**FLODIS: A Computer Model to Determine
the Flow Distribution and Thermal
Response of the Fort St. Vrain Reactor**

D. D. Paul

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Reactor Division

FLODIS: A COMPUTER MODEL TO DETERMINE THE FLOW
DISTRIBUTION AND THERMAL RESPONSE OF
THE FORT ST. VRAIN REACTOR

D. D. Paul

JUNE 1976

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FOREWORD

In February 1975, the Nuclear Regulatory Commission (NRC) asked Oak Ridge National Laboratory (ORNL) to perform an independent analysis of the thermal response of the Fort St. Vrain (FSV) reactor core and primary coolant system following a design-basis depressurization accident (DBDA) with operation on two circulators. The analysis was performed using the CCCM code¹ at ORNL with the flow distribution assumed to be either proportional to the radial peaking factors or uniform throughout the reactor. This initial study, the results of which were reported in a letter to R. A. Clark,² indicated the importance of being able to accurately determine the time dependent flow distribution in the reactor. For this reason, the development of the FLODIS code was initiated on March 21, 1975.

Licensing requirements necessitated the quick development of a core model to obtain flow rates to be used as input to the CCCM code. To expedite the initial development process, a simple core model was chosen; it was a model containing only one node per refueling region. This model was completed in May 1975, and the results are presented in a section of the preliminary report on the Fort St. Vrain DBDA.³

There was little or no development work done on the FLODIS code between May and August of 1975. However, on August 11-12, 1975, in meetings with the NRC staff in Washington, D.C., it became apparent that more detailed modeling would be necessary to insure the accuracy of the results. At that time, work was undertaken to extend the original one node per refueling region model to include a variable number of up to 100 nodes per refueling region. It should be kept in mind that the equations developed for the single node model are essentially the same as for a multinode model; the main effort was directed toward redimensioning of arrays and setting up DO loops within already existing subroutines. This work was completed in December 1975.

FLODIS: A COMPUTER MODEL TO DETERMINE THE FLOW
DISTRIBUTION AND THERMAL RESPONSE OF
THE FORT ST. VRAIN REACTOR

D. D. Paul

ABSTRACT

FLODIS is a combined heat transfer and fluid flow analysis calculation written specifically for the core of the Fort St. Vrain reactor. It is a lumped-node representation of the 37 refueling regions in the active core. Heat conduction to the coolant and in the axial direction is represented; however, the effect of conduction between refueling regions is not included. The calculation uses the specified operating conditions for the reactor at power to determine appropriate loss coefficients for the variable orifices in each refueling region. Flow distributions following reactor trip and a reduction in coolant pressure and flow are determined assuming that the orifice coefficients remain constant. Iterative techniques are used to determine the distribution of coolant flow as a function of time during the transient. Results are presented for the evaluation of the transient for the Fort St. Vrain reactor following depressurization and cooling with two circulators operating at 8000 rpm.

Key words: Helium, refueling region, conduction, convection, reflector, active core, core support block, orifice, plenum.

INTRODUCTION

The high-temperature gas-cooled reactor (HTGR) is currently being developed by General Atomic Company (GAC), San Diego, California. Although there have been only two commercial HTGRs built in the United States (Peach Bottom and Fort St. Vrain), the concept of a gas-cooled reactor is not new. In the past the American effort has been directed toward development of water-cooled reactors; however, the European effort (most notably the British) has been directed toward development of gas-cooled reactors. In fact, the British have over 20 years operating experience with gas-cooled reactors. To date, Fort St. Vrain is

the largest commercial HTGR built in the United States. It contains many design features proposed for larger gas-cooled reactors.

DESCRIPTION OF THE FORT ST. VRAIN HTGR

The Fort St. Vrain HTGR is a 330-MW(e) demonstration plant located about 60 Km north of Denver, Colorado. Figure 1 shows the arrangement of the primary system within the prestressed concrete reactor vessel (PCRVR).⁴ The reactor is located in the upper half of the PCRVR and is supported by posts attached to the core support floor. This results in a large plenum area where gas from the entire core can mix before entering the steam generator inlet ducts. Below the core support floor are 12 steam generator modules and 4 helium circulators.

As shown in Fig. 2, the Fort St. Vrain reactor core consists of 37 refueling regions.⁵ Each refueling region contains an orifice valve in the upper plenum and a central control column with two control rod channels and a reserve shutdown hole. In a regular refueling region, the central column is surrounded by 6 fuel columns; in a boundary refueling region the control column is surrounded by only 4 fuel columns. Note the boundary refueling regions in Fig. 2 are numbered 20, 23, 26, 29, 32, and 35. All others are regular refueling regions. Also shown in Fig. 2 are the radial peaking factors for each refueling region. The region peaking factors change throughout the fuel cycle. This particular power distribution was chosen as the basis for analysis because it has been judged to be the worst possible case should an accident occur.

About 3.5% of the total coolant flow passes through the spaces between the side reflector blocks. The other 96.5% of the total coolant flow is distributed among the 37 refueling regions. Coolant enters a refueling region from the upper plenum through an adjustable orifice valve⁶ shown in Fig. 3. The orifice regulates the amount of flow allowed in each refueling region by adjusting the flow area "seen" by the coolant in the upper plenum. Two concentric cylinders with rectangular slots comprise the orifice device. The orifice is closed by moving the outer cylinder up while the inner cylinder remains stationary.

After being distributed among the holes within a refueling region, the coolant flows downward through the core. Near the bottom of the core

Fig. 1. Reactor arrangement.⁴

Fig. 2. Reactor core arrangement.⁵

Fig. 3. Top plenum and orifice valve arrangement.⁶

the coolant empties into 6 large coolant channels. Figure 4 shows the details of the flow path.⁷ These 6 large coolant channels then collect into a single channel within the core support block before the coolant is discharged to the lower plenum. In the lower plenum, coolant from all 37 refueling regions and from the side reflector blocks mixes before entering the steam generator inlet ducts.

After passing through the 12 steam generator modules, the coolant collects and mixes below the lower floor. Suction produced by the 4 circulators forces the coolant into the open area outside the steam generator modules. From there the coolant moves up between the PCRV liner and the core barrel until it again collects in the upper plenum. The coolant flow loop is now complete.

For easy reference, design specifications for the Fort St. Vrain reactor, obtained from the Final Safety Analysis Report (FSAR), are included in Tables 1 and 2. Table 1 contains major design specifications and operating conditions.⁸ Table 2 contains data on the reactor core components and design parameters.⁹ Note that the information obtained from the FSAR was converted to conform to the International System of Units.

CAPABILITIES OF THE CODE

The FLODIS code was developed to study depressurization accidents in HTGRs, but it is written in a general format so that it may be used for other transient analyses following reactor trip. For instance, the code may be used to analyze the thermal response of the reactor during the normal shutdown sequence. Any transient where the time dependent inlet coolant temperature, total core flow, and coolant pressure are known, the thermal response of the core may be determined. This includes situations where there is no forced convection for short periods of time before start-up of the circulators.

Given the proper input data, the FLODIS code calculates the individual refueling region flows, pressure drops, and temperature distributions. Input data is kept to a minimum without unduly restricting the capabilities of the user. Output is printed in a manner that is easily read and interpreted by anyone familiar with the reactor. Throughout the entire development of the code, emphasis has been placed on making its use as simple and

Fig. 4. Core arrangement, elevation section.⁷

Table 1. Data on major design characteristics and operating conditions⁸

	842 MW(th)	879 MW(th)
1. <u>General</u>		
a. Reactor type	High temperature gas-cooled reactor employing a ^{235}U -thorium fuel cycle, helium cooling, and graphite moderation.	
b. Number of primary coolant loops	2	2
c. Design output		
Net electrical output (to main power transformer), kW	330,000	>330,000
Reactor thermal power, kW	842,000	879,000
2. <u>Reactor Physics</u>		
a. Prompt neutron lifetime for initial core, sec	2.4×10^{-4}	2.4×10^{-4}
b. Reactivity characteristics		
Excess reactivity (Δk) in the initial core at mid-cycle, ^{135}Xe and ^{233}Pa decayed, ^{149}Sm buildup.		
at 300 K	0.136	0.136
at 422 K	0.124	0.124
at operating temperature	0.075	0.075
c. Average Neutron Flux (initial core after one year), $\text{n/m}^2\cdot\text{s}$		
Thermal (<2.38 eV)	6.2×10^{17}	6.5×10^{17}
Fast (>0.18 MeV)	3.3×10^{17}	3.5×10^{17}
d. Reactivity defect in the initial core		
Temperature and power (300 K to operating), % Δk	7.2	7.2
Xe and Sm (at operating temperature), % Δk	3.5	3.5

Table 1. (continued)

