FATT -

A TRANSIENT TEMPERATURE
COMPUTER PROGRAM FOR
THE EGCR CORE

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Experimental Gas-Cooled Reactor Operated By
The Tennessee Valley Authority at Oak Ridge

ABSTRACT

This report describes a digital computer program for calculating the transient temperature distribution in the EGCR core. This program is written in Fortran for the IBM 7090 computer.

The program provides an arbitrary choice of axial increments for the reactor core. The heat transfer coefficients are made temperature-dependent. Provisions are available for plotting the results from the program on the Calcomp plotter.

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FATT

FINE AXIAL TRANSIENT TEMPERATURE

DIGITAL COMPUTER PROGRAM

The Experimental Gas-Cooled Reactor (reference 1) is a combined experimental and power demonstration reactor which is being constructed at Oak Ridge, Tennessee. It is fueled with enriched uranium dioxide clad in stainless steel, moderated with graphite, and cooled with helium. The plant is designed to produce 85 Mw of thermal power, at a gas outlet temperature of 1075 F, and 25 Mw of net electrical power.

One step in evaluating the thermal performance of the EGCR core will involve the transient temperature behavior. Thermal transients are to be expected during any manipulation of power or coolant flow. Some of these transients will result from:

1. Changes in power due to control rod movement. This may be a total reactor power change, a redistribution of power, or both.
2. Changes in power and flow in a fuel channel due to on-stream refueling.
3. Power excursions.
4. Variations in total coolant flow or coolant temperature due to changes in load on the steam side of the system.

To predict the temperature transients resulting from these manipulations, it is necessary to develop a calculative procedure for their analysis.

The experimental results obtained from the instrumented fuel columns will be correlated with the predictions and the adequacy of the procedures for general usage will thus be verified.

There have been several analog computer models of the EGCR core used in the past and proposed for use. The calculative procedures described here may be used to check these models since finer subdivisions may be used.

I. Description of the Physical System

This analysis is based on subdividing the EGCR core radially into a unit cell consisting of one fuel pin and sleeve and moderator associated with one fuel channel. The moderator is distorted from its normal square outer geometry into a cylinder containing the same volume.

This radial subdivision is carried further so that there is a total of 18 radial subdivisions in the major unit cell. See figure 1.

The fuel channel is subdivided axially into an arbitrary number of parts up to 85. These axial subdivisions may be of any length and need not all be the same length.

II. Statement of Problem

It is desired to calculate the time-dependent temperature variations in each subdivision of a given fuel channel. Input information to the problem will be (1) heat generation rate, both axial and radial; (2) total gas flow rate; (3) inlet gas temperature at the bottom of the core; and (4) all heat capacities and heat transfer coefficients as a function of temperature.

It is desired to allow the heat generation rate, total gas flow rate, fuel channel-to-annulus gas flow distribution, and inlet temperature to be functions of time.

III. Equations Describing the Physical System

The more general partial differential equation of time-dependent temperature distribution is simplified to an equation of the form:

$$W_i C_{p_i} \frac{dT_i}{dt} = Q_i - \sum_j K_{i-j} [T_i - T_j] \quad (A)$$

where

W_i = weight of the material in the i th subdivision (lb)

C_{p_i} = heat capacity of the material in the i th subdivision $\left(\frac{\text{Btu}}{^\circ\text{F-lb}}\right)$

Q_i = heat generation rate in the i th subdivision $\left(\frac{\text{Btu}}{\text{sec}}\right)$

K_{i-j} = conductance from node i to node j $\left(\frac{\text{Btu}}{^\circ\text{F-sec}}\right)$

T_i = characteristic temperature of the i th node ($^\circ\text{F}$)

T_j = characteristic temperature of the j th node ($^\circ\text{F}$)

This is the form of the equation that was solved in the solid regions in the problem.

