are printed:

BU	burnup, at. %;
A20 and A21	indicating simulation of normal and abnormal reactor conditions,
PP	plenum pressure;
QLSUM	volume, in liters, of fission gas released from the fuel element to the plenum;
TM	irradiation time, hr;
XLP	length of gas plenum, in.; and
MAX BURNUP	calculated maximum burnup, at. %. The element's maximum burnup is now being calculated and printed at each time of burnup step, along with the burnup, A20, A21, etc. This value is calculated by using the maximum value from the Q(N) array and the calculated average burnup, BU, which is also printed at each burnup step.

At the user's indication through the IPRNT option value, the following quantities for each axial node are printed at designated burnups in addition to the above:

Symbol	Description
N	Node number.
XTC	Coolant temperature, °F.
XTCLO	Cladding outside temperature, °F.
TCLI	Cladding inside temperature, °F.
TFO	Fuel surface temperature, °F.
TFB	Fuel average temperature, °F.
TF	Fuel centerline temperature, °F.
QR	Volume of fission gas retained in fuel pin, liters.
QL	Volume of fission gas released from fuel pin to the plenum, liters.
PR	Fuel-cladding contact pressure.
SP	Pressure stress on cladding.
SH	Thermal stress on cladding.
ST	Total stress on cladding.
E	Cladding creep ΔD/D.
ESW	Cladding swelling ΔD/D.
ET	Total cladding ΔD/D.
DVV	Fuel swelling, %.
FLU	Neutron fluence (x 10^{-22}). The neutron fluence for each axial fuel section is computed by using the average fast flux and flux profile when the other calculated values, e.g., total ΔD/D, are printed. This fluence is calculated with the Q array and if the QFFLX array is different the printed fluence may not be the fluence used to compute cladding swelling (see III.B.3. Damage Function (QFFLX Array)).

All of the above quantities are printed at terminal conditions.

After terminal conditions have been printed for a complete set of input data (including any change-case data), if the termination was not caused by the limit on total cladding ΔD/D, conditions of the element brought to room temperature, 70°F, are calculated and printed. For room-condition calculations the swelling of cladding and fuel are assumed to be the same as at the terminal conditions.

CONCLUSIONS

Addition of fueled experimental subassemblies to the blanket produces new irradiation conditions. With the model for blanket-fuel swelling, the effects on the cladding of a blanket element of greater fuel swelling and stress and strain that result from the new conditions can be studied.

The change-case capability, along with the burnup-limit termination feature, allows the user to study the effect of transient reactor conditions on blanket and driver-fuel elements during the lifetime of the element.

As new models for cladding and fuel swelling are developed, appropriate changes in BEMOD-I will be made.

APPENDIX A

Input Value for Heat-transfer Coefficient, HC

Heat-transfer coefficients from two equations for both the standard Mark-IA element and standard inner or outer blanket elements are shown in Figs. 9 through 12.

The Monson equation,[8] which was used for the design of EBR-II and gives the more conservative value for the heat-transfer coefficient, is as follows:

$$Nu = 2.3 + 0.23 \cdot Pe^{0.5} \quad \text{or}$$

$$h = \frac{k}{D}\left[2.3 + 0.23 \cdot \left(\frac{D \cdot v \cdot \rho \cdot c_p}{k}\right)^{0.5}\right].$$

where: Nu is the Nusselt number ($\equiv \frac{hD}{k}$);

Pe is the Peclet number ($\equiv$ Re x Pr; Re is Reynold's number and Pr is the Prandtl number);

h is the heat-transfer coefficient, Btu/hr-ft^2-°F;

k is the thermal conductivity of the fluid, Btu/hr-ft-°F;

D is the diameter of the fluid surface, ft;

v is the fluid velocity, ft/hr;

ρ is the fluid density, lb/ft^3;

c_p is the fluid specific heat, Btu/lb-°F.

The equivalent diameter, D_e, is used in place of D when there is no cylindrical-flow pipe. D_e is equal to 4 x (the cross-sectional area of flow)/(wetted perimeter of duct). The correlation is shown in Fig. 9 for a driver-fuel element (for a cladding OD of 0.174 in., D_e = 0.00828 ft) and in Fig. 11 for the blanket element (for a cladding OD of 0.493 in., D_e = 0.00422 ft).

The Subbotin[9] equation is:

$$Nu = 5.0 + 0.025 \cdot Pe^{0.8},$$

which was taken from an average curve drawn through data from experimental studies of conditions of uniform wall heat flux and fully developed flow and heat transfer.[9] This equation gives a more realistic heat-transfer coefficient than the Monson equation.

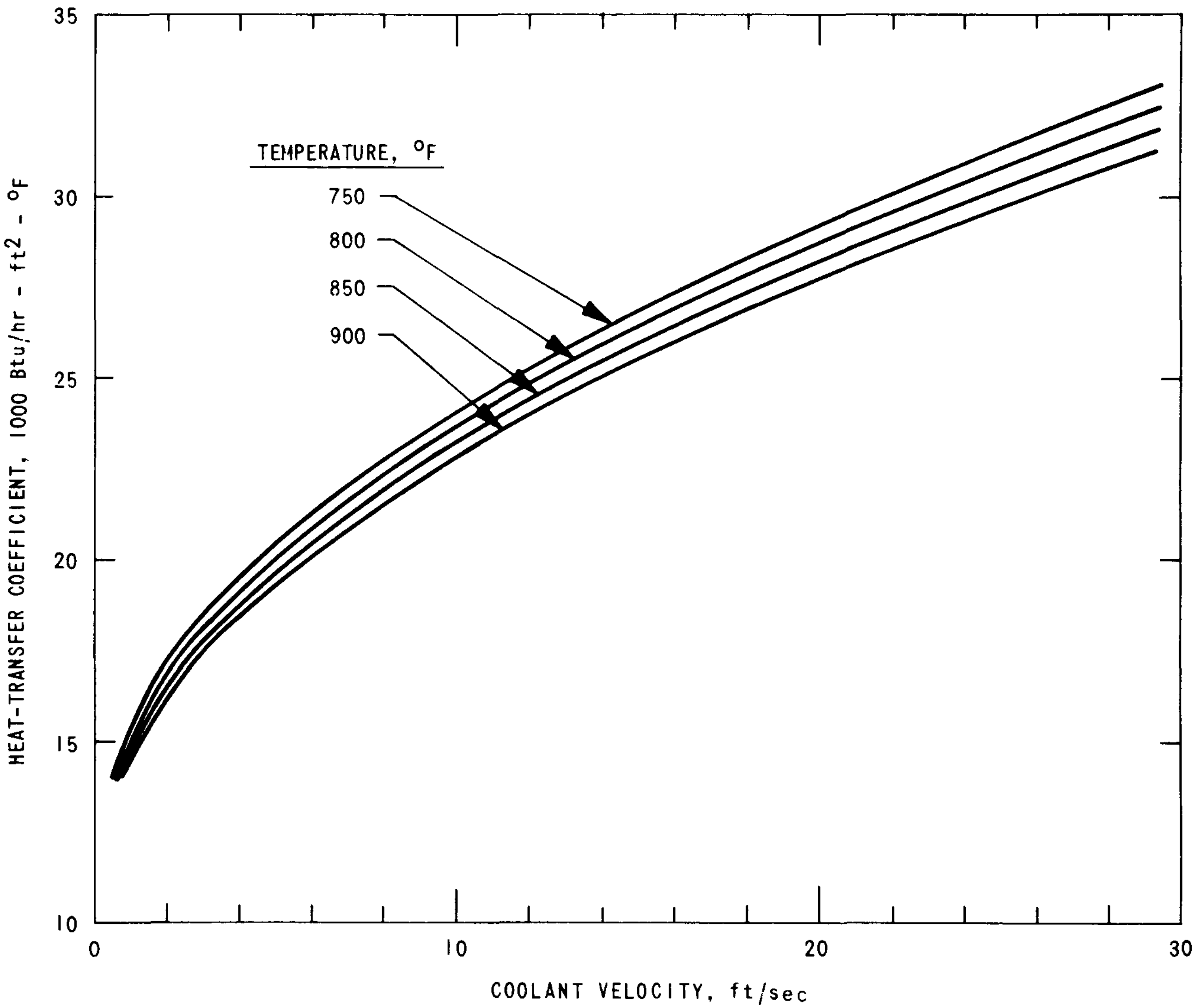

Fig. 9. Change in Heat-transfer Coefficient with Coolant Velocity and Temperature for a Driver-fuel Element (Monson Equation)

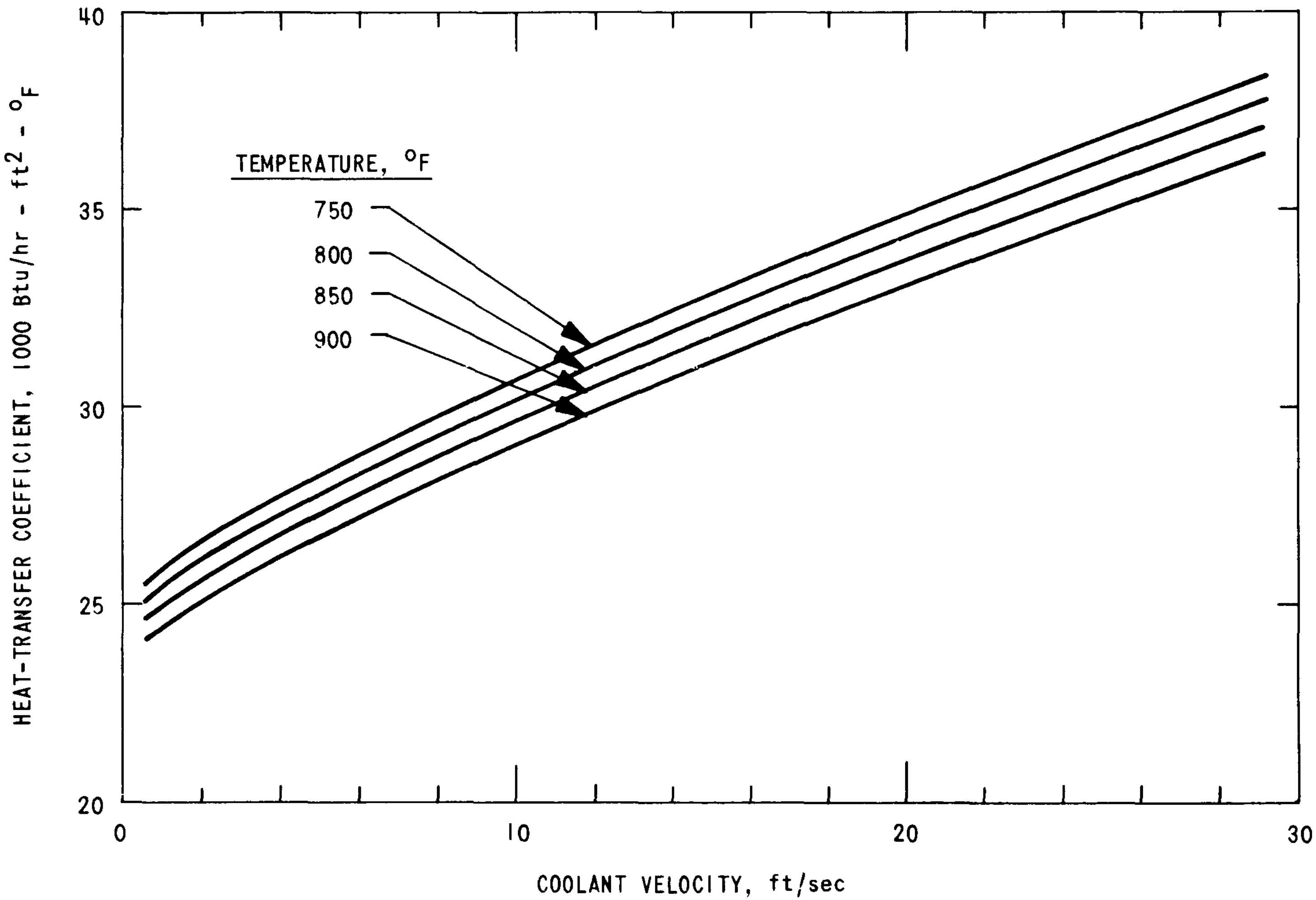

Fig. 10. Change in Heat-transfer Coefficient with Coolant Velocity and Temperature for a Driver-fuel Element (Subbotin Equation)

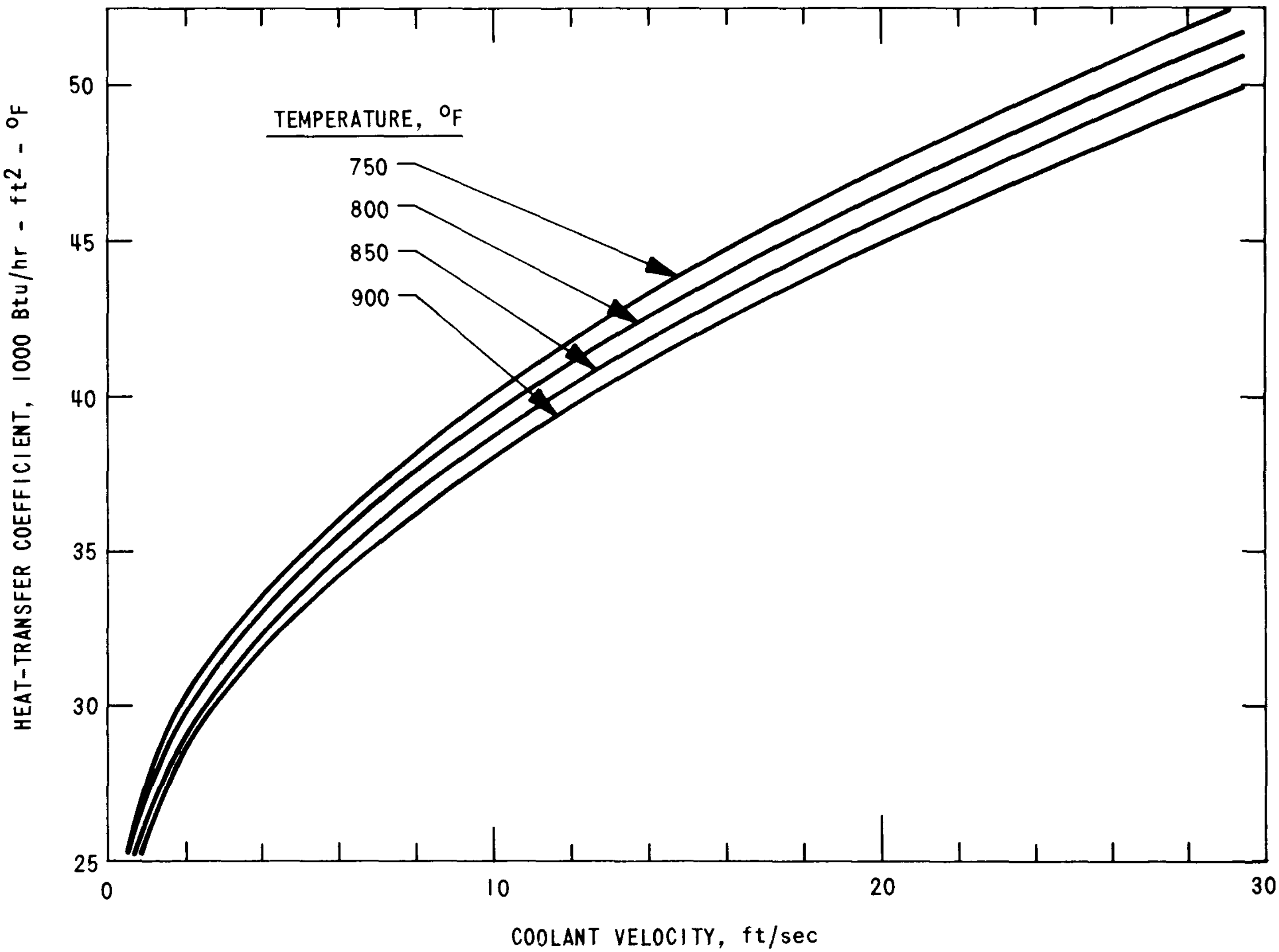

Fig. 11. Change in Heat-transfer Coefficient with Coolant Velocity and Temperature for a Blanket Element (Monson Equation)

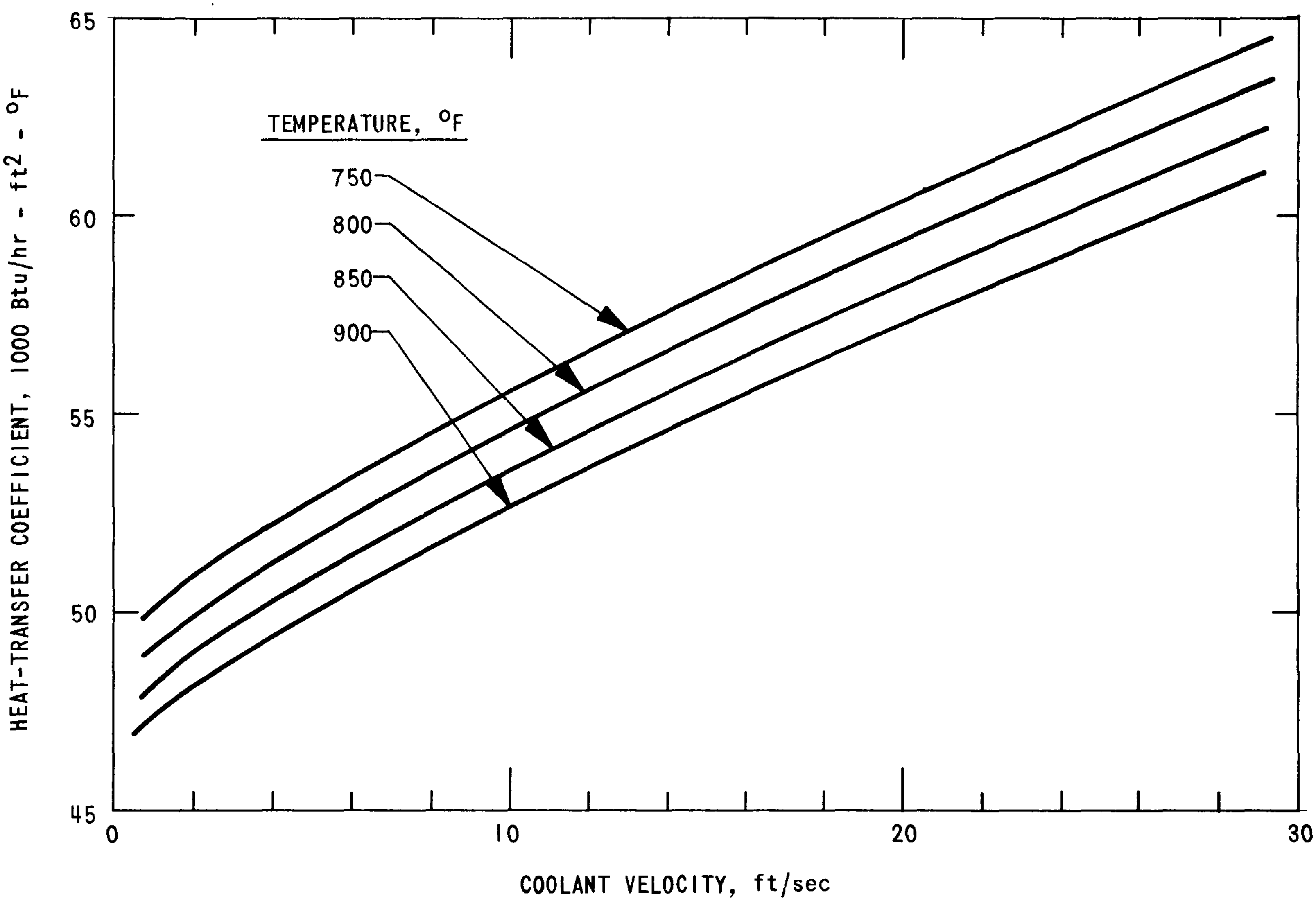

Fig. 12. Change in Heat-transfer Coefficient with Coolant Velocity and Temperature for a Blanket Element (Subbotin Equation)

Gas-plenum Length, XLPPP, and Sodium Length, XLNAO

Through use of acceptable tolerances, a range of plenum-gas lengths and sodium levels above the fuel pin may be calculated. Some extreme values are shown in Table I.

TABLE I. Calculated Values for XLPPP and XLNAO

Element	Sodium-level Condition	XLPPP	XLNAO
Mark-IA driver fuel,	Low	2.2442	0.4324
standard	Average	2.1353	0.5413
	High	2.0231	0.6535
Mark-II	Low	9.704	1.25
	Average	9.454	1.50
	High	9.204	1.75
Inner/outer blanket	Low	3.900	0.517
subassembly, standard	Average	3.538	0.879
	High	3.161	1.256

The code calculations of volume are based on tube diameters without taking into consideration any restrainer in the plenum region. Consequently, when XLPPP and XLNAO are hand calculated, the volume of any restrainer should be subtracted from the volume without the restrainer.

Q Array

Tables II and III give ratios for the axial distribution of the local-to-average power (fission) rating for the entire fuel rod (input values for the Q array) for 6 and 35 nodes respectively. Values for the standard Mark-IA element are based on a standard Mark-IA core (fuel 13.5 in. long) with a depleted-uranium blanket. Values for the Mark-II element (fuel 14.2 in. long) was based on a Mark-II element in the standard Mark-IA core with the depleted-uranium blanket (with the bottom of both the Mark-II and Mark-IA elements coinciding). Consequently, for substantially different core and

TABLE II. Q-array Values for Six Nodes

	Q		
Node	Mark-IA Element	Mark-II Element	Blanket Element
1	0.945	0.957	0.09
2	1.064	1.081	0.31
3	1.120	1.131	3.46
4	1.093	1.090	3.02
5	0.997	0.978	0.31
6	0.879	0.859	0.09

TABLE III. Q-array Values for 35 Nodes

Node	Q: Mark-IA Element	Mark-II Element	Blanket Element
1	0.888	0.897	0.05
2	0.911	0.922	0.06
3	0.935	0.947	0.08
4	0.958	0.971	0.10
5	0.981	0.995	0.12
6	1.003	1.018	0.14
7	1.023	1.039	0.16
8	1.042	1.059	0.20
9	1.060	1.077	0.26
10	1.075	1.092	0.36
11	1.089	1.105	0.50
12	1.100	1.116	0.71
13	1.109	1.124	1.14
14	1.115	1.129	2.20
15	1.119	1.131	2.93
16	1.120	1.131	3.24
17	1.120	1.127	3.40
18	1.116	1.121	3.46
19	1.111	1.113	3.40
20	1.102	1.102	3.24
21	1.092	1.088	2.93
22	1.079	1.073	2.20
23	1.065	1.055	1.14
24	1.049	1.036	0.71
25	1.031	1.016	0.50
26	1.012	0.994	0.36
27	0.992	0.972	0.26
28	0.971	0.950	0.20
29	0.950	0.928	0.16
30	0.930	0.907	0.14
31	0.909	0.887	0.12
32	0.890	0.869	0.10
33	0.871	0.853	0.08
34	0.855	0.840	0.06
35	0.841	0.831	0.05

blanket arrangements, these values will differ. Q-array values for the blanket are taken from data used for Fig. 2. The value for node 3 in Table II is the ratio of maximum-to-average values for the whole element. This value is used rather than the actual node value to determine the maximum fluence on the element as well as to calculate the maximum burnup.

APPENDIX B

Input/Output Samples for BEMOD-I

The sample inputs are for two problems. The first is for a driver-fuel element in a Mark-IA subassembly in row 1 during a 62.5-MWt irradiation. The second is for a blanket element in grid position 7N4 in a normal 50-MWt environment.

The maximum burnup limit, BUMAX, for the Mark-IA element is set high so that the problem will be terminated by the total ΔD/D limit, EMAX1, which was reached after approximately 60 burnup steps.

The blanket element was taken to 0.5 at. % maximum burnup, at which time the burnup step was decreased with change-case input to stabilize any unexpected oscillations before the element was exposed to 10%-overpower conditions via another set of change-case inputs. Both sets of change-case computations were allowed to run for only 10 burnup steps.

The complete output listing is not presented for either problem. For both problems the output consist of the input, calculations for a few burnup steps before terminal conditions, and terminal-condition computations. For the second problem two sets of change-case input and terminal conditions are also given, as well as room-temperature conditions.

COMPUTER INPUT DATA FORM

COST CODE ____________

PROGRAM BEMOD-I PROBLEM Sample Input ORIGINATOR DATE PAGE 1 OF 3

```
Burnup Maximum Set at 10 at. %; Total ΔD/D Limit Set at 2.0%
Reactor at 62.5 MWt with a ΔT of 222°F
BEMOD-I Input for a Mark-IA Fuel Pin in Row 1
    1    0    0    0    0    0    2                      0.        0.

    6  700.  222.   .174   32500   13.5   .156
.27   4.36 E20  2.1353   9.18   4.59 E-4  10.82   0.   4.79 E-22
2.321   6.015E-12  75.   -8.3822   .95 E05  -.01085   .0416   .05
0.   5.668   .00183   8.778 E-6   1.67 E-4   4.446 E-6   1.69 E-4   1.
.72   0.   0.   467.   -2.67 E-4   -22.62   7.   -86059.
1460000.   -4.44 E-4   9.329E-34   2.95 E07   -2.37 E-4   0.   -.541   .922
3.   20000   .47   E07   -2.37 E-4   .0118   7.71 E-4   .1731 E-10   .03
1.2   1.2   2.   .05   1836.   2.37 E15   10.   .144
.929   1.047   1.12   1.076   .985   .858
.745   .975   1.12   1.072   .875   .615   .447
1.5   1.5   1.5   1.5   1.5   1.5
33200.   20000.   33200.   0.   0.   0.   0.
2  3  8  0  1  1.92308   .3   14.7   .5413   64.2 E-6   680000.   22400.
910.   0.   0.   .07877   .4   2.   .7   140.
.04   .02   .25   .4   .6   .02   .001   .0005
```

AMD-9 (6-65)

COMPUTER INPUT DATA FORM

COST CODE ______________________

PROGRAM BEMOD-I PROBLEM Sample Input ORIGINATOR DATE PAGE 2 OF 3

200.	1	.12 E	-3 400	.	2.75	E-3 6	00.	4.4	1 E-3	800.	6	.25 E-3
1000.	8	.75 E	-3 111	2.	1.092	E-2 1	195.	1.4	58 E-2	1250.	1	.608 E-2

Burnup Maximum Set at 0.5 at. %; Total ΔD/D Limit Set at .02%

Normal Reactor Operation at 50 MWt

Blanket Subassembly in Position 7N4; ΔT = 191°F

0	1	0	0	0 1	1					.20		
780.	1	010.	1.2		-1.21	E-4 8	95.	250	.	1.2	E-5 1	000.
	35 7	00.	191	.	.493	5	4500.	55.		.457		
.27	4	.83 E	20 3.5	38	9.18	4	.59 E	-4 10.	82		4	.79 E-22
2.321	6	.015E-	12 75.		-8.38	22 9	.5 E	04 -.0	1085	.0416	.	005
	1	3.56	.00	0548	8.778	E-6 1	.67 E	-4				
					467.	-	2.67 E	-4 -22	.62	7.	-	8.6059E4
1.45	E05 -	.00044	4 9.3	29E-34	2.95	E07 -	2.37 E	-4		-.541	.	922
3.			4.5	38 E06	-2.37	E-4						
1.	1	.	1.		1.	1	400.	4.4	6 E14	.5	.	433
.05	.	06	.08		.1	.	11	.14		.16	.	2
.26	.	36	.5		.71	1	.14	2.2		2.93	3	.24
3.4	3	.46	3.4		3.24	2	.93	2.2		1.14	.	71
.5	.	36	.26		.2	.	16	.14		.11	.	1
.08	.	06	.05									

AMD-9 (6-65)

COMPUTER INPUT DATA FORM

COST CODE ____________

PROGRAM BEMOD-I PROBLEM Sample Input ORIGINATOR DATE PAGE 3 OF 3

1–6	7–12	13–18	19–24	25–30	31–36	37–42	43–48	49–54	55–60	61–66	67–72	73–80
.05	.	06	.08		.1	.	11	.14		.16	.	2
.26	.	36	.5		.71	1	.14	2.2		2.93	3	.24
3.4	3	.46	3.4		3.24	2	.93	2.2		1.14	.	71
.5	.	36	.26		.2	.	16	.14		.11	.	1
.08	.	06	.05		.05							
1.5	1	.5	1.5		1.5	1	.5	1.5		1.5	1	.5
1.5	1	.5	1.5		1.5	1	.5	1.5		1.5	1	.5
1.5	1	.5	1.5		1.5	1	.5	1.5		1.5	1	.5
1.5	1	.5	1.5		1.5	1	.5	1.5		1.5	1	.5
1.5	1	.5	1.5									
5720.	2	000.	572	0.								
2 3 8	0 1 .	948	.3		12.	.	879	6.42	E-5	6.8	E05 2	.24 E04
					10001.			1.			1	40.
.04	.	04	.9		1.	.	1			.001	.	0005
290.	.	002	540	.	.004	7	90.			1040.	.	0096
1165.	.	011	1240	0.	.012	1	265.			1415.	.	0174
Change-case Data; Burnup Increment (A26) Is Decreased												
1			1	1 1	4							
191.	5	4500.	1.		4.46	E14 5	720.	2.	E-16			
Change-case Data; 10% Overpower												

AMD 9 (6 65)

BURNUP MAXIMUM SET AT 10 ATOM PERCENT - TOTAL DELTA D/D LIMIT SET AT .02
REACTOR AT 62.5 MW - S/A DELTA T OF 222 DEGREES
BEMOD-I INPUT FOR A MARK I-A FUEL PIN IN ROW 1 - 222 DELTA T - 62.5 MW

NT	TCIN	DELTC	DOPP	HC	XLFPP	DPPP	AF	FCB	PLTBU
6	7.0000D 02	2.2200D 02	1.7400D-01	3.2500D 04	1.3500D 01	1.5600D-01	2.7000D-01	4.3600D 20	0.0

XLPPP	A1	A2	A3	A4	A5	A6	A9	A12	A13
2.1353D 00	9.1800D 00	4.5900D-04	1.0820D 01	0.0	4.7900D-22	2.3210D 00	6.0150D-12	7.5000D 01	-8.3822D 00

A14	A15	A25	A26	A27	A28	A29	A30	A31	A32
9.5000D 04	-1.0850D-02	4.1600D-02	5.0000D-02	0.0	5.6680D 00	1.8300D-03	8.7780D-06	1.6700D-04	4.6460D-06

A33	A34	A35	A36	A37	A38	A39	A40	A41	A42
1.6900D-04	1.0000D 00	7.2000D-01	0.0	0.0	4.6700D 02	-2.6700D-04	-2.2620D 01	7.0000D 00	-8.6059D 04

A43	A44	A45	A46	A47	A48	A49	A50	A51	A53
1.4600D 05	-4.4400D-04	9.3290D-34	2.9500D 07	-2.3700D-04	0.0	-5.4100D-01	9.2200D-01	3.0000D 00	2.0000D 04

A54	A55	A56	A57	A58	AA20	AA21	AB20	AB21	A300
4.7000D 06	-2.3700D-04	1.1800D-02	7.7100D-04	1.7130D-11	1.2000D 00	1.2000D 00	2.0000D 00	5.0000D-02	3.0000D-02

A401	A402	XLCL	XMNA	XMF	RHTHF	IOPT	ICALC	IPLT1	IRSWL	IHKNS	IFUEL	IPRNT
6.8000D 05	2.2400D 04	0.0	0.0	0.0	0.0	1	0	0	0	0	0	2

QPB	QPBD	QPBM	FFLX	BUMAX	EMAX1	TFMAX	ALPNA	PPO	XLNAO
3.3200D 04	2.0000D 04	3.3200D 04	2.3700D 15	1.0000D 01	2.0000D-02	1.8360D 03	6.4200D-05	1.4700D 01	5.4130D-01

NO	M1	NDL	NO1	NO2	GAMMA FRAC	DFDI	DOF	TB	GT	CORR	EPS1	EPS2
2	3	8	0	1	0.0	9.2308D-01	1.4400D-01	9.1000D 02	0.0	0.0	1.0000D-02	5.0000D-04

G1	G2	GB	PG	BUST	XNU	PMAX	TFBL	TFBH
7.8770D-02	7.0000D-01	2.0000D 00	1.4000D 02	4.0000D-01	3.0000D-01	0.0	0.0	0.0

GMO	GM1	V1	V2	FGR2	TFB1	TFB2	TFB3	TFB4	TFB5
4.0000D-02	2.0000D-02	2.5000D-01	4.0000D-01	6.0000D-01	0.0	0.0	0.0	0.0	0.0

TDL(I)=	2.0000D 02	4.0000D 02	6.0000D 02	8.0000D 02	1.0000D 03	1.1120D 03	1.1950D 03	1.2500D 03
DL(I)=	1.1200D-03	2.7500D-03	4.4100D-03	6.2500D-03	8.7500D-03	1.0920D-02	1.4580D-02	1.6080D-02

Q(N)	9.4500D-01	1.0640D 00	1.1200D 00	1.0930D 00	9.9700D-01	8.7900D-01	
QFFLX(N)	7.4500D-01	9.7500D-01	1.1200D 00	1.0720D 00	8.7500D-01	6.1500D-01	4.4700D-01
PO(N)	1.5000D 00	1.5000D 00	1.5000D 00	1.5000D 00	1.5000D 00	1.5000D 00	

BU= 2.8500000D 00 A20=1.000 A21=1.000 PP= 1.9333D 03 QLSUM= 1.9505D-03 TM= 3.6664D 03 XLP= 2.2374D-01 MAX BURNUP= 3.1920000D 00

N	XTC	XTCLO	TCLI	TFO	TFB	TF	QR	QL	PR	SP	SH	ST	E	ESW	ET	DVV	FLUENCE
1	717.	739.	783.	798.	931.	1056.	0.006851	0.000235	9.784D 02	15828.	7896.	23724.	6.853D-03	1.946D-03	8.799D-03	15.32	2.956
2	755.	779.	827.	845.	994.	1134.	0.007630	0.000348	1.043D 03	15828.	8640.	24468.	8.969D-03	3.821D-03	1.279D-02	16.59	3.328
3	795.	820.	871.	889.	1045.	1190.	0.007981	0.000417	1.045D 03	15828.	8837.	24665.	1.030D-02	5.577D-03	1.588D-02	17.18	3.504
4	836.	861.	909.	927.	1075.	1215.	0.007792	0.000403	1.039D 03	15828.	8398.	24225.	9.865D-03	5.573D-03	1.544D-02	16.88	3.419
5	875.	897.	941.	957.	1088.	1212.	0.007155	0.000320	9.898D 02	15828.	7485.	23313.	8.066D-03	4.046D-03	1.211D-02	15.85	3.119
6	909.	929.	968.	982.	1093.	1198.	0.006364	0.000227	9.414D 02	15828.	6470.	22298.	5.721D-03	2.212D-03	7.934D-03	14.57	2.750
7	926.	926.	926.	926.	0.	926.	0.002571	0.0	1.933D 03	15828.	0.	15828.	4.136D-03	1.285D-03	5.421D-03	0.0	0.0

BU= 2.9000000D 00 A20=1.000 A21=1.000 PP= 1.9484D 03 QLSUM= 2.0273D-03 TM= 3.7308D 03 XLP= 2.2711D-01 MAX BURNUP= 3.2480000D 00

N	XTC	XTCLO	TCLI	TFO	TFB	TF	QR	QL	PR	SP	SH	ST	E	ESW	ET	DVV	FLUENCE
1	717.	739.	783.	798.	931.	1056.	0.006965	0.000245	9.842D 02	15951.	7896.	23847.	7.283D-03	2.005D-03	9.288D-03	15.47	3.008
2	755.	779.	827.	845.	994.	1135.	0.007756	0.000362	1.047D 03	15951.	8640.	24591.	9.532D-03	3.937D-03	1.347D-02	16.76	3.387
3	795.	820.	871.	889.	1045.	1192.	0.008112	0.000433	1.050D 03	15951.	8837.	24788.	1.095D-02	5.746D-03	1.670D-02	17.36	3.565
4	836.	861.	909.	927.	1076.	1216.	0.007920	0.000419	1.034D 03	15951.	8398.	24349.	1.048D-02	5.741D-03	1.623D-02	17.05	3.479
5	875.	897.	941.	957.	1088.	1212.	0.007274	0.000333	9.966D 02	15951.	7485.	23436.	8.573D-03	4.168D-03	1.274D-02	16.00	3.174
6	909.	929.	968.	982.	1093.	1199.	0.006470	0.000236	9.508D 02	15951.	6470.	22421.	6.083D-03	2.279D-03	8.362D-03	14.71	2.798
7	926.	926.	926.	926.	0.	926.	0.002648	0.0	1.948D 03	15951.	0.	15951.	4.397D-03	1.324D-03	5.721D-03	0.0	0.0

BU= 2.9500000D 00 A20=1.000 A21=1.000 PP= 1.9676D 03 QLSUM= 2.1148D-03 TM= 3.7951D 03 XLP= 2.3080D-01 MAX BURNUP= 3.3040000D 00

N	XTC	XTCLO	TCLI	TFO	TFB	TF	QR	QL	PR	SP	SH	ST	E	ESW	ET	DVV	FLUENCE
1	717.	739.	783.	798.	931.	1057.	0.007078	0.000256	9.918D 02	16109.	7896.	24004.	7.726D-03	2.064D-03	9.790D-03	15.61	3.060
2	755.	779.	827.	845.	995.	1136.	0.007880	0.000378	1.052D 03	16109.	8640.	24749.	1.011D-02	4.053D-03	1.416D-02	16.92	3.445
3	795.	820.	871.	889.	1046.	1193.	0.008241	0.000451	1.053D 03	16109.	8837.	24946.	1.162D-02	5.916D-03	1.753D-02	17.52	3.627
4	836.	861.	909.	927.	1077.	1217.	0.008047	0.000436	1.036D 03	16109.	8398.	24506.	1.112D-02	5.911D-03	1.703D-02	17.22	3.539
5	875.	897.	941.	957.	1089.	1213.	0.007391	0.000347	1.002D 03	16109.	7485.	23594.	9.096D-03	4.292D-03	1.339D-02	16.15	3.228
6	909.	929.	968.	982.	1093.	1200.	0.006576	0.000246	9.580D 02	16109.	6470.	22578.	6.457D-03	2.347D-03	8.803D-03	14.83	2.846
7	926.	926.	926.	926.	0.	926.	0.002736	0.0	1.968D 03	16109.	0.	16109.	4.665D-03	1.363D-03	6.029D-03	0.0	0.0