	842 MW(th)	879 MW(th)
3. <u>Reactor</u>		
a. Number of fuel elements in core	1482	1482
b. Number of control rods	74 (37 pair)	74 (37 pair)
c. Number of control rod drives	37	37
d. Effective core diameter, m	5.974	5.974
e. Fuel element stack height (cold, new), m	4.755	4.755
f. Nominal average side reflector thickness (including borated portion for shielding), m	1.194	1.194
g. Top reflector thickness (including borated portion for shielding), m	0.991	0.991
h. Bottom reflector thickness (including borated portion for shielding), m	1.189	1.189
i. Reactor vessel inside diameter (inside liner), m	9.449	9.449
j. Reactor vessel inside height (inside liner), m	22.86	22.86
4. <u>Fuel Elements</u>		
a. Type	Hexagonal graphite blocks containing blended beds of fuel particles	
b. Cold core array pitch, m	0.3607	0.3607
c. Block length (cold), m	0.7925	0.7925
d. Active fuel elements per column	6	6
5. <u>Core Design Operating Conditions</u>		
a. Average power density, kW/m ³	6300	6600
b. Maximum power density, kW/m ³	20000	21000
c. Heat transfer surface area, m ²	5816	5816
d. Average heat flux, kW/m ²	142.0	148.3
e. Maximum heat flux, kW/m ²	441.7	460.6
f. Average fuel temperature, K	1088	1108
g. Maximum fuel temperature, K	1533	1561
h. Average surface temperature, K	978	988

Table 1. (continued)

	842 MW(th)	879 MW(th)
5. <u>Core Design Operating Conditions</u> (continued)		
i. Maximum surface temperature, K	1422	1433
j. Average fuel-moderator temperature, K	1033	1050
k. Average helium temperature at core outlet, K	1058	1060
l. Maximum helium temperature at core outlet, K	1256	1261
6. <u>Fuel Cycle</u>		
a. Refueling period, yr	1	1
b. Fuel lifetime, 85% capacity factor (fuel design basis only), yr	6	
c. Annual ^{235}U feed, equilibrium (in 93% enriched uranium), kg/yr	220	
d. Annual thorium feed, equilibrium, kg/yr	2400	
e. Conversion ratio	0.60	
f. Average burnup per tonne of U and Th, Mwd/tonne	100,000	
g. Fissions per initial fissile atom	1.3	
7. <u>Primary Coolant System</u>		
a. Total helium flow rate in steam generators, kg/s	429.7	451.1
b. Helium pressure at rated load (circulator discharge), MPa	4.826	4.875
c. Ratio of gross circulator power to gross thermal output	0.020	0.022
d. System pressure drop (nominal), MPa	0.09653	0.1062
e. Helium temperature at core inlet, K	679	685
f. Helium temperature at steam generator inlet, K	1048	1052
g. Coolant flow direction through core	Downward	Downward

Table 1. (continued)

	<u>842 MW(th)</u>	<u>879 MW(th)</u>
7. <u>Primary Coolant System</u> (continued)		
h. Number of primary coolant loops	2	2
i. Helium circulator type	Single-state axial compressor	
j. Number of helium circulators	4 (2/loop)	4 (2/loop)
k. Steam generator type	Once-through (1 per loop)	
l. Number of identical modules per steam generator	6	6
8. <u>Turbine Plant</u>		
a. Main turbine	Tandem-compound double-flow	
b. Throttle steam pressure, MPa (gauge)	16.55	16.55
c. Throttle steam temperature, K	811	811
d. Hot reheat steam pressure (rated load at reheater outlet), MPa	4.137	4.344
e. Reheat steam temperature (at turbine inlet), K	811	811
f. Throttle steam flow rate, kg/s	291.1	304.9
g. Nominal design back pressure, MPa (at 288 K temperature)	0.00844	0.00844
h. Feedwater temperature, K	479	482
9. <u>Overall Plant Output</u>		
a. Gross generator output, MW	342	>342
b. Auxiliary electrical power, MW	12	12
c. Net station output (to main power transformer), MW	330	>330
d. Net station heat rate, kJ/kW	9179	9168
e. Net station efficiency, %	39.2	39.3

Table 2. Core parameters and components⁹

<u>Fuel Element Assembly (room temperature dimensions)</u>		
Number required	1482	
Power density, kW/m ³	6300 (for 842 MW(th) operation)	
Shape	Hexagonal right prism	
Material	Graphite	
Width across flats, m	0.3599	
Length, m	0.7930	
Diameter of fuel holes, mm	12.70	
Diameter of coolant holes, mm	15.875 (6 are 12.70)	
Interconnecting dowels	3	
	<u>Standard fuel element</u>	<u>Control element</u>
Number of fuel holes	210	120
Number of coolant holes	108	57
Number of poison holes	6	4
<u>Fuel Beds</u>		
Bed diameter, mm	12.75	
Bed stack length, nominal, m	0.7404	
Bed composition	Blended beds of fissile and fertile in particles in specified fuel compositions	
Number of fuel compositions		
Initial core	13	
Equilibrium core	7	
<u>Reflector Element Assemblies</u>		
Number required	2200	
Shape	Hexagonal right prism	
Material, except topmost layer	Graphite and boronated graphite	
Material, topmost layer	Boronated graphite and steel	
Width across flats (room temp.), m	0.3599	
Flow area, top and bottom reflector	Same as fuel elements	
Interconnecting dowels	3	

Table 2. (continued)

<u>Permanent Reflector Block and Spacer Assemblies</u>		
Number required, blocks	312	
Number required, spacers	1152	
Shape	Irregular	
Material, except topmost layer	Graphite and boronated graphite	
Material, topmost layer	Boronated graphite and steel	
Approximate size, m		
Blocks	0.6 × 0.8 × 1.0	
Spacers	0.25 × 0.30 × 0.50	
Interconnecting dowels, blocks	3	
Interconnecting dowels, blocks	2	
<u>Core Arrangement</u>		
Pitch of fuel columns (room temp.), m	0.3610	
Number of fuel columns	247	
Number of hexagonal side reflector columns	66	
Number of irregular shaped side reflector columns	24	
Number of spacer columns	48	
Number of control rod channels	74 (2 per fuel region)	
Number of reserve shutdown channels	37 (1 per fuel region)	
Number of fuel regions	37	
Fuel region pitch (room temp.), m	0.9550	
Effective core diameter (including reflector), m	8.330	
Core height (including reflector), m	7.138	
Overall side reflector thickness, m	1.194	
Overall top and bottom reflector thickness, m	1.189	
<u>Thermal and Hydraulic Parameters at Reactor Design Conditions</u>		
Gross reactor thermal power MW(t)	<u>842</u>	<u>879</u>
Total core/reflector coolant flow rate, kg/s	427.1	448.6
Coolant inlet to core, K	679	685

Table 2. (continued)

Thermal and Hydraulic Parameters at Reactor Design Conditions (continued)		
Mixed-mean inlet to steam generators, K	1048	1052
Coolant channel frontal area fraction, % (core average)	17.2	17.2
Total core coolant channel frontal area, m ² (including column clearance)	5.323	5.323
Volume median fuel temperature, K	1089	1100
Volume median moderator temperature, K	1006	1011
Average coolant channel surface heat flux, kW/m ²	25,000	26,300
Average coolant surface heat transfer coefficient, W/m ² ·K	1306	1363
Coolant core inlet pressure, MPa	4.819	4.868
Total core pressure drop, max., MPa	0.0579	0.0724

straightforward as possible. This philosophy allows the user to concentrate on using the code as a tool to make evaluations and eliminates time wasted in searching through pages of awkward output data.

Although the code was specifically written for studying the Fort St. Vrain reactor, extension to other HTGR systems would require only redimensioning of arrays and modifying output subroutines. A convenient feature of the FLODIS code is that the number of nodes in the axial direction may be varied from 10 to 100, depending on the desired accuracy and computer time restrictions. An important limitation of the code is that it does not allow conduction of heat between refueling regions.

COMPUTATIONAL MODEL

A mathematical model of the active core and reflector was developed for the Fort St. Vrain reactor. Although the equations describing the system are a series of coupled differential equations, the iteration scheme shown in Fig. 5 allows one to treat the flow distribution independently from the temperature distribution calculations. Care should be exercised in interpreting the above statement. The flow and temperature calculations are coupled through the use of an appropriate iteration scheme. However, for clarity the mathematical model will be presented in two parts — the flow distribution and the temperature distribution.

Flow Distribution

The problem may be simply stated as follows: There exists an apparatus consisting of an upper plenum connected to a lower plenum by a number of independent flow regions. Given the total flow entering the upper plenum, determine how the flow will distribute among the various regions. If all the regions were identical, the solution would be obvious, i.e., each region would have the same flow. However, each region may have a different orifice setting, a different number of coolant holes, or a different temperature distribution. Each of these parameters play an important part in determining how the flow is distributed.