When determining the temperature change in the gas streams, it was assumed that the gas instantaneously assumed some function of the temperature of its surroundings. This assumes that the weight-heat capacity product for the gas is zero once it enters an axial increment. Of course, account must be taken of the gas

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EGCR CORE
TOP VIEW

DETAIL A
FUEL CHANNEL
WITH MODERATOR

FIG. 1
DEVELOPMENT of RADIAL SUBDIVISIONS

Fig. 2
TYPICAL AXIAL SUBDIVISIONS

WCp in the transport of heat between axial increments. One reason for making this assumption is that computer time would be prohibitively large if account were taken of gas WCp. The reason for this is pointed out later.

The equations that are solved for FATT are given below.

Refer to figure 1 for a description of each node.

$$W_1 Cp_1 \frac{dT_1}{dt} = Q_1 - K_{1-2} (T_1 - T_2) \quad (1)$$

$$W_2 Cp_2 \frac{dT_2}{dt} = Q_2 + K_{1-2} (T_1 - T_2) - K_{2-3} (T_2 - T_3) \quad (2)$$

$$W_3 Cp_3 \frac{dT_3}{dt} = Q_3 + K_{2-3} (T_2 - T_3) - K_{3-4} (T_3 - T_4) \quad (3)$$

$$W_4 Cp_4 \frac{dT_4}{dt} = Q_4 + K_{3-4} (T_3 - T_4) - K_{4-5} (T_4 - T_5) \quad (4)$$

$$W_5 Cp_5 \frac{dT_5}{dt} = Q_5 + K_{4-5} (T_4 - T_5) - K_{5-6} (T_5 - T_6) \quad (5)$$

$$W_6 Cp_6 \frac{dT_6}{dt} = Q_6 + K_{5-6} (T_5 - T_6) - K_{6-7} (T_6 - T_7) \quad (6)$$

$$W_7 Cp_7 \frac{dT_7}{dt} = K_{6-7} (T_6 - T_7) - UCG (T_7 - T_{17}) - RCS (T_7 - T_8) \quad (7)$$

$$W_8 Cp_8 \frac{dT_8}{dt} = Q_8 + K_{8-9} (T_9 - T_8) + RSC (T_7 - T_8) - USG (T_8 - T_{17}) \quad (8)$$

$$W_9 Cp_9 \frac{dT_9}{dt} = Q_9 + K_{9-10} (T_{10} - T_9) - K_{8-9} (T_9 - T_8) \quad (9)$$

$$W_{10} Cp_{10} \frac{dT_{10}}{dt} = Q_{10} - K_{9-10} (T_{10} - T_9) - K_{10-11} (T_{10} - T_{11}) \quad (10)$$

$$W_{11} Cp_{11} \frac{dT_{11}}{dt} = Q_{11} + K_{10-11} (T_{10} - T_{11}) - USA (T_{11} - T_{19}) - RSB (T_{11} - T_{12}) \quad (11)$$

$$W_{12} Cp_{12} \frac{dT_{12}}{dt} = Q_{12} + K_{12-13} (T_{13} - T_{12}) + RSB (T_{11} - T_{12}) - UBA (T_{12} - T_{19}) \quad (12)$$

$$W_{13} Cp_{13} \frac{dT_{13}}{dt} = Q_{13} + K_{13-14} (T_{14} - T_{13}) - K_{12-13} (T_{13} - T_{12}) \quad (13)$$

$$W_{14}Cp_{14} \frac{dT_{14}}{dt} = Q_{14} + K_{14-15} (T_{15} - T_{14}) - K_{13-14} (T_{14} - T_{13}) \quad (14)$$

$$W_{15}Cp_{15} \frac{dT_{15}}{dt} = Q_{15} + K_{15-16} (T_{16} - T_{15}) - K_{14-15} (T_{15} - T_{14}) \quad (15)$$

$$W_{16}Cp_{16} \frac{dT_{16}}{dt} = Q_{16} - K_{15-16} (T_{16} - T_{15}) \quad (16)$$