BU= 3.0000000D 00 A20=1.000 A21=1.000 PP= 1.9871D 03 QLSUM= 2.2010D-03 TM= 3.8594D 03 XLP= 2.3435D-01 MAX BURNUP= 3.3600000D 00

N	XTC	XTCLO	TCLI	TFO	TFB	TF	QR	QL	PR	SP	SH	ST	E	ESW	ET	DVV	FLUENCE
1	717.	739.	783.	798.	932.	1058.	0.007191	0.000268	9.997D 02	16269.	7896.	24165.	8.182D-03	2.124D-03	1.031D-02	15.74	3.112
2	755.	779.	827.	845.	995.	1137.	0.008004	0.000393	1.058D 03	16269.	8640.	24909.	1.071D-02	4.172D-03	1.488D-02	17.08	3.504
3	795.	820.	871.	889.	1046.	1194.	0.008370	0.000469	1.062D 03	16269.	8837.	25106.	1.230D-02	6.089D-03	1.839D-02	17.69	3.688
4	836.	861.	909.	927.	1077.	1218.	0.008173	0.000453	1.038D 03	16269.	8398.	24666.	1.178D-02	6.084D-03	1.786D-02	17.38	3.599
5	875.	897.	941.	957.	1089.	1214.	0.007508	0.000361	1.003D 03	16269.	7485.	23754.	9.634D-03	4.417D-03	1.405D-02	16.30	3.283
6	909.	929.	968.	982.	1094.	1200.	0.006681	0.000257	9.651D 02	16269.	6470.	22738.	6.841D-03	2.415D-03	9.256D-03	14.96	2.894
7	926.	926.	926.	926.	0.	926.	0.002822	0.0	1.987D 03	16269.	0.	16269.	4.942D-03	1.403D-03	6.345D-03	0.0	0.0

BU= 3.0500000D 00 A20=1.000 A21=1.000 PP= 1.9999D 03 QLSUM= 2.2890D-03 TM= 3.9237D 03 XLP= 2.3877D-01 MAX BURNUP= 3.4160000D 00

N	XTC	XTCLO	TCLI	TFO	TFB	TF	QR	QL	PR	SP	SH	ST	E	ESW	ET	DVV	FLUENCE
1	717.	739.	783.	798.	932.	1059.	0.007303	0.000279	1.007D 03	16373.	7896.	24269.	8.647D-03	2.185D-03	1.083D-02	15.90	3.164
2	755.	779.	827.	845.	996.	1138.	0.008128	0.000409	1.064D 03	16373.	8640.	25013.	1.132D-02	4.291D-03	1.561D-02	17.25	3.562
3	795.	820.	871.	889.	1047.	1195.	0.008499	0.000488	1.055D 03	16373.	8837.	25210.	1.300D-02	6.263D-03	1.926D-02	17.87	3.749
4	836.	861.	909.	927.	1078.	1220.	0.008299	0.000471	1.039D 03	16373.	8398.	24771.	1.245D-02	6.258D-03	1.871D-02	17.56	3.659
5	875.	897.	941.	957.	1090.	1215.	0.007625	0.000375	1.010D 03	16373.	7485.	23858.	1.018D-02	4.543D-03	1.473D-02	16.46	3.338
6	909.	929.	968.	982.	1094.	1201.	0.006786	0.000267	9.732D 02	16373.	6470.	22843.	7.234D-03	2.484D-03	9.718D-03	15.10	2.943
7	926.	926.	926.	926.	0.	926.	0.002910	0.0	2.000D 03	16373.	0.	16373.	5.225D-03	1.443D-03	6.668D-03	0.0	0.0

EXCESSIVE STRAIN AT N= 3

BU= 3.1000000D 00 A20=1.000 A21=1.000 PP= 2.0219D 03 QLSUM= 2.3837D-03 TM= 3.9881D 03 XLP= 2.4257D-01 MAX BURNUP= 3.47200000 00

N	XTC	XTCLO	TCLI	TFO	TFB	TF	QR	QL	PR	SP	SH	ST	E	ESW	ET	DVV	FLUENCE
1	717.	739.	783.	798.	933.	1060.	0.007415	0.000292	1.015D 03	16553.	7896.	24449.	9.128D-03	2.247D-03	1.137D-02	16.03	3.215
2	755.	779.	827.	845.	997.	1139.	0.008251	0.000426	1.067D 03	16553.	8640.	25194.	1.195D-02	4.412D-03	1.636D-02	17.40	3.620
3	795.	820.	871.	889.	1048.	1197.	0.008627	0.000507	1.055D 03	16553.	8837.	25391.	1.372D-02	6.440D-03	2.016D-02	18.04	3.811
4	836.	861.	909.	927.	1078.	1221.	0.008424	0.000490	1.042D 03	16553.	8398.	24951.	1.314D-02	6.435D-03	1.957D-02	17.71	3.719
5	875.	897.	941.	957.	1090.	1216.	0.007741	0.000390	1.015D 03	16553.	7485.	24038.	1.075D-02	4.671D-03	1.542D-02	16.60	3.392
6	909.	929.	968.	982.	1094.	1202.	0.006890	0.000278	9.811D 02	16553.	6470.	23023.	7.640D-03	2.554D-03	1.019D-02	15.22	2.991
7	926.	926.	926.	926.	0.	926.	0.003005	0.0	2.022D 03	16553.	0.	16553.	5.516D-03	1.484D-03	7.000D-03	0.0	0.0

TERMINAL CONDITIONS FOR
BEMOD-I INPUT FOR A MARK I-A FUEL PIN IN ROW 1 - 222 DELTA T - 62.5 MW
ARE AS FOLLOWS (LAST ROW MEANS PLENUM)

BU= 3.1000000D 00 A20=1.000 A21=1.000 PP= 2.0219D 03 QLSUM= 2.3837D-03 TM= 3.9881D 03 XLP= 2.4257D-01 MAX BURNUP= 3.47200000 00

N	XTC	XTCLO	TCLI	TFO	TFB	TF	QR	QL	PR	SP	SH	ST	E	ESW	ET	DVV	FLUENCE
1	717.	739.	783.	798.	933.	1060.	0.007415	0.000292	1.015D 03	16553.	7896.	24449.	9.128D-03	2.247D-03	1.137D-02	16.03	3.215
2	755.	779.	827.	845.	997.	1139.	0.008251	0.000426	1.067D 03	16553.	8640.	25194.	1.195D-02	4.412D-03	1.636D-02	17.40	3.620
3	795.	820.	871.	889.	1048.	1197.	0.008627	0.000507	1.055D 03	16553.	8837.	25391.	1.372D-02	6.440D-03	2.016D-02	18.04	3.811
4	836.	861.	909.	927.	1078.	1221.	0.008424	0.000490	1.042D 03	16553.	8398.	24951.	1.314D-02	6.435D-03	1.957D-02	17.71	3.719
5	875.	897.	941.	957.	1090.	1216.	0.007741	0.000390	1.015D 03	16553.	7485.	24038.	1.075D-02	4.671D-03	1.542D-02	16.60	3.392
6	909.	929.	968.	982.	1094.	1202.	0.006890	0.000278	9.811D 02	16553.	6470.	23023.	7.640D-03	2.554D-03	1.019D-02	15.22	2.991
7	926.	926.	926.	926.	0.	926.	0.003005	0.0	2.022D 03	16553.	0.	16553.	5.516D-03	1.484D-03	7.000D-03	0.0	0.0

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BU MAX SET AT .5 PERCENT - TOTAL DELTA D/D SET AT .02
NORMAL REACTOR OPERATION AT 50 MW - BLANKET S/A
BLANKET S/A IN POSITION 7N4 - 50 MW - 191 DELTA T

    NT        TCIN       DELTC        DOPP         HC         XLFPP        DPPP         AF          FCB        PLTBU
    35     7.0000D 02  1.9100D 02  4.9300D-01  5.4500D 04  5.5000D 01  4.5700D-01  2.7000D-01  4.8300D 20  0.0

  XLPPP        A1          A2          A3          A4          A5          A6          A9          A12         A13
3.5380D 00  9.1800D 00  4.5900D-04  1.0820D 01  0.0         4.7900D-22  2.3210D 00  6.0150D-12  7.5000D 01 -8.3822D 00

   A14         A15         A25         A26         A27         A28         A29         A30         A31         A32
9.5000D 04 -1.0850D-02  4.1600D-02  5.0000D-03  0.0         1.3560D 01  5.4800D-04  8.7780D-06  1.6700D-04  0.0

   A33         A34         A35         A36         A37         A38         A39         A40         A41         A42
0.0         0.0         0.0         0.0         0.0         4.6700D 02 -2.6700D-04 -2.2620D 01  7.0000D 00 -8.6059D 04

   A43         A44         A45         A46         A47         A48         A49         A50         A51         A53
1.4500D 05 -4.4400D-04  9.3290D-34  2.9500D 07 -2.3700D-04  0.0        -5.4100D-01  9.2200D-01  3.0000D 00  0.0

   A54         A55         A56         A57         A58         AA20        AA21        AB20        AB21        A300
4.5380D 06 -2.3700D-04  0.0         0.0         0.0         1.0000D 00  1.0000D 00  1.0000D 00  1.0000D 00  0.0

  A401        A402        XLCL        XMUA        XMF         FHTHF      IOPT ICALC IPLT1 IRSWL IHKNS IFUEL IPRNT
6.8000D 05  2.2400D 04  0.0         0.0         0.0         0.0          0     1     0     0     0     1     1

   QPP        QPBD        QPBM        FFLX        BUMAX       FMAX1       TFMAX       ALPHA        PPD        XLNAO
5.7200D 03  2.0000D 03  5.7200D 03  4.4600D 14  5.0000D-01  5.0000D-02  1.4000D 03  6.4200D-05  1.2000D 01  8.7900D-01

 NO  M1  NDL  NO1  NO2  GAMMA FRAC    DFPI        DOF         TB          GT         COPR        EPS1        EPS2
 2   3    8    0    1   2.0000D-01  9.4800D-01  4.3300D-01  0.0         0.0         0.0         1.0000D-03  5.0000D-04

   G1          G2          GR          PG         BUST         XNU        PMAX         TFBL        TFBH
1.0000D 03  0.0         1.0000D 00  1.4000D 02  0.0         3.0000D-01  1.0000D 03  7.8000D 02  1.0100D 03

   GMO         GM1         V1          V2         FGF2        TFB1        TFB2        TFB3        TFB4        TFB5
4.0000D-02  4.0000D-02  9.0000D-01  1.0000D 00  1.0000D 00  1.2000D 00 -1.2100D-04  8.9500D 02  2.5000D 02  7.5000D-05


   TPL(I)=  2.9000D 02  5.4000D 02  7.9000D 02  1.0400D 03  1.1650D 03  1.2400D 03  1.2650D 03  1.4150D 03


    PL(I)=  2.0000D-03  4.0000D-03  6.5000D-03  9.6000D-03  1.1000D-02  1.2000D-02  1.6000D-02  1.7400D-02


Q(N)        5.0000D-02 6.0000D-02 8.0000D-02 1.0000D-01 1.2000D-01 1.4000D-01 1.6000D-01 2.0000D-01 2.6000D-01 3.6000D-01
Q(N)        5.0000D-01 7.1000D-01 1.1400D 00 2.2000D 00 2.9300D 00 3.2400D 00 3.4000D 00 3.4600D 00 3.4000D 00 3.2400D 00
Q(N)        2.9300D 00 2.2000D 00 1.1400D 00 7.1000D-01 5.0000D-01 3.6000D-01 2.6000D-01 2.0000D-01 1.6000D-01 1.4000D-01
Q(N)        1.2000D-01 1.0000D-01 8.0000D-02 6.0000D-02 5.0000D-02


QFFLX(N)    5.0000D-02 6.0000D-02 8.0000D-02 1.0000D-01 1.2000D-01 1.4000D-01 1.6000D-01 2.0000D-01 2.6000D-01 3.6000D-01
QFFLX(N)    5.0000D-01 7.1000D-01 1.1400D 00 2.2000D 00 2.9300D 00 3.2400D 00 3.4000D 00 3.4600D 00 3.4000D 00 3.2400D 00
QFFLX(N)    2.9300D 00 2.2000D 00 1.1400D 00 7.1000D-01 5.0000D-01 3.6000D-01 2.6000D-01 2.0000D-01 1.6000D-01 1.4000D-01
QFFLX(N)    1.2000D-01 1.0000D-01 8.0000D-02 6.0000D-02 5.0000D-02 5.0000D-02


PO(N)       1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00
PO(N)       1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00
PO(N)       1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00
PO(N)       1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00 1.5000D 00
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BU= 1.4333333D-01 A20=1.000 A21=1.000 PP= 1.9556D 02 QLSUM= 2.2597D-03 TM= 1.3400D 04 XLP= 6.9949D-01 MAX BURNUP= 4.9593333D-01

BU= 1.4416667D-01 A20=1.000 A21=1.000 PP= 1.9687D 02 QLSUM= 2.3491D-03 TM= 1.3478D 04 XLP= 7.0180D-01 MAX BURNUP= 4.9881667D-01

BU= 1.4500000D-01 A20=1.000 A21=1.000 PP= 1.9744D 02 QLSUM= 2.3627D-03 TM= 1.3556D 04 XLP= 7.0109D-01 MAX BURNUP= 5.0170000D-01

NO FAILURE UP TO BU = 1.4500000D-01 TM = 1.3556D 04

TERMINAL CONDITIONS FOR
BLANKET S/A IN POSITION 7N4 - 50 MW - 191 DELTA T
ARE AS FOLLOWS (LAST ROW MEANS PLENUM)

BU= 1.4500000D-01 A20=1.000 A21=1.000 PP= 1.9744D 02 QLSUM= 2.3627D-03 TM= 1.3556D 04 XLP= 7.0109D-01 MAX BURNUP= 5.0170000D-01

N	XTC	XTCLO	TCLI	TFO	TFB	TF	QF	QL	PF	SP	SH	ST	E	ESW	FT	DVV	FLUENCE
1	700.	700.	700.	701.	701.	702.	0.000133	0.0	-1.012D 05	2392.	53.	2444.	1.186D-06	6.508D-06	7.694D-06	0.04	0.109
2	700.	700.	701.	701.	702.	702.	0.000160	0.0	-1.012D 05	2392.	63.	2455.	1.423D-06	8.917D-06	1.034D-05	0.05	0.131
3	701.	701.	701.	701.	702.	703.	0.000213	0.0	-1.010D 05	2392.	84.	2476.	1.898D-06	1.465D-05	1.654D-05	0.06	0.174
4	701.	701.	702.	702.	703.	704.	0.000267	0.0	-1.009D 05	2392.	105.	2497.	2.372D-06	2.157D-05	2.394D-05	0.08	0.218
5	702.	702.	703.	703.	704.	706.	0.000320	0.0	-1.007D 05	2392.	126.	2518.	2.847D-06	2.964D-05	3.249D-05	0.10	0.261
6	703.	703.	704.	704.	705.	707.	0.000374	0.0	-1.005D 05	2392.	147.	2539.	3.321D-06	3.887D-05	4.219D-05	0.11	0.305
7	703.	704.	704.	705.	707.	709.	0.000427	0.0	-1.004D 05	2392.	168.	2560.	3.796D-06	4.924D-05	5.304D-05	0.13	0.348
8	704.	705.	706.	706.	709.	711.	0.000534	0.0	-1.001D 05	2392.	210.	2602.	4.745D-06	7.287D-05	7.762D-05	0.17	0.435
9	706.	706.	707.	708.	711.	714.	0.000694	0.0	-9.958D 04	2392.	273.	2664.	6.168D-06	1.157D-04	1.219D-04	0.23	0.566
10	707.	708.	710.	710.	714.	719.	0.000961	0.0	-9.876D 04	2392.	377.	2769.	8.540D-06	2.056D-04	2.141D-04	0.33	0.784
11	710.	710.	713.	713.	719.	725.	0.001334	0.0	-9.748D 04	2392.	523.	2914.	1.186D-05	3.698D-04	3.817D-04	0.50	1.088
12	712.	714.	718.	718.	727.	735.	0.001895	0.0	-9.520D 04	2392.	740.	3132.	1.684D-05	6.977D-04	7.146D-04	0.81	1.545
13	718.	719.	725.	727.	740.	754.	0.003042	0.0	-8.862D 04	2392.	1183.	3574.	2.704D-05	1.657D-03	1.684D-03	1.75	2.481
14	727.	729.	741.	743.	769.	795.	0.005871	0.0	-5.066D 04	2392.	2263.	4654.	5.219D-05	5.636D-03	5.688D-03	6.97	4.788
15	741.	744.	760.	763.	797.	831.	0.007650	0.000159	2.754D 02	3355.	2980.	6336.	8.855D-05	1.032D-02	1.041D-02	13.90	6.377
16	759.	761.	779.	782.	819.	857.	0.008401	0.000246	5.176D 02	6302.	3256.	9558.	8.308D-04	1.367D-02	1.450D-02	14.82	7.052
17	776.	779.	798.	801.	840.	879.	0.008756	0.000317	6.433D 02	7837.	3374.	11211.	2.178D-03	1.634D-02	1.852D-02	15.71	7.400
18	795.	798.	817.	820.	860.	899.	0.008961	0.000372	7.128D 02	8698.	3390.	12089.	3.475D-03	1.828D-02	2.176D-02	16.43	7.531
19	814.	815.	835.	838.	877.	915.	0.008689	0.000384	7.348D 02	8955.	3290.	12245.	3.889D-03	1.896D-02	2.284D-02	16.67	7.400
20	832.	834.	852.	855.	892.	928.	0.008296	0.000350	7.207D 02	8782.	3098.	11880.	3.439D-03	1.837D-02	2.180D-02	16.39	7.052
21	849.	851.	867.	870.	902.	935.	0.007537	0.000282	6.601D 02	8042.	2772.	10814.	2.180D-03	1.604D-02	1.822D-02	15.65	6.377
22	863.	864.	876.	878.	903.	928.	0.005658	0.000213	5.003D 02	6090.	2065.	8155.	5.708D-04	1.004D-02	1.061D-02	13.97	4.788
23	872.	873.	879.	880.	893.	905.	0.003013	0.000029	1.734D 02	2392.	1066.	3458.	2.704D-05	3.290D-03	3.317D-03	11.74	2.481
24	877.	877.	881.	882.	890.	898.	0.001895	0.0	1.552D 01	2392.	663.	3054.	1.684D-05	1.472D-03	1.489D-03	7.30	1.545
25	880.	881.	883.	884.	889.	895.	0.001334	0.0	-6.222D 01	2392.	466.	2857.	1.186D-05	8.109D-04	8.228D-04	5.14	1.088
26	882.	883.	885.	885.	889.	893.	0.000961	0.0	-1.151D 02	2392.	335.	2727.	8.541D-06	4.635D-04	4.721D-04	3.70	0.784
27	884.	884.	886.	886.	889.	892.	0.000694	0.0	-1.529D 02	2392.	242.	2633.	6.168D-06	2.662D-04	2.723D-04	2.67	0.566
28	885.	885.	887.	887.	889.	891.	0.000534	0.0	-1.756D 02	2392.	186.	2577.	4.745D-06	1.702D-04	1.749D-04	2.05	0.435
29	886.	886.	887.	887.	889.	891.	0.000427	0.0	-1.907D 02	2392.	149.	2540.	3.796D-06	1.163D-04	1.201D-04	1.64	0.348
30	887.	887.	888.	888.	890.	891.	0.000374	0.0	-1.983D 02	2392.	130.	2522.	3.321D-06	9.264D-05	9.596D-05	1.44	0.305
31	888.	889.	889.	889.	890.	891.	0.000320	0.0	-2.060D 02	2392.	111.	2503.	2.847D-06	7.123D-05	7.408D-05	1.23	0.261
32	888.	888.	889.	889.	890.	891.	0.000267	0.0	-2.139D 02	2392.	93.	2484.	2.372D-06	5.218D-05	5.455D-05	1.03	0.218
33	889.	889.	889.	889.	890.	891.	0.000213	0.0	-2.219D 02	2392.	74.	2466.	1.898D-06	3.565D-05	3.754D-05	0.82	0.174
34	889.	889.	890.	890.	890.	891.	0.000160	0.0	-2.307D 02	2392.	56.	2447.	1.423D-06	2.180D-05	2.323D-05	0.62	0.131
35	890.	890.	890.	890.	890.	891.	0.000133	0.0	-2.353D 02	2392.	46.	2438.	1.186D-06	1.597D-05	1.715D-05	0.51	0.109
36	890.	890.	890.	890.	0.	890.	0.009569	0.0	1.974D 02	2392.	0.	2392.	1.186D-06	1.597D-05	1.715D-05	0.0	0.0

CHANGE CASE DATA - TEST - BU INCREMENT IS DECREASED

CHANGES MAY BE MADE IN THE FOLLOWING PARAMETERS

DELTCN	HC	BUINC	FFLX	QPB	A26	PLTBU	ICALC	IRSWL	IPLT1	IPPNT	IOF	IT2	IT
1.9100D 02	5.4500D 04	1.0000D 00	4.4600D 14	5.7200D 03	2.0000D-06	0.0	1	0	0	1	1	1	1

N	Q	QFFLX
1	0.050000	0.050000
2	0.060000	0.060000
3	0.080000	0.080000
4	0.100000	0.100000
5	0.120000	0.120000
6	0.140000	0.140000
7	0.160000	0.160000
8	0.200000	0.200000
9	0.260000	0.260000
10	0.360000	0.360000
11	0.500000	0.500000
12	0.710000	0.710000
13	1.140000	1.140000
14	2.200000	2.200000
15	2.930000	2.930000
16	3.240000	3.240000
17	3.400000	3.400000
18	3.460000	3.460000
19	3.400000	3.400000
20	3.240000	3.240000
21	2.930000	2.930000
22	2.200000	2.200000
23	1.140000	1.140000
24	0.710000	0.710000
25	0.500000	0.500000
26	0.360000	0.360000
27	0.260000	0.260000
28	0.200000	0.200000
29	0.160000	0.160000
30	0.140000	0.140000
31	0.120000	0.120000
32	0.100000	0.100000
33	0.080000	0.080000
34	0.060000	0.060000
35	0.050000	0.050000
36	0.0	0.050000

BU= 1.4500201D-01 A20=1.000 A21=1.000 PP= 1.9692D 02 QLSUM= 2.3669D-03 TM= 1.3556D 04 XLP= 7.0305D-01 MAX BURNUP= 5.0170695D-01

BU= 1.4500401D-01 A20=1.000 A21=1.000 PP= 1.9722D 02 QLSUM= 2.3859D-03 TM= 1.3556D 04 XLP= 7.0343D-01 MAX BURNUP= 5.0171387D-01

BU= 1.4500600D-01 A20=1.000 A21=1.000 PP= 1.9734D 02 QLSUM= 2.3861D-03 TM= 1.3557D 04 XLP= 7.0307D-01 MAX BURNUP= 5.0172077D-01

BU= 1.4500800D-01 A20=1.000 A21=1.000 PP= 1.9734D 02 QLSUM= 2.3862D-03 TM= 1.3557D 04 XLP= 7.0307D-01 MAX BURNUP= 5.0172769D-01

BU= 1.4501000D-01 A20=1.000 A21=1.000 PP= 1.9734D 02 QLSUM= 2.3862D-03 TM= 1.3557D 04 XLP= 7.0307D-01 MAX BURNUP= 5.0173460D-01

N	XTC	XTCLO	TCLI	TFO	TFB	TF	QP	QL	PP	SP	SH	ST	E	ESW	ET	DVV	FLUENCE
1	700.	700.	700.	701.	701.	702.	0.000133	0.0	-1.012D 05	2390.	53.	2443.	1.186D-06	6.508D-06	7.695D-06	0.04	0.109
2	700.	700.	701.	701.	702.	702.	0.000160	0.0	-1.012D 05	2390.	63.	2454.	1.424D-06	8.918D-06	1.034D-05	0.05	0.131
3	701.	701.	701.	701.	702.	703.	0.000214	0.0	-1.010D 05	2390.	84.	2475.	1.898D-06	1.465D-05	1.655D-05	0.06	0.174
4	701.	701.	702.	702.	703.	704.	0.000267	0.0	-1.009D 05	2390.	105.	2496.	2.373D-06	2.157D-05	2.394D-05	0.08	0.218
5	702.	702.	703.	703.	704.	706.	0.000320	0.0	-1.007D 05	2390.	126.	2517.	2.847D-06	2.965D-05	3.249D-05	0.10	0.261
6	703.	703.	704.	704.	705.	707.	0.000374	0.0	-1.005D 05	2390.	147.	2538.	3.322D-06	3.887D-05	4.219D-05	0.11	0.305
7	703.	704.	704.	705.	707.	709.	0.000427	0.0	-1.004D 05	2390.	168.	2558.	3.797D-06	4.925D-05	5.304D-05	0.13	0.348
8	704.	705.	706.	706.	708.	711.	0.000534	0.0	-1.001D 05	2390.	210.	2600.	4.746D-06	7.288D-05	7.763D-05	0.17	0.435
9	706.	706.	707.	708.	711.	714.	0.000694	0.0	-9.958D 04	2390.	273.	2663.	6.170D-06	1.157D-04	1.219D-04	0.23	0.566
10	707.	708.	710.	710.	714.	719.	0.000961	0.0	-9.876D 04	2390.	377.	2767.	8.542D-06	2.056D-04	2.142D-04	0.33	0.784
11	710.	711.	713.	713.	719.	725.	0.001334	0.0	-9.748D 04	2390.	523.	2913.	1.186D-05	3.699D-04	3.817D-04	0.50	1.088
12	713.	714.	718.	718.	727.	735.	0.001895	0.0	-9.520D 04	2390.	740.	3130.	1.685D-05	6.978D-04	7.146D-04	0.82	1.545
13	718.	719.	725.	727.	740.	754.	0.003042	0.0	-8.863D 04	2390.	1183.	3573.	2.705D-05	1.657D-03	1.684D-03	1.75	2.481
14	727.	729.	741.	743.	769.	795.	0.005871	0.0	-5.066D 04	2390.	2263.	4653.	5.220D-05	5.637D-03	5.689D-03	6.97	4.789
15	741.	744.	760.	763.	797.	831.	0.007649	0.000171	2.764D 02	3357.	2980.	6337.	8.859D-05	1.033D-02	1.041D-02	13.90	6.378
16	758.	761.	779.	782.	819.	857.	0.008399	0.000248	5.179D 02	6305.	3256.	9561.	8.311D-04	1.367D-02	1.450D-02	14.82	7.053
17	776.	779.	798.	801.	840.	879.	0.008754	0.000320	6.433D 02	7837.	3374.	11211.	2.179D-03	1.635D-02	1.853D-02	15.71	7.401
18	795.	798.	817.	820.	850.	899.	0.008858	0.000376	7.138D 02	8698.	3390.	12088.	3.476D-03	1.828D-02	2.176D-02	16.43	7.531
19	814.	816.	835.	838.	877.	915.	0.008686	0.000388	7.348D 02	8955.	3290.	12245.	3.890D-03	1.896D-02	2.285D-02	16.68	7.401
20	832.	834.	852.	855.	892.	928.	0.008290	0.000356	7.170D 02	8737.	3098.	11835.	3.439D-03	1.837D-02	2.181D-02	16.44	7.053
21	849.	851.	867.	870.	903.	935.	0.007535	0.000285	6.601D 02	8043.	2772.	10815.	2.180D-03	1.604D-02	1.822D-02	15.65	6.378
22	863.	864.	876.	878.	903.	928.	0.005659	0.000213	5.003D 02	6091.	2065.	8156.	5.710D-04	1.004D-02	1.061D-02	13.97	4.789
23	872.	873.	879.	880.	893.	905.	0.003013	0.000029	1.735D 02	2390.	1066.	3457.	2.705D-05	3.291D-03	3.318D-03	11.74	2.481
24	877.	877.	881.	882.	890.	898.	0.001895	0.0	1.654D 01	2390.	663.	3053.	1.685D-05	1.472D-03	1.489D-03	7.30	1.545
25	880.	880.	883.	884.	889.	895.	0.001334	0.0	-6.221D 01	2390.	466.	2856.	1.186D-05	8.110D-04	8.229D-04	5.14	1.088
26	882.	883.	885.	885.	889.	893.	0.000961	0.0	-1.151D 02	2390.	335.	2725.	8.542D-06	4.636D-04	4.721D-04	3.70	0.784
27	884.	884.	886.	886.	889.	892.	0.000694	0.0	-1.529D 02	2390.	242.	2632.	6.170D-06	2.662D-04	2.724D-04	2.67	0.566
28	885.	885.	887.	887.	889.	891.	0.000534	0.0	-1.756D 02	2390.	186.	2576.	4.746D-06	1.702D-04	1.749D-04	2.05	0.435
29	886.	886.	887.	887.	889.	891.	0.000427	0.0	-1.907D 02	2390.	149.	2539.	3.797D-06	1.153D-04	1.201D-04	1.64	0.348
30	887.	887.	888.	888.	890.	891.	0.000374	0.0	-1.982D 02	2390.	130.	2520.	3.322D-06	9.265D-05	9.598D-05	1.44	0.305
31	888.	888.	889.	889.	890.	891.	0.000320	0.0	-2.060D 02	2390.	111.	2502.	2.847D-06	7.124D-05	7.408D-05	1.23	0.261
32	888.	888.	889.	889.	890.	891.	0.000267	0.0	-2.139D 02	2390.	93.	2483.	2.373D-06	5.219D-05	5.456D-05	1.03	0.218
33	889.	889.	889.	889.	890.	891.	0.000214	0.0	-2.219D 02	2390.	74.	2465.	1.898D-06	3.565D-05	3.755D-05	0.82	0.174
34	889.	889.	890.	890.	890.	891.	0.000160	0.0	-2.307D 02	2390.	56.	2446.	1.424D-06	2.181D-05	2.323D-05	0.62	0.131
35	890.	890.	890.	890.	890.	891.	0.000133	0.0	-2.353D 02	2390.	46.	2437.	1.186D-06	1.597D-05	1.716D-05	0.51	0.109
36	890.	890.	890.	890.	0.	890.	0.009593	0.0	1.973D 02	2390.	0.	2390.	1.186D-06	1.597D-05	1.716D-05	0.0	0.0

BU= 1.4501200D-01 A20=1.000 A21=1.000 PP= 1.9734D 02 QLSUM= 2.3863D-03 TM= 1.3557D 04 XLP= 7.0306D-01 MAX BURNUP= 5.0174152D-01

BU= 1.4501400D-01 A20=1.000 A21=1.000 PP= 1.9735D 02 QLSUM= 2.3863D-03 TM= 1.3557D 04 XLP= 7.0306D-01 MAX BURNUP= 5.0174844D-01

BU= 1.4501600D-01 A20=1.000 A21=1.000 PP= 1.9735D 02 QLSUM= 2.3863D-03 TM= 1.3557D 04 XLP= 7.0306D-01 MAX BURNUP= 5.0175536D-01

BU= 1.4501800D-01 A20=1.000 A21=1.000 PP= 1.9735D 02 QLSUM= 2.3864D-03 TM= 1.3558D 04 XLP= 7.0306D-01 MAX BURNUP= 5.0176228D-01

BU= 1.4502000D-01 A20=1.000 A21=1.000 PP= 1.9735D 02 QLSUM= 2.3864D-03 TM= 1.3558D 04 XLP= 7.0306D-01 MAX BURNUP= 5.0176920D-01

N	XTC	XTCLO	TCLI	TFO	TFR	TF	QF	QL	PC	SP	SH	ST	F	FSW	ET	DVV	FLUENCE
1	700.	700.	700.	701.	701.	702.	0.000133	0.0	-1.012D 05	2390.	53.	2443.	1.187D-06	6.509D-06	7.696D-06	0.04	0.109
2	700.	700.	701.	701.	702.	702.	0.000160	0.0	-1.012D 05	2390.	63.	2454.	1.424D-06	8.919D-06	1.034D-05	0.05	0.131
3	701.	701.	701.	701.	702.	703.	0.000214	0.0	-1.010D 05	2390.	84.	2475.	1.899D-06	1.465D-05	1.655D-05	0.06	0.174
4	701.	701.	702.	702.	703.	704.	0.000267	0.0	-1.009D 05	2390.	105.	2496.	2.373D-06	2.157D-05	2.394D-05	0.08	0.218
5	702.	702.	703.	703.	704.	706.	0.000320	0.0	-1.007D 05	2390.	126.	2517.	2.848D-06	2.965D-05	3.250D-05	0.10	0.261
6	703.	703.	704.	704.	705.	707.	0.000374	0.0	-1.005D 05	2390.	147.	2538.	3.323D-06	3.887D-05	4.220D-05	0.11	0.305
7	703.	704.	704.	705.	707.	709.	0.000427	0.0	-1.004D 05	2390.	168.	2559.	3.797D-06	4.925D-05	5.305D-05	0.13	0.348
8	704.	705.	706.	706.	708.	711.	0.000534	0.0	-1.001D 05	2390.	210.	2600.	4.747D-06	7.289D-05	7.764D-05	0.17	0.435
9	706.	706.	707.	708.	711.	714.	0.000694	0.0	-9.958D 04	2390.	273.	2663.	6.171D-06	1.157D-04	1.219D-04	0.23	0.566
10	707.	708.	710.	710.	714.	719.	0.000961	0.0	-9.876D 04	2390.	377.	2767.	8.544D-06	2.056D-04	2.142D-04	0.33	0.784
11	710.	710.	713.	713.	719.	725.	0.001334	0.0	-9.748D 04	2390.	523.	2913.	1.187D-05	3.699D-04	3.818D-04	0.50	1.088
12	713.	714.	718.	718.	727.	735.	0.001895	0.0	-9.520D 04	2390.	740.	3130.	1.685D-05	6.979D-04	7.147D-04	0.82	1.546
13	718.	719.	725.	727.	740.	754.	0.003043	0.0	-8.863D 04	2390.	1183.	3573.	2.706D-05	1.657D-03	1.684D-03	1.75	2.482
14	727.	729.	741.	743.	769.	795.	0.005872	0.0	-5.066D 04	2390.	2263.	4653.	5.222D-05	5.638D-03	5.690D-03	6.97	4.789
15	741.	744.	760.	763.	797.	831.	0.007649	0.000171	2.765D 02	3357.	2980.	6337.	8.863D-05	1.033D-02	1.042D-02	13.90	6.378
16	758.	761.	779.	782.	819.	857.	0.008490	0.000248	5.179D 02	6306.	3256.	9561.	8.314D-04	1.367D-02	1.450D-02	14.82	7.053
17	776.	779.	798.	801.	840.	879.	0.008754	0.000320	6.433D 02	7838.	3374.	11211.	2.179D-03	1.635D-02	1.853D-02	15.71	7.401
18	795.	798.	817.	820.	860.	399.	0.008859	0.000376	7.138D 02	8699.	3390.	12099.	3.477D-03	1.829D-02	2.176D-02	16.43	7.532
19	814.	816.	835.	838.	877.	915.	0.008686	0.000398	7.349D 02	8955.	3290.	12245.	3.891D-03	1.896D-02	2.285D-02	16.68	7.401
20	832.	834.	852.	855.	892.	928.	0.008291	0.000356	7.170D 02	8737.	3098.	11836.	3.440D-03	1.837D-02	2.181D-02	16.45	7.053
21	849.	851.	867.	870.	903.	935.	0.007535	0.000285	6.602D 02	8043.	2772.	10815.	2.181D-03	1.604D-02	1.822D-02	15.65	6.378
22	863.	864.	876.	878.	903.	928.	0.005659	0.000213	5.003D 02	6091.	2065.	8156.	5.712D-04	1.004D-02	1.061D-02	13.97	4.789
23	872.	873.	879.	880.	893.	905.	0.003014	0.000029	1.735D 02	2390.	1066.	3457.	2.706D-05	3.291D-03	3.318D-03	11.74	2.482
24	877.	877.	881.	882.	890.	898.	0.001895	0.0	1.656D 01	2390.	663.	3053.	1.685D-05	1.472D-03	1.489D-03	7.30	1.546
25	880.	880.	883.	884.	889.	895.	0.001334	0.0	-6.220D 01	2390.	466.	2856.	1.187D-05	8.111D-04	8.230D-04	5.14	1.088
26	882.	883.	885.	885.	889.	893.	0.000961	0.0	-1.151D 02	2390.	335.	2725.	8.544D-06	4.637D-04	4.722D-04	3.70	0.784
27	884.	884.	886.	886.	889.	892.	0.000694	0.0	-1.529D 02	2390.	242.	2632.	6.171D-06	2.662D-04	2.724D-04	2.67	0.566
28	885.	885.	887.	887.	889.	891.	0.000534	0.0	-1.756D 02	2390.	186.	2576.	4.747D-06	1.702D-04	1.750D-04	2.05	0.435
29	886.	886.	887.	887.	889.	891.	0.000427	0.0	-1.907D 02	2390.	149.	2539.	3.797D-06	1.163D-04	1.201D-04	1.64	0.348
30	887.	887.	888.	888.	890.	891.	0.000374	0.0	-1.983D 02	2390.	130.	2520.	3.323D-06	9.266D-05	9.599D-05	1.44	0.305
31	888.	888.	889.	889.	890.	891.	0.000320	0.0	-2.060D 02	2390.	111.	2502.	2.848D-06	7.125D-05	7.409D-05	1.23	0.261
32	888.	888.	889.	889.	890.	891.	0.000267	0.0	-2.139D 02	2390.	93.	2483.	2.373D-06	5.219D-05	5.457D-05	1.03	0.218
33	889.	889.	889.	889.	890.	891.	0.000214	0.0	-2.219D 02	2390.	74.	2465.	1.899D-06	3.565D-05	3.755D-05	0.82	0.174
34	989.	889.	890.	890.	890.	891.	0.000160	0.0	-2.307D 02	2390.	56.	2446.	1.424D-06	2.181D-05	2.323D-05	0.62	0.131
35	890.	890.	890.	890.	890.	891.	0.000132	0.0	-2.353D 02	2390.	46.	2437.	1.187D-06	1.597D-05	1.716D-05	0.51	0.109
36	890.	893.	990.	890.	0.	890.	0.003593	0.0	1.974D 02	2390.	0.	2390.	1.187D-06	1.597D-05	1.716D-05	0.0	0.0