Fig. 5. Iteration procedure.

The philosophy used to solve the problem is very simple. Regardless of the physical differences between regions, the plenum-to-plenum pressure drop must be the same for all regions. Thus, the flow will distribute in such a manner as to yield the same plenum-to-plenum pressure drop across each region. Since a pressure drop must be calculated, the logical starting point in the analysis is to write a momentum balance.

Historically, Leonard Euler (1707-1783) in 1755, was the first to derive the fluid momentum equations. An important limitation of the Euler equations, as they are known today, is the underlying assumption that the fluid is non-viscous. This was remedied in 1822, when Louis Navier (1785-1836) extended the equations to include the effects of viscous dissipation. Later, George Gabriel Stokes (1819-1903) in a paper in 1845, re-derived the equations in a form that is mathematically more elegant than Navier's original derivation. In fact, it is the momentum equation, as written by Stokes, that is identified today as the Navier-Stokes Equation;

$$\frac{\partial \rho \vec{v}}{\partial t} = - [\vec{\nabla} \cdot \rho \vec{v} \vec{v}] - \vec{\nabla} p - [\vec{\nabla} \cdot \vec{t}] + \rho \vec{g} \quad (1)$$

where

- ρ = the local fluid density,
- $\vec{v}$ = the fluid velocity vector,
- p = the local normal pressure,
- $\vec{t}$ = the fluid stress tensor,
- $\vec{g}$ = the gravitational force vector,
- $\vec{\nabla}$ = the vector differential operator.

Note that the terms $\rho \vec{v} \vec{v}$ and $\vec{t}$ are not simple vector quantities, but rather are tensor quantities.

To apply the Navier-Stokes equations to the flow problem under consideration, it is desirable to derive a conservative relation of Eq. (1). The conservative form is obtained by taking the dot product of the local velocity vector with Eq. (1), and integrating over a fixed volume element. The derivation is too lengthy to present here (for an excellent discussion of this derivation see work by Bird^{10,11}), but the result is the widely

known Bernoulli equation,

$$\Delta \frac{1}{2} \rho \frac{\langle v^3 \rangle}{\langle v \rangle} + \rho g \Delta h + \Delta p + \Omega = 0 \quad (2)$$

where

Δ = the differencing operator,

h = the elevation,

$\langle \rangle$ = weighted average,*

Ω = the total irreversible rate of conversion of mechanical to internal energy. Often this term is referred to as the frictional loss, and generally is estimated by an empirical relationship based on experimental data (see section on fluid flow correlations).

All other quantities are the same as previously defined.

The above equation is equally valid for either laminar or turbulent flows. It is important to recognize the changes in Eq. (2) resulting from the study of different flow regimes.

The first term in Eq. (2) has a strong dependence on the flow regime. It is often written as:

$$\frac{\langle v^3 \rangle}{\langle v \rangle} = \lambda \langle v \rangle^2 \quad (3)$$

where λ = the kinetic energy correction factor.

If the fluid velocity distribution is known, the quantity λ can be calculated from Eq. (3). For turbulent flow in tubes, the velocity distribution can be approximated by Nikuradse's 1/7-th-power law.¹² Using this turbulent flow correlation, the value of λ is calculated to be 1.058. For laminar flow in tubes, the velocity distribution can be approximated

*The symbol $\langle \rangle$ means the quantity contained within is averaged. For circular tubes, the average velocity distribution is:

$$\langle v^n \rangle = \frac{\int_0^{2\pi} \int_0^R v^n r dr d\theta}{\int_0^{2\pi} \int_0^R r dr d\theta}$$

by Poiseuille flow.¹³ Using this relationship, the value of λ for laminar flow is 2.00. In general for any velocity distribution, the value of λ must necessarily be greater than 1.00. Although the value of λ is usually assumed, either knowingly or unknowingly, equal to 1.00 for turbulent flows, this assumption is extremely poor for the case of laminar flows.

The total irreversible rate of conversion of mechanical to internal energy also depends on the flow regime. In general, the quantity Ω can be written as,

$$\Omega = \frac{1}{2} \rho \langle v \rangle^2 \sum_{\substack{\text{loss} \\ \text{factors}}} e_v \quad (4)$$

where $\sum_{\substack{\text{loss} \\ \text{factors}}} e_v$ = the summation of all the loss factors for the particular section of channel under consideration.

Loss factors may include losses due to duct friction, an expansion, a contraction, or an orifice valve. Furthermore, the loss factors are also dependent on whether the flow is laminar or turbulent. For details on the loss factors, the reader is referred to the section on fluid flow correlations.

Equation (2) may be used for systems in which the viscosity, μ , or the density, ρ , varies significantly in the direction of flow by applying it on an incremental basis along the channel; and then summing the increments to obtain the total pressure drop. By using the equation of continuity,

$$G = \rho \langle v \rangle \quad (5)$$

where G = the mass flux in the coolant channels, and the ideal gas law, it is possible to derive from Eq. (2) a relationship between the mass flux and the plenum-to-plenum pressure drop as:

$$G = \sqrt{\frac{(P_u - P_L) + \sum_{\text{channel length}} \rho g \Delta h}{\frac{1}{2} \sum_{\text{channel length}} \left(\frac{1}{\rho} \left[\frac{\lambda \Delta T}{T} + \sum_{\text{loss factors}} e_v \right] \right)}} \quad (6)$$

where

P_u = the pressure in the upper plenum,

P_L = the pressure in the lower plenum,

and all other quantities are the same as previously defined.

Equation (6) may now be used in conjunction with an iteration scheme to determine how the flow will distribute among the various regions. The logic of the iteration scheme is:

1. Guess at the total plenum-to-plenum pressure drop.
2. Use Eq. (6) to calculate the flow in each region, based on the assumed pressure drop.
3. Sum the individual flows and compare the calculated total flow with the given total flow.
4. If the calculated total flow is within some small convergence criteria of the given total flow, the problem is solved. If the calculated total flow is not within the convergence criteria, the assumed plenum-to-plenum pressure drop is modified by the ratio of the total calculated flow to the total given flow. Steps 2 through 4 are then repeated until convergence is achieved.

Figure 5 shows complete details of the overall iteration procedure.

It is interesting to note that Eq. (6) is valid for upflow or downflow as long as proper care is used to determine the correct signs on the Δ quantities.

Temperature Distributions

A detailed temperature distribution must be calculated in order to determine the correct flow distribution. Models are needed to determine the temperatures in both the reactor core and coolant. The development

of a model will be presented in two parts; a core model consisting of the graphite moderator and fuel sticks, and a coolant model consisting only of fluid flow through the channels.

Core Temperature

Details of the derivation of the core model will be included because much of the derivation applies to other models currently being used, and this should help in comparing and evaluating these other models.

It is relatively easy to obtain a point-wise or differential energy balance on the entire system. The difficulty lies in trying to solve the resulting differential equation. In any case, the starting point for this analysis will be a statement of the general equation of energy for solids;

$$\rho(T) C_p(T) \frac{\partial}{\partial t} T(\vec{r}, t) = - \vec{\nabla} \cdot \vec{q}(\vec{r}, t) + J(\vec{r}, t) \quad (7)$$

where

$T(\vec{r}, t)$ = the temperature at position $\vec{r}$, and at time, t ,

$\vec{q}(\vec{r}, t)$ = the heat flux at position $\vec{r}$, time t ,

$J(\vec{r}, t)$ = the volumetric thermal source strength at position $\vec{r}$, time t ,

$\rho(T)$ = the solid density as a function only of the dependent variable temperature,

$C_p(T)$ = the heat capacity as a function only of the dependent variable temperature.

Care has been taken to write Eq. (7) in completely general form so that assumptions made during the subsequent derivation can be explicitly noted. Equation (7) is valid throughout the entire solid portion of the reactor, whether it be in the fuel sticks, or graphite moderator, or reflector elements. At this point no assumptions have been made.

Throughout the remainder of this section, the function notation will be eliminated. It will be implicitly assumed that the temperature, T , the heat flux, $\vec{q}$, and the volumetric thermal source strength, J , are functions of the position vector, $\vec{r}$, and the time, t . Furthermore, the density, ρ , and the heat capacity, C_p , will be implicitly assumed to be functions of the temperature.

It would not be an overstatement to say that it is impossible to finite difference Eq. (7) over the entire reactor. Most finite difference schemes are written for a homogeneous medium with constant thermal properties and "nice" geometries. By "nice" geometries we mean geometries where the boundaries lie naturally along the contours of an orthogonal coordinate system. Examples of nice geometries include rectangular boxes, right-circular cylinders, or spheres. For most practical problems, one or more of these conditions are not wholly satisfied.