$$0 = 7.0 \left[UCG (T_7 - T_{17}) \right] + USG (T_8 - T_{17}) - WgCp (T_{out} - T_{18}) \quad (17)$$

$$T_{17} = \frac{T_{18} + T_{out}}{2} \quad (18)$$

$$0 = USA (T_{11} - T_{19}) + UBA (T_{12} - T_{19}) - WgCp (T_{out} - T_{20}) \quad (19)$$

$$T_{19} = \frac{T_{20} + T_{out}}{2} \quad (20)$$

where

RCS is the equivalent radiation conductance from one fuel pin to the entire sleeve per foot length.

RSC is the equivalent radiation conductance from the sleeve to all fuel pins per foot length.

UCG is the film coefficient between the clad on one pin and gas per foot of fuel length.

USG is the film coefficient between the inner sleeve surface and the gas per foot length.

USA is the film coefficient between the outer sleeve surface and the annulus gas stream per foot length.

UBA is the film coefficient between the moderator and the annulus gas stream per foot length.

RSB is the equivalent radiation conductance between the sleeve and moderator per foot length.

Q_i is the heat generation in the i th element per foot length.

W_iCp_i is the weight-heat capacity product per foot length.

It should be noted that axial heat flow is not considered in the solid regions of the core. Each axial node is considered insulated from its neighbor. The only axial communication between nodes is through the gas stream.

For this program, the heat transfer coefficients are calculated internally in a subprogram.

The specific heat and thermal conductivity are temperature-dependent. In this program, the temperature dependence is fitted to a formula and a new value determined after each calculation.

The following formulas were used in the subprogram to calculate the thermal conductivity and specific heat. They are based on a fit to values taken from reference 3.

Assume that the temperature variation of thermal conductivity and thermal conductivity-specific heat ratio can be expressed by an equation of the form $k = \frac{A}{B + T}$ for UO_2 and graphite; where T is the temperature in $^{\circ}F$.

For UO_2 ,

$$k = \frac{5180}{1690 + T} \left(\frac{\text{Btu}}{\text{hr-ft-}^{\circ}F} \right) \text{ for 100 percent density,} \quad (21)$$

$$\text{and } \frac{k}{WC_p} = \frac{15.83}{1200 + T} \left(\frac{\text{lb}}{\text{hr-ft}} \right). \quad (22)$$

For unirradiated graphite,

$$k = \frac{84,000}{760 + T} \left(\frac{\text{Btu}}{\text{hr-ft-}^{\circ}F} \right) \quad (23)$$

$$\frac{k}{WC_p} = \frac{142,700}{167 + T} \left(\frac{\text{lb}}{\text{hr-ft}} \right). \quad (24)$$

For helium the following formula is used:

$$k = 0.08 + 0.000094T \left(\frac{\text{Btu}}{\text{hr-ft-}^{\circ}F} \right). \quad (25)$$

For stainless steel,

$$k = 90 \left(\frac{\text{Btu}}{\text{hr-ft-}^{\circ}F} \right). \quad (26)$$

The geometric conductance in each of the cylindrical regions was calculated with the formula

$$G = \frac{2\pi}{\ln \frac{r_{\text{outer}}}{r_{\text{inner}}}} \quad (\text{dimensionless}). \quad (27)$$

The equivalent radiation conductance was calculated from the formula

$$K_{\text{equiv}} = \frac{A (T_i^4 - T_j^4)}{T_i - T_j} \left(\frac{\text{Btu}}{\text{sec } ^\circ\text{F}} \right) \quad (28)$$

for the clad to sleeve.

A was evaluated from reference 4. From drawing 50681 of reference 4, a value was chosen for T_i and T_j . This determined a value for Q in the equation

$$Q = A (T_i^4 - T_j^4). \quad (29)$$

From this equation, it was possible to determine A. The chosen value of Q for the average rod was weighted between the heat emitted by the six outer rods and the inner rod.