NO FAILURE UP TO BU = 1.4502000D-01 TM = 1.3558D 04

TERMINAL CONDITIONS FOR
BLANKET S/A IN POSITION 7N4 - 50 MW - 191 DELTA T
ARE AS FOLLOWS (LAST ROW MEANS PLENUM)

BU= 1.4502000D-01 A20=1.000 A21=1.000 PP= 1.9735D 02 QLSUM= 2.3864D-03 TM= 1.3558D 04 XLP= 7.0306D-01 MAX BURNUP= 5.0176920D-01

N	XTC	XTCLO	TCLI	TFO	TFB	TF	QR	QL	PC	SP	SH	ST	E	ESW	ET	DVV	FLUENCE
1	700.	700.	700.	701.	701.	702.	0.000133	0.0	-1.012D 05	2390.	53.	2443.	1.187D-06	6.509D-06	7.696D-06	0.04	0.109
2	700.	700.	701.	701.	702.	702.	0.000160	0.0	-1.012D 05	2390.	63.	2454.	1.424D-06	8.919D-06	1.034D-05	0.05	0.131
3	701.	701.	701.	701.	702.	703.	0.000214	0.0	-1.010D 05	2390.	84.	2475.	1.899D-06	1.465D-05	1.655D-05	0.06	0.174
4	701.	701.	702.	702.	703.	704.	0.000267	0.0	-1.009D 05	2390.	105.	2496.	2.373D-06	2.157D-05	2.394D-05	0.08	0.218
5	702.	702.	703.	703.	704.	706.	0.000320	0.0	-1.007D 05	2390.	126.	2517.	2.848D-06	2.965D-05	3.250D-05	0.10	0.261
6	703.	703.	704.	704.	705.	707.	0.000374	0.0	-1.005D 05	2390.	147.	2538.	3.323D-06	3.887D-05	4.220D-05	0.11	0.305
7	703.	704.	704.	705.	707.	709.	0.000427	0.0	-1.004D 05	2390.	168.	2559.	3.797D-06	4.925D-05	5.305D-05	0.13	0.348
8	704.	705.	706.	706.	708.	711.	0.000534	0.0	-1.001D 05	2390.	210.	2600.	4.747D-06	7.289D-05	7.764D-05	0.17	0.435
9	706.	706.	707.	708.	711.	714.	0.000694	0.0	-9.958D 04	2390.	273.	2563.	6.171D-06	1.157D-04	1.219D-04	0.23	0.566
10	707.	708.	710.	710.	714.	719.	0.000961	0.0	-9.876D 04	2390.	377.	2767.	8.544D-06	2.056D-04	2.142D-04	0.33	0.784
11	710.	710.	713.	713.	719.	725.	0.001334	0.0	-9.748D 04	2390.	523.	2913.	1.187D-05	3.699D-04	3.818D-04	0.50	1.088
12	713.	714.	718.	718.	727.	735.	0.001895	0.0	-9.520D 04	2390.	740.	3130.	1.685D-05	6.979D-04	7.147D-04	0.82	1.546
13	718.	719.	725.	727.	740.	754.	0.003043	0.0	-9.853D 04	2390.	1183.	3573.	2.706D-05	1.657D-03	1.684D-03	1.75	2.482
14	727.	729.	741.	743.	769.	795.	0.005872	0.0	-5.066D 04	2390.	2263.	4653.	5.222D-05	5.638D-03	5.690D-03	6.97	4.789
15	741.	744.	760.	763.	797.	831.	0.007649	0.000171	2.765D 02	3357.	2980.	6337.	8.863D-05	1.033D-02	1.042D-02	13.90	6.378
16	758.	761.	779.	782.	819.	857.	0.008400	0.000248	5.179D 02	6306.	3256.	9561.	8.314D-04	1.367D-02	1.450D-02	14.82	7.053
17	776.	779.	798.	801.	840.	879.	0.008754	0.000320	6.433D 02	7838.	3374.	11211.	2.179D-03	1.635D-02	1.853D-02	15.71	7.401
18	795.	798.	817.	820.	860.	899.	0.008859	0.000376	7.138D 02	8699.	3390.	12089.	3.477D-03	1.829D-02	2.176D-02	16.43	7.532
19	814.	816.	835.	838.	877.	915.	0.008686	0.000388	7.349D 02	8955.	3290.	12245.	3.891D-03	1.896D-02	2.285D-02	16.68	7.401
20	832.	834.	852.	855.	892.	928.	0.008291	0.000356	7.170D 02	8737.	3098.	11836.	3.440D-03	1.837D-02	2.181D-02	16.45	7.053
21	849.	851.	867.	870.	903.	935.	0.007535	0.000285	6.602D 02	8043.	2772.	10815.	2.181D-03	1.604D-02	1.822D-02	15.65	6.378
22	863.	864.	876.	878.	903.	928.	0.005659	0.000213	5.003D 02	6091.	2065.	8155.	5.712D-04	1.004D-02	1.061D-02	13.97	4.789
23	872.	873.	879.	880.	893.	905.	0.003014	0.000029	1.735D 02	2390.	1066.	3457.	2.706D-05	3.291D-03	3.318D-03	11.74	2.482
24	877.	877.	881.	882.	890.	898.	0.001895	0.0	1.656D 01	2390.	663.	3053.	1.685D-05	1.472D-03	1.489D-03	7.30	1.546
25	880.	880.	883.	884.	889.	895.	0.001334	0.0	-6.220D 01	2390.	466.	2856.	1.187D-05	8.111D-04	8.230D-04	5.14	1.088
26	882.	883.	885.	885.	889.	893.	0.000961	0.0	-1.151D 02	2390.	335.	2725.	8.544D-06	4.637D-04	4.722D-04	3.70	0.784
27	884.	884.	886.	886.	889.	892.	0.000694	0.0	-1.529D 02	2390.	242.	2632.	6.171D-06	2.662D-04	2.724D-04	2.67	0.566
28	885.	885.	887.	887.	889.	891.	0.000534	0.0	-1.756D 02	2390.	186.	2576.	4.747D-06	1.702D-04	1.750D-04	2.05	0.435
29	886.	886.	887.	887.	889.	891.	0.000427	0.0	-1.907D 02	2390.	149.	2539.	3.797D-06	1.163D-04	1.201D-04	1.64	0.348
30	887.	887.	888.	888.	890.	891.	0.000374	0.0	-1.983D 02	2390.	130.	2520.	3.323D-06	9.256D-05	9.599D-05	1.44	0.305
31	888.	888.	889.	889.	890.	891.	0.000320	0.0	-2.061D 02	2390.	111.	2502.	2.848D-06	7.125D-05	7.409D-05	1.23	0.261
32	888.	888.	889.	889.	890.	891.	0.000267	0.0	-2.139D 02	2390.	93.	2483.	2.373D-06	5.219D-05	5.457D-05	1.03	0.218
33	889.	889.	889.	889.	890.	891.	0.000214	0.0	-2.219D 02	2390.	74.	2465.	1.899D-06	3.565D-05	3.755D-05	0.82	0.174
34	889.	889.	890.	890.	890.	891.	0.000160	0.0	-2.307D 02	2390.	56.	2446.	1.424D-06	2.181D-05	2.323D-05	0.62	0.131
35	890.	890.	890.	890.	890.	891.	0.000133	0.0	-2.353D 02	2390.	46.	2437.	1.187D-06	1.597D-05	1.716D-05	0.51	0.109
36	890.	890.	890.	890.	0.	890.	0.009593	0.0	1.974D 02	2390.	0.	2390.	1.187D-06	1.597D-05	1.716D-05	0.0	0.0

CHANGE CASE DATA - TEST - 10% OVERPOWER

CHANGES MAY BE MADE IN THE FOLLOWING PARAMETERS

DELTCM	HC	BUINC	FFLX	QPB	A26	PLTBU	ICALC	IPSWL	IPLT1	IPPNT	IOF	IT2	IT
2.1010D 02	5.4500D 04	1.0000D 00	4.9060D 14	6.2920D 03	2.0000D-06	0.0	0	0	0	1	1	1	1

N	Q	QFFLX
1	0.050000	0.050000
2	0.060000	0.060000
3	0.080000	0.080000
4	0.100000	0.100000
5	0.120000	0.120000
6	0.140000	0.140000
7	0.160000	0.160000
8	0.200000	0.200000
9	0.260000	0.260000
10	0.360000	0.360000
11	0.500000	0.500000
12	0.710000	0.710000
13	1.140000	1.140000
14	2.200000	2.200000
15	2.930000	2.930000
16	3.240000	3.240000
17	3.400000	3.400000
18	3.460000	3.460000
19	3.400000	3.400000
20	3.240000	3.240000
21	2.930000	2.930000
22	2.200000	2.200000
23	1.140000	1.140000
24	0.710000	0.710000
25	0.500000	0.500000
26	0.360000	0.360000
27	0.260000	0.260000
28	0.200000	0.200000
29	0.160000	0.150000
30	0.140000	0.140000
31	0.120000	0.120000
32	0.100000	0.100000
33	0.080000	0.080000
34	0.060000	0.060000
35	0.050000	0.050000
36	0.0	0.050000

BU= 1.4502000D-01 A20=1.000 A21=1.000 PP= 2.0873D 02 QLSUM= 2.3864D-03 TM= 1.3558D 04 XLP= 6.7724D-01 MAX BURNUP= 5.0176920D-01

BU= 1.4502200D-01 A20=1.000 A21=1.000 PP= 2.0853D 02 QLSUM= 2.3897D-03 TM= 1.3558D 04 XLP= 6.7806D-01 MAX BURNUP= 5.0177612D-01

BU= 1.4502400D-01 A20=1.000 A21=1.000 PP= 2.0863D 02 QLSUM= 2.3954D-03 TM= 1.3558D 04 XLP= 6.7816D-01 MAX BURNUP= 5.0178304D-01

BU= 1.4502800D-01 A20=1.000 A21=1.000 PP= 2.0863D 02 QLSUM= 2.3955D-03 TM= 1.3559D 04 XLP= 6.7816D-01 MAX BURNUP= 5.0179688D-01

BU= 1.4503000D-01 A20=1.000 A21=1.000 PP= 2.0863D 02 QLSUM= 2.3956D-03 TM= 1.3559D 04 XLP= 6.7816D-01 MAX BURNUP= 5.0180380D-01

N	XTC	XTCLO	TCLI	TFO	TFB	TF	QF	QL	PP	SP	SH	ST	E	ESW	ET	DVV	FLUENCE
1	700.	700.	701.	701.	701.	702.	0.000133	0.0	-1.012D 05	2528.	58.	2586.	1.187D-06	6.510D-06	7.697D-06	0.04	0.109
2	700.	701.	701.	701.	702.	703.	0.000160	0.0	-1.012D 05	2528.	69.	2598.	1.424D-06	8.920D-06	1.034D-05	0.05	0.131
3	701.	701.	701.	702.	703.	704.	0.000214	0.0	-1.010D 05	2528.	93.	2621.	1.899D-06	1.465D-05	1.655D-05	0.06	0.174
4	701.	702.	702.	702.	704.	705.	0.000267	0.0	-1.009D 05	2528.	116.	2644.	2.374D-06	2.157D-05	2.395D-05	0.08	0.218
5	702.	702.	703.	703.	705.	706.	0.000320	0.0	-1.007D 05	2528.	139.	2667.	2.849D-06	2.955D-05	3.250D-05	0.10	0.261
6	703.	703.	704.	704.	706.	708.	0.000374	0.0	-1.005D 05	2528.	162.	2690.	3.324D-06	3.888D-05	4.220D-05	0.11	0.305
7	704.	704.	705.	705.	707.	709.	0.000427	0.0	-1.004D 05	2528.	185.	2713.	3.798D-06	4.926D-05	5.306D-05	0.13	0.348
8	705.	705.	706.	707.	709.	712.	0.000534	0.0	-1.000D 05	2528.	231.	2759.	4.748D-06	7.290D-05	7.765D-05	0.17	0.435
9	706.	706.	708.	708.	712.	715.	0.000694	0.0	-9.952D 04	2528.	300.	2828.	6.173D-06	1.157D-04	1.219D-04	0.23	0.566
10	708.	709.	711.	711.	716.	721.	0.000961	0.0	-9.865D 04	2528.	414.	2943.	8.547D-06	2.057D-04	2.142D-04	0.33	0.784
11	711.	711.	714.	715.	721.	728.	0.001335	0.0	-9.728D 04	2528.	574.	3103.	1.187D-05	3.699D-04	3.818D-04	0.50	1.089
12	714.	715.	719.	720.	729.	739.	0.001895	0.0	-9.473D 04	2528.	813.	3341.	1.686D-05	6.980D-04	7.148D-04	0.82	1.546
13	720.	721.	728.	729.	744.	759.	0.003043	0.0	-8.704D 04	2528.	1299.	3827.	2.705D-05	1.657D-03	1.684D-03	1.75	2.482
14	730.	732.	745.	748.	776.	805.	0.005372	0.0	-3.950D 04	2528.	2483.	5011.	5.223D-05	5.638D-03	5.691D-03	6.97	4.789
15	745.	748.	766.	769.	807.	844.	0.007649	0.000171	3.779D 02	4595.	3267.	7862.	8.874D-05	1.033D-02	1.042D-02	13.90	6.379
16	764.	767.	786.	790.	831.	872.	0.008400	0.000248	5.993D 02	7300.	3565.	10865.	8.319D-04	1.367D-02	1.450D-02	14.82	7.053
17	784.	787.	807.	811.	854.	896.	0.008754	0.000321	7.197D 02	8770.	3689.	12459.	2.180D-03	1.635D-02	1.853D-02	15.71	7.402
18	804.	807.	828.	832.	875.	918.	0.008859	0.000376	7.591D 02	9373.	3702.	13075.	3.478D-03	1.829D-02	2.177D-02	16.43	7.532
19	825.	828.	848.	852.	894.	936.	0.008686	0.000389	7.574D 02	9230.	3588.	12819.	3.892D-03	1.896D-02	2.285D-02	16.68	7.402
20	845.	848.	857.	870.	910.	950.	0.008287	0.000361	7.043D 02	8581.	3375.	11957.	3.441D-03	1.837D-02	2.181D-02	16.45	7.053
21	863.	866.	883.	886.	922.	958.	0.007534	0.000287	6.206D 02	7560.	3017.	10577.	2.181D-03	1.604D-02	1.823D-02	15.65	6.379
22	879.	881.	894.	896.	923.	950.	0.005659	0.000213	4.639D 02	5646.	2246.	7892.	5.714D-04	1.004D-02	1.061D-02	13.97	4.789
23	889.	890.	896.	898.	912.	926.	0.003012	0.000030	1.635D 02	2528.	1159.	3687.	2.706D-05	3.292D-03	3.319D-03	11.75	2.482
24	894.	895.	899.	900.	909.	917.	0.001895	0.0	1.188D 01	2528.	720.	3248.	1.686D-05	1.472D-03	1.489D-03	7.30	1.546
25	898.	898.	901.	902.	908.	914.	0.001335	0.0	-6.579D 01	2528.	506.	3034.	1.187D-05	8.112D-04	8.231D-04	5.14	1.089
26	901.	901.	903.	903.	908.	912.	0.000961	0.0	-1.182D 02	2528.	364.	2892.	8.547D-06	4.637D-04	4.723D-04	3.70	0.784
27	902.	903.	904.	904.	908.	911.	0.000694	0.0	-1.557D 02	2528.	263.	2791.	6.173D-06	2.663D-04	2.724D-04	2.67	0.566
28	904.	904.	905.	905.	908.	910.	0.000534	0.0	-1.784D 02	2528.	202.	2730.	4.748D-06	1.702D-04	1.750D-04	2.06	0.435
29	905.	905.	906.	906.	908.	910.	0.000427	0.0	-1.937D 02	2528.	161.	2690.	3.799D-06	1.163D-04	1.201D-04	1.64	0.348
30	906.	906.	907.	907.	909.	910.	0.000374	0.0	-2.017D 02	2528.	141.	2669.	3.324D-06	9.268D-05	9.600D-05	1.44	0.305
31	907.	907.	907.	907.	909.	910.	0.000320	0.0	-2.097D 02	2528.	121.	2649.	2.849D-06	7.125D-05	7.410D-05	1.23	0.261
32	907.	907.	908.	908.	909.	910.	0.000267	0.0	-2.177D 02	2528.	101.	2629.	2.374D-06	5.220D-05	5.457D-05	1.03	0.218
33	908.	908.	908.	908.	909.	910.	0.000214	0.0	-2.259D 02	2528.	81.	2609.	1.899D-06	3.566D-05	3.756D-05	0.82	0.174
34	908.	908.	909.	909.	909.	910.	0.000160	0.0	-2.347D 02	2528.	60.	2589.	1.424D-06	2.181D-05	2.324D-05	0.62	0.131
35	909.	909.	909.	909.	910.	910.	0.000133	0.0	-2.397D 02	2528.	50.	2579.	1.187D-06	1.597D-05	1.716D-05	0.51	0.109
36	909.	909.	909.	909.	0.	909.	0.009602	0.0	2.086D 02	2528.	0.	2528.	1.187D-06	1.597D-05	1.716D-05	0.0	0.0

BU= 1.4503200D-01 A20=1.000 A21=1.000 PP= 2.0864D 02 QLSUM= 2.3957D-03 TM= 1.3559D 04 XLP= 6.7816D-01 MAX BURNUP= 5.0181072D-01

BU= 1.4503400D-01 A20=1.000 A21=1.000 PP= 2.0864D 02 QLSUM= 2.3958D-03 TM= 1.3559D 04 XLP= 6.7816D-01 MAX BURNUP= 5.0181764D-01

BU= 1.4503600D-01 A20=1.000 A21=1.000 PP= 2.0864D 02 QLSUM= 2.3959D-03 TM= 1.3559D 04 XLP= 6.7816D-01 MAX BURNUP= 5.0182456D-01

BU= 1.4503800D-01 A20=1.000 A21=1.000 PP= 2.0864D 02 QLSUM= 2.3960D-03 TM= 1.3559D 04 XLP= 6.7816D-01 MAX BURNUP= 5.0183148D-01

BU= 1.4504000D-01 A20=1.000 A21=1.000 PP= 2.0864D 02 QLSUM= 2.3961D-03 TM= 1.3560D 04 XLP= 6.7815D-01 MAX BURNUP= 5.0183840D-01

N	XTC	XTCLO	TCLI	TFO	TFR	TF	QP	QL	PS	SP	SH	ST	E	ESW	FT	DVV	FLUENCE
1	700.	700.	701.	701.	701.	702.	0.000133	0.0	-1.012D 05	2528.	58.	2586.	1.187D-05	5.511D-06	7.698D-06	0.04	0.109
2	700.	701.	701.	701.	702.	703.	0.000160	0.0	-1.012D 05	2528.	69.	2598.	1.425D-06	8.921D-06	1.035D-05	0.05	0.131
3	701.	701.	701.	702.	703.	704.	0.000214	0.0	-1.010D 05	2528.	93.	2621.	1.900D-06	1.465D-05	1.655D-05	0.06	0.174
4	701.	702.	702.	702.	704.	705.	0.000267	0.0	-1.009D 05	2528.	116.	2644.	2.375D-06	2.158D-05	2.395D-05	0.08	0.218
5	702.	702.	703.	703.	705.	706.	0.000320	0.0	-1.007D 05	2528.	139.	2667.	2.850D-06	2.966D-05	3.251D-05	0.10	0.261
6	703.	703.	704.	704.	706.	708.	0.000374	0.0	-1.005D 05	2528.	162.	2690.	3.325D-06	3.888D-05	4.221D-05	0.11	0.305
7	704.	704.	705.	705.	707.	709.	0.000427	0.0	-1.004D 05	2528.	185.	2713.	3.799D-06	4.927D-05	5.307D-05	0.13	0.348
8	705.	705.	706.	707.	709.	712.	0.000534	0.0	-1.000D 05	2528.	231.	2759.	4.749D-06	7.291D-05	7.766D-05	0.17	0.435
9	706.	706.	708.	708.	712.	715.	0.000694	0.0	-9.952D 04	2528.	300.	2828.	5.174D-06	1.157D-04	1.219D-04	0.23	0.566
10	708.	708.	711.	711.	716.	721.	0.000961	0.0	-9.865D 04	2528.	414.	2943.	8.549D-06	2.057D-04	2.142D-04	0.33	0.784
11	711.	711.	714.	715.	721.	728.	0.001335	0.0	-9.728D 04	2528.	574.	3103.	1.187D-05	3.700D-04	3.819D-04	0.50	1.089
12	714.	715.	719.	720.	729.	739.	0.001895	0.0	-9.473D 04	2528.	813.	3342.	1.686D-05	5.981D-04	7.149D-04	0.82	1.546
13	720.	721.	728.	729.	744.	759.	0.003043	0.0	-8.704D 04	2528.	1299.	3828.	2.707D-05	1.657D-03	1.685D-03	1.75	2.482
14	730.	732.	745.	748.	776.	805.	0.005873	0.0	-3.949D 04	2528.	2483.	5012.	5.224D-05	5.639D-03	5.691D-03	6.97	4.790
15	745.	749.	756.	769.	807.	844.	0.007650	0.000171	3.779D 02	4596.	3267.	7862.	8.885D-05	1.033D-02	1.042D-02	13.90	6.379
16	764.	767.	786.	790.	831.	872.	0.008400	0.000249	5.994D 02	7301.	3565.	10865.	8.324D-04	1.367D-02	1.451D-02	14.82	7.054
17	784.	787.	807.	811.	854.	896.	0.008755	0.000321	7.197D 02	8771.	3689.	12460.	2.181D-03	1.635D-02	1.853D-02	15.71	7.402
18	804.	807.	828.	832.	875.	918.	0.008860	0.000376	7.691D 02	9373.	3702.	13076.	3.479D-03	1.829D-02	2.177D-02	16.43	7.533
19	825.	828.	848.	852.	894.	936.	0.008687	0.000389	7.574D 02	9231.	3588.	12819.	3.893D-03	1.897D-02	2.286D-02	16.68	7.402
20	845.	848.	867.	870.	910.	950.	0.008288	0.000361	7.043D 02	8582.	3375.	11957.	3.442D-03	1.838D-02	2.182D-02	16.45	7.054
21	863.	866.	883.	886.	922.	958.	0.007535	0.000287	6.207D 02	7561.	3017.	10577.	2.182D-03	1.605D-02	1.823D-02	15.65	6.379
22	879.	881.	894.	896.	923.	950.	0.005660	0.000213	4.540D 02	5647.	2246.	7893.	5.715D-04	1.004D-02	1.061D-02	13.97	4.790
23	889.	893.	896.	898.	912.	926.	0.003013	0.000030	1.635D 02	2528.	1159.	3688.	2.707D-05	3.292D-03	3.319D-03	11.75	2.482
24	894.	895.	899.	900.	909.	917.	0.001895	0.0	1.190D 01	2528.	720.	3248.	1.686D-05	1.473D-03	1.489D-03	7.30	1.546
25	898.	898.	901.	902.	908.	914.	0.001335	0.0	-6.577D 01	2528.	506.	3035.	1.187D-05	8.113D-04	8.232D-04	5.14	1.089
26	901.	901.	903.	903.	908.	912.	0.000961	0.0	-1.182D 02	2528.	364.	2892.	8.549D-06	4.638D-04	4.723D-04	3.70	0.784
27	902.	903.	904.	904.	908.	911.	0.000694	0.0	-1.557D 02	2528.	263.	2791.	6.174D-06	2.653D-04	2.725D-04	2.67	0.566
28	904.	904.	905.	905.	908.	910.	0.000534	0.0	-1.784D 02	2528.	202.	2730.	4.749D-06	1.702D-04	1.750D-04	2.06	0.435
29	905.	905.	906.	906.	908.	910.	0.000427	0.0	-1.937D 02	2528.	161.	2690.	3.800D-06	1.164D-04	1.202D-04	1.64	0.348
30	906.	906.	907.	907.	909.	910.	0.000374	0.0	-2.017D 02	2528.	141.	2670.	3.325D-06	9.269D-05	9.601D-05	1.44	0.305
31	907.	907.	907.	907.	909.	910.	0.000320	0.0	-2.097D 02	2528.	121.	2649.	2.850D-06	7.126D-05	7.411D-05	1.23	0.261
32	907.	907.	908.	908.	909.	910.	0.000267	0.0	-2.177D 02	2528.	101.	2629.	2.375D-06	5.221D-05	5.458D-05	1.03	0.218
33	908.	908.	908.	908.	909.	910.	0.000214	0.0	-2.259D 02	2528.	81.	2609.	1.900D-06	3.566D-05	3.756D-05	0.82	0.174
34	908.	908.	909.	909.	909.	910.	0.000160	0.0	-2.347D 02	2528.	60.	2589.	1.425D-06	2.181D-05	2.324D-05	0.62	0.131
35	909.	909.	909.	909.	910.	910.	0.000133	0.0	-2.397D 02	2528.	50.	2579.	1.187D-06	1.598D-05	1.716D-05	0.51	0.109
36	909.	909.	909.	909.	0.	909.	0.009603	0.0	2.086D 02	2528.	0.	2528.	1.187D-06	1.597D-05	1.716D-05	0.0	0.0

NO FAILURE UP TO BU = 1.4504000D-01 TM = 1.2327D 04

TERMINAL CONDITIONS FOR
BLANKET S/A IN POSITION 7N4 - 50 MW - 191 DELTA T
ARE AS FOLLOWS (LAST ROW MEANS PLENUM)

BU= 1.4504000D-01 A20=1.000 A21=1.000 PP= 2.0864D 02 QLSUM= 2.3961D-03 TM= 1.3560D 04 XLP= 6.7816D-01 MAX BURNUP= 5.0183840D-01

N	XTC	XTCLO	TCLI	TFO	TFB	TF	QF	QL	PS	SP	SH	ST	E	ESW	ET	DVV	FLUENCE
1	700.	700.	701.	701.	701.	702.	0.000133	0.0	-1.012D 05	2528.	58.	2586.	1.187D-06	6.511D-06	7.698D-06	0.04	0.109
2	700.	701.	701.	701.	702.	703.	0.000160	0.0	-1.012D 05	2528.	69.	2598.	1.425D-06	8.921D-06	1.035D-05	0.05	0.131
3	701.	701.	701.	702.	703.	704.	0.000214	0.0	-1.010D 05	2528.	93.	2621.	1.900D-06	1.465D-05	1.655D-05	0.06	0.174
4	701.	702.	702.	702.	704.	705.	0.000267	0.0	-1.009D 05	2528.	116.	2644.	2.375D-06	2.158D-05	2.395D-05	0.08	0.218
5	702.	702.	703.	703.	705.	706.	0.000320	0.0	-1.007D 05	2528.	139.	2667.	2.850D-06	2.966D-05	3.251D-05	0.10	0.261
6	703.	703.	704.	704.	706.	708.	0.000374	0.0	-1.005D 05	2528.	162.	2690.	3.325D-06	3.888D-05	4.221D-05	0.11	0.305
7	704.	704.	705.	705.	707.	709.	0.000427	0.0	-1.004D 05	2528.	185.	2713.	3.799D-06	4.927D-05	5.307D-05	0.13	0.348
8	705.	705.	706.	707.	709.	712.	0.000534	0.0	-1.000D 05	2528.	231.	2759.	4.749D-06	7.291D-05	7.766D-05	0.17	0.435
9	706.	706.	708.	708.	712.	715.	0.000694	0.0	-9.952D 04	2528.	300.	2828.	6.174D-06	1.157D-04	1.219D-04	0.23	0.566
10	708.	708.	711.	711.	716.	721.	0.000961	0.0	-9.865D 04	2528.	414.	2943.	8.549D-06	2.057D-04	2.142D-04	0.33	0.784
11	711.	711.	714.	715.	721.	728.	0.001335	0.0	-9.728D 04	2528.	574.	3103.	1.187D-05	3.700D-04	3.819D-04	0.50	1.089
12	714.	715.	719.	720.	729.	739.	0.001895	0.0	-9.473D 04	2528.	813.	3342.	1.686D-05	6.981D-04	7.149D-04	0.82	1.546
13	720.	721.	728.	729.	744.	759.	0.003043	0.0	-8.704D 04	2528.	1299.	3828.	2.707D-05	1.657D-03	1.685D-03	1.75	2.482
14	730.	732.	745.	748.	776.	805.	0.005873	0.0	-3.949D 04	2528.	2483.	5012.	5.224D-05	5.639D-03	5.691D-03	6.97	4.790
15	745.	748.	756.	769.	807.	844.	0.007650	0.000171	3.779D 02	4596.	3267.	7862.	8.885D-05	1.033D-02	1.042D-02	13.90	6.379
16	764.	767.	786.	790.	831.	872.	0.008400	0.000248	5.994D 02	7301.	3565.	10865.	8.324D-04	1.367D-02	1.451D-02	14.82	7.054
17	784.	787.	807.	811.	854.	896.	0.008755	0.000321	7.197D 02	8771.	3689.	12460.	2.181D-03	1.635D-02	1.853D-02	15.71	7.402
18	804.	807.	828.	832.	875.	918.	0.008860	0.000375	7.691D 02	9373.	3702.	13076.	3.479D-03	1.829D-02	2.177D-02	16.43	7.533
19	825.	828.	848.	852.	894.	936.	0.008687	0.000389	7.574D 02	9231.	3588.	12819.	3.893D-03	1.897D-02	2.286D-02	16.68	7.402
20	845.	848.	867.	870.	910.	950.	0.008288	0.000361	7.043D 02	8582.	3375.	11957.	3.442D-03	1.838D-02	2.182D-02	16.45	7.054
21	863.	866.	883.	886.	922.	958.	0.007535	0.000287	6.207D 02	7561.	3017.	10577.	2.182D-03	1.605D-02	1.823D-02	15.65	6.379
22	879.	881.	894.	896.	923.	950.	0.005660	0.000213	4.640D 02	5647.	2246.	7893.	5.715D-04	1.004D-02	1.061D-02	13.97	4.790
23	889.	890.	896.	898.	912.	926.	0.003013	0.000030	1.635D 02	2528.	1159.	3688.	2.707D-05	3.292D-03	3.319D-03	11.75	2.482
24	894.	895.	899.	900.	909.	917.	0.001895	0.0	1.190D 01	2528.	720.	3248.	1.686D-05	1.473D-03	1.489D-03	7.30	1.546
25	898.	898.	901.	902.	908.	914.	0.001335	0.0	-6.577D 01	2528.	506.	3035.	1.187D-05	8.113D-04	8.232D-04	5.14	1.089
26	901.	901.	903.	903.	908.	912.	0.000961	0.0	-1.182D 02	2528.	364.	2892.	8.549D-06	4.638D-04	4.723D-04	3.70	0.784
27	902.	903.	904.	904.	908.	911.	0.000694	0.0	-1.557D 02	2528.	263.	2791.	6.174D-06	2.663D-04	2.725D-04	2.67	0.566
28	904.	904.	905.	905.	908.	910.	0.000534	0.0	-1.794D 02	2528.	202.	2730.	4.749D-06	1.702D-04	1.750D-04	2.06	0.435
29	905.	905.	906.	906.	908.	910.	0.000427	0.0	-1.937D 02	2528.	161.	2690.	3.800D-06	1.164D-04	1.202D-04	1.64	0.348
30	906.	906.	907.	907.	909.	910.	0.000374	0.0	-2.017D 02	2528.	141.	2670.	3.325D-06	9.269D-05	9.601D-05	1.44	0.305
31	907.	907.	907.	907.	909.	910.	0.000320	0.0	-2.097D 02	2528.	121.	2649.	2.850D-05	7.126D-05	7.411D-05	1.23	0.261
32	907.	907.	908.	908.	909.	910.	0.000267	0.0	-2.177D 02	2528.	101.	2629.	2.375D-06	5.221D-05	5.458D-05	1.03	0.218
33	908.	908.	908.	908.	909.	910.	0.000214	0.0	-2.259D 02	2528.	81.	2609.	1.900D-06	3.566D-05	3.756D-05	0.82	0.174
34	908.	908.	909.	909.	909.	910.	0.000160	0.0	-2.347D 02	2528.	60.	2589.	1.425D-06	2.181D-05	2.324D-05	0.62	0.131
35	909.	909.	909.	909.	910.	910.	0.000133	0.0	-2.397D 02	2528.	50.	2579.	1.187D-06	1.598D-05	1.716D-05	0.51	0.109
36	909.	909.	909.	909.	0.	909.	0.009603	0.0	2.086D 02	2528.	0.	2528.	1.187D-06	1.597D-05	1.716D-05	0.0	0.0

CONDITIONS OF FUEL ELEMENT BROUGHT TO ROOM TEMPERATURE ARE AS FOLLOWS

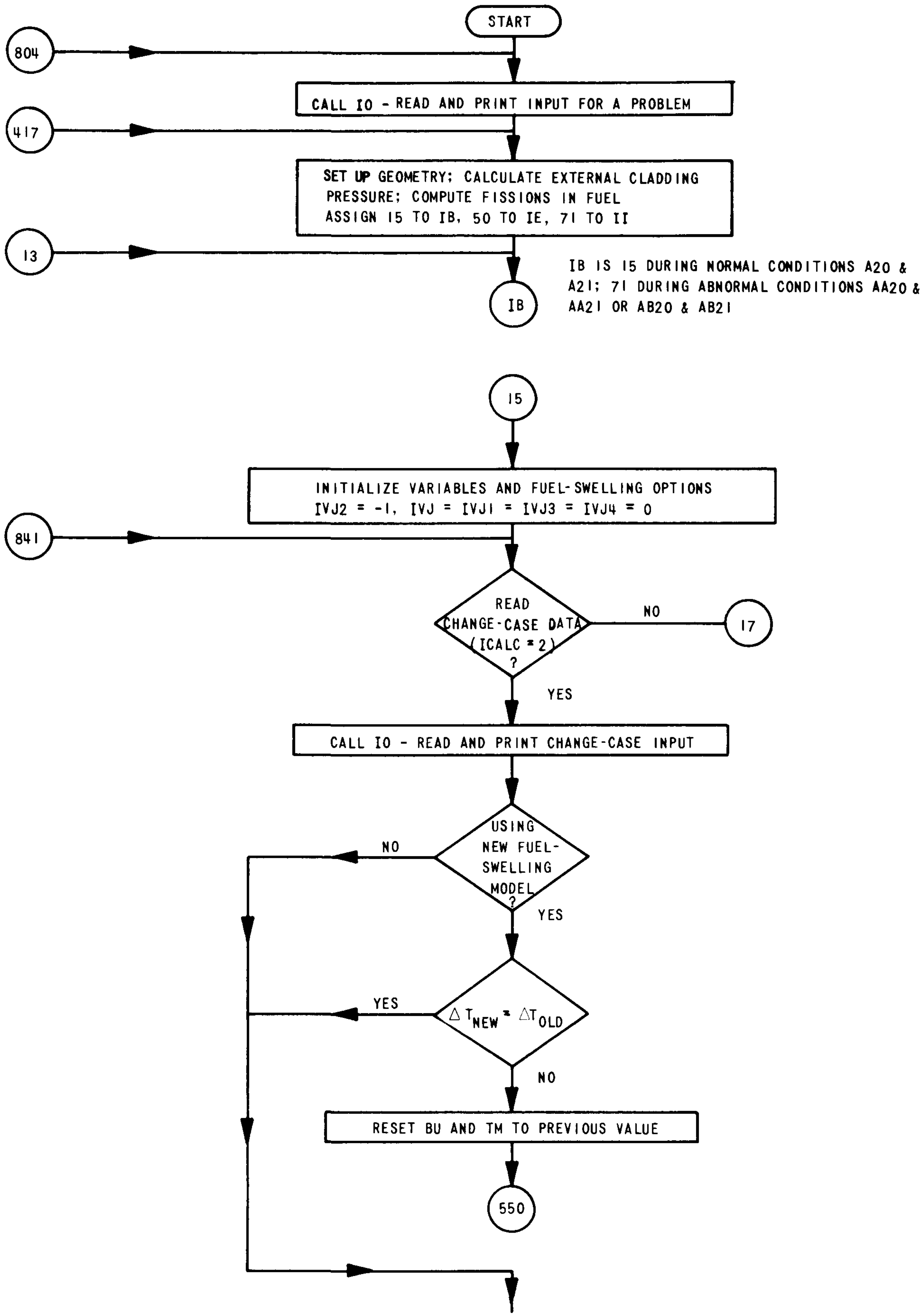
BU= 1.4504000D-01 A20=0.0 A21=0.0 PP= 1.6732D 01 DLSUM= 2.3961D-03 TM= 1.3560D 04 XLP= 1.7998D 00 MAX BURNUP= 5.0183840D-01