For the case of an HTGR core, which consists of a matrix of hexagonal fuel blocks made of pure graphite with fuel sticks, coolant holes, poison rods, and/or control rod channels interspaced, none of these conditions are satisfied. But the situation is not really as despairing as it first sounds. Equation (7) is simply a statement of energy conservation for an infinitesimal element of volume. If it is integrated over all directions, the result will be a statement of energy conservation for a small volume element. This is called a conservative relation. The conservative relation is what we are really interested in if we are going to consider the whole reactor core.

Choose as a volume element an axial slice of a refueling region as shown in Fig. 6.

The entire reactor core can be constructed using the volume element shown above. Equation (7) is integrated over this typical volume element, V , to give

$$\int_V \rho C_p \frac{\partial T}{\partial t} dV = \int_V - (\vec{\nabla} \cdot \vec{q}) dV + \int_V J dV \quad (8)$$

(a) (b) (c)

For term (a), the integral is evaluated by first making the assumption that the core can be homogenized so that the density, ρ , and heat capacity, C_p , are constant over the volume element and are functions only of the volume average temperature. Then using Leibnitz's rule, term (a) becomes

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Fig. 6. Axial slice of a refueling region.

$$\int_V \rho C_p \frac{\partial T}{\partial t} dV = \rho C_p V \frac{\partial}{\partial t} \frac{1}{V} \int_V T dV = m C_p \frac{\partial \langle T \rangle}{\partial t} \quad (9)$$

where

$m = \rho V$ = the total mass of the volume element under consideration,
 $\langle T \rangle$ = the volume average temperature.

Term (b) is perhaps the most interesting of the terms. By applying the divergence theorem, and dividing the closed surface bounding the volume element into three open surfaces, term (b) becomes

$$\int_V -(\vec{\nabla} \cdot \vec{q}) dV = \int_{S_1} -q_{n_1} dS + \int_{S_2} -q_{n_2} dS + \int_{S_3} -q_{n_3} dS \quad (10)$$

(b₁) (b₂) (b₃)

where

S_1 = the surface bounding the ends of volume element (see Fig. 6),

S_2 = the surface bounding the outside of the volume element (see Fig. 6),

S_3 = the surface bounding the inside of the coolant holes in the volume element (see Fig. 6),

$q_{n_1}, q_{n_2}, q_{n_3}$ = the normal fluxes to the surfaces S_1, S_2 , and S_3 , respectively.

Term (b₁) represents the net rate of energy input by axial conduction of heat. By using Fourier's law of heat conduction, and Gauss's theorem, term (b₁) may be written

$$\int_{S_1} -q_{n_1} dS = \int_{S_1} k \frac{\partial T}{\partial n} dS = \int_V k \frac{\partial^2 T}{\partial n^2} dV = K_a V \frac{\partial^2 \langle T \rangle}{\partial n^2} \quad (11)$$

where K_a = the effective axial thermal conductivity of the volume element.

Term (b₂) represents the net rate of heat input by conduction from adjacent refueling regions. Since the surface, S_2 , does not conform to the contours of an orthogonal coordinate system, the heat flux, q_{n_2} , cannot be replaced by a simple expression of Fourier's law of heat conduction

as was done for term (b₁). For the time being, the problem is more or less ignored by assuming the heat flux, q_{n_2} , through this surface is negligibly small in comparison with the other terms in the equation. This is equivalent to saying that S_2 is an adiabatic surface.* Thus, term (b₂) is

$$\int_{S_2} -q_{n_2} dS = \int_{S_2} 0 dS = 0 \quad (12)$$

It is interesting to note that had a volume element been chosen that conformed to an orthogonal coordinate system, Fourier's law could have been applied and the combined result of terms (b₁) and (b₂) would give

$$\int_{S_1} -q_{n_1} dS + \int_{S_2} -q_{n_2} dS = kV\nabla^2 \langle T \rangle, \quad (13)$$

which is Laplace's equation for heat conduction.

Term (b₃) is the integral over the coolant channel surfaces. By assuming Newton's law of cooling is valid, term (b₃) becomes

$$\int_{S_3} -q_{n_3} dS = \int_{S_3} H(\theta - \langle T \rangle) dS = HA\zeta(\theta_{in} - \langle T \rangle) \quad (14)$$

where

H = the local heat transfer coefficients,

A = the total heat transfer area within the volume element,

θ = the coolant temperature,

ζ = an averaging factor, defined in the section on coolant temperatures, which accounts for the variation of coolant temperature over the length of the volume element.

If Eqs. (11), (12), and (14) are combined, the final expression for term (b) is

$$\int_V -(\vec{\nabla} \cdot \vec{q}) dV = kV \frac{\partial^2 \langle T \rangle}{\partial n^2} + 0 + HA\zeta(\theta_{in} - \langle T \rangle) \quad (15)$$

*The RECA code,¹⁴ written by General Atomic Company, does not make this assumption, and therefore must make some approximation for this integral.

Term (c) is easily evaluated. By definition, the volumetric thermal source strength is the heat generated per unit volume per unit time at a particular location. The integral over the volume is thus

$$\int_v J \, dV = Q \quad (16)$$

where Q = the total heat generated per unit time in the volume element.

By substituting Eqs. (9), (15), and (16) into Eq. (7) the following conservative relation is obtained:

$$m C_p \frac{\partial \langle T \rangle}{\partial t} = kV \frac{\partial^2 \langle T \rangle}{\partial n^2} - HA \zeta (\langle T \rangle - \theta_{in}) + Q \quad (17)$$

Note that the differential equation is now written in terms of volume average temperatures of a nodal element instead of point-wise temperatures. Since Eq. (17) was derived for an arbitrary volume element, it may be finite differenced throughout the reactor core. A differencing method proposed by Crank and Nicholson¹⁵ is used to reduce Eq. (17) to a set of linear algebraic equations. The algebraic equations are solved using a Gauss-Seidel iteration procedure.¹⁶

Coolant Temperatures

Heat transfer in a moving fluid is a very complicated physical process that depends strongly on the flow regime. Without the use of experimental data, only the simplest of fluid heat transfer problems could be solved. However, experimental data is available in the form of correlations that relate a heat transfer coefficient to the flow regime and fluid properties. Using these correlations, an energy balance gives

$$WC_p \frac{d\theta}{dz} = HP (\langle T \rangle - \theta) \quad (18)$$

where

θ = the bulk coolant temperature,

$\langle T \rangle$ = the corresponding volume average core temperature,

H = the local heat transfer coefficient,

W = the coolant mass flow rate,
 C_p = the coolant heat capacity,
 P = the wetted perimeter of the channel,
 z = the axial length along the channel.

Equation (18) implicitly assumes the thermal "inertia" of the fluid is negligibly small in comparison with the other terms. This is a good approximation for most gases. Integrating Eq. (18) over the length of the volume element shown in Fig. 6 gives

$$\theta(z) = \langle T \rangle - (\langle T \rangle - \theta_{in})e^{-\alpha z} \quad (19)$$

where

$$\alpha = \frac{HP}{WC_p} \quad (20)$$

It is assumed the inlet fluid temperature is known. Equation (19) may then be used in conjunction with Eq. (17) to obtain the thermal response of the system. Note that Eq. (19) must be solved over each nodal volume.

It is convenient to use Eq. (19) to determine the total quantity of heat transported from a volume element by convection. By definition, for a differential segment dz , the differential quantity of heat transported by convection is

$$dQ_c = HP[\langle T \rangle - \theta(z)]dz \quad (21)$$

Equation (19) may be substituted into Eq. (21), and the differential quantities summed by integration to give

$$Q_c = HPL \left[(\langle T \rangle - \theta_{in}) \frac{1 - e^{-\alpha L}}{\alpha L} \right] \quad (22)$$

where L = the length of the volume element.

The expression in brackets can be interpreted as the average temperature difference between the wall and the coolant over a single nodal volume. For convenience, the averaging factor can be defined as,

$$\zeta = \frac{1 - e^{-\alpha L}}{\alpha L} \quad (23)$$

and the convective heat transport term becomes

$$Q_c = HPL\zeta (\langle T \rangle - \theta_{in}) \quad (24)$$

This expression is now exact in that it correctly accounts for the variation of the temperature difference between the wall and the coolant. Note that Eq. (24) is the same as the expression given in Eq. (17) for the convective heat transport, except now the term ζ has been defined by Eq. (23).

CORRELATIONS

Correlations of existing experimental data are needed before the momentum and energy equations can be solved. The correlations chosen for use in the FLODIS code were picked for either their wide acceptance or particular applicability to HTGRs. These correlations may be divided into three classes — fluid flow correlations, heat transfer correlations, and design correlations.