For the sleeve to moderator, a value of 0.85 was chosen for the emissivity, and the equation

$$Q = A\epsilon\sigma (T_s^4 - T_b^4) \text{ was solved.} \quad (30)$$

Where

A is the area of outer sleeve portion

ϵ is the emissivity (.85)

σ is the Stefan-Boltzmann constant

T_s is the sleeve outer surface temperature

T_b is the moderator surface temperature at the annulus.

The film coefficients are calculated in a manner similar to PTD (reference 2). The PTD program uses the formula

$$h_c = 17 Wg^{0.8} Cl \frac{T_{\text{gas}}}{T_{\text{clad}}} \left[\frac{9.4 \times 10^{-5} T_{\text{clad}} + 0.4}{5.3 \times 10^{-5} T_{\text{clad}} + 0.23} \right] \quad (31)$$

for the clad-to-gas film coefficient.

The terms in brackets represent the effect of variations in gas conductivity and viscosity with temperature. It will be noted, however, that for wide variations in clad temperature, this term may be neglected with very small error (the error is 1 percent at 2500°F based on 500°F). The formula that was used in this analysis was

$$h_c = 30.0 W_g^{0.8} C_l \frac{T_{gas}}{T_{clad}} \left(\frac{\text{Btu}}{\text{hr-ft}^2 \text{-}^\circ\text{F}} \right). \quad (32)$$

Where

$$h_c \text{ is the film coefficient } \left(\frac{\text{Btu}}{\text{hr-ft}^2 \text{-}^\circ\text{F}} \right)$$

$$W_g \text{ is the fuel stream gas weight flow } \left(\frac{\text{lb}}{\text{hr}} \right)$$

C_l is a correction to the film coefficient due to the effect of spacers and hangers. See figure 3.

Similar reasoning was applied to the sleeve-to-fuel channel gas to yield the formula

$$h_s = 0.787 W_g^{0.8} C_s \left(\frac{\text{Btu}}{\text{hr-ft}^2 \text{-}^\circ\text{F}} \right). \quad (\text{See figure 4 for } C_s.) \quad (33)$$

The film coefficient in the annulus was examined for temperature dependence using the PTD program (reference 2). It was found that a variation of 20 percent could be expected from the extreme temperature variations under laminar flow conditions. It was decided to use an average value and suffer the ± 10 percent error.

In the laminar region ($Re < 2000$), the film coefficient has the form

$$ha_1 = A Wa^{.45}. \quad (34)$$

From PTD an average value of 43 for ha_1 was determined at 800°F and a flow rate of 72.4 lb/hr. This gives the formula

$$ha_1 = 6.3 Wa^{0.45} \left(\frac{\text{Btu}}{\text{hr-ft}^2 \text{-}^\circ\text{F}} \right). \quad (35)$$

In the turbulent region ($Re > 6000$), the Dittus-Boelter equation used in PTD (reference 2) was solved at 800°F to determine the constant in the equation

$$ha_2 = 1.49 Wa^{0.8} \left(\frac{\text{Btu}}{\text{hr-ft}^2 \text{-}^\circ\text{F}} \right). \quad (36)$$

In the transition region ($2000 < Re < 6000$), it was assumed that the film coefficient varied directly as the flow rate. The following formula was used to connect ha_1 and ha_2 :

Fig. 3

Distance Corresponding To That Along Fuel Elements (in.)

Fig. 4

Fig. 5

$$ha_3 = ha_1 + \left[\frac{Re}{4000} - \frac{1}{2} \right] [ha_2 - ha_1] \left(\frac{Btu}{hr \ ft^2 \ ^\circ F} \right). \quad (37)$$

IV. Computer Solution of Equations

The method of solution of equations similar to (1)-(20) by the computer utilizes a finite difference method. This is done by making the following approximation in equation (A):

$$W_1 C_{p1} \frac{dT_1}{dt} \approx W_1 C_{p1} \left[\frac{T_1(t + \Delta t) - T_1(t)}{\Delta t} \right] \quad (38)$$

where t is the current time.