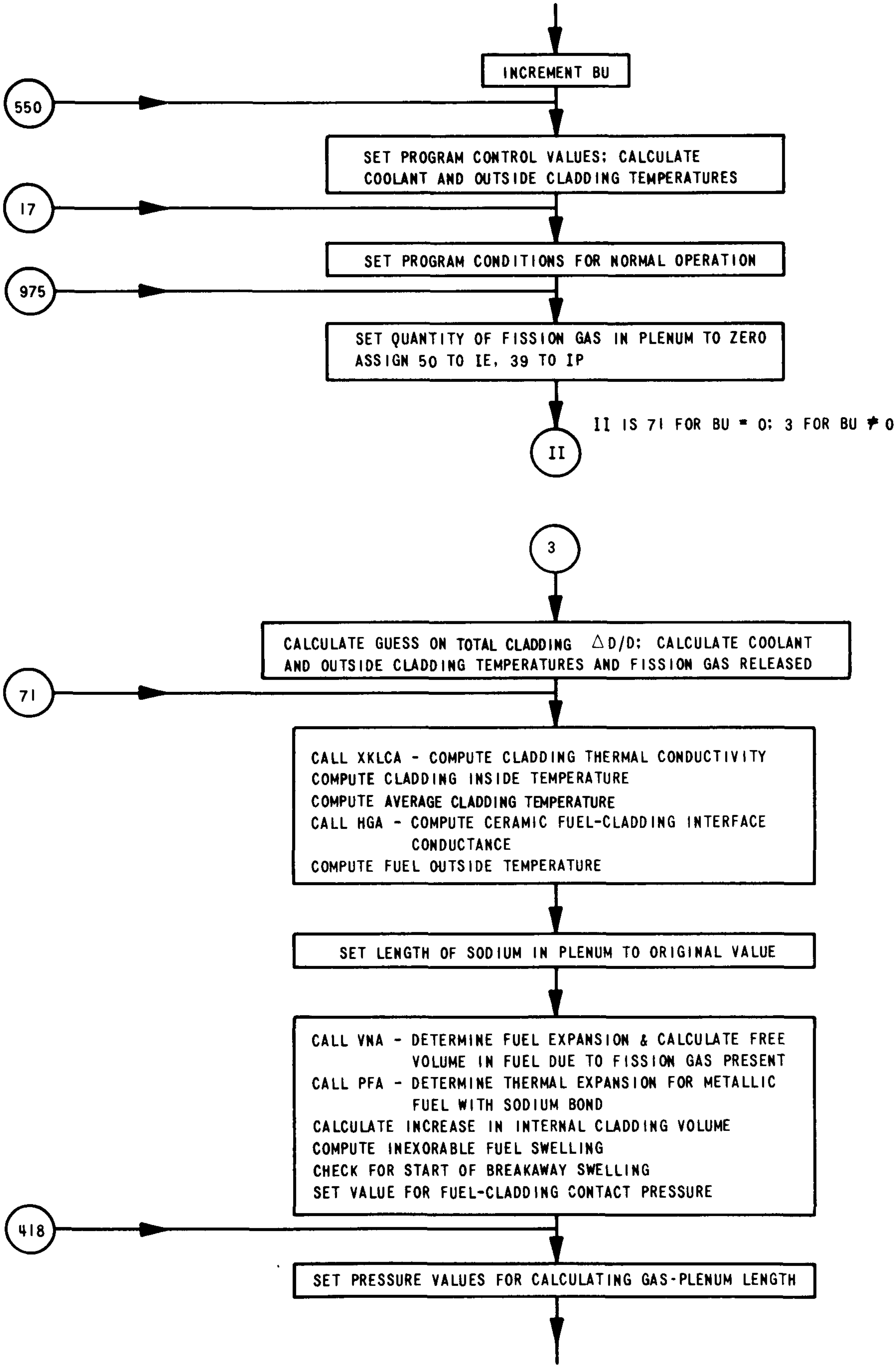
N	DR	DL	PF	SP	SH	ST	E	ESW	ET	DVV	TF	TFB	FLUENCE
1	0.000133	0.0	-1.1649D 05	185.	0.	185.	1.1873D-06	6.5107D-06	7.6981D-06	0.04	70.0	70.0	0.109
2	0.000160	0.0	-1.1641D 05	185.	0.	185.	1.4248D-06	8.9211D-06	1.0346D-05	0.05	70.0	70.0	0.131
3	0.000214	0.0	-1.1626D 05	185.	0.	185.	1.8997D-06	1.4653D-05	1.6553D-05	0.06	70.0	70.0	0.174
4	0.000267	0.0	-1.1611D 05	185.	0.	185.	2.3747D-06	2.1576D-05	2.3950D-05	0.08	70.0	70.0	0.218
5	0.000320	0.0	-1.1596D 05	185.	0.	185.	2.8496D-06	2.9656D-05	3.2506D-05	0.10	70.0	70.0	0.261
6	0.000374	0.0	-1.1581D 05	185.	0.	185.	3.3246D-06	3.8884D-05	4.2209D-05	0.11	70.0	70.0	0.305
7	0.000427	0.0	-1.1565D 05	185.	0.	185.	3.7995D-06	4.9266D-05	5.3065D-05	0.13	70.0	70.0	0.348
8	0.000534	0.0	-1.1534D 05	185.	0.	185.	4.7494D-06	7.2910D-05	7.7659D-05	0.17	70.0	70.0	0.435
9	0.000694	0.0	-1.1487D 05	185.	0.	185.	6.1742D-06	1.1574D-04	1.2191D-04	0.23	70.0	70.0	0.566
10	0.000961	0.0	-1.1405D 05	185.	0.	185.	8.5488D-06	2.0569D-04	2.1424D-04	0.33	70.0	70.0	0.784
11	0.001335	0.0	-1.1280D 05	185.	0.	185.	1.1873D-05	3.6999D-04	3.8187D-04	0.50	70.0	70.0	1.089
12	0.001895	0.0	-1.1060D 05	185.	0.	185.	1.6860D-05	6.9806D-04	7.1492D-04	0.82	70.0	70.0	1.546
13	0.003042	0.0	-1.0452D 05	185.	0.	185.	2.7071D-05	1.6575D-03	1.6845D-03	1.75	70.0	70.0	2.482
14	0.005873	0.0	-7.1501D 04	185.	0.	185.	5.2243D-05	5.6391D-03	5.6913D-03	6.97	70.0	70.0	4.790
15	0.007650	0.000171	1.9522D 03	23824.	0.	23824.	8.8853D-05	1.0329D-02	1.0418D-02	13.90	70.0	70.0	6.379
16	0.008400	0.000248	2.1186D 03	25856.	0.	25856.	8.3241D-04	1.3673D-02	1.4505D-02	14.82	70.0	70.0	7.054
17	0.008755	0.000321	2.1121D 03	25776.	0.	25776.	2.1810D-03	1.6353D-02	1.8534D-02	15.71	70.0	70.0	7.402
18	0.008860	0.000376	2.1349D 03	26055.	0.	26055.	3.4788D-03	1.8291D-02	2.1770D-02	16.43	70.0	70.0	7.533
19	0.008687	0.000389	2.1784D 03	26586.	0.	26586.	3.8926D-03	1.8965D-02	2.2858D-02	16.68	70.0	70.0	7.402
20	0.008288	0.000361	2.2336D 03	27260.	0.	27260.	3.4419D-03	1.8375D-02	2.1817D-02	16.45	70.0	70.0	7.054
21	0.007535	0.000287	2.3134D 03	28235.	0.	28235.	2.1819D-03	1.6046D-02	1.8228D-02	15.65	70.0	70.0	6.379
22	0.005660	0.000213	2.4349D 03	29719.	0.	29719.	5.7151D-04	1.0043D-02	1.0615D-02	13.97	70.0	70.0	4.790
23	0.003013	0.000030	-3.8174D 03	185.	0.	185.	2.7071D-05	3.2920D-03	3.3191D-03	11.75	70.0	70.0	2.482
24	0.001895	0.0	-4.5247D 04	185.	0.	185.	1.6860D-05	1.4726D-03	1.4894D-03	7.30	70.0	70.0	1.546
25	0.001335	0.0	-6.5318D 04	185.	0.	185.	1.1873D-05	8.1134D-04	8.2322D-04	5.14	70.0	70.0	1.089
26	0.000961	0.0	-7.9892D 04	185.	0.	185.	8.5489D-06	4.6377D-04	4.7232D-04	3.70	70.0	70.0	0.784
27	0.000694	0.0	-8.5864D 04	185.	0.	185.	6.1742D-06	2.6630D-04	2.7247D-04	2.67	70.0	70.0	0.566
28	0.000534	0.0	-9.3719D 04	185.	0.	185.	4.7494D-06	1.7025D-04	1.7500D-04	2.06	70.0	70.0	0.435
29	0.000427	0.0	-9.8509D 04	185.	0.	185.	3.7995D-06	1.1636D-04	1.2016D-04	1.64	70.0	70.0	0.348
30	0.000374	0.0	-1.0072D 05	185.	0.	185.	3.3246D-06	9.2689D-05	9.6013D-05	1.44	70.0	70.0	0.305
31	0.000320	0.0	-1.0300D 05	185.	0.	185.	2.8496D-06	7.1264D-05	7.4113D-05	1.23	70.0	70.0	0.261
32	0.000267	0.0	-1.0532D 05	185.	0.	185.	2.3747D-06	5.2207D-05	5.4582D-05	1.03	70.0	70.0	0.218
33	0.000214	0.0	-1.0765D 05	185.	0.	185.	1.8998D-06	3.5663D-05	3.7563D-05	0.82	70.0	70.0	0.174
34	0.000160	0.0	-1.1000D 05	185.	0.	185.	1.4248D-06	2.1814D-05	2.3239D-05	0.62	70.0	70.0	0.131
35	0.000133	0.0	-1.1113D 05	185.	0.	185.	1.1874D-06	1.5976D-05	1.7163D-05	0.51	70.0	70.0	0.109
36	0.009603	0.0	1.6732D 01	185.	0.	185.	1.1874D-06	1.5975D-05	1.7162D-05	0.0	70.0	0.0	0.0

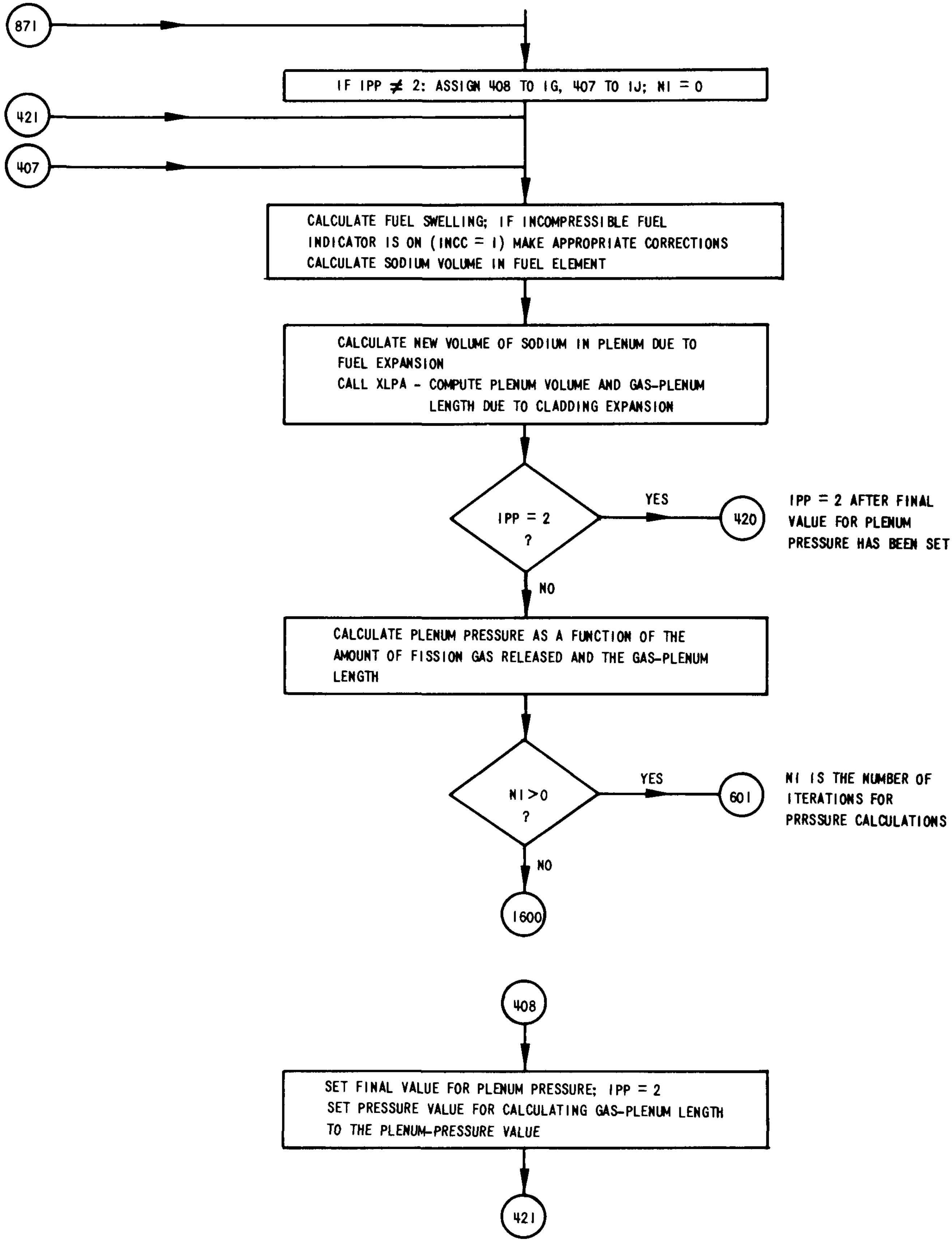
ALL PROBLEMS HAVE BEEN PROCESSED.

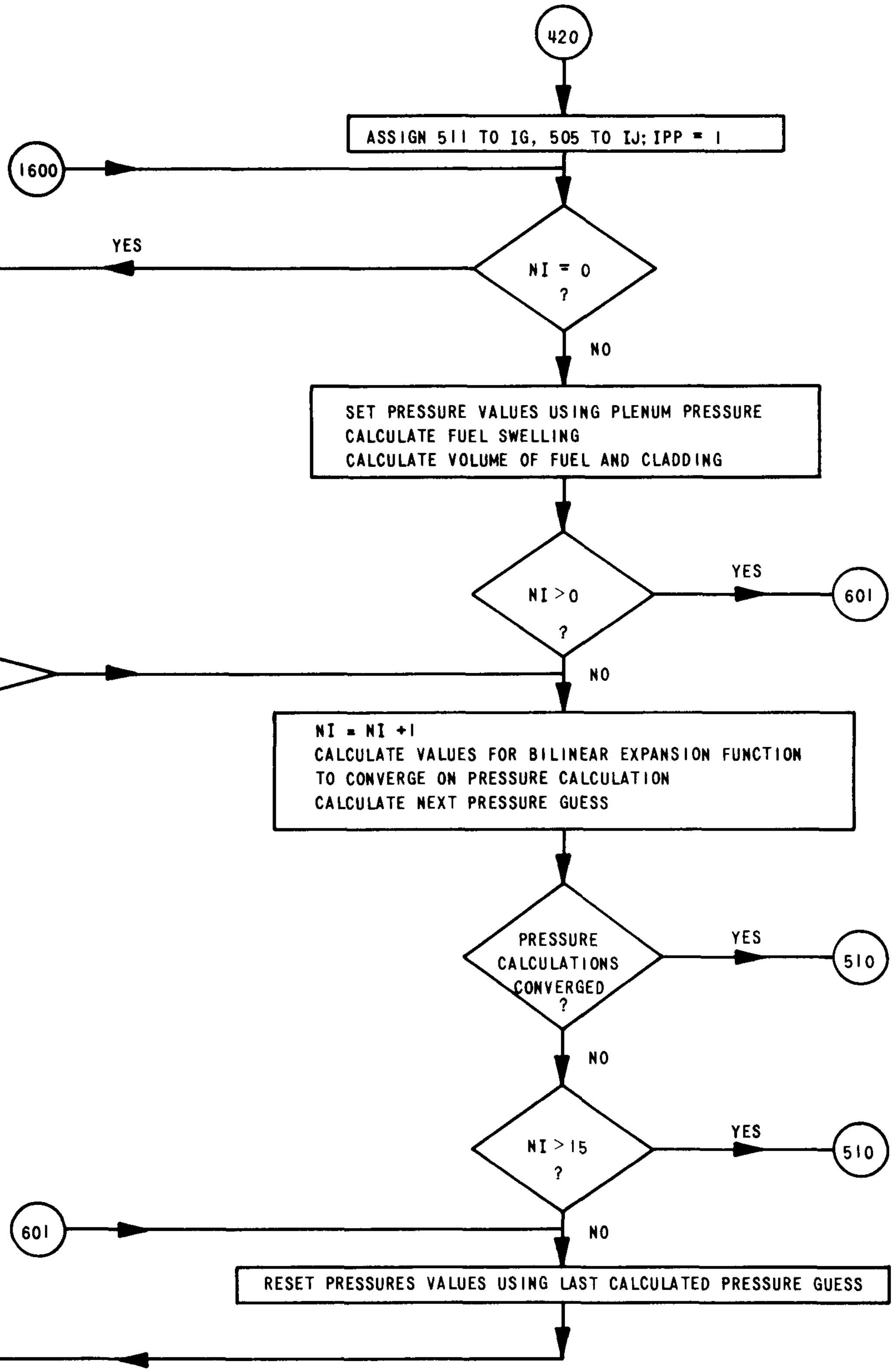
APPENDIX C

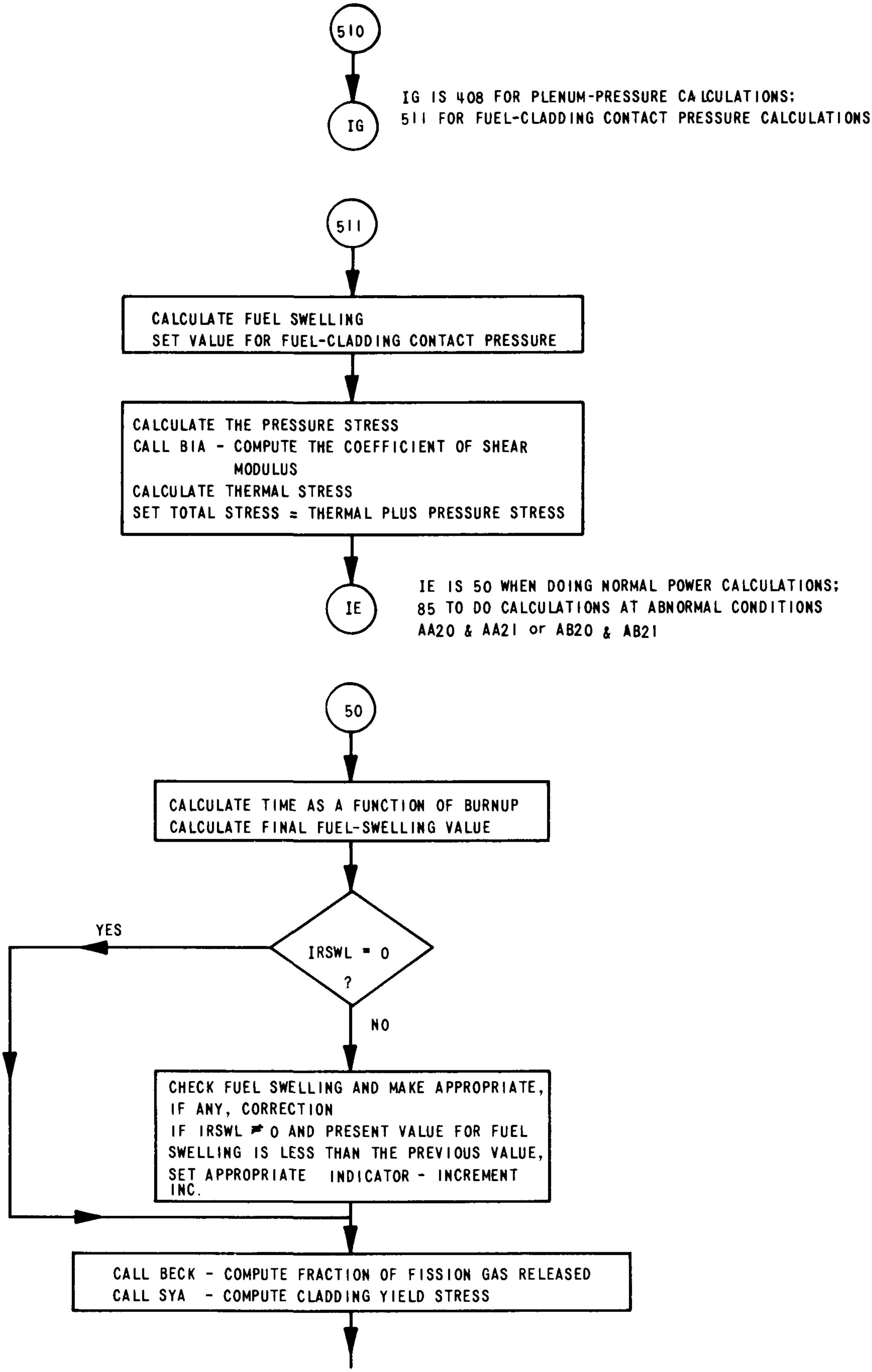
Program Flowchart and Listing for BEMOD-I

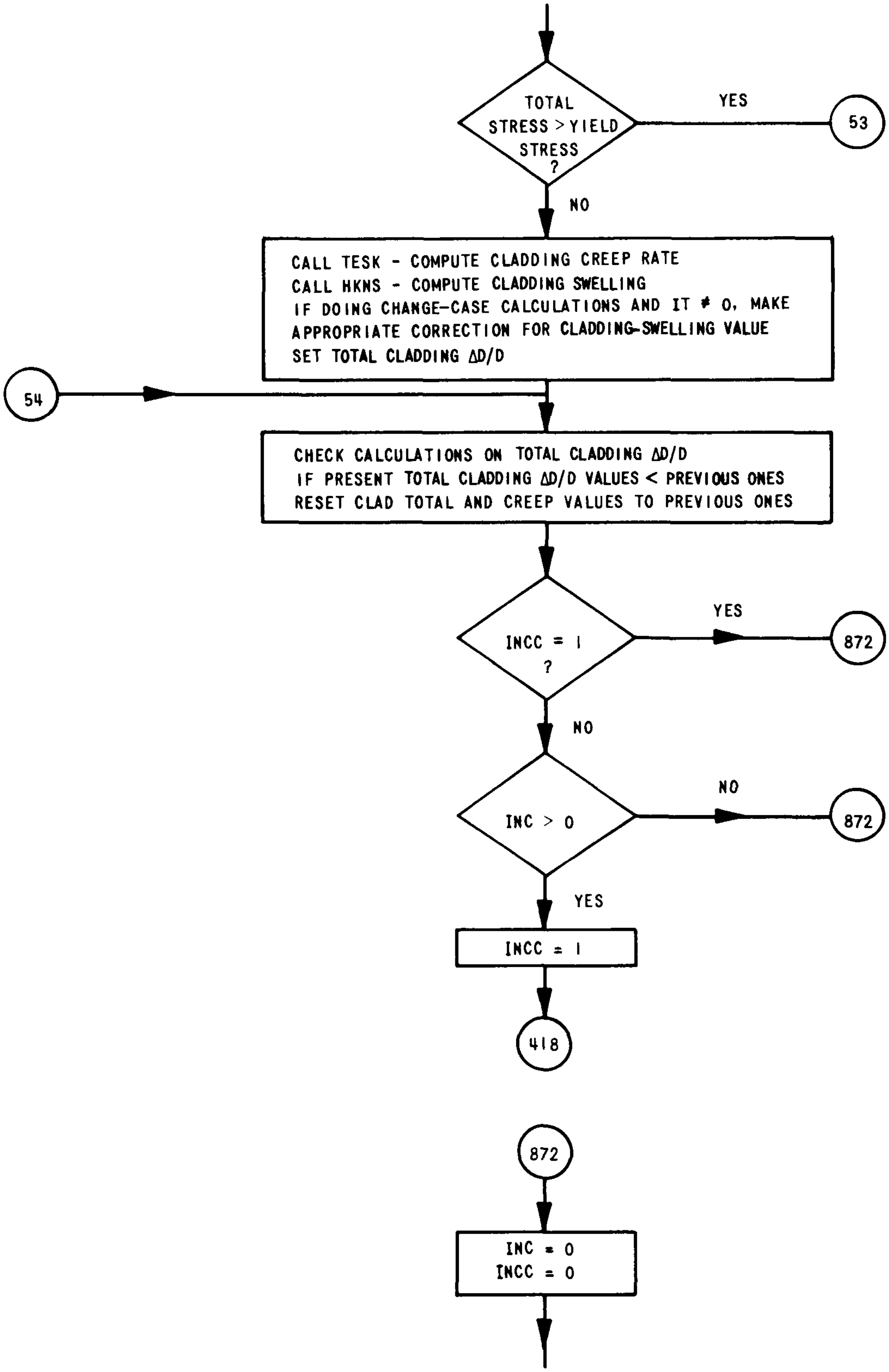

START
804
CALL IO - READ AND PRINT INPUT FOR A PROBLEM
417
SET UP GEOMETRY; CALCULATE EXTERNAL CLADDING PRESSURE; COMPUTE FISSIONS IN FUEL ASSIGN 15 TO IB, 50 TO IE, 71 TO II
13
IB
IB IS 15 DURING NORMAL CONDITIONS A20 & A21; 71 DURING ABNORMAL CONDITIONS AA20 & AA21 OR AB20 & AB21
15
INITIALIZE VARIABLES AND FUEL-SWELLING OPTIONS IVJ2 = -1, IVJ = IVJ1 = IVJ3 = IVJ4 = 0
841
READ CHANGE-CASE DATA (ICALC = 2) ?
NO
17
YES
CALL IO - READ AND PRINT CHANGE-CASE INPUT
USING NEW FUEL-SWELLING MODEL ?
NO
YES
ΔT NEW = ΔT OLD
YES
NO
RESET BU AND TM TO PREVIOUS VALUE
550

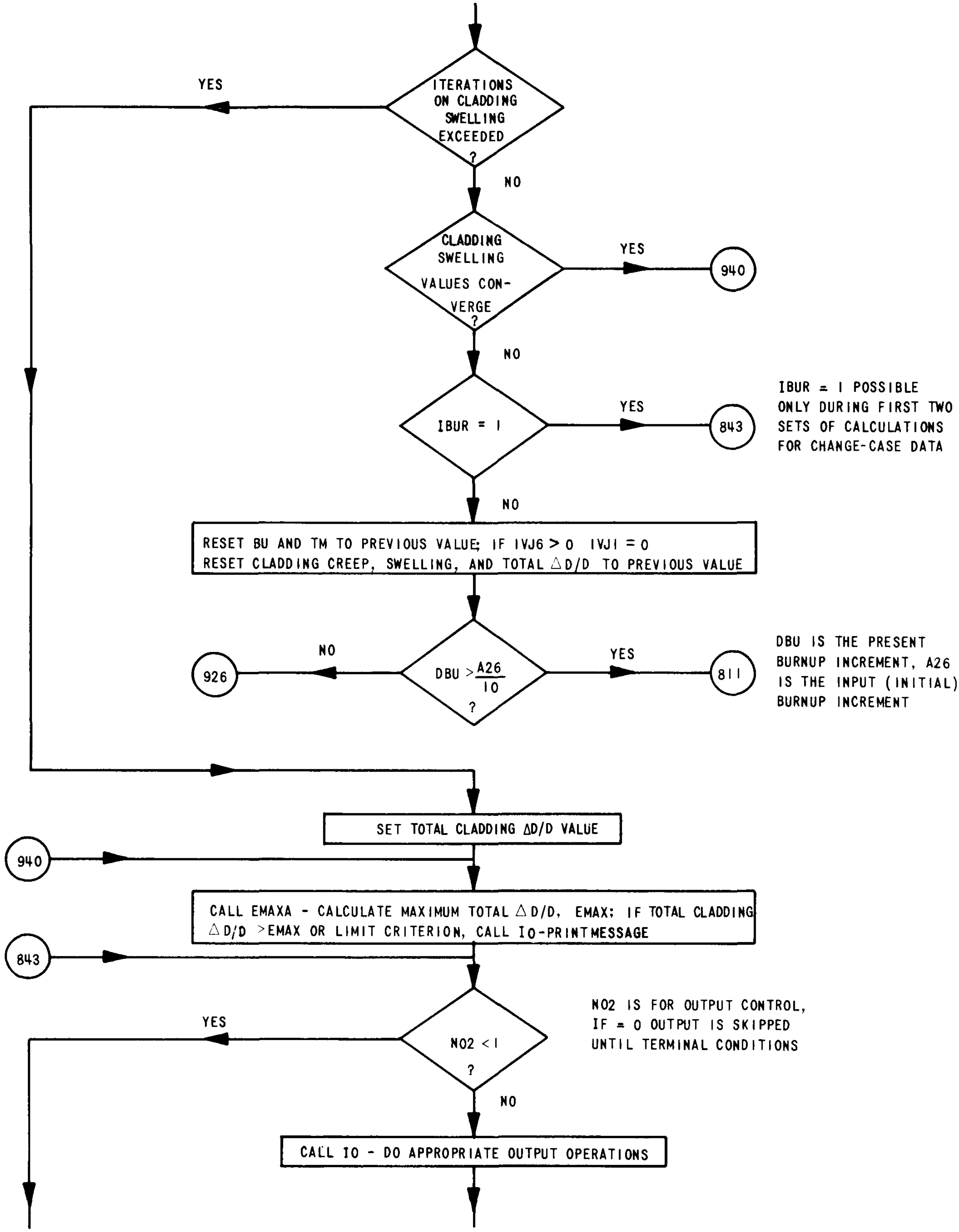

INCREMENT BU
550
SET PROGRAM CONTROL VALUES; CALCULATE COOLANT AND OUTSIDE CLADDING TEMPERATURES
17
SET PROGRAM CONDITIONS FOR NORMAL OPERATION
975
SET QUANTITY OF FISSION GAS IN PLENUM TO ZERO ASSIGN 50 TO IE, 39 TO IP
II
II IS 71 FOR BU = 0; 3 FOR BU ≠ 0
3
CALCULATE GUESS ON TOTAL CLADDING ΔD/D; CALCULATE COOLANT AND OUTSIDE CLADDING TEMPERATURES AND FISSION GAS RELEASED
71
CALL XKLCA - COMPUTE CLADDING THERMAL CONDUCTIVITY
COMPUTE CLADDING INSIDE TEMPERATURE
COMPUTE AVERAGE CLADDING TEMPERATURE
CALL HGA - COMPUTE CERAMIC FUEL-CLADDING INTERFACE CONDUCTANCE
COMPUTE FUEL OUTSIDE TEMPERATURE
SET LENGTH OF SODIUM IN PLENUM TO ORIGINAL VALUE
CALL VNA - DETERMINE FUEL EXPANSION & CALCULATE FREE VOLUME IN FUEL DUE TO FISSION GAS PRESENT
CALL PFA - DETERMINE THERMAL EXPANSION FOR METALLIC FUEL WITH SODIUM BOND
CALCULATE INCREASE IN INTERNAL CLADDING VOLUME
COMPUTE INEXORABLE FUEL SWELLING
CHECK FOR START OF BREAKAWAY SWELLING
SET VALUE FOR FUEL-CLADDING CONTACT PRESSURE
418
SET PRESSURE VALUES FOR CALCULATING GAS-PLENUM LENGTH

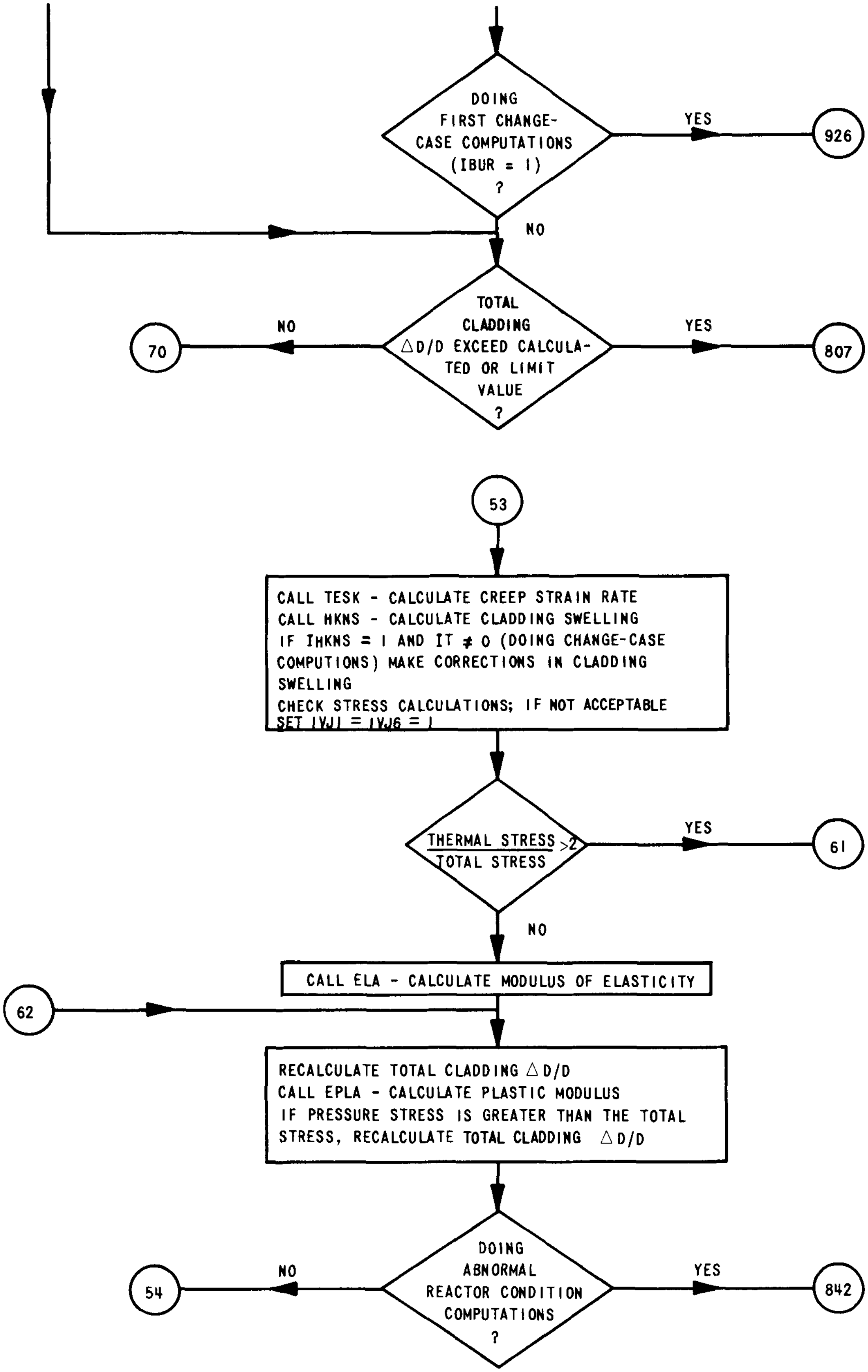

871
IF IPP ≠ 2: ASSIGN 408 TO IG, 407 TO IJ; NI = 0
421
407
CALCULATE FUEL SWELLING; IF INCOMPRESSIBLE FUEL INDICATOR IS ON (INCC = 1) MAKE APPROPRIATE CORRECTIONS
CALCULATE SODIUM VOLUME IN FUEL ELEMENT
CALCULATE NEW VOLUME OF SODIUM IN PLENUM DUE TO FUEL EXPANSION
CALL XLPA - COMPUTE PLENUM VOLUME AND GAS-PLENUM LENGTH DUE TO CLADDING EXPANSION
IPP = 2 ?
YES
420
IPP = 2 AFTER FINAL VALUE FOR PLENUM PRESSURE HAS BEEN SET
NO
CALCULATE PLENUM PRESSURE AS A FUNCTION OF THE AMOUNT OF FISSION GAS RELEASED AND THE GAS-PLENUM LENGTH
NI > 0 ?
YES
601
NI IS THE NUMBER OF ITERATIONS FOR PRRSSURE CALCULATIONS
NO
1600
408
SET FINAL VALUE FOR PLENUM PRESSURE; IPP = 2
SET PRESSURE VALUE FOR CALCULATING GAS-PLENUM LENGTH TO THE PLENUM-PRESSURE VALUE
421

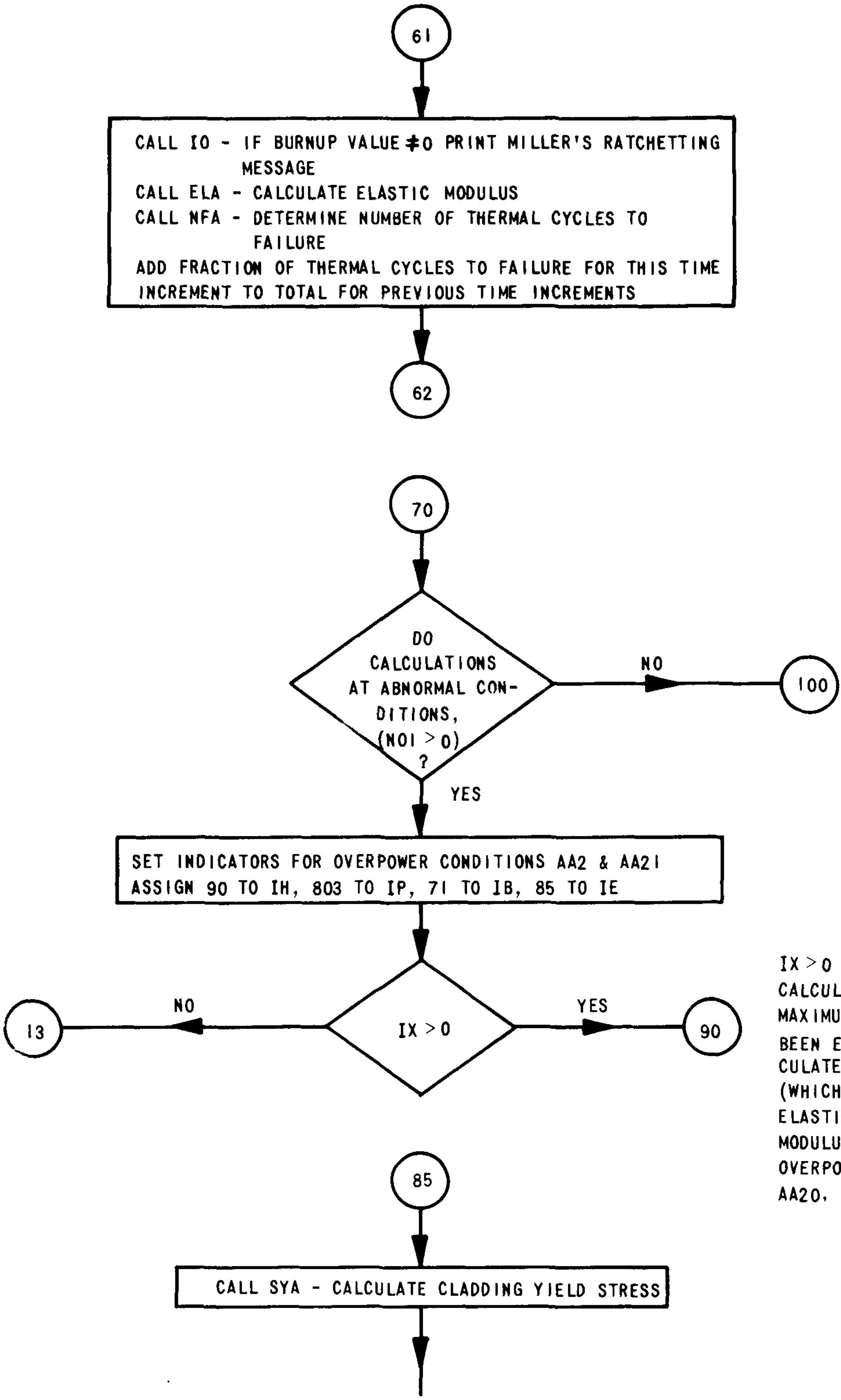

420
ASSIGN 511 TO IG, 505 TO IJ; IPP = 1
1600
NI = 0 ?
YES
NO
SET PRESSURE VALUES USING PLENUM PRESSURE
CALCULATE FUEL SWELLING
CALCULATE VOLUME OF FUEL AND CLADDING
NI > 0 ?
YES
601
NO
NI = NI + 1
CALCULATE VALUES FOR BILINEAR EXPANSION FUNCTION
TO CONVERGE ON PRESSURE CALCULATION
CALCULATE NEXT PRESSURE GUESS
PRESSURE CALCULATIONS CONVERGED ?
YES
510
NO
NI > 15 ?
YES
510
601
NO
RESET PRESSURES VALUES USING LAST CALCULATED PRESSURE GUESS