Fluid Flow Correlations

Perhaps the most important parameter, as far as determining the flow distribution, is the loss factor due to friction in the channel. This loss factor is defined by,

$$e_f = \frac{4L}{D} f \quad (25)$$

where

e_f = channel friction loss factor to be used in Eq. (6),

L = length of channel under consideration,

D = hydraulic diameter of the channel,

f = Fanning friction factor.*

The Fanning friction factor is a function of the flow regime.

For turbulent flows, $Re \geq 4291$, Drew, Koo, and McAdams¹⁷ have found that the friction factor data could be correlated to within $\pm 5\%$ by

*Note: the Moody friction factor, f' , is defined by $f' = 4f$. Both friction factors are used extensively throughout the literature, and special attention should be given to using them properly.

$$f = 0.0014 + 0.125 \text{ Re}^{-0.32} \quad (26)$$

where Re = Reynolds number.

Strictly speaking, the above friction factor is valid only for isothermal flow in smooth pipes. For non-isothermal flow, Davenport and Magee¹⁸ have found that local values of the friction factor were correlated when the fluid properties were evaluated at the film temperature, defined to be the average of the wall and bulk temperature. Thus, Eq. (26) can be used for non-isothermal flow if the viscosity, used to calculate the Reynolds number, is evaluated at the film temperature.

For laminar flows, $\text{Re} \leq 1600$, the friction factor is determined by the classical result of Hagen-Poiseuille^{13,19},

$$f = \frac{16}{\text{Re}} . \quad (27)$$

In the transition zone, $1600 < \text{Re} < 4291$, a friction factor is arbitrarily defined to be a straight line on semi-log paper, connecting the points at $\text{Re} = 1600$ and $\text{Re} = 4291$. This necessarily makes the friction factor a continuous, single-valued function of the Reynolds number. Because the bounding limits of the Reynolds number were nicely chosen, the value of the friction factor in the transition region is constant,

$$f = 0.01 . \quad (28)$$

Correlations for expansion and contraction loss coefficients are also needed. Kays²⁰ has derived analytical expressions that have been checked and found to be in good agreement with experimental data. For expansion loss coefficients, Kays suggests

$$e_e = 1 - 2\beta_s \sigma + \sigma^2 (2\beta_L - 1) \quad (29)$$

where

e_e = loss coefficient due to a sudden expansion,

σ = ratio of small area to large area,

β_L = momentum correction factor for large tube,

β_s = momentum correction factor for small tube.*

For contraction loss coefficients, Kays suggests

$$e_c = \frac{1 - \lambda_L \sigma^2 C^2 - 2C + 2\beta_s C^2}{C^2} - (1 - \sigma^2) \quad (30)$$

where

e_c = loss coefficient due to a sudden contraction,

C = jet contraction area,

λ_L = kinetic energy correction factor in large tube (see Eq. (3) for a detailed definition).

Values of the jet contraction area, as a function of the ratio of areas, σ , is given by Rouse²¹ in Table 3.

Table 3. Jet contraction area²¹

Ratio of areas, σ	Jet contraction area, C
0.0	0.611
0.1	0.612
0.2	0.616
0.3	0.622
0.4	0.631
0.5	0.644
0.6	0.662
0.7	0.687
0.8	0.722
0.9	0.781
1.0	1.000

Equations (29) and (30) are valid for any flow regime provided the momentum and kinetic energy correction factors are known. For laminar flow, the correction factors may be calculated assuming Poiseuille flow¹³,

*The momentum correction factor may be calculated if the velocity distribution is known. By definition,

$$\beta = \frac{\langle V^2 \rangle}{\langle V \rangle^2}.$$

See Eq. (2) for more details concerning the averaging notation, $\langle \rangle$.

they are $\beta_s = 1.33$, $\beta_L \approx 1.00$, and $\lambda_L \approx 1.00$. For turbulent flow, there is little error in assuming the velocity distribution is flat; the correction factors are $\beta_s \approx 1.00$, $\beta_L \approx 1.00$, and $\lambda_L \approx 1.00$. Using the above information, the expansion and contraction loss coefficients, given by Eqs. (29) and (30), respectively, are functions only of the ratio of areas, σ .

Finally, a correlation is needed to determine the orifice loss coefficient. A diagram of the orifice is shown in Fig. 3. Applying the Bernoulli equation across the orifice opening gives the classical result

$$W = C_D A_o \sqrt{2\rho \Delta P_o} \quad (31)$$

where

C_D = coefficient of discharge,

A_o = orifice area,

ΔP_o = pressure drop across orifice.

Solving for the pressure drop, and multiplying and dividing by the square of the channel flow area, A_c^2 , gives

$$\Delta P_o = \left[\frac{1}{C_D^2} \frac{A_c^2}{A_o^2} \right] \frac{W^2}{2\rho A_c^2} \quad (32)$$

The quantity in brackets is the orifice loss coefficient to be used in Eq. (6). By definition,

$$C_o = \left[\frac{1}{C_D^2} \frac{A_c^2}{A_o^2} \right] \quad (33)$$

where C_o = orifice loss coefficient.

The coefficient of discharge, C_D , was first measured experimentally by Sir Isaac Newton and found to have a value of 0.61, which is the accepted value today. Admittedly, the above analysis is a somewhat oversimplification of the orifice model considering the complexity of the design. Experimental verification is needed before the results of this model can be documented.

Heat Transfer Correlations

Classically, three heat transfer regimes are identified – turbulent, laminar and transitional. In the turbulent region, $Re \geq 10,000$, Seider and Tate²² have recommended the following correlation,

$$Nu = 0.023 Re^{0.8} Pr^{0.33} \left(\frac{\mu}{\mu_w} \right) \quad (34)$$

where

Nu = Nusselt number,

Re = Reynolds number,

Pr = Prandtl number,

μ = fluid viscosity evaluated at the bulk temperature,

μ_w = fluid viscosity evaluated at the wall temperature.

All fluid thermal properties are evaluated at the bulk temperature, except μ_w as already noted.

In the laminar region, $Re \leq 2100$, a Graetz number correlation given by McCabe and Smith²³ is used,

$$Nu = 1.85 Gr^{0.33} \left(\frac{\mu}{\mu_w} \right) \quad (35)$$

where $Gr = (Re Pr \frac{D}{L})$ = Graetz number.

All fluid thermal properties are again evaluated at the bulk temperature, except μ_w as already noted.

In the transition region, a heat transfer coefficient is not easily defined due to instabilities of the fluid motion. Fortunately, the transition region is small, $2100 < Re < 10000$, and not likely to be encountered in most calculations. A transition region heat transfer coefficient was defined by a linear interpolation on log-log paper of the heat transfer coefficient versus Reynolds number between the points at $Re = 2100$ and $Re = 10,000$. This necessarily makes the heat transfer coefficient a continuous, single-valued function over the entire flow spectrum.

Design Correlations

A design correlation by General Atomic Company²⁴ was used to simulate the time dependent decay heat following scram of the reactor. This correlation is given by:

$$f(t) = 0.128 (t + 0.0003796)^{-0.261} \quad (36)$$

where

$f(t)$ = fraction of steady-state power remaining after t seconds following shutdown,

t = time following shutdown, seconds.

It is desirable for calculating the core temperature distribution to define an average heat generation rate over a time step. By definition, the average value during interval from t_1 to t_2 is:*

$$\langle f \rangle = \frac{0.1732}{(t_2 - t_1)} (t_2 + 3.796E-4)^{0.739} - (t_1 + 3.796E-4)^{0.739} \quad (37)$$

Equation (37) is used to calculate the average heat generation rate over an interval of time. The average heat generation rate, Q , will be used in conjunction with Eq. (17).

PHYSICAL PROPERTIES

In general, the physical properties of most materials are dependent on the temperature. For gases, some properties may further depend on the pressure. Since the thermal response of the reactor is likely to span a wide range of temperatures and pressures, the dependence of the physical properties on these parameters must be accurately known to model the system.

*The average value over an interval of time is given by

$$\langle f \rangle = \frac{\int_{t_1}^{t_2} f(t) dt}{\int_{t_1}^{t_2} dt}$$

Physical Properties of Helium

The physical properties of pure helium have been studied widely and are very well known.^{25,26,27} At ORNL, Tallackson²⁸ has made an extensive study of many of the correlations currently available and good agreement with experimental data has been confirmed. The set of properties used in the FLODIS code were obtained from Sanders,²⁹ who has summarized and elaborated on data presented by Wilson,³⁰ General Dynamics Corporation. Helium properties of interest are viscosity, thermal conductivity, heat capacity at constant pressure, and density.