Equation (A) may then be rewritten

$$T_1(t + \Delta t) = T_1(t) + \frac{\Delta t}{W_1 C_{p1}} \left[Q_1 - \sum_j K_{1-j} (T_1 - T_j) \right]. \quad (39)$$

The restriction on the use of this equation is that

$$\frac{\Delta t \sum_j K_{1-j}}{W_1 C_{p1}} \leq 1.0, \quad i \neq j, \quad (40)$$

or

$$\Delta t \leq \frac{W_1 C_{p1}}{\sum_j K_{1-j}} \quad i \neq j. \quad (41)$$

Before a transient solution can be obtained, it is necessary to make a steady-state calculation to determine the starting point for the transient solution. This was done in this program by setting the left-hand member of equations (1) through (16) to zero. This says that the temperature is not changing, but has reached equilibrium with the given parameters.

The twenty equations, (1) through (20), are then solved simultaneously for each of 20 T_1 's at an axial node. This is repeated for each axial node until the length of the fuel channel is traversed.

The program calculates its own coefficients based on the temperature distribution; therefore, it is necessary to put in an assumed temperature distribution at the beginning of the program. A uniform temperature from top to bottom of the core is assumed. Further, all fuel is at a uniform temperature,

the sleeve is at a uniform temperature, and the block is at a uniform temperature. The heat transfer coefficients at this assumed temperature are calculated by the program, and a steady-state temperature distribution is determined.

This produces a better value for the assumed temperatures. Again the heat transfer coefficients are calculated and a steady-state temperature determined. This process is continued until there is a convergence of temperatures to a constant value. Experience has shown that four or five iterations are sufficient to obtain good convergence.

Having determined the steady-state temperatures, the program then solves equations similar to (39) to determine a new temperature at time $(t + \Delta t)$. This is accomplished by using the gas inlet temperature from the previous axial node as input information and solving the 20 equations for the radial temperature distribution at $(t + \Delta t)$ time. This yields an outlet gas temperature that is used as inlet gas temperature for the next axial node. It is possible to advance in this manner from the bottom of the reactor to the top.

Once the reactor is traversed, $T(t + \Delta t)$ is set equal to $T(t)$, and a new calculation made of the heat transfer coefficients. $T(t)$ is then modified to determine $T(t + \Delta t)$ as before.

The input parameters, such as flow, power, and inlet temperature, may be changed during this time, if desired. These changes are input data to the program and consist of up to 25 straight line segments to approximate a desired curve.

A general program flow diagram is included. The appendix contains the description and use of the program.

V. Results

The results from two calculations are included here as typical output from the program. This calculation was made using 17 axial nodes. An average power channel is used, with a bank rod insertion of 62 inches.

Figure 6 shows the temperatures resulting from a loss of power scram. The three temperatures included are the clad and inner fuel temperatures at axial location eight (73 inches to 85 inches from bottom of core), and the reactor outlet gas temperature. Figure 7 shows the straight line fit to the parameter change rates used by the program.

Figure 8 shows the temperatures resulting from a scram with no reduction in coolant flow.

GENERAL FLOW DIAGRAM

Figure 6

Figure 7

Parameter Change Rates
Reactor Scram from Loss
of Electrical Power

Figure 8

Reactor Scram from 100 Percent
Power and Flow with No Blower
Speed Change

Average Power Channel

Fuel and Clad Temperatures
at 73 - 85 Inches from
Bottom of Core

REFERENCES

1. Experimental Gas-Cooled Reactor, Final Hazards Summary Report, Volume I. October 10, 1962. Oak Ridge Operations Office, USAEC.
2. James C. Robinson. Axial Temperature and Pressure Distribution in EGCR - Development of the PTD-1 Code. October 5, 1962.
3. Memorandum dated January 7, 1963, D. C. Keeton to E. G. Beasley, Subject: Thermal Properties of EGCR Core Materials.
4. L. G. Epel. Radiative Heat Transfer in Multisurfaced Nonblack Enclosures with Application to the EGCR Fuel Bundle. ORNL CF 60-7-71, July 22, 1960.