510
IG
IG IS 408 FOR PLENUM-PRESSURE CALCULATIONS;
511 FOR FUEL-CLADDING CONTACT PRESSURE CALCULATIONS
511
CALCULATE FUEL SWELLING
SET VALUE FOR FUEL-CLADDING CONTACT PRESSURE
CALCULATE THE PRESSURE STRESS
CALL BIA - COMPUTE THE COEFFICIENT OF SHEAR MODULUS
CALCULATE THERMAL STRESS
SET TOTAL STRESS = THERMAL PLUS PRESSURE STRESS
IE
IE IS 50 WHEN DOING NORMAL POWER CALCULATIONS;
85 TO DO CALCULATIONS AT ABNORMAL CONDITIONS
AA20 & AA21 or AB20 & AB21
50
CALCULATE TIME AS A FUNCTION OF BURNUP
CALCULATE FINAL FUEL-SWELLING VALUE
YES
IRSWL = 0 ?
NO
CHECK FUEL SWELLING AND MAKE APPROPRIATE, IF ANY, CORRECTION
IF IRSWL ≠ 0 AND PRESENT VALUE FOR FUEL SWELLING IS LESS THAN THE PREVIOUS VALUE, SET APPROPRIATE INDICATOR - INCREMENT INC.
CALL BECK - COMPUTE FRACTION OF FISSION GAS RELEASED
CALL SYA - COMPUTE CLADDING YIELD STRESS

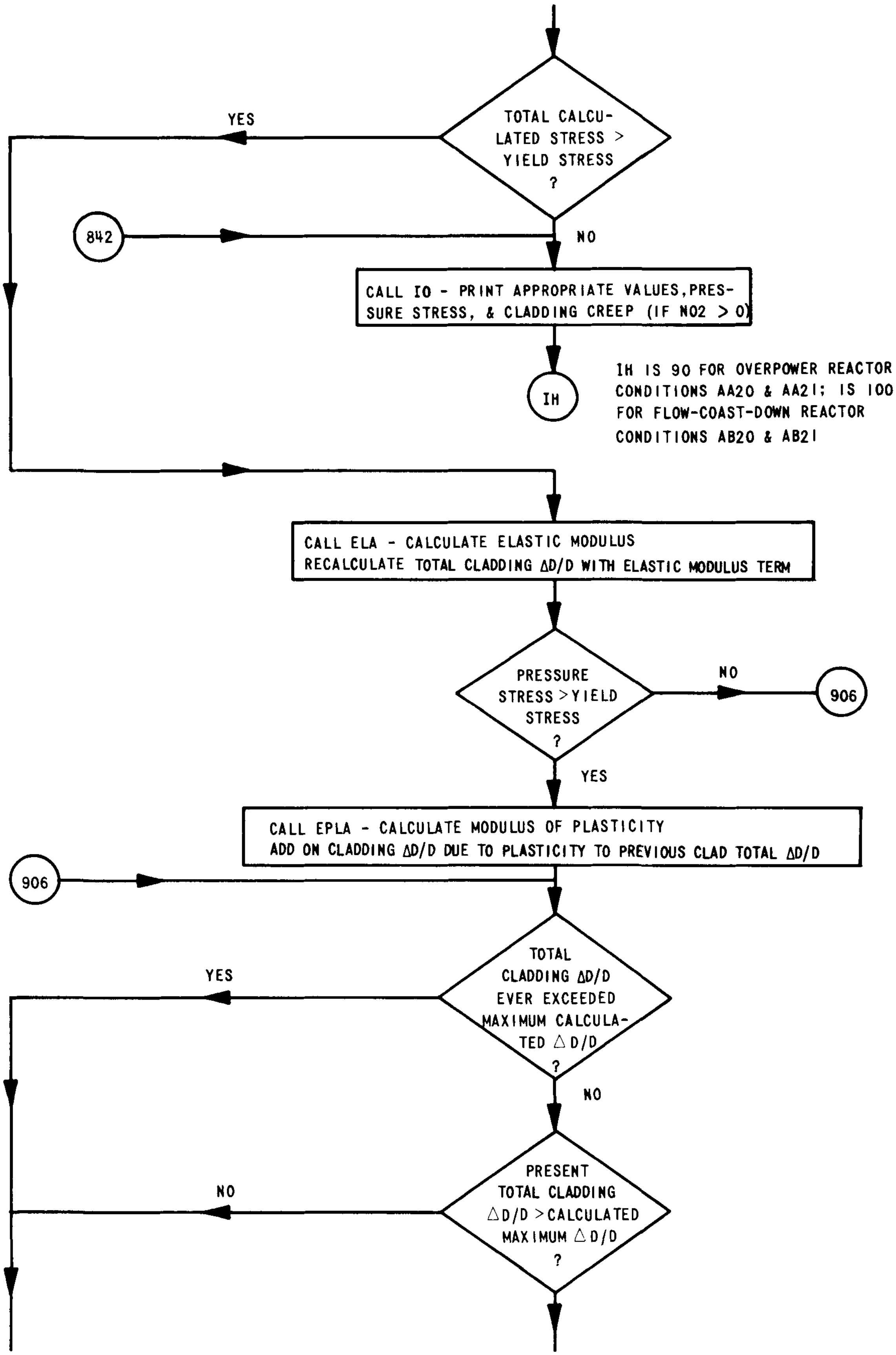

TOTAL STRESS > YIELD STRESS ?
YES
53
NO
CALL TESK - COMPUTE CLADDING CREEP RATE
CALL HKNS - COMPUTE CLADDING SWELLING
IF DOING CHANGE-CASE CALCULATIONS AND IT ≠ 0, MAKE APPROPRIATE CORRECTION FOR CLADDING-SWELLING VALUE
SET TOTAL CLADDING ΔD/D
54
CHECK CALCULATIONS ON TOTAL CLADDING ΔD/D
IF PRESENT TOTAL CLADDING ΔD/D VALUES < PREVIOUS ONES
RESET CLAD TOTAL AND CREEP VALUES TO PREVIOUS ONES
INCC = 1 ?
YES
872
NO
INC > 0
NO
872
YES
INCC = 1
418
872
INC = 0
INCC = 0

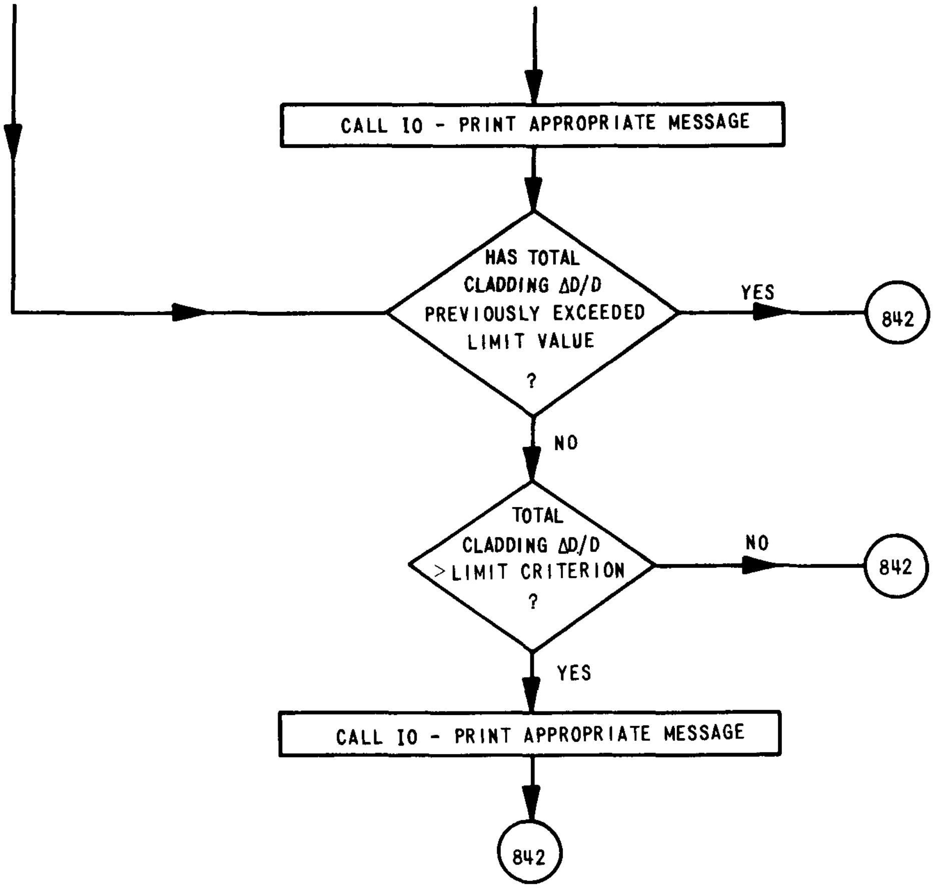

ITERATIONS ON CLADDING SWELLING EXCEEDED ?
YES
NO
CLADDING SWELLING VALUES CONVERGE ?
YES
940
NO
IBUR = I
YES
843
IBUR = I POSSIBLE ONLY DURING FIRST TWO SETS OF CALCULATIONS FOR CHANGE-CASE DATA
NO
RESET BU AND TM TO PREVIOUS VALUE; IF IVJ6 > 0 IVJI = 0
RESET CLADDING CREEP, SWELLING, AND TOTAL ΔD/D TO PREVIOUS VALUE
DBU > A26/10 ?
NO
926
YES
811
DBU IS THE PRESENT BURNUP INCREMENT, A26 IS THE INPUT (INITIAL) BURNUP INCREMENT
SET TOTAL CLADDING ΔD/D VALUE
940
CALL EMAXA - CALCULATE MAXIMUM TOTAL ΔD/D, EMAX; IF TOTAL CLADDING ΔD/D >EMAX OR LIMIT CRITERION, CALL IO-PRINTMESSAGE
843
NO2 < I ?
YES
NO
NO2 IS FOR OUTPUT CONTROL, IF = 0 OUTPUT IS SKIPPED UNTIL TERMINAL CONDITIONS
CALL IO - DO APPROPRIATE OUTPUT OPERATIONS

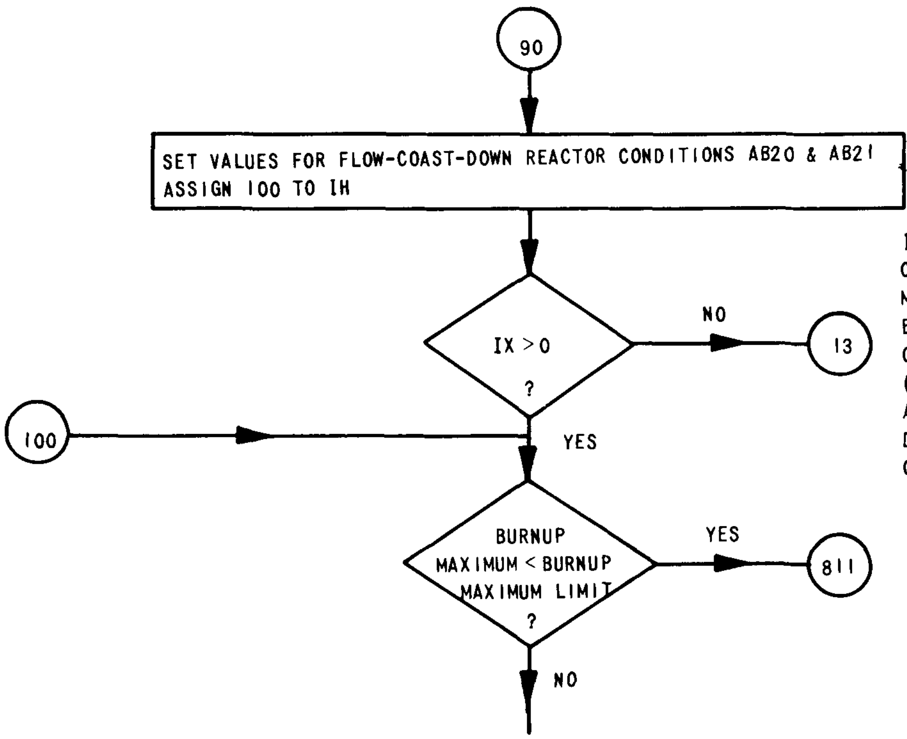

DOING FIRST CHANGE-CASE COMPUTATIONS (IBUR = 1) ?
YES
926
NO
TOTAL CLADDING △D/D EXCEED CALCULATED OR LIMIT VALUE ?
NO
70
YES
807
53
CALL TESK - CALCULATE CREEP STRAIN RATE
CALL HKNS - CALCULATE CLADDING SWELLING
IF IHKNS = 1 AND IT ≠ 0 (DOING CHANGE-CASE COMPUTIONS) MAKE CORRECTIONS IN CLADDING SWELLING
CHECK STRESS CALCULATIONS; IF NOT ACCEPTABLE SET IVJ1 = IVJ6 = 1
THERMAL STRESS / TOTAL STRESS >2
YES
61
NO
CALL ELA - CALCULATE MODULUS OF ELASTICITY
62
RECALCULATE TOTAL CLADDING △D/D
CALL EPLA - CALCULATE PLASTIC MODULUS
IF PRESSURE STRESS IS GREATER THAN THE TOTAL STRESS, RECALCULATE TOTAL CLADDING △D/D
DOING ABNORMAL REACTOR CONDITION COMPUTATIONS ?
NO
54
YES
842



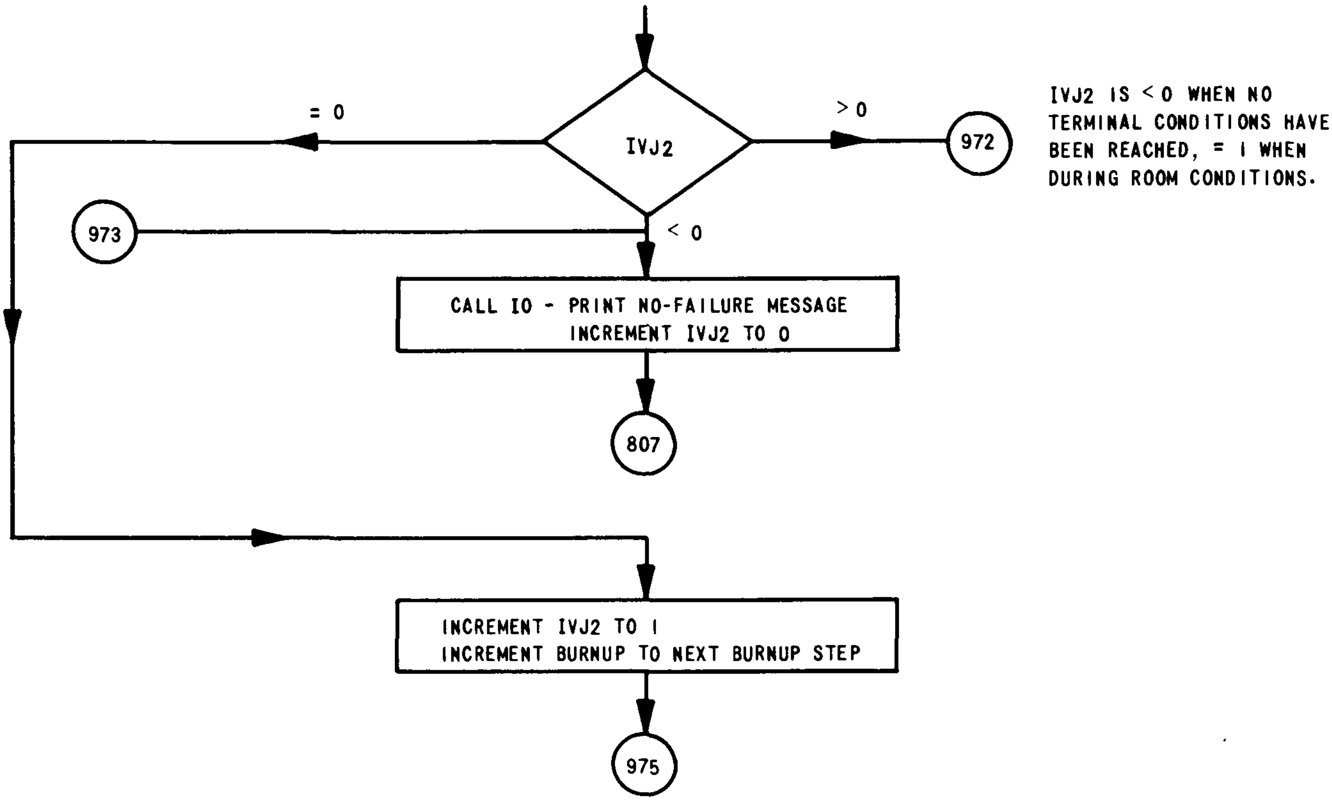
IX > 0 ONLY IF BOTH THE CALCULATED MAXIMUM AND MAXIMUM △D/D LIMIT HAVE BEEN EXCEEDED BY THE CALCULATED TOTAL △D/D (WHICH INCLUDES THE ELASTIC AND PLASTIC MODULUS TERMS) DURING OVERPOWER CONDITIONS AA20, AA21

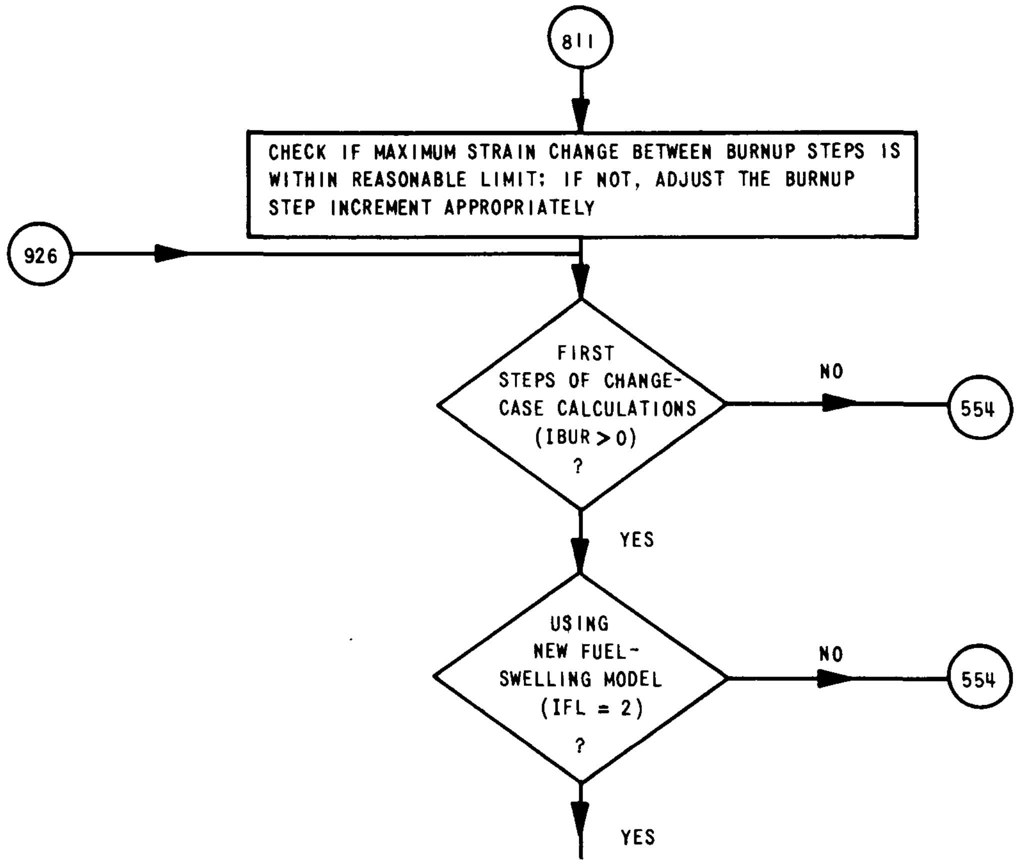

TOTAL CALCULATED STRESS > YIELD STRESS ?
YES
NO
842
CALL IO - PRINT APPROPRIATE VALUES, PRESSURE STRESS, & CLADDING CREEP (IF NO2 > 0)
IH
IH IS 90 FOR OVERPOWER REACTOR CONDITIONS AA20 & AA21; IS 100 FOR FLOW-COAST-DOWN REACTOR CONDITIONS AB20 & AB21
CALL ELA - CALCULATE ELASTIC MODULUS
RECALCULATE TOTAL CLADDING ΔD/D WITH ELASTIC MODULUS TERM
PRESSURE STRESS > YIELD STRESS ?
NO
906
YES
CALL EPLA - CALCULATE MODULUS OF PLASTICITY
ADD ON CLADDING ΔD/D DUE TO PLASTICITY TO PREVIOUS CLAD TOTAL ΔD/D
906
TOTAL CLADDING ΔD/D EVER EXCEEDED MAXIMUM CALCULATED ΔD/D ?
YES
NO
PRESENT TOTAL CLADDING ΔD/D > CALCULATED MAXIMUM ΔD/D ?
NO

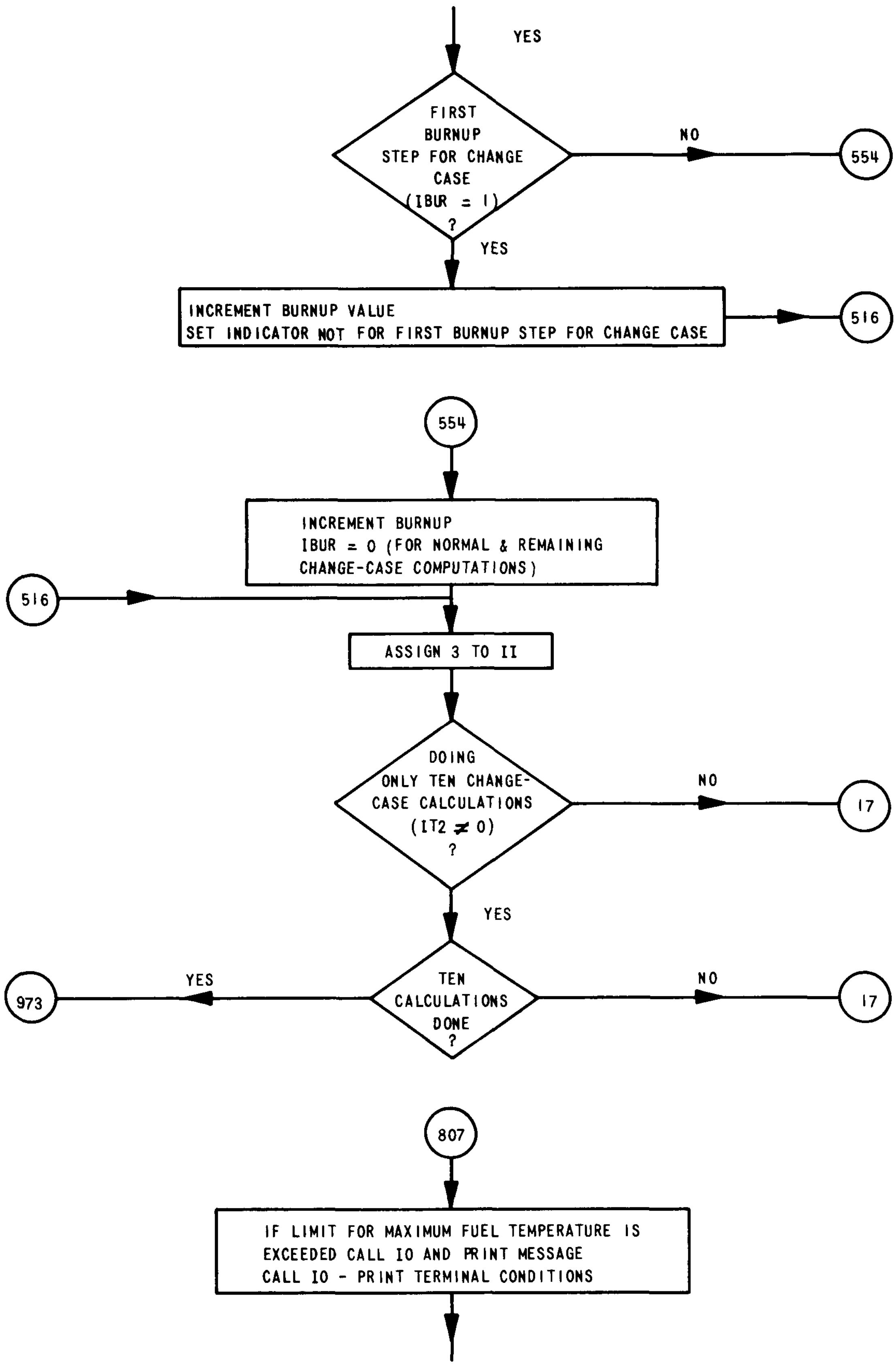


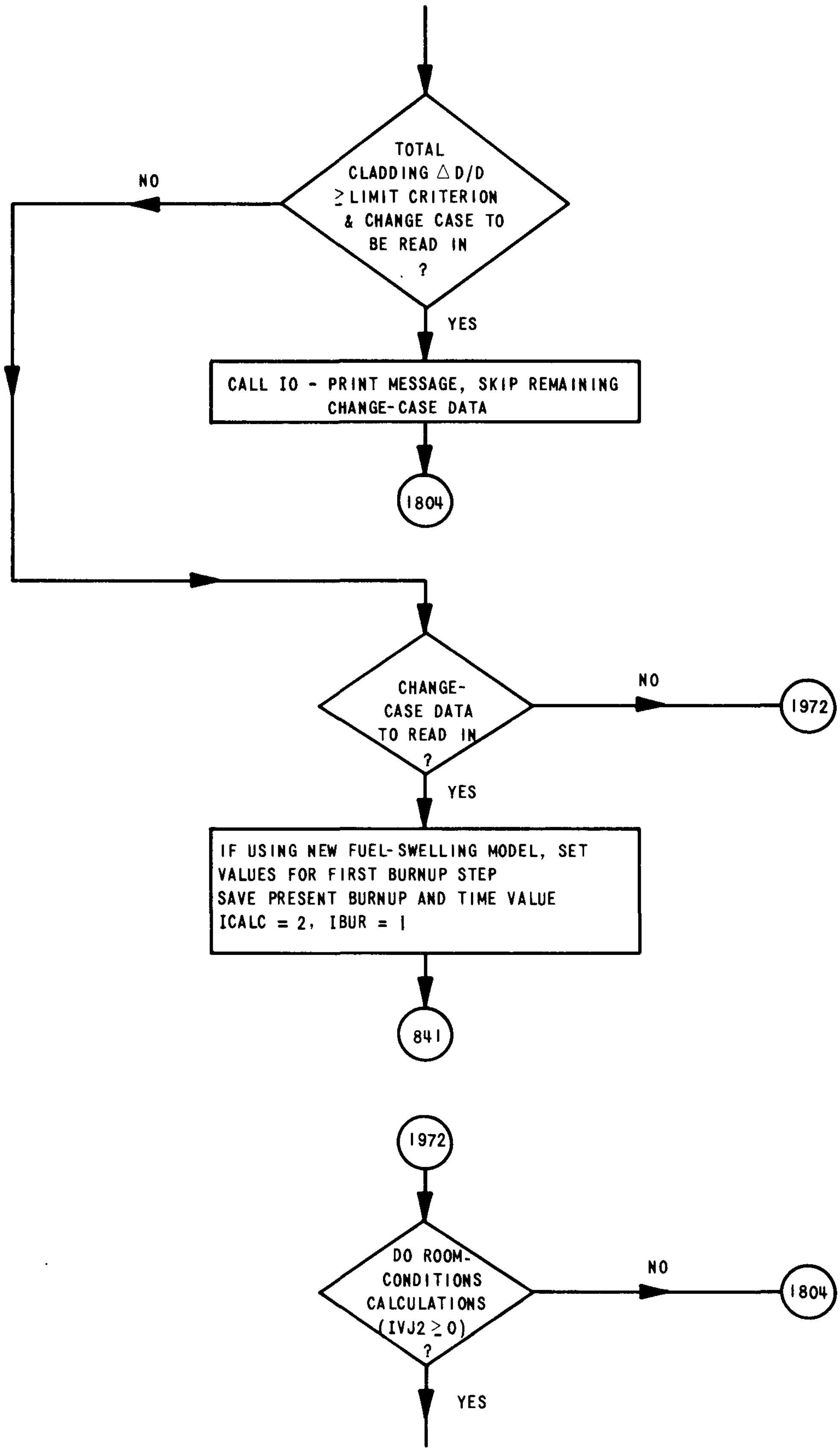


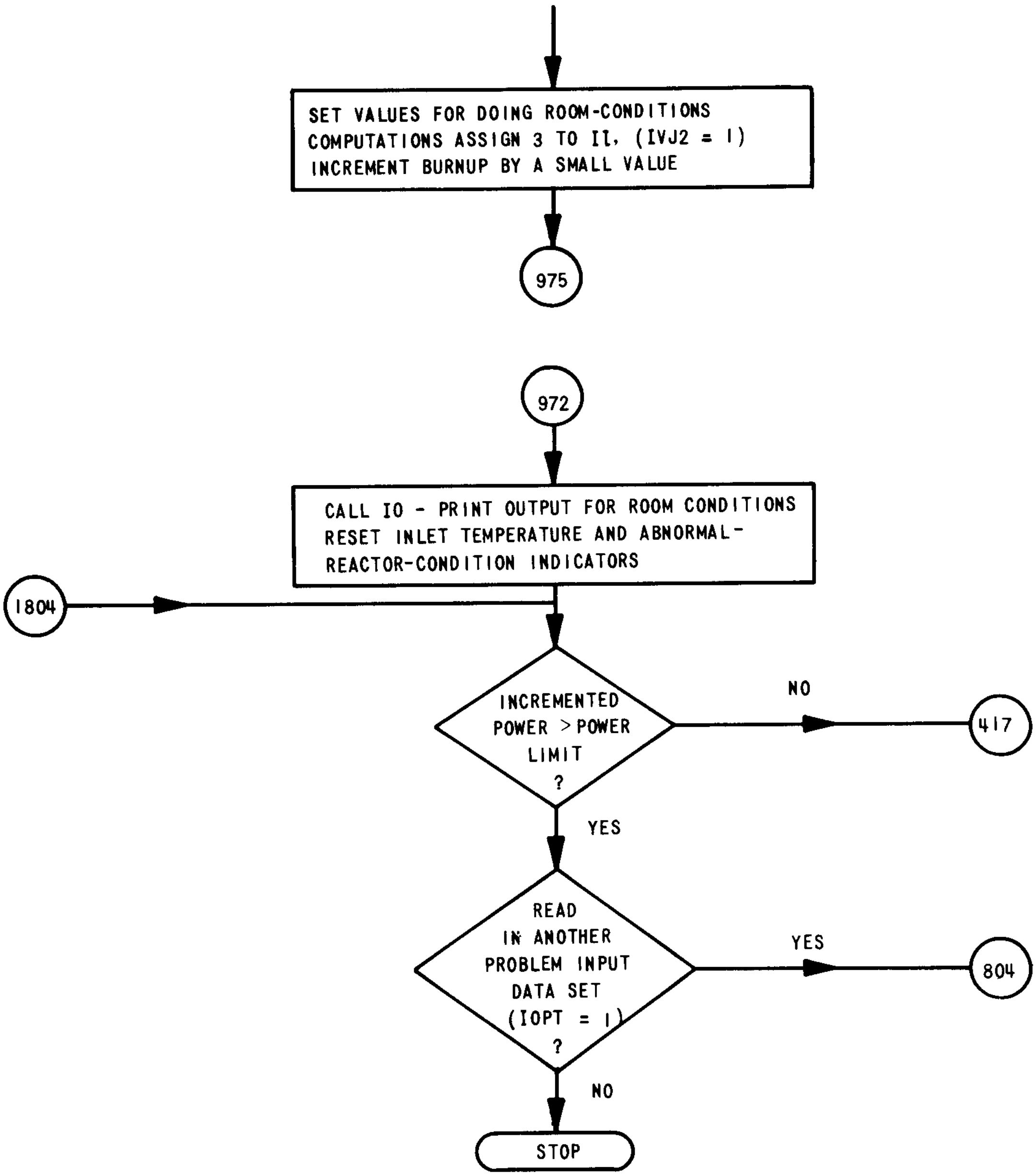
IX > 0 ONLY IF BOTH THE CALCULATED MAXIMUM AND MAXIMUM ΔD/D LIMIT HAVE BEEN EXCEEDED BY THE CALCULATED TOTAL ΔD/D (WHICH INCLUDES THE ELASTIC AND PLASTIC MODULUS TERMS) DURING FLOW-COAST-DOWN CONDITIONS AB20, AB21


IVJ2
= 0
> 0
972
IVJ2 IS < 0 WHEN NO TERMINAL CONDITIONS HAVE BEEN REACHED, = 1 WHEN DURING ROOM CONDITIONS.
973
< 0
CALL IO - PRINT NO-FAILURE MESSAGE
INCREMENT IVJ2 TO 0
807
INCREMENT IVJ2 TO 1
INCREMENT BURNUP TO NEXT BURNUP STEP
975


811
CHECK IF MAXIMUM STRAIN CHANGE BETWEEN BURNUP STEPS IS WITHIN REASONABLE LIMIT: IF NOT, ADJUST THE BURNUP STEP INCREMENT APPROPRIATELY
926
FIRST STEPS OF CHANGE-CASE CALCULATIONS (IBUR > 0) ?
NO
554
YES
USING NEW FUEL-SWELLING MODEL (IFL = 2) ?
NO
554
YES


YES
FIRST BURNUP STEP FOR CHANGE CASE (IBUR = 1) ?
NO
554
YES
INCREMENT BURNUP VALUE
SET INDICATOR NOT FOR FIRST BURNUP STEP FOR CHANGE CASE
516
554
INCREMENT BURNUP
IBUR = 0 (FOR NORMAL & REMAINING CHANGE-CASE COMPUTATIONS)
516
ASSIGN 3 TO II
DOING ONLY TEN CHANGE-CASE CALCULATIONS (IT2 ≠ 0) ?
NO
17
YES
TEN CALCULATIONS DONE ?
YES
973
NO
17
807
IF LIMIT FOR MAXIMUM FUEL TEMPERATURE IS EXCEEDED CALL IO AND PRINT MESSAGE
CALL IO - PRINT TERMINAL CONDITIONS


TOTAL CLADDING △D/D ≥ LIMIT CRITERION & CHANGE CASE TO BE READ IN ?
NO
YES
CALL IO - PRINT MESSAGE, SKIP REMAINING CHANGE-CASE DATA
1804
CHANGE-CASE DATA TO READ IN ?
NO
1972
YES
IF USING NEW FUEL-SWELLING MODEL, SET VALUES FOR FIRST BURNUP STEP
SAVE PRESENT BURNUP AND TIME VALUE
ICALC = 2, IBUR = 1
841
1972
DO ROOM-CONDITIONS CALCULATIONS (IVJ2 ≥ 0) ?
NO
1804
YES