The viscosity of helium is represented by the empirical relation,

$$\mu = (6.7 \times 10^{-4}) T^{0.68} \quad (38)$$

where

μ = viscosity of helium, lb_m/ft. h (1 lb_m/ft. h = 4.134E-4 Pa·s),

T = absolute temperature, °R (1 °R = 0.5556 K)

The thermal conductivity of helium may be represented by polynomials of the form,

$$K = A(P) + B(P)T + C(P)T^2 \quad (39)$$

where

K = thermal conductivity of helium, Btu/hr·ft·°F

(1 Btu/hr·ft·°F = 1.7307 W/m·K)

T = absolute temperature, °R (1 °R = 0.5556 K)

P = pressure, psia (1 psia = 6895 Pa)

and the coefficients $A(P)$, $B(P)$, and $C(P)$ are obtained from

Table 4.

The thermal conductivity at any particular temperature and pressure may be found by calculating the thermal conductivity at the temperature and two bounding pressures given in Table 4; then a linear interpolation between these two values will yield the thermal conductivity at the desired pressure.

The heat capacity of helium remains essentially constant over the operating conditions experienced in HTGRs. A value of 1.2425 (Btu/lb_m·°F) was chosen for the Fort St. Vrain analysis.

Table 4. Polynomial coefficients for thermal conductivity of helium²⁹

Pressure (psia)	A	B × 10 ⁵	C × 10 ⁸
14.7	0.08092	9.994	-1.100
100.0	0.08350	10.084	-1.136
1000.0	0.08638	10.161	-1.204
2000.0	0.08691	10.309	-1.278

The density of helium may be calculated directly from the ideal gas law. The relationship is

$$\rho = \frac{PM}{RT} \quad (40)$$

where

- ρ = density of helium,
- P = pressure,
- M = molecular weight of helium,
- R = gas constant,
- T = absolute temperature.

Compressibility factors for helium at design conditions in HTGRs are on the order of 1.01. At depressurized conditions, the compressibility factor is 1.00. Therefore, the ideal gas law may be used with little error at all temperatures and pressures existing in HTGRs.

Physical Properties of Graphite, Blended Fuel Particle Columns, and the Composite Core

The following information was obtained from the Fort St. Vrain Final Safety Analysis Report,³¹ unless otherwise noted. The physical properties of interest are density, thermal conductivity, and heat capacity.

For pure graphite, the bulk density is approximately 1714 kg/m³ (107 lb_m/ft³). Its thermal conductivity varies from 38.1 W/m·K (22 Btu/h·ft·°F) for unirradiated graphite to 17.3 W/m·K (10 Btu/h·ft·°F) for graphite irradiated to an accumulated fast neutron fluence greater than 5 × 10²¹ nvt.

The heat capacity of pure graphite may be calculated as a function of temperature by,

$$C_p = -0.103 + 6.472 \times 10^{-4} T - 2.667 \times 10^{-7} T^2 + 3.97 \times 10^{-11} T^3 \quad (41)$$

where

C_p = heat capacity, Btu/lb_m·°F (1 Btu/lb_m·°F = 4184 J/kg·K)

T = absolute temperature, °R (1°R = 0.5556 K)

For blended fuel particle columns, the thermal conductivity is given conservatively as 3.5 W/m·K (2.0 Btu/h·ft·°F) from 1170 K (1650°F) to 1590 K (2400°F). The volumetric heat capacity is given by

$$\rho C_p = 3.38 + 2.74 \times 10^{-2} T - 4.88 \times 10^{-6} T^2 - 0.146 \times 10^6 / T^2 \quad (42)$$

where

ρ = density of fuel column, lb_m/ft³ (lb_m/ft³ = 16.02 kg/m³)

C_p = heat capacity of fuel column, Btu/lb_m·°F (1 Btu/lb_m·°F = 4184 J/kg·K)

T = absolute temperature, °R (1°R = 0.5556 K)

For the composite core, the effective thermal conductivity is different in the axial and radial directions. Turner and Siman-Tov³² recommended the following relationship be used for calculating the effective thermal conductivity in the axial direction,

$$K_a = \sum_{i=1}^3 P_i K_i \quad (43)$$

where

K_a = effective axial thermal conductivity,

P_i = percentage of axial, cross-sectional area associated with the fuel, graphite, and helium, respectively, and

K_i = thermal conductivity of the fuel, graphite, and helium, respectively.

Using conservatively low values of the component thermal conductivities gives an effective axial thermal conductivity of 9.81 W/m·K (5.67 Btu/hr·ft·°F).

For the effective thermal conductivity in the radial direction, Turner and Siman-Tov³³ recommend

$$K_r = \frac{1}{W} \sum_{i=1}^7 W_i K_i \quad (44)$$

where

K_r = effective radial thermal conductivity,

W_i = width of the i th heat flow path,

K_i = effective thermal conductivity of the i th heat flow path,

$$W = \sum_{i=1}^7 W_i \quad (45)$$

$$K_i = \frac{L}{\frac{L_i}{K_r} + \frac{L - L_i}{K_g}} ; i = 1 \text{ to } 3 \quad (46)$$

$$K_i = \frac{L}{\frac{L_i}{K_f} + \frac{L - L_i}{K_g}} ; i = 4 \text{ to } 6 \quad (47)$$

$$K_7 = K_g \quad (48)$$

L = total length of each of the seven heat flow paths,

L_i = length of heat flow path in either the coolant or fuel,

K_f = thermal conductivity of fuel,

K_r = effective thermal conductivity across the coolant due to radiation,

K_g = thermal conductivity of graphite.

Since the FLODIS code neglects the effect of heat conduction between refueling regions, the above expression is presented for purely academic reasons.

The heat capacity of the composite core is obtained by taking the mass weighted average of the component heat capacities. The temperature dependent component heat capacities are obtained from Eqs. 41 and 42 for the graphite and fuel, respectively.

ANALYSIS OF FORT ST. VRAIN DBDA

During routine examination prior to startup, cracks were discovered in the curvic coupling and bucket areas of the Pelton turbines. Further investigation³⁴ revealed the cause of the cracks was high-cycle fatigue resulting from operation of the circulators at 10,550 rpm. Results of the above study indicated the problem could be eliminated by the Pelton turbines at a reduced speed. A reduced high-speed trip setting of 8800 rpm was chosen by Public Service Company of Colorado (PSC).

The reduction in speed of the helium circulators when driven by Pelton turbines will reduce the gas flow available for emergency cooling. This led to a review of postulated reactor events that involve operation of the Pelton turbines. PSC concluded that the rapid depressurization accident resulted in the most severe conditions requiring operation of the Pelton turbines. What follows is an independent analysis of the DBDA with the Pelton turbines operating at the reduced specifications.

Description of the DBDA

There are many different sequences of design basis depressurization accidents. The accident considered in this report consisted of the following assumptions and events: The reactor is operating at 105% power. All fission products are at their equilibrium values. At time zero, the reactor instantaneously experiences a depressurization from 4.868 MPa (706 psia) to 0.0876 MPa (12.7 psia), and simultaneously the control rods shutdown the reactor. The reactor heat generation follows a standard decay curve. It is assumed the reactor heats up adiabatically for the first 300 seconds (5 min) before forced convective cooling by the Pelton turbines is started. Furthermore, when the cooling is started it is assumed only two of the four available circulators are operational; in other words, it is assumed that complete failure of one of the redundant loops has occurred. Thus, only six of the 12 steam generator ducts are providing suction for the circulation of helium. The remaining two circulators are assumed to be operating at a speed of 8000 rpm.

At 8000 rpm, the actual total flow delivered by the circulators as a function of time is given in Fig. 7. The corresponding helium temperature

Fig. 7. Total helium flow delivered by two circulators operating at 8000 rpm.³⁵

at the core inlet as a function of time is given in Fig. 8. Both of these curves were constructed using data provided by PSC.³⁵ All of the input data needed to execute a transient analysis is now known.

Results

The above information along with other required input (see Appendix A for code input specifications) were used to perform the analysis of the rapid depressurization accident. For interpreting the results, the temperature corresponding to the critical safety limit is compared with the temperature calculated by the FLODIS code for any given component. In general, the critical safety limit is defined as the temperature at which the material or component no longer satisfactorily meets its design requirements. Values of the critical safety limit for a few materials of interest are presented in Table 5. This table also shows the maximum temperature attained by the same material during the course of the transient as calculated by the FLODIS code.

Table 5. Critical safety limits

Material or component	Critical safety limit (K)	FLODIS maximum temperature (K)
Coated fuel particles	1870	1550
Silica thermal barrier on the surface of the core support floor	1640	1480
Thermal barrier lining of the steam generator inlet ducts	1370	1280 ^a

^aThis value should be considered the best estimate based on experimental mixing data from Walker.³⁷ It is not necessarily a conservative value.