APPENDIX I

LIST OF INPUT DATA

The FORTRAN conversion is indicated for each card.

- I Input that is normally not changed unless the number of axial increments is changed.

<u>Field</u>	<u>Variable Name</u>	<u>Definition And Use</u>
<u>Card 1a (7I-10)</u>		
1-10	IC	Number of axial increments
11-20	INC	If an initial temperature distribution is to be specified, use a 1. If no initial distribution is given, use zero.

Cards 2a (9F 8.0)

T(K,L)	If INC is 1, specify the initial temperature distribution here. K is the axial position starting at the bottom of the reactor. L is the radial location starting at the center of the fuel. Each new axial increment must start on a new card. Twenty numbers are specified for each axial position.

If INC is 0, skip these cards.

Card 3a (9F 8.0)

1-8	CCGC	Conductance of the clad per foot of fuel length, Btu per second per °F per foot of fuel length.
9-16	CCP	K/WC_p for clad.
17-24	RCP	$1.0/WC_p$ for clad per foot of fuel length.
25-32	CPG	Cp of helium.
33-40	QF	Average Btu per foot of fuel length per second generated in a fuel pin in an average power channel.
41-48	QS	Average Btu per foot axial length per second generated in the sleeve.
49-56	QB	Average Btu per foot axial length per second generated in the moderator.
57-64	HEGP	He gap width in fuel element, in mils.

<u>Field</u>	<u>Variable Name</u>	<u>Definition And Use</u>
	<u>Cards 4a (9F 8.0)</u>	
S(K)		Ratio of Btu per foot sleeve and moderator in axial section K to the average Btu per foot sleeve and moderator for the entire axial length. These numbers are read from plots of axial power distribution.
	<u>Cards 5a (9F 8.0)</u>	
F(K)		Same ratio as above except in the fuel.
	<u>Cards 6a (9F 8.0)</u>	
Z(K)		Length in feet of axial section K.
	<u>Cards 7a (9F 8.0)</u>	
CL(K)		Correction to the clad-to-gas film coefficient to account for the flow disturbers.
	<u>Cards 8a (9F 8.0)</u>	
CS(K)		Correction to the sleeve-to-gas film coefficient to account for flow distrubers.
	<u>Cards 9a (9F 8.0)</u>	
G(L)		Geometric conductance between radial increment L and L + 1.
	<u>Cards 10a (9F 8.0)</u>	
R(L)		Ratio of heat generated in radial section L to that generated in all fuel, sleeve, or moderator in the axial section. For example, R(1) is the ratio of heat generated in the inner one-sixth of the fuel to that generated in all 6 fuel increments.

<u>Field</u>	<u>Variable Name</u>	<u>Definition And Use</u>
<u>Card 11a (7I 10)</u>		
1-8	NGE	Digit to choose the number of print-outs to include on the graph.
<u>Cards 12a (7I 10)</u> (2 cards)		
1-8	NOG	Digit to choose the number of graphs to plots. It may have a value from 1 to 10, and does not include the parameter graph.
9-72	JA(L)	Digits from 1 to 85 to choose an axial increment for plotting. L may go to 10.
<u>Cards 13a (7I 10)</u> (3 cards)		
1-8	NOP	Digit to choose the number of plots per graph.
9-72	JR(L)	Digits from 1 to 16 to choose a radial position to plot.
<u>Card 14a (7F 10.0)</u>		
1-10	WIDE	Decimal number to determine the width in inches of the graphs.
11-20	SPE	Decimal number to determine the seconds per inch of graph.
21-30	OFFST	Temperature at the origin of the graph. It is a decimal number.
31-40	DPI	Number of degrees per inch on the graph. It is a decimal number.