SET VALUES FOR DOING ROOM-CONDITIONS COMPUTATIONS ASSIGN 3 TO IL, (IVJ2 = 1) INCREMENT BURNUP BY A SMALL VALUE
975
972
CALL IO - PRINT OUTPUT FOR ROOM CONDITIONS RESET INLET TEMPERATURE AND ABNORMAL-REACTOR-CONDITION INDICATORS
1804
INCREMENTED POWER > POWER LIMIT ?
NO
417
YES
READ IN ANOTHER PROBLEM INPUT DATA SET (IOPT = 1) ?
YES
804
NO
STOP

```
C      BEMOD-I
C
        IMPLICIT REAL*8 (A-H,O-Z)
       REAL*8 NN1
       COMMON /XMAIN/
     1               TDL(60),    DL(60),     Q(60),      XTC(60),
     2   XTCLO(60),  TCLO(60),   PR(100),    PRO(60),    DGDI(60),
     3   TCLB(60),   TCLI(60),   TFO(60),    TF(60),     QR(60),
     4   GL(100),    SP(100),    SH(100),    PS(60),     E(100),
     5   ET(100),    TG(60),     EMAX(60),   PO(60),     ST(100),
     6   BUT(60),    SUME(60),   SUM(60),    POD(60),    TGB(60),
     7   DGDI2(60),  DELE(60),   TC(60),     ET1(60),    TRIG1(60),
     8   VCL(60),    VFT(60),    TFB(60),    FR(60),     GM(60),
     9   XING(60),   ET2(60),    W2(60),     DET2(60),   W3(60),
     A   GFFLX(60),  V(60),      ESW(100),   D(60),      DVV(100),
     B   DET3(60),   SWO(60),    SWN(60),    BMX(100),   PPMX(100),
     C   PRMX(100),  ETMX(100),  XLPMX(100),NN1(60),     OTM(60),
     E   TRIG(60),   TRIGO1(60), TRIGO2(60),TRG1(60),    TRG101(60),
     F   TRG102(60), TRG2(60),   TRG201(60),TRG202(60),TRIG2(60),
     G   FLU(60),    FLUO(60),   TITLE1(10),TITLE2(10),TITLE3(10),
     H   PGS(3),     W(3),       ER(3),      DF(60),     MAX(2),
     I   MX1(2)
      COMMON /IOCOM/
     1N,NT,NT1,IOPT,ICALC,IPLT1,IRSWL,IHKNS,IFUEL,IPRNT,NO,M1,NDL,NO1,NO
     22,IT,IT2,NY,KNT,IPR,IDV,IBUM,IOUT,IERR,IQF,IFLG/XIO/BU,TCIN,DELTC,
     3DELTCN,GAMFR,PLTBU,TFBL,TFBH,TFB1,TFB2,TFB3,TFB4,TFB5,PMAX,BUINC,
     4BUMX,DOPP,HC,XLFPP,XLPPP,A1,A2,A3,A4,A5,A6,A9,A12,A13,A14,A15,A25,
     5A27,A28,A29,A30,A31,A32,A33,A34,A35,A36,A37,A38,A39,A40,A41,A42,
     6A43,A44,A45,A46,A47,A48,A49,A50,A51,A53,A54,A55,A56,A57,A58,A300,
     7AA20,AA21,AB20,AB21,TFMAX,FFLX,BUMAX,DOF,QPB,QPBD,QPBM,XLCL,XMNA,
     8XMF,RHTHF,DFDI,XNU,PPO,XLNAO,ALPNA,A401,A402,TB,GT,CORR,G1,BUST,
     9GB,G2,PG,GMO,GM1,V1,V2,FGR2,EMAX1,EPS1,EPS2,TRA,FCB,XLP,QLSUM,PP,
     ATM,TM2,TMO,ETA,AF,DPPP,P1,A26,A20,A21,SY
C
  8.4 CALL IO (1)
      DELTCS = DELTC
      FFLXS = FFLX
      SAVA26 = A26
      QPBSAV = QPB
C
C     SET UP GEOMETRY--COMPUTE DIAMETERS
C
  417 IT = 0
      INC = 0
      INCC = 0
      ITM = 0
      IBUR = 0
      IBUM = 0
      IERR = 0
      IBUM4 = (NT1/5)*2
      C = 16.387064
      PI4 = 12.5664
```

```
      IBUM1 = NT1/3
      IBUM2 = 2*IBUM1
      ARG1 = Q(IBUM1-1)
      DO 883 I=IBUM1,IBUM2
      ARG2 = Q(I)
      XMULT = DMAX1(ARG1,ARG2)
  883 ARG1 = XMULT
      DODI = DOPP/DPPP
      X=XMF*RHTHF
      IF (X) 6,6,5
    5 DEN =RHTHF*XLFPP*0.7854
      DOF2 = XMF*C/DEN
      DOF = DOF2**(0.5)
    6 IF (DOF) 10,10,8
    8 DFDI = DOF/DPPP
   10 VO= 1. - DFDI**2
      XNT=NT
      Q(NT1) = 0.
      T1=DELTC/(2.*XNT)
      DD=DODI**2.
      DDD=.7854*(DOPP/DODI)**2.
      T2=DLOG(DODI)
      DODI1=DD-1.
      T3=-T2/DODI1+.5
      AFLND=A5*AF*FCB*(XLFPP/XNT)*(DOPP/DODI)**2.
      PPA6=A6/DPPP**2.
      PRA6=.7854*A6
      DODI2=DD+1.
      VCLO =  DDD * XLFPP / XNT
      VFO  = VCLO * DFDI**2
      VNAO = VCLO - VFO
C
C     COMPUTE EXTERNAL CLAD PRESSURE IN EACH AXIAL SECTION
C     NT IS NUMBER OF AXIAL SECTIONS
C
      DO 2 I=1,NT
    2 POD(I) = PO(I)*DODI2
      POD(NT1) = DODI2*(3.*PO(NT)-PO(NT - 1))/2.
      X = XMNA*XLCL
      IF (X) 137,137,136
  136 VT = XLCL*DDD
      VF = VFO*XNT
      VNA1 = XMNA/0.9686/C
      VPL = VT - VF - VNA1
      XLPPP = VPL/DDD
      VNAP = VNA1 - VNAO*XNT
      XLNAO = VNAP/DDD
      CALL IO (2)
  137 IF(NO - 1) 903,903,138
  903 CALL IO (3)
      GO TO 1804
  138 A20 = 1.
      A21 = 1.
```

```
      IVJ = 0
      IVJ1 = 0
      IPR = 0
      ASSIGN 50 TO IE
C
C     COMPUTE FISSIONS IN FUEL
C     QPB IS LINEAR POWER(BTU/HR-FT)
C
      AA9 = A9*FCB*DDD*(1.-VO)/(QPB*(1.-GAMFR))
      ASSIGN 15 TO IB
      QPB5=QPB/PI4
      QPB1=48.*QPB5/HC/DOPP
      QPB2=2.*QPB5*T2
      QPB3=2.*QPB5*T3
      QPB4=QPB1*HC*DODI
      QPB6=QPB5/(1-VO)
      QLIN = 0.00081277*PPO*XLPPP*DPPP**2
      PP = PPO* (TCIN + A20*DELTC + 460.)/530. - 14.7
13    XTC(1)=TCIN+A20*T1*Q(1)
 11.1 DO 11 I=2,NT1
11    XTC(I)=XTC(I-1)+A20*T1*(Q(I-1)+Q(I))
      TF(NT1) = XTC(NT1)
      DO 12 I=1,NT1
      ET1(I) = ET(I)
12    XTCLO(I)=XTC(I)+A21*Q(I)*QPB1
      ASSIGN 71 TO II
      GOTO IB ,(15,71)
C
C     INITIALIZE VARIABLES
C
   15 BU = 0.
      BUL = 0.
      TM = 0.
      XK = 1.
      Z1 = 10.D-20
      IVJ2 = -1
      IVJ3 = 0
      IVJ4 = 0
      IBUM3 = 2
      IPP = 1
      MAX(1) = 0
      MAX(2) = 0
      MX1(1) = 0
      MX1(2) = 0
      IT2 = 0
      KNT1 = 1
      DBU = A26
      DO 659 I=1,100
      QL(I) = 0.
      SP(I) = 0.
      E(I) = 0.
      ESW(I) = 0.
  659 ET(I) = 0.
```

```
C     XTC IS COOLANT INLET TEMP
      DO 16 I=1,NT1
      OTM(I) = 0.
      QR(I) = 0.
      PRO(I) = 100.
      DGDI(I) = .5
      V(I) = 0.
      FR(I) = 0.
      DET2(I) = 0.
      W2(I) = 0.
      BUT(I) = C.
      SUM(I) = 0.
      SUME(I) = 0.
      ET1(I) = 10.D-20
      TC(I) = XTC(I)
      TCLO(I) = XTCLO(I)
   16 GM(I) = GMO
      IFLG = 1
      IFL = 2
      IF ((IFUEL.EQ.0).OR.(IFUEL.EQ.4)) IFL = 1
  841 IF (ICALC.NE.2) GO TO 17
      CALL IO (4)
      BUMAX = BU+BUINC
      DBU = A26
      GO TO (549,587),IFL
  587 GO TO (549,548,549),IFLG
C
C     THE FIRST PRINTOUT AFTER READING IN CHANGE CASE DATA SHOULD BE FOR
C     CALCULATIONS DONE AT THE BURNUP OF THE PREVIOUS TERMINAL
C     CONDITION AND THE NEW CHANGE IN TEMPERATURE (PROVIDED A NEW TEM-
C     PERATURE IS READ IN) - ONLY FOR USING THE NEW FUEL SWELLING MODEL-
C     USED FOR OVERPOWER AND FLOW COAST DOWN CALCULATIONS
C
  548 IF (DELTCN-DELTC) 594,593,594
  594 BU = BUO
      TM = TMO
      GO TO 550
  593 IFLG = 1
  549 BU = BU+DBU
  550 KNT = 1
      IVJ2 = -1
      IOUT = 0
      DELTC = DELTCN
      IF (IGF.EQ.1) GO TO 647
      ARG1 = Q(IBUM1-1)
      DO 884 I=IBUM1,IBUM2
      ARG2 = Q(I)
      XMULT = DMAX1(ARG1,ARG2)
  884 ARG1 = XMULT
  647 T1 = DELTC/(2.*XNT)
      AA9 = A9*FCB*DDD*(1.-VO)/(QPB*(1.-GAMFR))
      QPB5 = QPB/PI4
      QPB1 = 48.*QPB5/HC/DOPP
```

```
      QPB2 = 2.*QPB5*T2
      QPB3 = 2.*QPB5*T3
      QPB4 = QPB1*HC*DODI
      QPB6 = QPB5/(1.-VO)
      XTC(1) = TCIN + A20*T1*Q(1)
      DO 111 I=2,NT1
111   XTC(I) = XTC(I-1) + A20*T1*(Q(I-1)+Q(I))
      TF(NT1) = XTC(NT1)
      DO 112 I=1,NT1
      TC(I) = XTC(I)
      XTCLO(I) = XTC(I) + A21*Q(I)*QPB1
112   TCLO(I) = XTCLO(I)
   17 A20=1.
      A21=1.
  975 QLSUM = 0.
      Z1 = 10.D-20
      X1 = 0.
      IVJ5 = 0
      IVJ6 = 0
      IPR = 0
      ASSIGN 39 TO IP
      ASSIGN 50 TO IE
      GOTO II ,(3,71)
    3 DO 21 I=1,NT1
      ET1(I) = ET(I) + ET1(I)/XK
      W2(I) = W2(I)*XK
      DET2(I) = DET2(I) /XK
      W3(I) = W3(I)*XK
      DET3(I) = DET3(I)/XK
      XTC(I) = TC(I)
   21 XTCLO(I) = TCLO(I)
      XK = 1.
  901 DO 902 I=1,NT1
      DGDI(I) = 0.
      QT = AFLND*(1.-VO)*BU*Q(I)
      QL(I) = QT*FR(I)
      QR(I) = QT - QL(I)
  902 QLSUM = QLSUM + QL(I)
      QR(NT1) = QLSUM + QLIN
      QL(NT1) = 0.
   71 DO 18 I=1,NT1
      IJ=1
      N = I
    9 CALL XKCLA (IJ,IK,XKCL)
C     COMPUTE INSIDE CLAD TEMP
      TCLI(I)=XTCLO(I)+A21*Q(I)*QPB2/XKCL
      IF(IK-1)7,7,4
7     IJ=2
      GOTO 9
C     COMPUTE AVG CLAD TEMP
    4 TCLB(I)=XTCLO(I)+A21*Q(I)*QPB3/XKCL
      CALL HGA (HG)
C     COMPUTE FUEL OUTSIDE TEMP
```

```
18     TFB(I)=TCLI(I)+A21*G(I)*GPB4/HG
   37 XLNA = XLNAB
      S = 0.
      DØ 801 I=1,NT
      N = I
      CALL VNA (DDD,VN,VO,XNT)
      PR1 = PRA6 * GR(I) * (TGB(I) + 460.)/VN
      CALL PFA (DØDI,VN,PF,PR1,PI4,VFØ,IFL)
C     CALCULATE INCREASE ØF CLADDING INSIDE VØLUME
      VCL(I) = VCLØ*(1.+3.*A30*(1.+A31*(TCLB(I)+70.)/2.)*(TCLB(I)-70.)
     1 + 2.*ET1(I))
      S = S + ESW(I)
      BUN = BU * Q(I)
      GAM = GM(I)
C
C     TRIG2 IS FØR INEXØRABLE FUEL SWELLING
C
      TRIG2(I) = GAM*BU*Q(I)*((TFB(I)+460.)/(TB+460.))**GT+CØRR
      IF (TRIG2(I)) 501,502,502
  501 TRIG1(I) = 0.
      XING(I) = 0.
      GØ TØ 503
  502 TRIG1(I) = TRIG2(I)
      XING(I) = TRIG2(I)
  503 IF (IFUEL.EQ.1) GØ TØ 544
C
C     CHECK FØR START ØF BREAKAWAY SWELLING
C
      IF (BUN-BUST) 801,801,504
  504 TRIG1(I)=TRIG1(I)+ G1*(BUN-BUST)**GB
      GØ TØ 801
  544 TRIG1(I) = 100.
  801 PR(I) = PR1 - PF
      TM2 = AA9*BU
      ETP = 2.*ET1(NT1) + ESW(NT1) +S* XLFPP/NT/(XLPPP+XLNAØ)
      NY= NT1
  418 PGS(2) = PP
      IF (PP)521,521,522
  521 PGS(1) = -1.+ PP
      PGS(3) =   1. + PP
      GØ TØ 978
  522 PGS(1) = 0.9*PP
      PGS(3) = 1.1*PP
  978 P2 = PP
  871 IF (IPP.EQ.2) GØ TØ 421
      ASSIGN 408 TØ IG
      ASSIGN 407 TØ IJ
      NI = 0
  421 J = 1
  400 P = PGS(J)
  407 VNAPL = 0.0
      N = 1
C
```

```
C      THIS IS THE NEW FUEL SWELLING MODEL
C      IF IFUEL = 0 OR 4, USE OLD FUEL SWELLING MODEL
C
  646 GO TO (556,844),IFL
  556 TRIG(N) = XING(N)+G2/(1.+P/PG)
      GO TO 641
  844 IF ((TFB(N).LE.TFBL).OR.(TFB(N).GE.TFBH)) GO TO 989
      IF (P-PMAX) 612,612,683
  612 PRS = P
      GO TO 684
  683 PRS = PMAX
  684 TRIG(N) = XING(N)+BU*Q(N)*TFB1*DEXP(TFB2*(TFB3-TFB(N))**2)
     1/(1.+(PRS/TFB4)*(1.-TFB5*(TFB3-TFB(N))**2))
      GO TO (641,557,641),IFLG
  557 TRIG02(N) = TRIG(N)
      GO TO 641
  989 TRIG(N) = XING(N)+BU*Q(N)*TFB1*DEXP(TFB2*(TFB3-TFB(N))**2)
      GO TO (641,558,641),IFLG
  558 TRIG02(N) = TRIG(N)
C
  641 IF (INC) 990,990,865
  865 TRIG(N) = XING(N)+SW0(N)
      GO TO (990,580),IFL
  580 GO TO (990,559,990),IFLG
  559 TRIG02(N) = TRIG(N)
  990 TRIG2(N) = TRIG1(N)
      GO TO (562,591),IFL
  591 GO TO (562,561,560),IFLG
  560 TRIG(N) = TRIG01(N)+(TRIG(N)-TRIG02(N))
      GO TO 562
  561 TRIG(N) = TRIG02(N)
  562 IF (P+PG) 401,401,980
  980 IF (TRIG(N)-TRIG2(N)) 402,402,401
  401 TRIG(N) = TRIG2(N)
  402 X = VCL(N)-VFT(N)-VF0*TRIG(N)
     1  +2.*VCL0*(P*(2.-XNU)/2.-P0(N)+XNU*P0(NT)/2.)/(D0DI-1.)/A46
     2  /(1.+A47*TCLB(N))
      IF (X) 403,404,404
  403 X = 0.0
  404 T = TF0(N)
      CP = 1.6*(10.)**(-6)
      F = 1.-3.*ALPHA*(T - 70.) + CP*P
      IF (T - 207.) 410,409,409
  409 F = F -0.0218
  410 VSQ = VNA0 -X*F
 405  VNAPL = VNAPL + VSQ
      N = N+1
      IF (N.LE.NT) GO TO 646
      XLNA = XLNA0 + VNAPL/(0.7854*DPPP**2)
      CALL XLPA (XLNA,ETP,P)
      IF (IPP.EQ.2) GO TO 420
      TPRAN =TCIN + A20*DELTC + 460.
      PP = PPA6*QLSUM*TPRAN/XLP +PP0* (XLPPP/XLP)*TPRAN/530.-14.7
```

```
     1 + A401*DEXP(-A402/TPRAN)
      ER1    = (PP - P)
 608  IF (NI) 406,406,601
  406 ER(J) = ER1
  419 J = J+1
      IF (J.LE.3) GO TO 400
      GO TO 1600
  408 PP = P2
      PGS(1) = PP
      IPP = 2
      GO TO 421
  420 IPP = 1
  412 ASSIGN 511 TO IG
      ASSIGN 505 TO IJ
C
C     COMPUTE PLENUM PRESSURE DUE TO FUEL SWELLING
C
 1600 N = 1
  845 IF (NI.EQ.0) GO TO 507
      NY= N
      C = 1.
  982 PGS(1) = 0.9*PP
      PGS(2) = PP
      PGS(3) = 1.1*PP
      IF (PP) 517,517,979
  517 PGS(1) = PP - 1.
      PGS(3) = PP + 1.
  979 P2 = PP
      NI = 0
      Y = TRIG1(N) - XING(N)
      J = 1
  840 P = PGS(J)
  505 GO TO (592,630),IFL
  592 TRG1(N) = G2/(1.+P/PG)-Y
      GO TO 642
  630 IF ((TFB(N).LE.TFBL).OR.(TFB(N).GE.TFBH)) GO TO 984
      IF (P-PMAX) 614,614,685
  614 PRS = P
      GO TO 686
  685 PRS = PMAX
  686 TRG1(N) = BU*W(N)*TFB1*DEXP(TFB2*(TFB3-TFB(N))**2)
     1/(1.+(PRS/TFB4)*(1.-TFB5*(TFB3-TFB(N))**2))-Y
      GO TO (642,563,642),IFLG
  563 TRG102(N) = TRG1(N)
      GO TO 642
  984 TRG1(N) = BU*Q(N)*TFB1*DEXP(TFB2*(TFB3-TFB(N))**2)-Y
      GO TO (642,564,642),IFLG
  564 TRG102(N) = TRG1(N)
  642 IF (INC) 515,515,866
  866 TRG1(N) = SWO(N)-Y
      GO TO (515,581),IFL
  581 GO TO (515,566,565),IFLG
  565 TRG1(N) = TRG101(N)+(TRG1(N)-TRG102(N))
```

```
      GO TO 515
  566 TRG1(N) = TRG102(N)
  515 VF = VFT(N)+VF0*(TRIG1(N)+C*TRG1(N))
      VC =VCL(N)+2.*VCL0*(P-P0(N) +XNU*(P0(NT)-PP)/2.)/(D0DI-1.)/A46
     1  /(1.+A47*TCLB(N))
      ER1 = VC - VF
      IF (NI) 506,506,601
C
  506 ER(J) = ER1
      J = J+1
      IF (J.LE.3) GO TO 840
  507 NI = NI + 1
      P1 = P2
C     WHEN ER IS A BILINEAR FUNCTION OF P ,THE FOLLOWING INTERPOLATION IS
C
C      CALCULATE CONSTANTS FOR BILINEAR EXPANSION FOR PRESSURE DUE TO
C      FISSION GAS IN PLENUM. ITERATE OVER CALCULATED AND GUESSED PRES.
C
      QW1 = (PGS(3) - PGS(2)) * ER(3)*ER(2)
      QW2 = (PGS(1) - PGS(3)) * ER(1)*ER(3)
      QW3 = (PGS(2) - PGS(1)) * ER(2)*ER(1)
      WDEM = QW1 + QW2 + QW3
      IF (WDEM) 6005,523,6005
 6005 P2 = (PGS(1)*QW1   + PGS(2)*QW2    + PGS(3)*QW3   )/WDEM
      IF(P2 + 14.7) 520,519,519
  520 IF (NY - NT1) 519,523,523
  523 IF ((ER(3)-ER(2)).NE.0.) GO TO 657
      P2 = 0.
      X = 0.
      GO TO 510
  657 P2 = (PGS(2)*ER(3) - PGS(3)*ER(2))/(ER(3) - ER(2))
  519 IF (P2.EQ.0.) GO TO 509
      X =(P2 - P1)/P2
       IF (X) 508,509,509
  508 X = -X
  509 IF (X - EPS1) 510,600,600
  600 IF (NI - 15) 608,609,609
  609 NX = IVJ4
      GO TO 510
  608 P = P2
      IF (P + PG) 518,518,514
  518 P = -P - 2.*PG
  514 J = 3
      GO TO IJ,(407,505)
  601 IF (P - PGS(1)) 602,602,603
  602 PGS(3) = PGS(2)
      PGS(2) = PGS(1)
      PGS(1) = P
      ER(3) = ER(2)
      ER(2) = ER(1)
      ER(1) = ER1
      GO TO 507
  603 IF (P - PGS(2)) 604,604,605
```

```
  604 PGS(3) = PGS(2)
      PGS(2) = P
      ER(3) = ER(2)
      ER(2) = ER1
      GO TO 507
  605 IF (P - PGS(3)) 606,606,607
  606 PGS(1) = PGS(2)
      PGS(2) = P
      ER(1) = ER(2)
      ER(2) = ER1
      GO TO 507
  607 PGS(1) = PGS(2)
      PGS(2) = PGS(3)
      PGS(3) = P
      ER(1) = ER(2)
      ER(2) = ER(3)
      ER(3) = ER1
      GO TO 507
  510 GO TO IG,(408,511)
  511 P = P2
      GO TO (567,631),IFL
  567 TRG2(N) = (G2/(1.+P/PG)-Y)*C
      GO TO 987
  631 IF ((TFB(N).LE.TFBL).OR.(TFB(N).GE.TFBH)) GO TO 986
      IF (P-PMAX) 616,616,687
  616 PRS = P
      GO TO 688
  687 PRS = PMAX
  688 TRG2(N) = (BU*Q(N)*TFB1*DEXP(TFB2*(TFB3-TFB(N))**2)
     1/(1.+(PRS/TFB4)*(1.-TFB5*(TFB3-TFB(N))**2))-Y)*C
      GO TO (987,568,987),IFLG
  568 TRG202(N) = TRG2(N)
      GO TO 987
  986 TRG2(N) = (BU*Q(N)*TFB1*DEXP(TFB2*(TFB3-TFB(N))**2)-Y)*C
      GO TO (987,569,987),IFLG
  569 TRG202(N) = TRG2(N)
  987 IF (INC) 635,635,636
  636 TRG2(N) = (SWO(N)-Y)*C
      GO TO (635,582),IFL
  582 GO TO (635,570,571),IFLG
  570 TRG202(N) = TRG2(N)
      GO TO 635
  571 TRG2(N) = TRG201(N)+(TRG2(N)-TRG202(N))
  635 IF (TRG2(N)) 415,415,981
  981 C = 0.
      GO TO 982
  415 PR(N) =  P
      N = N+1
      IF (N.LE.NT) GO TO 845
C
C     PR IS CONTACT PRESSURE DUE TO FUEL SWELLING OUT TO CLAD
  416 PR(NT1) = PP
      DO 38 I=1,NT1
```

```
      N = I
      GO TO IP,(39,803)
   39 IF (PR(I)-100.) 300,300,301
  300 PRO(I) = 100.
      GO TO 803
  301 PRO(I) = PR(I)
  803 IF (PR(I) - PP) 42,42,43
42    PS(I) = PP
      GOTO 44
43    PS(I) = PR(I)
C
C     CALCULATE CLADDING HOOP STRESS DUE TO PRESSURE
44    SP(I) = (2.*PS(I)-POD(I))/DODI1
  705 CALL B1A (B1)
      SH(I) = B1*(TCLB(I)-XTCLO(I))
C
C     CALCULATE THERMAL HOOP STRESS
   38 ST(I) = SP(I)+SH(I)
      GOTO IE,(50,85)
50    TM1=TM
      IF(ITM .NE. 1) GO TO 1050
      TM = AA9*(BU - BU7) + TMO
      GO TO 1051
 1050 TM = AA9*BU
 1051 DELTM = TM - TM1
      N = 1
  846 P = PS(N)
      GO TO (572,634),IFL
  572 TRIG(N) = XING(N)+G2/(1.+P/PG)
      GO TO 993
  634 IF ((TFB(N).LE.TFBL).OR.(TFB(N).GE.TFBH)) GO TO 992
      IF (P-PMAX) 618,618,689
  618 PRS = P
      GO TO 690
  689 PRS = PMAX
  690 TRIG(N) = XING(N)+(BU*Q(N)*TFB1*DEXP(TFB2*(TFB3-TFB(N))**2))
     1/(1.+(PRS/TFB4)*(1.-TFB5*(TFB3-TFB(N))**2))
      GO TO (993,573,993),IFLG
  573 TRIGO2(N) = TRIG(N)
      GO TO 993
  992 TRIG(N) = XING(N)+BU*Q(N)*TFB1*DEXP(TFB2*(TFB3-TFB(N))**2)
      GO TO (993,574,993),IFLG
  574 TRIGO2(N) = TRIG(N)
  993 TRIG2(N) = TRIG1(N)
      GO TO (577,583),IFL
  583 GO TO (577,576,575),IFLG
  575 TRIG(N) = TRIGO1(N)+(TRIG(N)-TRIGO2(N))
      GO TO 577
  576 TRIG(N) = TRIGO2(N)
  577 IF (TRIG(N) -TRIG2(N))543,543,542
C
C     TRIG IS THE FUEL SWELLING
  542 TRIG(N) = TRIG2(N)
```

```
  543 X = -1.+VFT(N)/VF0+TRIG(N)
C
C      IF STATEMENT CHECKS FOR INCOMPRESSIBLE FUEL OPTION
       IF (IRSWL.EQ.0) GO TO 869
       IF (TRIG(N)-DVV(N)) 868,869,869
  868 SWO(N) = DVV(N)-XING(N)
       INC = INC+1
       TRIG(N) = DVV(N)
       X = -1.+VFT(N)/VF0+TRIG(N)
  869 V(N) = X
       DVV(N) = TRIG(N)
       CALL BECK (X)
       Y = ET(N)
       ET2(N) = ET(N)
       CALL SYA (SY)
       IF (ST(N)-SY) 52,52,847
  847 TRA = ST(N)-SY
       CALL IO (6)
       GO TO 53
52     SE=ST(N)
       MM=5048
       CALL TESK (SE,EDOT)
       FLX = FFLX*QFFLX(N)
       T = TCLB(N)
       ESW1 = ESW(N)
       CALL HKNS (T,FLX,KNT1,TK)
       ESW(N) = NN1(N)/3.
       IF (IHKNS.EQ.1) GO TO 885
C
C      ONLY DURING CHANGE CASE COMPUTATIONS WILL 'IT' BE OTHER THAN ZERO
C      THIS PROHIBITS THE CLAD SWELLING, ESW(N), FROM DECREASING
       IF  (IT.EQ.0) GO TO 885
       ESWO = (4.9D-49*(FLX*(TM-DELTM)*3600.)**1.71*10.**(1.55D04/TK-
     15.99D06/TK**2))/1.D02/3.
       ESWD = ESW(N)-ESWO
       ESW(N) = ESW1+ESWD
  885 D(N) = ESW(N)-ESW1
       DELE(N)=EDOT*DELTM
       E(N)=E(N)+DELE(N)
       ET(N)=E(N)+ ESW(N)
C      DET IS CHANGE IN INELASTIC STRAIN
       DET = ET(N) - Y
  54   Z = ET(N) - ET1(N)
        IF ( Z  .EQ. 0.) GO TO 1054
       W1 = 1./Z
        GO TO 1055
 1054   W1 = 0.
 1055 IF(DET .EQ. 0) GO TO 1949
       X = Z/DET
       GO TO 1950
 1949   X = 0.
 1950 IF(IVJ4-2)952,952,949
  949 IF (XK - 1.0001 )953,953,952
```

```
  953 IF (W1*W2(N)) 963,963,950
  950 IF (W1*W3(N))951,951,965
  951 W2(N) = W3(N)
      DET2(N) = DET3(N)
  963  IF ( W1 .EQ. 0.) GO TO 943
       IF ( W2(N) .EQ. 0. ) GO TO 943
      ET1(N) = (DET + DET2(N) - 1./W1 - 1./W2(N) )/2.
      GO TO 964
  965 ET1(N) = DET
      GO TO 964
  952  IF ( W1 - W2(N)) 1952,  943, 1952
 1952 ET1(N) = (W1*DET - W2(N)*DET2(N)) / (W1 - W2(N))
  964 IF (ET1(N)) 943,944,944
  943 ET1(N) = 0.
  944 W3(N) = W2(N)
      DET3(N) = DET2(N)
      W2(N) = W1
      DET2(N) = DET
      IF (DET) 918 ,930,930
C
C     E IS CREEP STRAIN
C     ET IS TOTAL INELASTIC STRAIN
  918 ET(N) = ET2(N)
      E(N) = E(N) - DELE(N)
      IVJ5 = 1
      IF (DET - Z) 958,958,930
  958 Z = 0.
  930 IF (X) 945,946,946
  945 X = -X
  946 IF (X-TRG2(N)) 948,948,947
  947 GO TO (585,584),IFL
  584 GO TO (948,578,948),IFLG
  578 TRG2O2(N) = X
  585 TRG2(N) = X
  948 IF (Z) 702,702,703
  702 Z = -Z
  703 IF (Z - Z1 )  51, 51,931
  931 Z1 = Z
      NVJ = N
      IF (INC.GT.360) GO TO 1805
   51 N = N+1
      IF (N.LE.NT1) GO TO 846
      IF (INCC.EQ.1) GO TO 872
      IF (INC) 872,872,873
  873 INCC = 1
      GO TO 418
  872 INC = 0
      INCC = 0
      IF (IVJ4 ) 707,707,941
  941 IVJ5 = 1
      IF (IVJ4 - 10) 707,707,960
  707 IF (Z1 - EPS2) 940,938,938
  938 IF (IBUR.EQ.1) GO TO 843
```

```
      BU = BU - DBU
      TM = TM - DELTM
      BUL = BU +DBU
      IVJ4 = IVJ4 + 1
      DO 939 I=1,NT1
      E(I) = E(I) -DELE(I)
      ESW(I) = ESW(I) - D(I)
  939 ET(I) = ET2(I)
      IF (IVJ6) 959,959,962
  962 IVJ1 = 0
  959 IF (DBU - A26/10.) 926,926,811
  960 DO 961 I=1,NT1
      X = ET1(I) - DELE(I)
      E(I) = E(I) + X
      DET2(I) = ET1(I)
      IF (X) 961,961,966
  966 DELE(I) = ET1(I)
  961 ET(I) = ET2(I) + ET1(I)
  940 DO 932 I=1,NT1
      N = I
      CALL EMAXA (DELTM)
      IF(ET (I)-EMAX(I))912, 912, 200
  912 IF(ET (I)-EMAX1) 932,932,200
  200 CALL IO (22)
      IVJ = 1
  932 CONTINUE
  843 IF (NO2-1) 913,914,913
  913 CALL IO (7)
  914 X = BU/A26
      BUMX = BU*XMULT
      CALL IO (8)
  678 IF (IPLT1.EQ.0) GO TO 610
      IBUM3 = IBUM3+1
      IF (((IBUM3/3-1).EQ.0).OR.(IVJ.EQ.1)) GO TO 652
      GO TO 610
  652 IBUM3 = 0
      ARG1 = PR(1)
      ARG3 = ET(1)
      IBUM= IBUM+1
      DO 619 I=2,NT1
      ARG2 = PR(I)
      ARG4 = ET(I)
      IF (I.EQ.NT1) GO TO 424
      PRMX(IBUM) = DMAX1(ARG1,ARG2)
      ARG1 = PRMX(IBUM)
  424 ETMX(IBUM) = DMAX1(ARG3,ARG4)
  619 ARG3 = ETMX(IBUM)
      PPMX(IBUM) = PP
      XLPMX(IBUM) = XLP
      BMX(IBUM) = BUMX
  610 CALL IO (9)
  870 IF(IBUR .EQ. 1) GO TO 926
      IVJ4 = 0
```

```
 513  IF(N02 .LE. 0) GO TO 972
      IF(IVJ)70,70,807
   53 SE=SY
      CALL TESK (SE,EDOT)
      FLX = FFLX*QFFLX(N)
      T = TCLB(N)
      ESW1 = ESW(N)
      CALL HKNS (T,FLX,KNT1,TK)
      ESW(N) = NN1(N)/3.
      IF (IHKNS.EQ.1) GO TO 886
      IF  (IT.EQ.0) GO TO 886
      ESW0 = (4.9D-49*(FLX*(TM-DELTM)*3600.)**1.71*10.**(1.55D04/TK-
     15.99D06/TK**2))/1.D02/3.
      ESWD = ESW(N)-ESW0
      ESW(N) = ESW1+ESWD
  886 D(N) = ESW(N)-ESW1
      DELE(N)=EDOT*DELTM
      E(N)=E(N)+DELE(N)
      IF(SP(N)/SY-.5)56,57,57
56    IF((SH(N)+8.*SP(N))/SY-6.)58,202,202
  202 IF (IVJ1 ) 904,904,58
  904 CALL IO (10)
      IVJ1 = 1
      IVJ6 = 1
58    IF(SH(N)/SY-2.)204,204,205
204   MM=5050
      GOTO 60
205   MM=5051
      GOTO 61
   60 CALL ELA (EL)
62    ET(N)=E(N)+(ST(N)-SY)/EL + ESW(N)
      CALL EPLA (EPL,SY)
  709 IF (SP(N) - SY) 710,710,63
  63  ET(N) = ET(N) + (SP(N) - SY)/EPL
  710 DET = ET(N) - Y
  711 IF (MM.GE.5052) GO TO 860
      CALL IO (11)
  860 IF (MM-5052) 54,842,842
57    IF((SH(N)+4.*SP(N))/SY-4.)203,201,201
203   MM=5049
      GOTO 60
  201 IF ( IVJ1 ) 916,916,203
  916 CALL IO (12)
  877 IVJ1 = 1
      IVJ6 = 1
      GO TO 203
61    IF(BUT(N))64,64,65
64    BUT(N)=BU
      CALL IO (13)
   65 CALL ELA (EL)
      EP=(SH(N)-2.*SY)/EL
      CALL NFA (EP,EL,SY,NF)
      NC=A25*DELTM
```

```
      SUM(N)=SUM(N)+NC/NF
      GOTO 62
   70 IF (NO1) 100,100,933
  933 A20=AA20
      A21=AA21
      MM=5052
      ASSIGN 90 TO IH
      ASSIGN 803 TO IP
      ASSIGN 71 TO IB
      ASSIGN 85 TO IE
      IPR = 1
      IX = MAX(IPR)*MX1(IPR)
      IF (IX) 13,13,90
   85 DO 73 I=1,NT1
      N = I
      CALL SYA (SY)
      DS = ST(I)-SY
      IF(DS)73,73,84
73    CONTINUE
  842 IF (NO2-1) 808,915,915
  915 CALL IO (14)
  808 GOTO IH ,(90,100)
   84 CALL ELA (EL)
      ETA  =E(N)+DS/EL + ESW(N)
      DS1 = SP(N) - SY
      IF (DS1) 906,906,905
  905 CALL EPLA (EPL,SY)
      ETA = ETA + DS1/EPL
  906 IF (MAX(IPR)) 907,907,909
  907 IF (ETA - EMAX(N)) 909,909,908
  908 MAX(IPR) = 1
      CALL IO (15)
  909 IF (MX1(IPR)) 910,910,842
  910 IF (ETA-EMAX1) 842,842,911
  911 MX1(IPR) = 1
      CALL IO (16)
  881 GO TO 842
90    A20=AB20
      A21=AB21
      MM=5053
      ASSIGN100 TO IH
      IPR = 2
      IX = MAX(IPR)*MX1(IPR)
      IF (IX) 13,13,100
  100 IF (BUMX-BUMAX)811,810,810
  810 IF (IVJ2) 973,976,972
  973 CALL IO (17)
      IVJ2 = IVJ2 + 1
      GO TO 807
  976 IVJ2 = IVJ2 + 1
      BU = BU + DBU
      GO TO 975
  811 KBU = BU/A26 + 1.
```

```
      X = KBU*A26 - BU - 0.00004
1922  IF(X) 922,922,923
 922  X1 = A26 + X + 0.00004
      GO TO 919
 923  X1 = X + 0.00004
 919  Y = Z1/EPS2
      IF (Y - 0.5) 954,957,955
 954  Y = 0.5
 955  IF (Y - 2.) 957,957,956
 956  Y = 2.
 957  KX = Y * (X1/DBU) + 1.
      KX1 = X1/DBU + 0.99999
      IF (DBU - A26/10.) 967,968,968
 967  IF (IVJ5)  970,970,969
 970  IF (KX1- KX) 969,706,706
 969  KX = KX1
      GO TO 706
 968  IF (IVJ5) 706,706,935
 935  IF (KX1 - KX) 706,706,936
 936  KX = KX1
 706  XK = KX*(DBU/X1)
      DBU = DBU/XK
 926  IF (IBUR-1) 554,553,553
 553  GO TO (554,586),IFL
 586  GO TO (554,555,554),IFLG
 555  BU = BU+DBU
      IFLG = 3
      GO TO 516
 554  BU = BU+DBU
      IBUR = 0
 516  ASSIGN  3 TO II
      IF (IT2.EQ.0) GO TO 17
      IF (IOUT.LE.9) GO TO 17
      BU = BU-DBU
      IOUT = 0
      GO TO 973
 807  DO 81 I=1,NT
      N = I