For coated fuel particles the critical safety limit is the temperature above which there is a rapid deterioration of the fission product barrier. This limit occurs at a temperature of 1870°K (2900°F). Figure 9 shows the maximum active core temperatures for selected refueling

Fig. 8. Temperature of helium in the upper plenum following a DBDA.³⁵

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Fig. 9. Refueling region maximum temperatures in the active core following a DBDA.

regions. The top two curves correspond to the regions with the highest power generation rates. Between the curves with radial peaking factors (RPF) of 1.54 and 1.06, there are 14 regions with maximum temperature curves bounded by these limits. There are 20 regions that have curves which lie below the bounding curve with $RPF = 1.06$. From this graph it is obvious that none of the 37 refueling regions have temperatures that exceed the critical safety limit for coated fuel particles. Furthermore, the maximum temperatures are low enough so as to ensure that there will not be any abnormal release of fission products from the coated fuel particles as a consequence of this severe accident.

Lining the core support floor are cast silica blocks. These blocks form a thermal barrier between the hot gas leaving the refueling regions and the concrete of the core support floor. It may be assumed that hot gas leaving a refueling region impinges in a jet against the silica thermal barrier. Thus, the gas outlet temperature of a refueling region may conservatively be taken as the local temperature of the silica thermal barrier. The critical safety limit for this component is the temperature which causes creep deformation of 2% at the expected operating stress level in the structural elements in one hour. Table 5 gives its critical safety limit as 1640°K (2500°F). Figure 10 shows the refueling region outlet gas temperature following a rapid depressurization accident. Again, the top two curves represent the highest powered regions. The regions with radial peaking factors equal to 1.78 and 1.54, the two hottest regions, have maximum exit gas temperatures which are approximately 160°K (300°F) and 300°K (540°F) below the critical safety limit of 1640°K (2500°F). The other 35 refueling regions have maximum exit gas temperatures which are much cooler than the above mentioned hot channels. It may be concluded that the silica thermal barrier lining the core support floor maintains good structural integrity throughout the accident sequence and should not be significantly altered in any way due to the thermal response of the reactor during the analyzed transient.

At this time, the FLODIS code does not have the capabilities to calculate the temperature of the thermal barrier lining the steam generator inlet ducts. However, based on physical arguments, an understanding of the magnitude of these temperatures can be estimated. In this accident

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Fig. 10. Refueling region outlet gas temperature following a DBDA.

sequence only six of the steam generator inlet ducts are providing suction for the circulation of the coolant. Each inlet duct must have roughly the same flow, and thus approximately 6 ($37/6 \approx 6$) refueling region outlet gas streams must combine to flow down each duct. Figure 11 shows details of the lower plenum arrangement. Before the refueling region streams can combine in the steam generator inlet duct, the outlet gas from each region impinges in a jet on the lower core support floor. From here it spreads out radially, flowing around the core support posts in the lower plenum. Finally, the gas must make a right angle turn to enter the steam generator inlet duct. This process is going to be very conducive to mixing of the gas streams, and one would expect the maximum gas temperature in the steam generator inlet ducts to be near the mixed mean outlet gas temperature of all the refueling regions. Indeed, mixing experiments made by GAC show this to be the case.^{36,37} Unfortunately, the results of these studies are not directly applicable to the Fort St. Vrain reactor arrangement or to the flow conditions encountered during operation of the Pelton turbines. Thus, the value listed in Table 5 for the maximum temperature of the steam generator inlet ducts should be considered only as an intelligent guess based on the mixing data of Walker.³⁷ Discussions concerning the updating of this mixing data for the Fort St. Vrain reactor have taken place with members of the Nuclear Regulatory Commission.

Conclusion

Considering the seriousness of a design basis depressurization accident, the above results show that the thermal response of the Fort St. Vrain reactor and components is satisfactory. The Nuclear Regulatory Commission has made the following licensing decision concerning the Fort St. Vrain reactor:³⁸

"... we conclude that the requested reduction of circulator Pelton turbine high speed trip point setting from 10550 rpm to 8800 rpm is acceptable and that (a) because the change does not involve a significant increase in the probability or consequences of accidents previously considered and does not involve a significant decrease in a safety margin, the change does not involve a significant hazards consideration, (b) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, and (c) such

Fig. 11. Lower plenum arrangement.

activities will be conducted in compliance with the Commission's regulations and the issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public."

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APPENDIX A

This appendix contains information concerning the setup and use of the FLODIS code. Table A.1 contains the definitions of variables used as input to the code. Table A.2 has the complete FORTRAN IV listing of the FLODIS program. Table A.3 lists a set of sample input data cards for the Fort St. Vrain DBDA. All input is in namelist format.

Note that most of the code input and output is given in English units instead of SI units. The reason is that the code was written before SI units came into general use at ORNL; also the specifications for the Fort St. Vrain reactor design are given in the English system of units.

Table A.1 Definitions of FLODIS input variables

RGWGTS	= standard refueling region segment weights, lb _m
RGWGTB	= boundary refueling region segment weights, lb _m
VOLS	= standard refueling region segment volumes, ft ³
VOLB	= boundary refueling region segment volumes, ft ³
DCOOLS	= diameter of the small coolant holes, in.
DCOOLL	= diameter of the large coolant holes, in.
ALCF	= standard refueling region segment lengths, ft
ALCT	= boundary refueling region segment lengths, ft
APTS	= standard refueling region flow area of upper plenum, ft ²
APTN	= boundary refueling region flow area of upper plenum, ft ²
APSI	= standard core support block flow area in upper level, ft ²
APS2	= standard core support block flow area in lower level, ft ²
APS3	= standard core support block flow area in lower plenum, ft ²
APW1	= boundary core support block flow area in upper level, ft ²
APW2	= boundary core support block flow area in lower level, ft ²
APW3	= boundary core support block flow area in lower plenum, ft ²
ALLT	= total length of a refueling region, ft
NREG	= total number of refueling regions in the core
NSEG	= total number of axial segments in a refueling region
NSUB	= total number of subdivisions per axial segment
NCOOLS	= total number of small coolant holes in a standard refueling region
NCOOLL	= total number of large coolant holes in a standard refueling region
NCLBS	= total number of small coolant holes in a boundary refueling region
NCLBL	= total number of large coolant holes in a boundary refueling region
NCOLT	= total number of fuel block columns in the active core
NSTEP	= beginning step number
NSTEPS	= ending step number
IQMAX	= refueling region where a detailed temperature map is desired — usually the highest powered region
NTREF	= node number where top reflector ends
NBIREF	= node number where bottom reflector starts
NB2REF	= node number where upper level of core support block begins
NB3REF	= node number where lower level of core support block begins
NADBAT	= number of equal time steps during adiabatic heatup
SP	= wide open orifice area, ft ²
WPER	= wetted perimeter of orifice, ft
AKOX	= loss coefficient for entrance losses in the orifice
OMIN	= minimum orifice area allowed, ft ²
KTMAX	= not used in present version
KQMAX	= not used in present version
KFLOW	= not used in present version
KFRIC	= not used in present version
KITER	= maximum iterations in flow distribution calculation
KIOUT	= maximum iterations between flow and temperature distribution calculations

Table A.1 (continued)

KFLAG1	= maximum iterations in steady state temperature distribution calculations
KFLAG2	= not used in present version
KFLAG3	= not used in present version
KFLAG4	= not used in present version
KFLAG5	= not used in present version
KFLAG6	= if not equal to 2, there is an adiabatic heatup of the reactor before startup of circulators
E1	= not used in present version
E2	= not used in present version
E3	= not used in present version
E4	= percentage error allowed in flow distribution calculations
E5	= total percentage error for all coolant node temperatures
E6	= total percentage error for all core node temperatures
E7	= percentage error in steady state core temperatures
E8	= percentage error in steady state coolant temperatures
E9	= percentage error in transient temperature calculations
RF	= effective radius of solid node for calculation of an overall heat transfer coefficient, ft
TFC	= effective axial thermal conductivity, Btu/hr-ft-°F
AXLS1	= standard refueling region effective area for axial heat conduction in the active core, ft ²
AXLS2	= standard refueling region effective area for axial heat conduction in the upper level of the core support block, ft ²
AXLS3	= standard refueling region effective area for axial heat conduction in the lower level of the core support block, ft ²
AXLB1	= boundary refueling region effective area for axial heat conduction in the active core, ft ²
AXLB2	= boundary refueling region effective area for axial heat conduction in the upper level of the core support block, ft ²
AXLB3	= boundary refueling region effective area for axial heat conduction in the lower level of the core support block, ft ²
SSQT	= steady-state total power generated in the reactor, MW(t)
SSWT	= steady-state total flow to be distributed among the refueling regions, lb _m /hr
HECP	= helium heat capacity at constant pressure, Btu/lb _m -°F
HECV	= helium heat capacity at constant volume, Btu/lb _m -°F
SSTIN	= steady-state inlet helium temperature, °F
SSC	= coefficient of discharge for orifices
PSS	= steady-state reactor pressure, psia
PDBA	= pressure in reactor at start of transient, psia
DELAY	= delay time in starting helium circulators, min
PR	= radial peaking factors
PA1	= axial peaking factors in upper reflector
PA2	= axial peaking factors in first fuel block level
PA3	= axial peaking factors in second fuel block level
PA4	= axial peaking factors in third fuel block level
PA5	= axial peaking factors in fourth fuel block level
PA6	= axial peaking factors in fifth fuel block level