- II Data that is normally changed from case to case. If plotting is specified, data must be stacked from card 11a. If no plotting is done, stack from card 1b.

<u>Field</u>	<u>Variable Name</u>	<u>Definition And Use</u>
<u>Card 1b (12A 6)</u>		
1-72	IDENT	Case identification card. Any information may be punched in this card. Make the first punch a 1.
<u>Card 2b (7F 10.0)</u>		
1-10	RNTM	Case run-time in seconds of reactor time.
11-20	DELT	Time increment included in each calculation in seconds. This must be based on stability requirements as indicated in equation 41.
21-30	FRI	Initial radial power ratio.
31-40	WGTH	Total helium mass flow rate in pounds per second.
41-50	TGTH	Initial reactor inlet temperature, °F.
<u>Card 3b (7F 10.0)</u>		
1-10	PTIV	Number to decide the method of advancing the print interval. A value of 0.0 causes a printout between equal time increments (PI). A value of 1.0 gives a printout that advances with time increments proportional to the number of printouts.
As an example, if $PI = 2.0$, and $PTIV = 0.0$, a printout would occur at 2.0, 4.0, 6.0, 8.0 --- seconds. If $PI = 2.0$, and $PTIV = 1.0$, a printout would occur at 2.0, 6.0, 12.0, 20.0, 30.0 --- seconds.		
11-20	PI	Initial printout interval in seconds.
21-30	PTINF	Number to choose between printing-out an infinite time solution or not. A value of 0.0 gives no infinite time solution, and a value of 1.0 gives an infinite time solution.
31-40	PLT	Number to allow a plot or no-plot. A value of 0.0 gives no-plot; a value of 1.0 produces a plot.

<u>Field</u>	<u>Variable Name</u>	<u>Definition And Use</u>
<u>Card 4b (7I 10)</u>		
1-10	NDS	Digit to choose the axial position to start the printout.
11-20	NDE	Digit to choose the axial position to end the printout.
21-30	INT	Digit to choose the number of axial positions to skip between printout. As an example, if <u>NDS</u> is 10, <u>NDE</u> is 12, <u>INT</u> is 46, then a printout will occur for axial positions 10, 22, 34, and 46.
31-40	IT	Digit to choose the number of iterations of the steady-state solution to allow convergence of the heat transfer coefficients.

Card 5b (7I 10)

1-10	NTBL 1	Number of entries in table 1.
11-20	NTBL 2	Number of entries in table 2.
21-30	NTBL 3	Number of entries in table 3.
31-40	NTBL 4	Number of entries in table 4.

At least one should be specified in each field.

Cards 6b (7F 10.0)

TBL 1 (K)	Table of power change rates versus time. The first number is the time out to which the change rate is effective. The second number is the change rate associated with the first number. Each card is filled with alternating time and change rate. Twenty-five changes are possible. A change rate should be specified out to run time, even if it is zero.

In the case of power, the change rate is in per unit per second, that is, fractional power change per second. For instance, a value of .1 gives a positive power change rate of .1 per second.

<u>Field</u>	<u>Variable Name</u>	<u>Definition And Use</u>
	<u>Cards 7b (7F 10.0)</u>	
TBL 2 (K)		Same as above except for total He flow. The change rate is in pounds per second per second. For instance a value of .01 gives a positive flow change rate of .01 pounds per second per second.
	<u>Cards 8b (7F 10.0)</u>	
TBL 3 (K)		Same as above except annulus-to-fuel coolant balance. The change rate is fractional annulus flow change per second.
	<u>Cards 9b (7F 10.0)</u>	
TBL 4 (K)		Same as above except inlet He temperature change rate. The change rate is in degrees per second.

APPENDIX II

FATT FLOW DIAGRAM

COEFS SUBROUTINE

PLTS SUBROUTINE