      IF (TF(I)-TFMAX) 81,82,82
  82  CALL IO (23)
81    CONTINUE
      CALL IO (18)
      IF ((IVJ.EQ.1).AND.(ICALC.EQ.1)) GO TO 655
      IF(ICALC .EQ. 1) GO TO 1971
      GO TO 1972
 655  CALL IO (19)
      IERR = 4
      CALL IO (4)
      GO TO 1804
1971  ICALC = 2
      BU7 = BU
      ADBU = DBU/100000.
      BU = BU + ADBU
```

```
      GØ TØ (547,545),IFL
  545 DØ 546 I=1,NT1
      TRG1Ø1(I) = TRG1(I)
      TRG2Ø1(I) = TRG2(I)
  546 TRIGØ1(I) = TRIG(I)
      IFLG = 2
      GØ TØ 422
  547 IFLG = 3
  422 DØ 423 I=1,NT1
  423 FLUØ(I) = FLU(I)
      ITM = 1
      BUØ = BU7
      TMØ = TM
      IBUR = 1
      GØ TØ 841
 1972 IF (IVJ2)1804,971,971
  971 TCIN1 = TCIN
      TCIN = 70.
      DØ 977 I=1,NT1
      TC(I) = TCIN
  977 TCLØ(I) = TCIN
      TF(NT1) = TCIN
      A20 = 0.
      A21 = 0.
      NØX1= NØ1
      NØX2= NØ2
      NØ1 = 0
      NØ2 = 0
      IRSWL = 1
      IBUR = 1
      IT = 1
      XK = 100000.
      DBU = DBU/XK
      BU = BU + DBU
      ASSIGN 3 TØ I1
      IVJ2 = 1
      GØ TØ 975
  972 CALL IØ (20)
      IVJ2 = -1
      ICALC = 0
      NØ1 = NØX1
      NØ2 = NØX2
      TCIN = TCIN1
      CALL IØ (21)
      CALL IØ (24)
 1804 QPB = QPBSAV*(1.0+QPBD)
      IF (QPB.LE.QPBM) GØ TØ 999
      IF (IØPT-1) 1805,804,1805
  999 DELTC = DELTCS*(1.0+QPBD)
      FFLX = FFLXS*(1.0+QPBD)
      A26 = SAVA26
      CALL IØ (25)
      GØ TØ 417
```

```
C
 1805 CALL IO(26)
      RETURN
      END


      BLOCK DATA
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 NN1
      COMMON /XMAIN/
     1              TDL(60),     DL(60),      Q(60),       XTC(60),
     2   XTCLO(60), TCLO(60),    PR(100),     PRO(60),     DGDI(60),
     3   TCLB(60),  TCLI(60),    TFO(60),     TF(60),      QR(60),
     4   QL(100),   SP(100),     SH(100),     PS(60),      E(100),
     5   ET(100),   TG(60),      EMAX(60),    PO(60),      ST(100),
     6   BUT(60),   SUME(60),    SUM(60),     POD(60),     TGB(60),
     7   DGDI2(60), DELE(60),    TC(60),      ET1(60),     TRIG1(60),
     8   VCL(60),   VFT(60),     TFB(60),     FR(60),      GM(60),
     9   XING(60),  ET2(60),     W2(60),      DET2(60),    W3(60),
     A   QFFLX(60), V(60),       ESW(100),    D(60),       DVV(100),
     B   DET3(60),  SWO(60),     SWN(60),     BMX(100),    PPMX(100),
     C   PRMX(100), ETMX(100),   XLPMX(100),NN1(60),       OTM(60),
     E   TRIG(60),  TRIGO1(60),  TRIGO2(60),TRG1(60),      TRG1O1(60),
     F   TRG1O2(60), TRG2(60),   TRG2O1(60),TRG2O2(60),TRIG2(60),
     G   FLU(60),   FLUO(60),    TITLE1(10),TITLE2(10),TITLE3(10),
     H   PGS(3),    W(3),        ER(3),       DF(60),      MAX(2),
     I   MX1(2)
      COMMON /IOCOM/
     1N,N1,NT1,IOPT,ICALC,IPLT1,IKSWL,IHKNS,IFUEL,IPRNT,NO,M1,NDL,NO1,NO
     22,IT,IT2,NY,KNT,IPR,IDV,IBUM,IOUT,IERR,IQF,IFLG/XIO/BU,TCIN,DELTC,
     3DELTCN,GAMFR,PLTBU,TFBL,TFBH,TFB1,TFB2,TFB3,TFB4,TFB5,PMAX,BUINC,
     4BUMX,DOPP,HC,XLFPP,XLPPP,A1,A2,A3,A4,A5,A6,A9,A12,A13,A14,A15,A25,
     5A27,A28,A29,A30,A31,A32,A33,A34,A35,A36,A37,A38,A39,A40,A41,A42,
     6A43,A44,A45,A46,A47,A48,A49,A50,A51,A53,A54,A55,A56,A57,A58,A300,
     7AA20,AA21,AB20,AB21,TFMAX,FFLX,BUMAX,DOF,QPB,QPBD,QPBM,XLCL,XMNA,
     8XMF,RHTHF,DFDI,XNU,PPO,XLNAO,ALPNA,A401,A402,TB,GT,CORR,G1,BUST,
     9GB,G2,PG,GMO,GM1,V1,V2,FGR2,EMAX1,EPS1,EPS2,TRA,FCB,XLP,QLSUM,PP,
     ATM,TM2,TMO,ETA,AF,DPPP,P1,A26,A20,A21,SY
C
      DATA Q,XTC,XTCLO,TCLO,PR,PRO,DGDI,TCLB,TCLI,TFO,TF,QR,SP,SH,PS,E,
     1ET,TG,EMAX,PO,ST,BUT,SUME,SUM,POD,TGB,DGDI2,DELE,TC,ET1,TRIG1,VCL,
     2VFT,TFB,FR,GM,XING,ET2,W2,DET2,W3,DET3,DVV,TDL,DL,QL,PGS,ER,W,MAX,
     3MX1/60*0.,60*0.,60*0.,60*0.,100*0.,60*0.,60*0.,60*0.,60*0.,60*0.,
     460*0.,60*0.,100*0.,100*0.,60*0.,100*0.,100*0.,60*0.,60*0.,60*0.,
     5100*0.,60*0.,60*0.,60*0.,60*0.,60*0.,60*0.,60*0.,60*0.,60*0.,60*0.
     6,60*0.,60*0.,60*0.,60*0.,60*0.,60*0.,60*0.,60*0.,60*0.,60*0.,60*0.
     7,100*0.,60*0.,60*0.,100*0.,3*0.,3*0.,3*0.,2*0,2*0/
      DATA SWO,SWN,NN1,OTM/60*0.,60*0.,60*0.,60*0./,BMX/100*0./
      DATA TRIG,TRIGO1,TRIGO2,TRG1,TRG1O1,TRG1O2,TRG2,TRG2O1,TRG2O2,
     1 TRIG2,FLU / 60*0.,60*0.,60*0.,60*0.,60*0.,60*0.,60*0.,60*0.,60*0.
     2 ,60*0.,60*0. /,FLUO/60*0./,DF/60*0./
C
```

```
C
      END


      SUBROUTINE B1A (B1)
C     COEFFICIENT OF SHEAR MODULUS COMPUTED
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /XMAIN/ SKP1(580),TCLB(60) /IOCOM/ N /XIO/ BU,SKP2(42),A38,
     1A39
      B1=A38*(1.+A39*(TCLB(N)))
      RETURN
      END


      SUBROUTINE BECK (X)
      IMPLICIT REAL*8(A-H,O-Z)
C     CALCULATE FRACTION OF FISSION GAS RELEASED
      COMMON /XMAIN/ SKP1(2500),FR(60),GM(60) /IOCOM/ N /XIO/ SKP2(94),
     1GMO,GM1,V1,V2,FGR2
      Y1 = FR(N)
      IF (X - V1) 544,544,545
  544 FR(N) = 0.
      GO TO 549
  545 IF (X - V2) 546,546,547
  546 FR(N) = FGR2 * (X - V1)/(V2 - V1)
  549 Y = -0.0855 + 0.675*X
      IF (Y - FR(N)) 548,548,550
  550 FR(N) = Y
      GO TO 548
  547 FR(N) = 1. - (1. - FGR2) *V2/X
  548 IF (Y1 - FR(N)) 552,552,551
  551 FR(N) = Y1
  552 GM(N) = GMO + (GM1 - GMO) * FR(N)
      RETURN
      END


      SUBROUTINE DPLOT (IPLT,YMIN,YMAX,YEXP1,YEXP2,YEXP3,YEXP4)
C
C     THIS IS A PROGRAM TO PLOT INFORMATION FROM THE BEMOD PROGRAM
C
C       IPLT                       DESCRIPTION
C         1    -    PLOT FUEL CLAD CONTACT PRESSURE VS FUEL PIN LENGTH
C         2    -    PLOT THERMAL STRESS VS FUEL PIN LENGTH
C         3    -    PLOT CREEP STRAIN  VS FUEL PIN LENGTH
C         4    -    PLOT TOTAL INELASTIC STRAIN VS FUEL PIN LENGTH
C         5    -    PLOT CLAD SWELLING STRAIN VS FUEL PIN LENGTH
C         6    -    PLOT CLAD TOTAL STRESS VS FUEL PIN LENGTH
C         7    -    PLOT AVERAGE HOOP STRESS VS FUEL PIN LENGTH
C         8    -    PLOT PERCENT FUEL SWELLING VS FUEL PIN LENGTH
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C         9   -   PLOT FISSION GAS RELEASE VS FUEL PIN LENGTH
C        10   -   PLOT PLENUM PRESSURE VS MAXIMUM BURNUP PERCENT
C        11   -   PLOT FUEL CLAD CONTACT PRESSURE VS MAXIMUM BURNUP PERCE
C        12   -   PLOT MAXIMUM INELASTIC STRAIN VS MAXIMUM BURNUP PERCENT
C        13   -   PLOT GAS PLENUM LENGTH VS MAXIMUM BURNUP PERCENT
C
C     PLOTS OF VARIABLES VS MAXIMUM BURNUP PERCENT HAVE AN UPPER LIMIT
C     OF 15% ON THE MAXIMUM BURNUP - ALSO THERE IS AN 11% UPPER LIMIT
C     ON THE DELTA D/D VS LENGTH PLOTS
C
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*4 DELTA,DMX
      COMMON /XMAIN/
     ASKP(360),PR(100),SKP1(420),GL(100),SP(100),SH(100),PS(60),E(100),
     1ET(100),SKP2(180),ST(100),SKP3(1320),ESW(100),D(60),DVV(100),SKP4
     2(180),BMX(100),PPMX(100),PRMX(100),ETMX(100),XLPMX(100),SKP5(860),
     3TITLE3(10) /IOCOM/ N,NT,NT1,JSKP1(5),IFUEL,JSKP2(12),IBUM,IOUT,
     4IERR
      DIMENSION YEXP(4),YPT(100),XNUM(6),XNUM1(31),YNUM(4),YNUM1(4),
     1XNUM2(5),YNUM2(23),YD1(11),XNUM3(3),YNUM3(5),IPTSY(11)
      DATA DMX/Z002/4000/,DELTA/1H;/,DECADS,YLEN/3.,7.5/
      DATA XNUM1/3H0  ,3H.5 ,3H1  ,3H1.5,3H2  ,3H2.5,3H3  ,3H3.5,3H4  ,
     13H4.5,3H5  ,3H   ,3H6  ,3H   ,3H7  ,3H   ,3H8  ,3H   ,3H9  ,3H   ,
     23H10 ,3H   ,3H11 ,3H   ,3H12 ,3H   ,3H13 ,3H   ,3H14 ,3H   ,3H15 /
      DATA YD1/3.75,1.875,1.25,.9375,.75,1.25,1.071428,.9375,.83333,.75,
     1.68182/,IPTSY/3,5,7,9,11,13,15,17,19,21,12/
      DATA XNUM2/2H0 ,2H3 ,2H6 ,2H9 ,2H12/,XNUM3/2H 0,2H 7,2H14/
      DATA YNUM2/3H0. ,3H0.5,3H1.0,3H1.5,3H2.0,3H2.5,3H3.0,3H3.5,3H4.0,
     13H4.5,3H5.0,3H   ,3H6.0,3H   ,3H7.0,3H   ,3H8.0,3H   ,3H9.0,3H   ,
     23H10.,3H   ,3H11./,YNUM3/2H0 ,2H3 ,2H6 ,2H9 ,2H12/
      DATA XNUM/2H0 ,2H10,2H20,2H30,2H40,2H50/
     1,YNUM1/5H    0,5H10000,5H20000,5H30000/,YNUM/2H0.,2H1.,2H2.,2H3./,
     2XDMT/0.16667/
      CALL PLOTS (9.5,-11.,-3)
      CALL PLTMRK (.5,.5)
      CALL PLOT (2.,1.75,-3)
      CALL SYMBL5 (222,4,DMX)
      YEXP(1) = YEXP1
      YEXP(2) = YEXP2
      YEXP(3) = YEXP3
      YEXP(4) = YEXP4
      ISKIP = 2
      IERR = 0
C
C     PLOT THE Y-AXIS AND APPROPRIATE TITLE
C
      GO TO (10,20,30,40,50,60,70,80,90,92,94,96,98),IPLT
   10 CALL SYMBL4  (-.5,1.89,.15,30HFUEL-CLADDING CONTACT PRESSURE,90.,
     130)
      DO 5 I=1,NT1
    5 YPT(I) = PR(I)
      GO TO 100
   20 CALL SYMBL4 (-.5,2.88,.15,14HTHERMAL STRESS,90.,14)
```

```
      DØ 15 I=1,NT1
   15 YPT(I) = SH(I)
      GØ TØ 140
   30 CALL SYMBL4 (-.5,2.02,.15,27HCLADDING CREEP  D/D PERCENT,90.,27)
      CALL SYMBL4 (-.5,3.948,.15,DELTA,90.,1)
      DØ 25 I=1,NT1
   25 YPT(I) = E(I)
      GØ TØ 142
   40 CALL SYMBL4 (-.5,2.02,.15,27HCLADDING TØTAL  D/D PERCENT,90.,27)
      CALL SYMBL4 (-.5,3.948,.15,DELTA,90.,1)
      DØ 35 I=1,NT1
   35 YPT(I) = ET(I)
      GØ TØ 142
   50 CALL SYMBL4 (-.5,1.98,.15,30HCLADDING SWELLING  D/D PERCENT,90.,
     130)
      CALL SYMBL4 (-.5,4.293,.15,DELTA,90.,1)
      DØ 45 I=1,NT1
   45 YPT(I) = ESW(I)
      GØ TØ 142
   60 CALL SYMBL4 (-.5,2.51,.15,21HCLADDING TØTAL STRESS,90.,21)
      DØ 55 I=1,NT1
   55 YPT(I) = ST(I)
      GØ TØ 140
   70 CALL SYMBL4 (-.5,2.55,.15,19HAVERAGE HØØP STRESS,90.,19)
      DØ 65 I=1,NT1
   65 YPT(I) = SP(I)
      GØ TØ 140
   80 CALL SYMBL4 (-.5,2.45,.15,21HPERCENT FUEL SWELLING,90.,21)
      DØ 75 I=1,NT1
   75 YPT(I) = DVV(I)
      GØ TØ 100
   90 CALL SYMBL4 (-.5,2.1,.15,29HLITERS ØF FISSIØN GAS RELASED,90.,29)
      DØ 91 I=1,NT1
   91 YPT(I) = GL(I)
      GØ TØ 100
   92 CALL SYMBL4 (-.5,2.47,.15,21HPLENUM PRESSURE (PSI),90.,21)
      DØ 93 I=1,IBUM
   93 YPT(I) = PPMX(I)
      GØ TØ 100
   94 CALL SYMBL4 (-.5,1.36,.15,38HMAXIMUM FUEL-CLADDING CØNTACT PRESSUR
     1E,90.,38)
      DØ 95 I=1,IBUM
   95 YPT(I) = PRMX(I)
      GØ TØ 100
   96 CALL SYMBL4 (-.5,1.55,.15,35HMAXIMUM CLADDING TØTAL  D/D PERCENT,
     190.,35)
      CALL SYMBL4 (-.5,4.5,.15,DELTA,90.,1)
      DØ 97 I=1,IBUM
   97 YPT(I) = ETMX(I)
      GØ TØ 142
   98 CALL SYMBL4 (-.5,2.36,.15,22HGAS PLENUM LENGTH (IN),90.,22)
      DØ 99 I=1,IBUM
   99 YPT(I) = XLPMX(I)
```

```
      GO TO 141
  100 Y = -.1
      NPTS = NT1
      IF (IPLT.GT.9) NPTS=IBUM
      DY = DECADS/YLEN
      CALL LAXIS (0.,0.,1H ,1,YLEN,90.,0.,DY,0)
      DO 110 I=1,4
      CALL SYMBL4 (-.10,Y,.15,2H10,90.,2)
      CALL SYMBL4 (-.20,Y+.32,.1,YEXP(I),90.,2)
  110 Y = Y+2.5
      CALL PLOT (0.,0.,3)
      IF (IPLT.LE.9) GO TO 131
      GO TO 510
  140 ISKIP = 1
      INCR = 1
      NPTS = NT1
      DO 143 I=1,NPTS
      IF (YPT(I).GT.20000.) GO TO 144
  143 CONTINUE
      CALL PLINE (0.,.750,FACTX,FACTY,11,NPTS,0,IPLT)
      IPTS = 3
      YD = 3.75
      FACTY = .000375
      GO TO 126
  144 CALL PLINE (0.,.625,FACTX,FACTY,13,NPTS,0,IPLT)
      IPTS = 4
      YD = 2.5
      FACTY = 0.00025
      GO TO 126
  141 IF (YPT(1).GT.3.) GO TO 562
      CALL PLINE (0.,.5,FACTX,FACTY,16,INCR,0,IPLT)
      IXLP = 1
      IPTS = 4
      YD = 2.5
      GO TO 554
  562 CALL PLINE (0.,.625,FACTX,FACTY,13,INCR,0,IPLT)
      IXLP = 2
      IPTS = 5
      YD = 1.875
  554 ADJ = 0.
      NPTS = NT1
      IF (IPLT.GT.9) NPTS=IBUM
      DO 560 I=1,IPTS
      DIST = ADJ*YD-.1
      GO TO (556,558),IXLP
  556 CALL SYMBL4 (-.25,DIST,.15,YNUM(I),90.,2)
      GO TO 560
  558 CALL SYMBL4 (-.25,DIST,.15,YNUM3(I),90.,2)
  560 ADJ = ADJ+1.
      CALL PLOT (0.,0.,3)
      GO TO 510
  142 NPTS = NT1
      IF (IPLT.GT.9) NPTS=IBUM
```

```
      INCR = NPTS
      CALL PLINE (0.,YD,FACTX,FACTY,IPTS,INCR,2,IPLT)
      IF (IERR-2) 146,145,146
  145 CALL SYMBL4 (1.,4.,.2,36HTHE DELTA D/D VALUE HAS EXCEEDED THE,0.,
     136)
      CALL SYMBL4 (1.,3.7,.2,27HPLOTTING LIMIT VALUE OF 11.,0.,27)
      RETURN
  146 ISKIP = 0
      INCR = 2
      IF ((IPTS.LE.5).OR.(IPTS.EQ.11)) INCR = 1
C     IPTS FROM PLINE IS IEMAX, THE INDEX USED TO GET CORRECT DISTANCE
C     INCREMENTS AND THE NUMBER OF TIMES INCREMENT IS TO BE USED
      YD = YD1(IPTS)
      IPTS = IPTSY(IPTS)
  126 ADJ = 0.
      DO 130 I=1,IPTS,INCR
      DIST = YD*ADJ
      IF (ISKIP.EQ.1) GO TO 127
      CALL SYMBL4 (-.2,DIST-.07,.15,YNUM2(I),90.,3)
      GO TO 129
  127 CALL SYMBL4 (-.2,DIST-.3,.15,YNUM1(I),90.,5)
  129 ADJ = ADJ+1.
  130 CONTINUE
      IF (IPLT.EQ.12) GO TO 510
C
C     PLOT THE X-AXIS AND TITLE - FOR IPLT LESS THAN 10
C
  131 CALL SYMBL4 (-.95,-.95,.12,TITLE3,0.,80)
      IF ((IPLT.EQ.2).OR.(IPLT.EQ.8).OR.(IPLT.EQ.9)) GO TO 135
      CALL SYMBL4 (.2,-.6,.15,44HFUEL PIN LENGTH (IN) - LAST POINT FOR P
     1LENUM,0.,44)
      GO TO 150
  135 CALL SYMBL4 (1.5,-.6,.15,20HFUEL PIN LENGTH (IN),0.,20)
  150 CALL PLOT (0.,0.,3)
      IF (IFUEL.EQ.0) GO TO 119
      GO TO (120,119,121,121),IFUEL
  119 CALL PLINE (.22222,0.,FACTX,FACTY,28,INCR,0,IPLT)
      XD = 1.33333
      IPTS = 5
      GO TO 13
  120 CALL PLINE (0.54545,0.,FACTX,FACTY,12,INCR,0,IPLT)
      XD = 1.09091
      IPTS = 6
      GO TO 13
  121 CALL PLINE (.4219,0.,FACTX,FACTY,15,INCR,0,IPLT)
      XD = 2.9536
      IPTS = 3
   13 ADJ = 0.
      DO 18 I=1,IPTS
      DIST = XD*ADJ-.07
      IF (IFUEL.EQ.0) GO TO 16
      GO TO (14,16,17,17),IFUEL
   14 CALL SYMBL4 (DIST,-.3,.12,XNUM(I),0.,2)
```

```
      GO TO 18
   16 CALL SYMBL4 (DIST,-.3,.12,XNUM2(I),0.,2)
      GO TO 18
   17 CALL SYMBL4 (DIST,-.3,.12,XNUM3(I),0.,2)
   18 ADJ = ADJ+1.
C
C     PLOT POINTS FOR IPLT LESS THAN OR EQUAL TO 9
C
      IF (ISKIP.EQ.1) GO TO 3010
      IF (ISKIP.EQ.0) GO TO 2060
      XYMAX = DLOG10(YMAX/YMIN)/DY
      XD = 1.
      DO 3000 I=1,NPTS
      IF (YPT(I).LT.YMIN) GO TO 3000
      YPT(I) = DLOG10(YPT(I)/YMIN)/DY
      IF (YPT(I).GT.XYMAX) GO TO 3000
      DIST = XD*XDMT
 2050 CALL SYMBL4 (DIST,YPT(I),.05,1H0,0.,1)
 3000 XD = XD+1.
      GO TO 990
 3010 XD = 1.
      DO 3020 I=1,NPTS
      IF ((YPT(I).LE.0.).OR.(YPT(I).GT.YMAX)) GO TO 3020
      XDIST = XD*XDMT
      YDIST = YPT(I)*FACTY
      CALL SYMBL4 (XDIST,YDIST,.05,1H0,0.,1)
 3020 XD = XD+1.
      GO TO 990
 2060 ADJ = 1.
      DO 2075 I=1,NPTS
      IF (YPT(I).LT.0.) GO TO 2075
      YDIST = YPT(I)*FACTY
      XDIST = ADJ*XDMT
      CALL SYMBL4 (XDIST,YDIST,.05,1H0,0.,1)
 2075 ADJ = ADJ+1.
      GO TO 990
C
C     FOR IPLT GREATER THAN 9
C     PLOT X-AXIS FOR IPLT GREATER THAN 9
C
  510 CALL PLINE (XD,0.,FACTX,FACTY,IPTS,INCR,1,IPLT)
      IF (IERR-1) 512,511,512
  511 CALL SYMBL4 (1.,4.,.2,28HTHE MAXIMUM BURNUP VALUE FOR,0.,28)
      CALL SYMBL4 (1.,3.7,.2,32HPLOTTING (15) HAS BEEN EXCEEDED.,0.,32)
      RETURN
  512 ADJ = 0.
      DO 550 I=1,IPTS,INCR
      DIST = XD*ADJ-.05
      CALL SYMBL4 (DIST,-.25,.15,XNUM1(I),0.,3)
      IF (INCR.EQ.2) GO TO 549
      ADJ = ADJ+1.
      GO TO 550
  549 ADJ = ADJ+2.
```

```
  550 CONTINUE
      CALL SYMBL4 (1.6,-.6,.15,22HMAXIMUM BURNUP PERCENT,0.,22)
      CALL SYMBL4 (-.95,-.95,.12,TITLE3,0.,80)
      CALL PLOT (0.,0.,3)
  520 IF (IPLT.EQ.13) GO TO 850
      IF (IPLT.EQ.12) GO TO 875
C
C     PLOT POINTS FOR IPLT = 10 & 11
C
      XYMAX = DLOG10(YMAX/YMIN)/DY
      DO 700 I=1,NPTS
      IF (YPT(I).LE.0.) GO TO 700
  750 YPT(I) = DLOG10(YPT(I)/YMIN)/DY
      IF ((YPT(I).LT.0.).OR.(YPT(I).GT.XYMAX)) GO TO 700
      XDIST = BMX(I)*FACTX
  702 CALL SYMBL4 (XDIST,YPT(I),.05,1H0,0.,1)
  700 CONTINUE
      GO TO 990
C
C     PLOT POINTS FOR IPTL = 12
C
  875 ADJ = 1.
      DO 880 I=1,NPTS
      IF (YPT(I).LT.0.) GO TO 880
      XDIST = BMX(I)*FACTX
      YDIST = YPT(I)*FACTY
      CALL SYMBL4 (XDIST,YDIST,.05,1H0,0.,1)
  880 CONTINUE
      GO TO 990
C
C     PLOT POINTS FOR IPLT = 13
C
  850 YD = 2.5
      IF (YPT(1).GT.3.) YD = .625
      DO 900 I=1,NPTS
      YPT(I) = YD*YPT(I)
      XDIST = BMX(I)*FACTX
  900 CALL SYMBL4 (XDIST,YPT(I),.05,1H0,0.,1)
  990 ISKIP = 2
      RETURN
 5000 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE ELA (EL)
C     CALCULATE MODULUS OF ELASTICITY
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /XMAIN/ SKP1(240),XTCLO(60) /IOCOM/ N /XIO/ BU,SKP2(50),A46
     1,A47
      EL=A46*(1.+A47*XTCLO(N))
      RETURN
      END



      SUBROUTINE EMAXA (DELTM)
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 NN1
      COMMON /XMAIN/
     A SKP(120),Q(60),SKP1(60),XTCLO(60),SKP2(1040),ET(100),TG(60),EMAX
     1(60),PO(60),ST(100),BUT(60),SUME(60),SUM(60),SKP3(180),DELE(60),
     2SKP4(660),DET2(60)
     3/IOCOM/ N /XIO/ SKP6(27),A12,A13,A14,A15,SKP7(8),A34,SKP8(5),
     4A40,A41,A42,SKP9(21),FFLX,SKP0(37),TM
C
C     CALCULATE TIME FOR CLAD TO RUPTURE
C
      S = ST(N)
      T = XTCLO(N)
    3 IF (S)4,4,5
 4    S = 1.0
 5    EXF = A12 + A13*DLOG(S) + A14/(T+460.)
      IF(EXF .LT. 170.) GO TO 10
      EXF = 170.
 10   TTF = (1. + A15*DLOG(1. + A34*FFLX*Q(N)*TM*3600.)) + DEXP(EXF)
      IF(DELTM) 6, 7, 6
 6    EDOT = DELE(N) /DELTM
      GO TO 8
 7    EDOT = 0.
 8    EMAX2 = EDOT*TTF
      DET = DET2(N)
      IF (EMAX2) 2,2,1
  1   SUME(N)=SUME(N)+DET     /EMAX2
  2   DELE2=EMAX2*(1.-SUME(N)-SUM(N))
      EMAX(N)=ET(N) + DELE2
      RETURN
      END



      SUBROUTINE EPLA (EPL,SY)
      IMPLICIT REAL*8(A-H,O-Z)
C
C     CALCULATE PLASTIC MODULUS, EPL
C
      COMMON /XMAIN/ SKP1(120),Q(60),XTC(60),XTCLO(60),SKP2(280),
```

```
     1 TCLB(60)   /IOCOM/ N /XIO/ BU,SKP3(57),A54,A55
      T = TCLB(N)
      EPL = A54*(1. + A55*T)
      RETURN
      END



      SUBROUTINE HGA (HG)
      IMPLICIT REAL*8(A-H,O-Z)
C
C     CALCULATE CERAMIC FUEL-CLADDING INTERFACE CONDUCTANCE
C
      COMMON /XMAIN/ SKP1(460),PRO(60)                     /IOCOM/ N /XIO/
     1BU,SKP3(21),A3,A4
      HG=DEXP(A3+A4*PRO(N)**3.)
      RETURN
      END



      SUBROUTINE HKNS (TEMP,FLX,KNT1,TK)
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8    N9,M1,M2,N2,K1,K2,K3,L1,I,N3,M3,M9,NN1,I5
      COMMON /XMAIN/ SKP1(3980),NN1(60),OTM(60) /IOCOM/ N,NT,NT1,
     1JSKP1(4),IHKNS /XIO/ SKP2(107),TM
      DIMENSION        R1(60),R2(60),N2(60),N3(60),X4(60),X5(60),M(60)
      DATA R1,R2,N2,N3,X4,X5/60*1.D-08,60*1.D-08,60*0.,60*0.,
     160*1.D08,60*0./,M/60*0/
      DATA L1,N9,M3,C5,R9,G1,C2,C9/1.D08,1.D08,1.D-07,.1D00,1.D-05,
     12.D-03,3.5D-24,5.05D02/,S5,C7,U3/0.3D02,0.3D01,1.D30/
      IF (IHKNS.EQ.0) GO TO 1000
      TM1 = 3600.*TM
      IF (TM1.LE.OTM(N)) GO TO 199
C
C     Y6 IS INITIALIZED AT 10 FOR EACH NODE POINT
C
      Y6 = 10.
   70 O1 = FLX/1.D15
      IOPT = 1
      T = (TEMP-32.)/1.8 +273.
      TK = T
      N9 = 10.**8
      X1 = 10.** (-30000./(4.6*T))
      X2 = 10.** (-3000./(4.6*T))
      X3 = 10.** (-38000./(4.6*T))
      U1 = 10.**(-100000./(4.6*T))
      GO TO 105
  100 X6 = (X4(N)*2.*R1(N)+X5(N)*2.*R2(N)+2.*N9*R9)**.5+L1**.5
      M(N) = M(N)+1
      K1 = 7.72/T*1.D-12*C5*(2.6D07-1.5D04*(T-283.))
      F1 = 1.D-07+K1
      X7 = 12.56*X1*R1(N)*X4(N)
```

```
      M1 = 1./X6
      M2 = 1./F1
      K3 = DLOG(M2*M1)
      K2 = 6.28*X2*(L1+6.28*R2(N)*X5(N))/K3
      X8 = X1*6.28*(L1+6.28*R2(N)*X5(N))/DLOG(M1/M3)
      X9 = K2
      Z1 = X7*X2/X1
      G2 = 6.*X1/(G1*M1)
      G3 = 6.*X2/(G1*M1)
      G4 = G3*G2+G3*X8+G3*X7+G2*K2+Z1*G2
      Z2 = X2/(2.76D-08)**2
      W1 = 12.56*R9*N9*X1
      Z3 = Z2*(X7+X8+G2+W1)
      W2 = 12.56*X2*R9*N9
      Z4 = X7*Z1+X7*X9+Z1*X8+X9*X8
      W3 = G2*W2+X7*W2+X8*W2+W1*G3+W1*Z1+W1*K2+W1*W2
      G5 = Z4+G4+W3
      IF (T.GT.623.) GO TO 156
      S5 = 0.D00
      GO TO 160
  156 IF (T.LT.673.) GO TO 159
      Z6 = 9.D-08*O1
      GO TO 161
  159 S5 = 30.*(1.-((673.-T)/50.))
  160 Z6 = 3.D-09*O1*S5
  161 Z5 = (-(X9+Z1+G3+W2))*Z6
      Z7 = -(Z5/G5)
      IF (Z7.LT.1.D-09) GO TO 171
      Z7 = (-G5+(G5**2-(4.*Z3*Z5))**0.5)/(2.*Z3)
  171 IF (S5.GT.0.) GO TO 180
      Z8 = 9.D-08*O1/((Z1+K2+G3+W2)+Z2*X3)
      N9 = 9.D-08*O1/(12.6*Z8*R9*X2)
      GO TO 185
  180 Z8 = Z7*(G2+X7+X8+W1)/(G3+K2+Z1+W2)
  185 A1 = (X7*Z7-Z1*Z8)*8.4D22
      IF (A1.GT.0.) GO TO 188
      A1 = 0.
  188 A2 = (K2*Z8-X8*Z7)*8.4D22
      IF (A2.GT.0.) GO TO 191
      A2 = 0.
  191 A3 = (G2*Z7-G3*Z8)*0.8428D23
      V1 = Z7/X3
      IF (V1.LT.1.) GO TO 202
      Y2 = DLOG(V1)
      A7 = (W1*Z7-W2*Z8)*8.4D22
      R8 = 2.*C9/(1.16D07*T*DLOG(V1))
      M9 = ((12.56*R8*X1*Z7)-(12.56*X2*Z8*R8))*8.4D22
      Y8 = 744.*C9**3/(2.3*T**3*Y2**2)
      IF (Y8.LT.25.) GO TO 205
  202 I = 0.
      GO TO 220
  205 C1 = O1*4.25D20
      I = M9*10.**(-Y8)*7.5D14*O1
```

```
      V2 = Z8/U1
      U2 = 1.17D-06/(C7*DLOG(V2))
      U4 = A2*U2/(L1+6.28*R2(N)*X5(N))
      U5 = 4.65D03/(C7**2*DLOG(V2))
      IF (U5.LT.25.) GO TO 220
      I5 = 0.
      GO TO 219
  220 I5 = U3*10.**(-U5)*U4
  219 X4(N) = X4(N)+I*Y6
      X5(N) = X5(N)+I5*Y6
C
C     N3 ADDS UP THE SWELLING WHICH IS DEPENDENT UPON THE TIME, TEMPERATURE,
C     AND FLUX
C
      N3(N) = N3(N)+A1*C2*Y6
      IF (N3(N).LE.0.) GO TO 221
      R1(N) = (N3(N)/(4.*X4(N)))**.33
  221 A4 = 39.4384*R2(N)*X5(N)*X2/K3
      A6 = 39.4384*X1*R2(N)*X5(N)/DLOG(M1/M3)
      A5 = (A4*Z8-A6*Z7)*0.8428D23
      IF (A5.GT.0.) GO TO 250
      A5 = 0.
  250 N2(N) = N2(N)+A5*C2*Y6
      IF (N2(N).LE.0.) GO TO 252
      R2(N) = (N2(N)/(9.42D-08*X5(N)))**.5
  252 OTM(N) = OTM(N)+Y6
C
C     IF IOPT = 3, THE LAST CALCULATION HAS BEEN DONE
C
      IF (IOPT.EQ.3) GO TO 915
      IOPT = 2
  105 DIFT = TM1-OTM(N)
      IF (DIFT) 900,900,1
    1 IF (DIFT-Y6) 7,7,4
    7 IOPT = 3
    2 Y6 = DIFT
      GO TO 100
    4 IF (M(N).LT.10) GO TO 100
      Y6 = 100.
      IF (M(N).LT.20) GO TO 100
      Y6 = 1000.
      IF (M(N).LT.120) GO TO 100
      Y6 = 1.D04
      IF (M(N).LT.130) GO TO 100
      Y6 = 2.D05
      IF (M(N).LT.179) GO TO 100
      Y6 = 1.D06
      GO TO 100
  900 IF (IOPT-1) 199,905,910
  905 RETURN
C     IF IOPT = 2, Y6 IS SET TO DIFT AND THE LAST CALCULATION IS DONE
  910 IF (IOPT-2) 900,7,915
  915 NN1(N) = 4.1762*X4(N)*R1(N)**3
```

```
      KNT1 = KNT1+1
  199 RETURN
C
C     THIS IS PNL'S SWELLING MODEL THAT IS USED IN PLACE OF HARKNESS' IF
C     IHKNS = 0
 1000 TK = 5./9.*(TEMP-32.)+273.
      NN1(N) = (4.9D-49*(FLX*TM*3600.)**1.71*10.**(1.55D04/TK-5.99D06/
     1TK**2))/1.D02
      RETURN
      END



      SUBROUTINE IO (IOGOTO)
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 NN1
      COMMON /XMAIN/
     1               TDL(60),     DL(60),      G(60),      XTC(60),
     2 XTCLO(60),    TCLO(60),    PR(100),     PRO(60),    DGDI(60),
     3 TCLB(60),     TCLI(60),    TFO(60),     TF(60),     QR(60),
     4 QL(100),      SP(100),     SH(100),     PS(60),     E(100),
     5 ET(100),      TG(60),      EMAX(60),    PO(60),     ST(100),
     6 BUT(60),      SUME(60),    SUM(60),     POD(60),    TGB(60),
     7 DGDI2(60),    DELE(60),    TC(60),      ET1(60),    TRIG1(60),
     8 VCL(60),      VFT(60),     TFB(60),     FR(60),     GM(60),
     9 XING(60),     ET2(60),     W2(60),      DET2(60),   W3(60),
     A QFFLX(60),    V(60),       ESW(100),    D(60),      DVV(100),
     B DET3(60),     SWO(60),     SWN(60),     BMX(100),   PPMX(100),
     C PRMX(100),    ETMX(100),   XLPMX(100),NN1(60),      OTM(60),
     E TRIG(60),     TRIGO1(60),  TRIGO2(60),TRG1(60),     TRG101(60),
     F TRG102(60),   TRG2(60),    TRG201(60),TRG202(60),TRIG2(60),
     G FLU(60),      FLUO(60),    TITLE1(10),TITLE2(10),TITLE3(10),
     H PGS(3),       W(3),        ER(3),       DF(60),     MAX(2),
     I MX1(2)
      COMMON /IOCOM/
     1N,NI,NT1,IOPT,ICALC,IPLT1,IRSWL,IHKNS,IFUEL,IPRNT,NO,M1,NDL,NO1,NO
     22,IT,IT2,NY,KNT,IPR,IDV,IBUM,IOUT,IERR,IQF,IFLG/XIO/BU,TCIN,DELTC,
     3DELTCN,GAMFR,PLTBU,TFBL,TFBH,TFB1,TFB2,TFB3,TFB4,TFB5,PMAX,BUINC,
     4BUMX,DOFP,HC,XLFPP,XLPPP,A1,A2,A3,A4,A5,A6,A9,A12,A13,A14,A15,A25,
     5A27,A28,A29,A30,A31,A32,A33,A34,A35,A36,A37,A38,A39,A40,A41,A42,
     6A43,A44,A45,A46,A47,A48,A49,A50,A51,A53,A54,A55,A56,A57,A58,A300,
     7AA20,AA21,AB20,AB21,TFMAX,FFLX,BUMAX,DOF,QPB,QPBD,QPBM,XLCL,XMNA,
     8XMF,RPTHF,DFD1,XNU,PPO,XLNAO,ALPNA,A401,A402,TB,GT,CORR,G1,BUST,
     9GB,G2,PG,GMO,GM1,V1,V2,FGR2,EMAX1,EPS1,EPS2,TRA,FCB,XLP,QLSUM,PP,
     ATM,TM2,TMO,ETA,AF,DPPP,P1,A26,A20,A21,SY
C
      GO TO (1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,
     123,24,999,26),IOGOTO
C                             READ  INPUT
C
C
    1 PRINT 3002
      READ 3001, TITLE1
```

```
      PRINT 3004, TITLE1
      READ 3001, TITLE2
      PRINT 3004, TITLE2
   84 READ 3001, TITLE3
C
C     THE FLUENCE PRINTED OUT IS IN SECONDS AND SHOULD BE MULTIPLIED
C     BY 10**22 FOR THE COMPLETE ANSWER.
C     IF IOPT = 1 ANOTHER PROBLEM MAY BE READ IN
C     IF ICALC = 1 A CHANGE CASE MAY BE READ IN
C     IF IPLT1 = 1, PLOTS WILL BE MADE AT TERMINAL CONDITIONS
C     IPLT1 = 2, PLOTS WILL BE MADE AT MAX BURNUP = PLTBU & AT TERMINAL
C     CONDITIONS - IPLT1 = 3, WHEN USING 6 NODE POINTS & PLOTS VARIABLE
C     VS MAXIMUM BURNUP
C     IRSWL = 1 FOR INCOMPRESSIBLE FUEL
C     IHKNS = 1 FOR USING HARKNESS'S ROUTINE, =0 FOR USING PNL MODEL
C     IFUEL = 1, USE NEW FUEL SWELLING MODEL (BLANKET MATERIAL)
C     IFUEL = 2, USE NEW FUEL SWELLING MODEL (CORE FUEL), OTHERWISE 0
C     IFUEL = 3 - CORE FUEL OF LENGTH 14.22 INCHES - USE NEW MODEL - MKII
C     IFUEL = 4 - CORE FUEL OF LENGTH 14.22 INCHES - USE OLD MODEL - MKII
C     IPRNT = 1 - PRINT CALCULATIONS EVERY FIFTH BURNUP STEP (FOR 36 NODE
C     IPRNT = 2 - PRINT CALCULATIONS EVERY BURNUP STEP (FOR 7 TOTAL NODES
C     IPRNT = 3 - PRINT CALCULATIONS EVERY OTHER BURNUP STEP (36 NODES)
C     IPRNT = 4 - PRINT CALCULATIONS EVERY BURNUP STEP (36 NODES)
C     GAMFR IS THE FRACTION OF TOTAL PIN HEATING (QPB) DUE TO GAMMA
C     HEATING
C
      READ 1100,IOPT,ICALC,IPLT1,IRSWL,IHKNS,IFUEL,IPRNT,GAMFR,PLTBU
      READ 2000,TFBL,TFBH,TFB1,TFB2,TFB3,TFB4,TFB5,PMAX
      READ 1000,NT,ICIN,DELTC,DOPP,HC,XLFPP,DPPP
      NT1 = NT + 1
   86 READ2000,AF,FCB,XLPPP,A1,A2,A3,A4,A5
      READ2000,A6,A9,A12,A13,A14,A15,A25,A26
      READ2000,A27,A28,A29,A30,A31,A32,A33,A34
      READ2000,A35,A36,A37,A38,A39,A40,A41,A42
      READ2000,A43,A44,A45,A46,A47,A48,A49,A50
      READ2000,A51,A53,A54,A55,A56,A57,A58,A300
      READ2000,AA20,AA21,AB20,AB21,TFMAX,FFLX,BUMAX,DOF
      READ2000,(Q(I),I=1,NT)
      READ2000,(QFFLX(I),I=1,NT1)
      READ2000,(PO(I),I=1,NT)
      READ 2000,(DF(I),I=1,NT1)
      READ2000,QPB ,QPBD,QPBM,X, XLCL ,XMNA,XMF,RHTHF
      READ 3000, NO,M1,NDL,NO1,NO2,DFDI,XNU,PPO,XLNAO,ALPNA,A401,A402
      READ 2000, TO , GT,CORR,G1,BUST,GB,G2,PG
      READ 2000, GMO,GM1,V1,V2,FGR2,EMAX1 ,EPS1,EPS2
      READ 2000, (TDL(I),DL(I),I=1,NDL)
C
C                         PRINT  INPUT
C
  999 IF (IOGOTO.NE.25) GO TO 400
      PRINT 3002
  400 KNT = 1
      PRINT 3004, TITLE3
```

```
      PRINT5000
      PRINT 5010, NT,TCIN,DELTC,DDPP,HC,XLFPP,DPPP,AF,FCB,PLTBU
      PRINT5001
      PRINT5011,XLPPP,A1,A2,A3,A4,A5,A6,A9,A12,A13
      PRINT5002
      PRINT5011,A14,A15,A25,A26,A27,A28,A29,A30,A31,A32
      PRINT5003
      PRINT5011,A33,A34,A35,A36,A37,A38,A39,A40,A41,A42
      PRINT5004
      PRINT 5011,A43,A44,A45,A46,A47,A48,A49,A50,A51,A53
      PRINT 5005
      PRINT5011,A54,A55,A56,A57,A58,AA20,AA21,AB20,AB21,A300
      PRINT 5044
      PRINT 5087,A401,A402,XLCL,XMNA,XMF,RHTHF,IMPT,ICALC,IPLT1,IRSWL,
     1IHKNS,IFUEL,IPRNT
      PRINT5043
      PRINT 5011,QPB,QPBD,QPBM,FFLX,BUMAX,EMAX1,TFMAX,ALPNA,PP0,XLNA0
      PRINT 5012
      PRINT 5013,N0,M1,NDL,N01,N02,GAMFR,DFDI,D0F,TB,GT,C0RR,EPS1,EPS2
      PRINT 5083
      PRINT 5011,G1,G2,GB,PG,BUST,XNU,PMAX,TFBL,TFBH
      PRINT 5086
      PRINT 5011,GMU,GM1,V1,V2,FGR2,TFB1,TFB2,TFB3,TFB4,TFB5
   33 PRINT 3003
   35 PRINT 5014 , ( TDL(I), I=1,NDL )
      PRINT 3003
      PRINT 5015 , (  DL(I), I=1,NDL )
      PRINT 3003
      PRINT5006,(Q(I),I=1,NT)
      PRINT 3003
      PRINT 5105, (QFFLX(I),I=1,NT1)
      PRINT 3003
      PRINT5007,(P0(I),I=1,NT)
      PRINT 3002
      RETURN
C
    2 PRINT 5016, XLNA0,XLPPP
      RETURN
C
    3 PRINT 5023
      RETURN
C
C     READ IN CHANGES IN C0OLANT, BURNUP AND FLUX PARAMETERS
C     IF IQF = 1, QF & QFFLX NEED N0T BE READ IN
C     IF IT2 = 1, 0NLY 10 CALCULATI0NS WILL BE MADE F0R THE CHANGE CASE
C     IF 'IT' EQUALS 1, THERE WILL BE N0 CLAD SHRINKAGE DURING CHANGE CAS
C     CALCULATI0NS - IT IS USUALLY THE CASE WHERE 'IT' = 1
C
    4 READ 3001, TITLE1
      READ 1100,ICALC,IRSWL,IPLT1,IQF,IT2,IT,IPRNT,PLTBU
      READ 1001,DELTCN,HC,BUINC,FFLX,QPB,A26
      IF (IQF.NE.0) G0 T0 650
      READ 2000, (Q(I),I=1,NT)
```

```
      READ 2000, (QFFLX(I),I=1,NT1)
  650 IF (IERR-4) 38,36,38
   36 IF (ICALC-1) 37,4,37
   37 IERR = 0
      RETURN
   38 PRINT 3004,TITLE3
      PRINT 3004,TITLE1
      PRINT 5017,DELTCN,HC,BUINC,FFLX,QPB,A26,PLTBU,ICALC,IRSWL,IPLT1,
     1 IPRNT,IQF,IT2,IT
      PRINT 6006
      DO 867 I=1,NT1
  867 PRINT 6007,I,Q(I),QFFLX(I)
      PRINT 3002
      RETURN
C
    5 PRINT 5109,(PGS(I),I=1,3),(ER(I),I=1,3),N
      RETURN
C
    6 PRINT 848,N,TRA
      RETURN
C
    7 PUNCH 5103 ,BU, TM,  PP, QLSUM
      PUNCH 5103, SP
      PUNCH 5103, ET
      PUNCH 5103, E
      RETURN
C
C             PRINT INTERIM BURNUP STEP OUTPUT
    8 PRINT 5100,BU,A20,A21, PP, QLSUM , TM, XLP,BUMX
      KNT = KNT+1
      GO TO (681,637,682,637),IPRNT
  681 IF (KNT-6) 678,637,637
  682 IF (KNT-3) 678,637,637
  637 PRINT 6002
C
C     THE FLUENCE PRINTED OUT IS IN SECONDS AND SHOULD BE MULTIPLIED
C     BY 10**22 FOR THE COMPLETE ANSWER.
C
   40 IF (IFLG.GE.2) GO TO 595
      DO 579 I=1,NT1
  579 FLU(I) = TM*Q(I)*FFLX*3600./1.D22
      GO TO 597
  595 DO 596  I=1,NT1
  596 FLU(I) = FLUO(I)+(TM-TMO)*Q(I)*FFLX*3600./1.D22
  597 IF (IOGOTO.EQ.18) GO TO 31
      IDV = 1
      DO 638 I=1,NT1
      DVV1 = DVV(I)*100.
      IF (DVV1.GT.10.) IDV = 2
  638 PRINT 6003,I,XTC(I),XTCLO(I),TCLI(I),TFO(I),TFB(I),TF(I),QR(I),
     1QL(I),PR(I),SP(I),SH(I),ST(I),E(I),ESW(I),FT(I),DVV1,FLU(I)
      IF (IT2.NE.0) IOUT = IOUT+1
  678 RETURN
```

```
C
    9 IF (IPLT1.NE.2) GØ TØ 610
      IF (BUMX.LT.PLTBU) GØ TØ 610
      IF ((PR(NT1/2).LE.0.).ØR.(PR(NT1/2+1).LE.0.)) GØ TØ 670
      CALL DPLØT (1,1.E01,1.E04,2H1 ,2H2 ,2H3 ,2H4 )
  670 GØ TØ (676,677),IDV
  676 CALL DPLØT (8,1.E-4,1.E-1,2H-2,2H-1,2H0 ,2H1 )
      GØ TØ 679
  677 CALL DPLØT (8,1.E-3,1.E00,2H-1,2H0 ,2H1 ,2H2 )
  679 CALL DPLØT (6,0.,30000.,2H  ,2H  ,2H  ,2H  )
      CALL DPLØT (4,1.E-4,1.E-1,2H-2,2H-1,2H0 ,2H1 )
      CALL DPLØT (5,1.E-4,1.E-1,2H-2,2H-1,2H0 ,2H1 )
      CALL DPLØT (7,0.,30000.,2H  ,2H  ,2H  ,2H  )
      CALL DPLØT (2,0.,30000.,2H  ,2H  ,2H  ,2H  )
      CALL DPLØT (3,1.E-4,1.E-1,2H-2,2H-1,2H0 ,2H1 )
      CALL DPLØT (9,1.E-4,1.E-1,2H-4,2H-3,2H-2,2H-1)
  648 IPLT1 = 1
  610 GØ TØ (551,588,589,590),IPRNT
  551 IF (KNT-6) 870,644,644
  588 IF (KNT-6) 870,644,644
  589 IF (KNT-3) 870,644,644
  644 KNT = 1
  590 PRINT 3002
  870 RETURN
C
   10 PRINT 5081, BU, N, SP(N), SH(N), SY
      PRINT 5047
      RETURN
C
   11 PRINT 861,N
      RETURN
C
   12 PRINT 5081, BU, N, SP(N), SH(N), SY
      PRINT 5046
      RETURN
C
   13 PRINT5041 ,N, BU
      RETURN
C
   14 PRINT 5100,BU,A20,A21, PP, QLSUM,TM, XLP,BUMX
      PRINT 6012
      DØ 875 I=1,NT1
  875 PRINT 6013,I,SP(I),E(I)
      RETURN
C
   15 PRINT 5101, ETA, EMAX(N),IPR, N, BU
      RETURN
C
   16 PRINT 5102 ,ETA, IPR, N, BU
      RETURN
C
   17 PRINT 5082, BU,TM2
      RETURN
```

```
C
C              PRINT TERMINATION OUTPUT
C
   18 PRINT 5040, TITLE3
      PRINT 5100, BU, A20, A21, PP, QLSUM, TM, XLP, BUMX
      PRINT 6002
      GO TO 30
   31 IDV = 1
      DO 863 I=1,NT1
      DVV1 = DVV(I)*100.
      IF (DVV1.GT.10.) IDV = 2
  863 PRINT 6003,I,XTC(I),XTCLO(I),TCL1(I),TFO(I),TFB(I),TF(I),QR(I),
     1QL(I),PR(I),SP(I),SH(I),ST(I),E(I),ESW(I),ET(I),DVV1,FLU(I)
      IF (IPLT1.EQ.0) GO TO 640
      IF (ICALC.EQ.1) GO TO 640
      IF (IPLT1.EQ.3) GO TO 651
      IF ((PR(NT1/2).LE.0.).OR.(PR(NT1/2+1).LE.0.)) GO TO 671
      CALL DPLOT (1,1.E01,1.E04,2H1 ,2H2 ,2H3 ,2H4 )
  671 CALL DPLOT (4,1.E-4,1.E-1,2H-2,2H-1,2H0 ,2H1 )
      CALL DPLOT (2,0.,30000.,2H  ,2H  ,2H  ,2H  )
      CALL DPLOT (6,0.,30000.,2H  ,2H  ,2H  ,2H  )
      CALL DPLOT (5,1.E-4,1.E-1,2H-2,2H-1,2H0 ,2H1 )
      GO TO (674,675),IDV
  674 CALL DPLOT (8,1.E-4,1.E-1,2H-2,2H-1,2H0 ,2H1 )
      GO TO 651
  675 CALL DPLOT (8,1.E-3,1.E00,2H-1,2H0 ,2H1 ,2H2 )
  651 IF (PRMX(IBUM).LE.0.) GO TO 672
      CALL DPLOT (11,1.E1,1.E4,2H1 ,2H2 ,2H3 ,2H4 )
  672 CALL DPLOT (12,1.E-4,1.E-1,2H-2,2H-1,2H0 ,2H1 )
      CALL DPLOT (10,1.E1,1.E4,2H1 ,2H2 ,2H3 ,2H4 )
      CALL DPLOT (13,0.,2.,2H  ,2H  ,2H  ,2H  )
      IF (IPLT1.EQ.3) GO TO 640
      CALL DPLOT (3,1.E-4,1.E-1,2H-2,2H-1,2H0 ,2H1 )
      CALL DPLOT (7,0.,30000.,2H  ,2H  ,2H  ,2H  )
      CALL DPLOT (9,1.E-4,1.E-1,2H-4,2H-3,2H-2,2H-1)
  640 PRINT 3002
      RETURN
C
   19 PRINT 5107
      RETURN
C
   20 PRINT 5106
      RETURN
C
   21 PRINT 5100,BU,A20,A21, PP, QLSUM,TM, XLP , BUMX
      RETURN
C
   22 PRINT 5045, N
      RETURN
C
   23 PRINT5042, N
      RETURN
C
```

```
   24 PRINT 6004
      DO 639 I=1,NT1
      DVV1 = DVV(I)*100.
  639 PRINT 6011,I,QR(I),QL(I),PR(I),SP(I),SH(I),ST(I),E(I),ESW(I),ET(I)
     1,DVV1,TF(I),TFB(I),FLU(I)
      RETURN
C
   26 PRINT 5111
      RETURN
C
C                         MAIN FORMAT STATEMENTS
C
 1000 FORMAT (I10,6E10.4)
 1001 FORMAT (6E10.4)
 1100 FORMAT (7I5,25X,2E10.4)
2000  FORMAT(8E10.4)
 3000 FORMAT (5I2, 7E10.4)
 3001 FORMAT (10A8)
 3002 FORMAT (1H1)
 3003 FORMAT (/)
 3004 FORMAT (10X10A8)
  848 FORMAT (10X,'N ='I2,' ST(N)-SY ='1PE12.6,' TRANSFERRING TO STMT 53
     1')
  861 FORMAT (10X'TRANSFERRING TO STMNT 54 WITH N ='I3)
 6002 FORMAT (' N  XTC  XTCLO  TCLI  TFO  TFB   TF'5X'QR'7X'QL'7X'PR'
     18X'SP'5X'SH'5X'ST'6X'E'9X'ESW'7X'ET'6X'DVV'4X'FLUENCE')
 6003 FORMAT (1XI2,6(1XF5.0),2(1XF8.6),1PE11.3,0P3(F7.0),1P3(E10.3),0P
     1F6.2,F7.3)
 6004 FORMAT (2X'N',5X'QR',9X'QL', 7X'PR', 8X'SP',5X'SH',6X'ST', 9X'E',
     110X'ESW'10X'ET'8X'DVV'5X'TF'5X'TFB'3X'FLUENCE'/)
 6006 FORMAT (3X'N',6X'Q',9X'QFFLX'/)
 6007 FORMAT (2XI2,2(3XF8.6 ) )
 6009 FORMAT (2XI2,2XF8.0,2(2XE11.4 ))
 6010 FORMAT (3X'N',5X'SP',10X'E',12X'PR'/)
 6011 FORMAT (1XI2,1X,2(1XF8.6 ),1PE12.4,0P1X3(1XF7.0 ),1P1X3(1XE11.4 ),
     10P1X,F6.2,1XF6.1,1XF6.1,1XF7.3)
 6012 FORMAT (3X'N',4X'SP',9X'E'/)
 6013 FORMAT (2XI2,2XF6.0,1P2XE11.4/)
 5000 FORMAT (1H0,5X'NT',10X,'TCIN',9X,'DELTC',7X,'DOPP',8X,'HC',9X,'XLF
     1PP',8X,'DPPP',8X,'AF',9X,3HFCB,7X'PLTBU')
5001  FORMAT(/,5X,5HXLPPP,7X,2HA1,10X,2HA2,10X,2HA3,10X,2HA4,10X,2HA5,10
     1X,2HA6,10X,2HA9,10X,3HA12,9X,3HA13)
5002  FORMAT(/,5X,3HA14,9X,3HA15,9X,3HA25,9X,3HA26,9X,3HA27,9X,3HA28,9X,
     13HA29,9X,3HA30,9X,3HA31,9X,3HA32)
5003  FORMAT(/,5X,3HA33,9X,3HA34,9X,3HA35,9X,3HA36,9X,3HA37,9X,3HA38,9X,
     13HA39,9X,3HA40,9X,3HA41,9X,3HA42)
5004  FORMAT(/,5X,3HA43,9X,3HA44,9X,3HA45,9X,3HA46,9X,3HA47,9X,3HA48,9X,
     13HA49,9X,3HA50,9X,3HA51,9X,3HA53)
5005  FORMAT(/,5X,3HA54,9X,3HA55,9X,3HA56,9X,3HA57,9X,3HA58,9X,4HAA20,8X
     1,4HAA21,8X,4HAB20,8X,4HAB21,8X,'A300')
 5043 FORMAT (/5X'QPB'9X'QPBD'8X'QPBM'7X'FFLX'8X'BUMAX'7X'EMAX1'7X'TFMAX
     1'7X'ALPHA'7X'PPO'9X'XLNAO')
 5044 FORMAT (/4X'A401'8X'A402'8X'XLCL'8X'XMNA'8X'XMF'9X'RHTHF'4X'IOPT'1
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     1X'ICALC IPLT1 IRSWL IHKNS IFUEL IPRNT')
 5083 FORMAT (/,5X'G1'10X'G2'10X'GB'10X'PG'9X'BUST'8X'XNU'9X'PMAX'
     18X'TFBL'8X'TFBH')
 5086 FORMAT (/5X'GMO'9X'GM1'10X'V1'10X'V2'8X'FGR2'8X'TFB1'8X'TFB2'8X
     1'TFB3'8X'TFB4'8X'TFB5')
 5087 FORMAT (1P6E12.4,0P2XI2,3XI2,6(4XI2))
 5014 FORMAT (5X, 7HTDL(I)= ,1P9E12.4 )
 5015 FORMAT (5X, 7H DL(I)= ,1P9E12.4 )
5006  FORMAT  (5H W(N),5X,1P10E11.4)
 5105 FORMAT (10H WFFLX(N)  ,1P10E11.4 )
5007  FORMAT(6H P0(N),4X,1P10E11.4)
5009  FORMAT(7H XTC(N),3X,1P10E11.4)
 5010 FORMAT (I8,4X,1P9E12.4)
5011  FORMAT (1P10E12.4)
 5012 FORMAT (/'   N0  M1  NDL  N01  N02  GAMMA FRAC    DFDI'9X'D0F'9X
     1'TB'10X'GT'9X'CORR'8X'EPS1'8X'EPS2')
 5013 FORMAT (3XI2,2(2XI2),2(3XI2),1P1X8E12.4)
 5016 FORMAT (1H0,72HFOLLOWING INPUT PARAMETERS PERTAINING TO PLENUM HAV
     1E BEEN CHANGED INTO   ,/,9H XLNA0 =   ,1PE11.4 ,9H XLPPP =   ,E11.4)
 5017 FORMAT (1H0,20X'CHANGES MAY BE MADE IN THE FOLLOWING PARAMETERS'/
     13X'DELTCN'8X'HC'10X'BUINC'6X'FFLX'9X'QPB'9X'A26'8X'PLTBU'6X 'ICALC
     2 IRSWL IPLT1 IPRNT  IQF   IT2   IT'/1P7(2XE10.4),0P7(4XI2)/)
5020  FORMAT(9H XTCL0(N),1X,1P10E11.4/)
5021  FORMAT(6H PR(N),4X,1P10E11.4/)
 5023 FORMAT (1H0, 72HSORRY, BEMOD DOES NOT HANDLE CERAMIC FUEL ELEMENTS
     1 (N0=0,OR 1) ANYMORE. / 70H FOR FAST COMPUTATION CONSULT THE LATES
     2T VERSION OF SWELL BY T.BUMP .   )
5025  FORMAT(8H TCLI(N),2X,1P10E11.4/)
5026  FORMAT(7H TF0(N),3X,1P10E11.4/)
5027  FORMAT(6H TF(N),4X,1P10E11.4/)
5028  FORMAT(6H QR(N),4X,1P10E11.4/)
5029  FORMAT(6H QL(N),4X,1P10E11.4 /)
 5110 FORMAT (10H DF(N)    ,1P10E11.4)
5030  FORMAT(6H SP(N),4X,1P10E11.4 /)
5031  FORMAT(6H SH(N),4X,1P10E11.4/)
5033  FORMAT(5H E(N),5X,1P10E11.4/)
5034  FORMAT(6H ET(N),4X,1P10E11.4 /)
5035  FORMAT(6H TG(N),4X,1P10E11.4 /)
5036  FORMAT( 7H ESW(N),3X,1P10E11.4)
5037  FORMAT(6H ST(N),4X,1P10E11.4 /)
 5038 FORMAT(6H PR(N), 4X,1P10E11.4/)
 5040 FORMAT (1H1,47X,25H TERMINAL CONDITIONS FOR  ,/,20X,10A8,/,
     1 38X,39H ARE AS FOLLOWS (LAST ROW MEANS PLENUM)  ,/ )
 5041 FORMAT (38HOTHERMAL STRESS FATIGUE BEGINS FOR N =,I2,9H AT BU = ,
     1 1PE11.4)
 5042 FORMAT (34HONOTE THAT TF EXCEEDS TFMAX AT N =  ,I2 )
 5045 FORMAT (24HOEXCESSIVE STRAIN AT N=  , I2 )
5046  FORMAT(1X, 47H(SH+4*SP)/SY EXCEEDS 4. , SH IS LESS THAN 2*SY  )
5047  FORMAT(1X, 43H(SH+8*SP)/SY EXCEEDS 6. AND SH EXCEEDS 2*SY )
 5081 FORMAT (39HOMILLER,S RATCHETTING MAY START AT BU=  ,1PE11.4,
     1 7H FOR N= ,0PI2, 12H WHEN SP(N)= ,1PE11.4,7H,SH(N)= ,E11.4,4H,SY=
     2,E11.4 ,/50X,44HONLY LAST STATEMENT ON RATCHETTING IS VALID. )
 5082 FORMAT (24H0 NO FAILURE UP TO BU =  ,1PE14.7, 5H TM = ,E12.4,/ )
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 5100 FORMAT (/'  BU='1PE14.7,' A20='0PF5.3,' A21='F5.3,' PP='1PE11.4,'
     1QLSUM='E11.4,' TM='E11.4,' XLP='E11.4,' MAX BURNUP='E14.7/)
 5101 FORMAT (16HOTOTAL STRAIN (= ,1PE11.4,19H) EXCEEDS EMAX(N) = ,E11.4
     1,23H AT ABNORMAL CONDITION ,0PI2,12H,FIRST AT N= ,I2,8H AND BU=  ,
     2 1PE14.7/)
 5102 FORMAT (16HOTOTAL STRAIN (= ,1PE11.4,39H) EXCEEDS EMAX1 AT ABNORMA
     1L CONDITION ,0PI2,12H,FIRST AT N= ,I2,8H AND BU= 1PE11.4/)
 5103 FORMAT (8E10.4)
 5104 FORMAT (44HO*****PRESSURE CALCULATION DID NOT CONVERGE  ,61X,
     1 15H*****ERROR*****,/,8H AT BU = , 1PE11.4,
     2                           24H AND ABNORMAL CONDITION ,0PI2,37H( 0 MEAN
     2S NOMINAL CONDITION ) FOR N = ,I2 /,29H PRECEEDING PRESSURE GUESS
     3=  ,1PE11.4, 18H FINAL PRESSURE =  ,E11.4/,108H IGNORE THIS STATEM
     4ENT IF THE RIGHTMOST NUMBER ON THIS LINE IS FOLLOWED BY A LARGER N
     5UMBER ON THE NEXT LINE. , 10X, 0PI2/)
 5107 FORMAT (14X'***** EXCESSIVE STRAIN WAS DETECTED, THEREFORE A CHANG
     1E CASE PROBLEM CANNOT BE READ IN AT THIS TIME *****')
 5106 FORMAT (1HO, 25X, 70HCONDITIONS OF FUEL ELEMENT BROUGHT TO ROOM TE
     1MPERATURE ARE AS FOLLOWS    , / )
 5109 FORMAT (/' VALUES IN CALCULATING BILINEAR EXPANSION CONSTANTS'/'
     1PGS(1) = '1PE10.4,' PGS(2) = 'E10.4,' PGS(3) = 'E10.4,' ER(1) = '
     2E10.4,' ER(2) = 'E10.4,' ER(3) = 'E10.4,/' AT NODE NUMBER '0PI2)
 5111 FORMAT (1H1'   ALL PROBLEMS HAVE BEEN PROCESSED.')
C
      RETURN
      END


      SUBROUTINE NFA (EP,EL,SY,NF)
      IMPLICIT REAL*8(A-H,O-Z)
C
C     DETERMINE NUMBER OF THERMAL CYCLES TO FAILURE
C
      COMMON /XIO/ SKP1(54),A49,A50
      NF=DEXP((A49-DLOG(EP))/A50)
      RETURN
      END


      SUBROUTINE PFA (DODI,VN,PF,PR1,PI4,VFO,IFL)
      IMPLICIT REAL*8(A-H,O-Z)
C
C     DETERMINE THERMAL EXPANSION FOR METALLIC FUEL WITH SODIUM BOND
C
      COMMON /XMAIN/
     A        TDL(60),DL(60),Q(60),SKP1(340),DGDI(60),SKP2(120),TFO(60),
     1TF(60),SKP3(1140),TGB(60),SKP4(360),VFT(60),TF3(60),SKP5(480),
     2V(60) /IOCOM/ N,NT,NT1,JSKP1(7),NO,M1,NDL /XIO/ BU,SKP6(15),DOPP,
     3SKP7(16),A28,A29,SKP8(5),A35,A36,A37,SKP9(29),OPB,SKP0(43),A21
      IF (NO-1) 1,1,2
    1 PF = A35*(1. + A36*VN)*PR1
```

```
      RETURN
    2 XNT = NT
      A281 = A28
      IF (IFL.EQ.2) GO TO 22
C     CONDUCTIVITY OF THE SOLID FUEL,A28 OF THE INPUT,IS REDUCED DUE TO
C     POROSITY BY R.DI NOVI TO
      A28 =  A28*((1.-V(N))/(1.+1.7*V(N)))
   22 M2 = 2*M1 + 1
      XINT = 0.
      XINT1 = 0.
      XM2 = M2 - 1
      UN = 1.
      DO 21 J = 1,M2
      UN = -UN
      FT = 3.+UN
      XJ = J- 1
      Y1 = QPB * Q(N) *(1 - (XJ/XM2)**2) /PI4*A21
      X1 = TFO(N)*(1. + A29*TFO(N)/2.) + Y1/A28
      E1 = A29*X1
      T = 2.*X1/(1. + DSQRT(1. + 2.*E1))
C     IT IS ASSUMED THAT THERMAL CONDUCTIVITY OF NA IS VERY LARGE AND FU
C     IS ASSUMED TO FILL THE INITIAL CLADDING.  A28 IS SMALLER THAN SOLI
   10 IF (J - 1) 3,3,4
    3 TF(N) = T
    4 NDL1 = NDL - 1
      T1 = TDL(1)
      IF (T - T1) 11,12,12
   11 DLT = DL(1)*(T - 70.)/(T1 -70.)
      GO TO 15
   12 DO 14 I = 1,NDL1
      T1 = TDL(I)
      T2 = TDL(I+1)
      IF (T -T2) 13,13,14
   13 DLT = DL(I) + (DL(I+1)-DL(I))*(T-T1)/(T2-T1)
      GO TO 15
   14 CONTINUE
      DLT = DL(NDL) + (DL(NDL)-DL(NDL1))*(T-T2)/(T2-T1)
   15 FUN = 3.* DLT * XJ
      FUN1 = T * XJ
      XINT1 = XINT1 + FT*FUN1
   21 XINT = XINT + FT*FUN
      XINT =(XINT - FUN)/3.
      XINT = XINT * 2./XM2**2
      VFT(N) = VFO *(1.+ XINT)
      XINT1 =(XINT1 - FUN1)/3.
      XINT1 = XINT1* 2./XM2**2
      TFB(N) = XINT1
      PF = PR1
      A28 = A281
C     WHEN NO IS LARGER THAN 1, PFA CALCULATES ONLY THE AXIAL TEMPERATUR
C     OF FUEL ,TF, AND THE THERMALLY EXPANDED VOLUME OF FUEL SECTION, VF
C     ALSO THE AVERAGE TEMPERATURE OF FUEL , TFB .
      RETURN
```

```
      END


      SUBROUTINE PLINE (XD,YD,FACTX,FACTY,IPTS,INCR,IAXIS,IPLT)
C     THIS SUBROUTINE IS USED FOR DRAWING THE X AND Y AXISES
C
C     IAXIS = 0 IMPLIES JUST DRAW A DUMMY AXIS WITH THE INFORMATION GIVEN
C     IAXIS = 1 IMPLIES DRAW X-AXIS OF MAXIMUM BURNUP
C     IAXIS = 2 IMPLIES DRAW Y-AXIS OF DELTA D/D
C
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /XMAIN/
     A        SKP1(1240),E(100),ET(100),SKP2(1600),ESW(100),SKP3(640),
     1ETMX(100) /IOCOM/ JSKP1(23),IERR /XIO/ SKP4(15),BUMX
      DIMENSION XD1(15),YD1(11),XFACT(15),YFACT(11),XMAX(100),IPTSX(15),
     1IPTSY(11),INCRY(11)
      DATA XD1/3.,1.5,1.,.75,.6,.5,.42857,.375,.33333,.3,.27273,.25,
     1.4615,.4286,.4/,IPTSX/3,5,7,9,11,13,15,17,19,21,23,25,14,15,16/,
     2XFACT/6.,3.,2.,1.5,1.2,1.,.85714,.75,.6667,.6,.54545,.5,.4615,
     3.4285,.4/,
     4YD1/.75,.9375,.625,.9375,.75,.625,.535714,.46875,.416667,.375,
     5.68182/ ,IPTSY/ 11,9,13,9,11,13,15,17,19,21,12/ ,INCRY/ 1,2,2,1,2,
     62,2,2,2,2,1/ ,YFACT/ 750.,375.,250.,187.5,150.,125.,107.14286,
     793.75,83.33333,75.,68.18182/
      CALL PLOT (0.,0.,3)
      IF (IAXIS) 11,11,20
   20 GO TO (30,31),IAXIS
   30 IBU = BUMX+1.
      IF (BUMX-14.5) 17,17,16
   16 IERR = 1
      RETURN
   17 XD = XD1(IBU)
      FACTX = XFACT(IBU)
      IPTS = IPTSX(IBU)
      INCR = 1
      IF (IBU.GT.5) INCR = 2
      GO TO 11
   31 IB = (INCR/5)*2
      IF (IPLT.EQ.3) GO TO 32
      IF (IPLT.EQ.4) GO TO 34
      IF (IPLT.EQ.5) GO TO 36
      IF (IPLT.EQ.12) GO TO 38
   32 DO 33 I=IB,INCR
   33 XMAX(I) = E(I)
      ARG1 = E(IB-1)
      GO TO 42
   34 DO 35 I=IB,INCR
   35 XMAX(I) = ET(I)
      ARG1 = ET(IB-1)
      GO TO 42
   36 DO 37 I=IB,INCR
   37 XMAX(I) = ESW(I)
```

```
      ARG1 = ESW(IB-1)
      GO TO 42
   38 DO 39 I=IB,INCR
   39 XMAX(I) = ETMX(I)
      ARG1 = ETMX(IB-1)
   42 DO 45 I=IB,INCR
      ARG2 = XMAX(I)
      XMAX1 = DMAX1(ARG1,ARG2)
   45 ARG1 = XMAX1
      IEMAX = XMAX1*100.+1.
      IF (XMAX1*100.-10.5) 19,19,18
   18 IERR = 2
      RETURN
   19 YD = YD1(IEMAX)
      FACTY = YFACT(IEMAX)
      IPTS = IPTSY(IEMAX)
      INCR = INCRY(IEMAX)
   11 ADJ = 0.
      DO 10 I=1,IPTS
      XDIST = XD*ADJ
      YDIST = YD*ADJ
      CALL PLOT (XDIST,YDIST,2)
    5 IF (XD) 6,7,6
    6 CALL PLOT (XDIST,-0.05,2)
      GO TO 8
    7 CALL PLOT (-0.05,YDIST,2)
    8 CALL PLOT (XDIST,YDIST,2)
   10 ADJ = ADJ+1.
      CALL PLOT (0.,0.,3)
      IF (IAXIS.NE.1) GO TO 60
      IF (IBU-12) 60,60,55
   55 XD = .5*XD
      IPTS = 2*IPTS-1
C     NEXT STATEMENT IS FOR SENDING IEMAX BACK TO DPLOT
   60 IF (IAXIS.EQ.2) IPTS = IEMAX
      RETURN
      END


      SUBROUTINE SYA (SY)
C     CALCULATE YIELD STRESS-LARGE VALUE=SMALL YIELD
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /XMAIN/
     1SKP1(240),XTCLO(60) /IOCOM/ N /XIO/ BU,SKP2(47),A43,A44
      SY=A43*(1.+A44*XTCLO(N))
      RETURN
      END


      SUBROUTINE TESK (SE,EDOT)
      IMPLICIT REAL*8(A-H,O-Z)
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C
      COMMON /XMAIN/ SKP1(240),XTCLO(60),SKP2(280),TCLB(60),SKP3(340),
     1 SP(100),SKP4(540),ST(100),SKP5(1200),QFFLX(60)    /IOCOM/    N,
     2 JSKP1(9),NO     /XIO/   SKP6(42),A37,A38,A39,A40,A41,A42,A43,A44,
     3 A45,SKP7(5),A51,SKP8(12),FFLX
C
      XNO = NO
      XNO = (XNO-1.5)**2
      IF (XNO-.26) 2,2,1
C
C     NO = 0 OR 3 CALCULATES EDOT AS THE OLD SWELL USING THE CLADDING
C     OUTSIDE TEMPERATURE AND THE CLADDING TOTAL STRESS OR YIELD STRESS
C     NO = 1 OR 2  THE NEW OPTION IS USED USING THE AVERAGE CLADDING
C     TEMPERATURE AND THE CLADDING PRESSURE STRESS
C
    1 T = XTCLO(N)
      S = SE
      GO TO 3
    2 T = TCLB(N)
      S = SP(N)
    3 IF (S) 4,4,5
    4 S = .001
    5 EDOT = DEXP(A40+(A41+A37/(T+460.))*DLOG(S)+A42/(T+460.))
     1 +A45*FFLX*QFFLX(N)*S**A51
C
      RETURN
      END



      SUBROUTINE VNA (DDD,VN,VO,XNT)
      IMPLICIT REAL*8(A-H,O-Z)
C
C     DETERMINE FUEL EXPANSION
C     CALCULATES FREE VOLUME IN FUEL DUE TO FISS GAS PRESENT
C
      COMMON /XMAIN/
     ASKP1(120),Q(60),SKP2(340),DGDI(60),TCLB(60),SKP3(120),TF(60),
     1SKP4(520),ET(100),TG(60),SKP5(460),TGB(60),DGDI2(60) /IOCOM/ N
     2/XIO/ BU,SKP6(17),XLFPP,SKP7(16),A30,A31,A32,A33,SKP8(24),A300
      ALPHA=A30*(1.+A31*TCLB(N))
      ALF=A32*(1.+A33*TGB(N))
      IF(DGDI(N))132,132,133
132   VN=DDD*((1.+ALPHA*(TCLB(N)-70.)+ET(N))**2.-(1.-VO)*(1.+2.*ALF*(TGB
     1(N)-70.)+A300*BU*Q(N)))*XLFPP/XNT
      RETURN
133   IF(DGDI(N)-1.)134,135,135
  135 DGDI2(N) = 1.
134   ALFC=A32*(1.+A33*(TF(N)+TG(N))/2.)
      VN=DDD*((1.+ALPHA*(TCLB(N)-70.)+ET(N))**2.-(1.-VO-(DGDI2(N)/(1.+2.
     1*ALFC*((TF(N)+TG(N))/2.-70.))))*(1.+2.*ALF*(TGB(N)-70.))-DGDI2(N)-
     2(1.-VO)*A300*BU*Q(N))*XLFPP/XNT
      RETURN
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      END


      SUBROUTINE XKCLA (IJ,IK,XKCL)
      IMPLICIT REAL*8(A-H,O-Z)
C
C     CALCULATE THERMAL CONDUCTIVITY OF CLAD
C
      COMMON /XMAIN/ SKP1(240),XTCLO(60),SKP2(340),TCLI(60) /IOCOM/ N
     1 /XIO/ SKP3(20),A1,A2
      IF(IJ-1)5,5,8
C     LINEAR COND
5     XKCL=A1*(1.+A2*XTCLO(N))
      IK=1
      RETURN
C     INTEGRATED COND
8     XKCL=A1*(1.+A2*(XTCLO(N)+TCLI(N))/2.)
      IK=2
      RETURN
      END


      SUBROUTINE XLPA (XLNA,ETP,P)
      IMPLICIT REAL*8(A-H,O-Z)
C     CALC PLENUM VOLUME DUE TO EXPANSION OF CLAD
      COMMON /XIO/ BU,TCIN,DELTC,SKP1(16),XLPPP,SKP2(15),A30,A31,
     1SKP3(45),XLNA0,ALPNA,SKP4(20),XLP,SKP5(10),A20
      T     = TCIN + A20*DELTC
      ALPHA = A30*(1. + A31*(T     + 70. )/2.)
      CP = 1.6*(10.)**(-6)
      F = 1.-3.*ALPNA*(T - 70.) + CP*P
      IF (T - 207.) 410,409,409
  409 F = F -0.0218
  410 XLP = (XLPPP + XLNA0)*(1. + 3.*ALPHA*(T -70.) + ETP + 0.6*(10.)
     1 **(-6)*P ) - XLNA  / F
C     XLP IS ALLOWED TO BECOME NEGATIVE TO IMPROVE CONVERGENCE IN PP CAL
      RETURN
      END
```

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