Table A.1 (continued)

PA7	= axial peaking factors in sixth fuel block level
DPT	= hydraulic diameter of refueling region of upper plenum, ft
DB1	= hydraulic diameter of upper level of core support block, ft
DB2	= hydraulic diameter of lower level of core support block, ft
DB3	= hydraulic diameter of lower plenum, ft

Table A.2. Listing of FLODIS Fortran Program

C	*****	MAIN	1
C	PORT SAINT VRAIN FLOW REDISTRIBUTION PROGRAM	MAIN	2
C	THIS PROGRAM CALCULATES THE FLOW DISTRIBUTION AND THERMAL	MAIN	3
C	RESPONSE OF THE FCFT ST VRAIN REACTOR FOLLOWING A	MAIN	4
C	DEPRESSURIZATION ACCIDENT	MAIN	5
C	*****	MAIN	6
	COMMON/COERIS/ AKC(37), AKC(37), AKF(37,100), AKE1(37),	MAIN	7
1	AKE2(37), AKE3(37), AKG(37), AKT(37,100)	MAIN	8
	COMMON/OUTPT/ TIME, WTOT, WI(37), WF(37), TCOOLI(37,101),	MAIN	9
1	TCOOLF(37,101), TFUELI(37,10,10), TFUELF(37,10,10),	MAIN	10
2	SSPW(37,10,10)	MAIN	11
	COMMON/INPUT1/ AC(37), APT(37), APB1(37), APB2(37), APB3(37),	MAIN	12
1	WGT(37,10,10), AHT(37,10,10)	MAIN	13
	COMMON/INPUT2/ DCS, DCL, ALCF(10), ALCT(10), DP,	MAIN	14
1	DPE1, DPE2, DPB3, DPT	MAIN	15
	COMMON/INPUT3/ NCOL(37), NREG, NSEG, NSUB, NCOLT, NSTEPS, IQMAX,	MAIN	16
1	NSTEP	MAIN	17
	COMMON/INPUT4/ SP, WPER, AKOX	MAIN	18
	COMMON/INPUT5/ KTHAX, KQMAX, KFLOW, KFRIC, KIERR, KIOUT	MAIN	19
	COMMON/INPUT6/ E1, E2, E3, E4, E5, E6, E7, E8, E9	MAIN	20
	COMMON/SIGNAL/KFLAG1,KFLAG2,KFLAG3,KFLAG4,KFLAG5,KFLAG6	MAIN	21
	COMMON/INPUT7/ RF, TCF, F1, F2, ALLT	MAIN	22
	COMMON/INPUT8/ SSQT, SSWT, HECF, SSTIN, SSC, PSS, PDBA	MAIN	23
	COMMON/INPUT9/ PR(37), PA(10,10), PRE(37)	MAIN	24
	COMMON/PAWM2/ WOLD, TIN, DELT, SO(37)	MAIN	25
	COMMON/PRESDE/ ODP(37), EDP(37), CDP(37), VOL(37,10)	MAIN	26
	COMMON/IMPORY/ PWR(100),TF(100),TI(100),AAT(100),AKON(100),	MAIN	27
1	SUM(100),GS(100),GE(100),HTCI(37,100),	MAIN	28
1	HTCF(37,100),TAU(100),G3(100),AWGT(100),DELAY	MAIN	29
	COMMON/LOCATE/NTREF,NB1REF,NB2REF,NB3REF,NADBAT	MAIN	30

Table A.2 (continued)

	DIMENSION TP (37,10,10) , TO (37,101) , WX (37)	MAIN	31
	OLDTME = 0.0	MAIN	32
	NPASS = 1	MAIN	33
	NSTEP = 1	MAIN	34
	TIME = 0.0	MAIN	35
C	READ INPUT DATA	MAIN	36
	CALL INP UT	MAIN	37
C	SET ORIFICES AND GET STEADY-STATE TEMPERATURES	MAIN	38
	CALL SSTEMF	MAIN	39
	CALL ORSET	MAIN	40
	CALL OUTPUT	MAIN	41
	CALL OUTPT2	MAIN	42
	CALL OUTPT3 (IQMAX)	MAIN	43
	WRITE (12) TIME, WTOT, (WF (I) , I=1, NREG)	MAIN	44
	DO 9 I=1, NREG	MAIN	45
	WRITE (12) (TCOOLF (I, L) , L=1, 101)	MAIN	46
9	CONTINUE	MAIN	47
	DO 11 I=1, NREG	MAIN	48
	WRITE (12) ((TFUELF (I, J, K) , K=1, NSUB) , J=1, NSEG)	MAIN	49
11	CONTINUE	MAIN	50
	IF (KFLAG6.EQ.2) GO TO 22	MAIN	51
	NSTEP = NSTEP + 1	MAIN	52
	DO 49 I=1, NREG	MAIN	53
	WF (I) = 0.0	MAIN	54
49	CONTINUE	MAIN	55
C	READ FIRST TIME STEP INFORMATION	MAIN	56
	CALL INITAI	MAIN	57
C	ADIABATIC HEAT-UP OF REACTOR	MAIN	58
	FNAD = FLOAT (NADBAT)	MAIN	59
	DELT = DELAY / (60.0 * FNAD)	MAIN	60

Table A.2 (continued)

	NF = NADBAT	MAIN	61
	TIME = 0.0	MAIN	62
	DO 26 N=1,NF	MAIN	63
	TIME = TIME + DELT	MAIN	64
	CALL NOFLOW	MAIN	65
	CALL OUTPUT	MAIN	66
	CALL OUTPT3(IQMAX)	MAIN	67
26	CONTINUE	MAIN	68
	WRITE(12) TIME,WTCT,(WF(I),I=1,NREG)	MAIN	69
	DO 12 I=1,NREG	MAIN	70
	WRITE(12) (T COOLF(I,L),L=1,101)	MAIN	71
12	CONTINUE	MAIN	72
	DO 13 I=1,NREG	MAIN	73
	WRITE(12) ((TFUELF(I,J,K),K=1,NSUB),J=1,NSEG)	MAIN	74
13	CONTINUE	MAIN	75
22	CONTINUE	MAIN	76
C	READ NEXT TIME STEP DATA	MAIN	77
	CALL INITAI	MAIN	78
C	GUESS AT FLOW DISTRIBUTION	MAIN	79
	FNT = NCOLT	MAIN	80
	WAVG = WIOI/FNT	MAIN	81
	DO 51 I=1,NREG	MAIN	82
	FNCOL = NCOL(I)	MAIN	83
	WF(I) = FNCOI*WAVG	MAIN	84
51	CONTINUE	MAIN	85
	IOUT = 1	MAIN	86
	GO TO 200	MAIN	87
100	IOUT = 1	MAIN	88
C	READ NEXT TIME STEP DATA	MAIN	89
	CALL INITAI	MAIN	90

Table A.2 (continued)

C	GUESS AT FLOW DISTRIBUTION	MAIN	91
C	BASED ON OLD FLOW VALUES	MAIN	92
	CALL OI DFLW	MAIN	93
200	ITER = 1	MAIN	94
C	CALCULATE TEMPERATURES AT NEW TIME LEVEL	MAIN	95
	CALL TEMPCR	MAIN	96
C	CALCULATE LOSS COEFFICIENTS BASED ON MOST	MAIN	97
C	RECENTLY OBTAINED FLOWS AND TEMPERATURES	MAIN	98
	CALL COEFIS	MAIN	99
	IF (NPASS.EQ. 1) DP = .11	MAIN	100
	NPASS = 2	MAIN	101
C	CALCULATE NEW FLOW DISTRIBUTION	MAIN	102
	CALL REFLOW	MAIN	103
C	CHECK FOR CONVERGENCE OF FLOW RATES	MAIN	104
C	SUM INDIVIDUAL FLCWS	MAIN	105
300	WOLD = 0.0	MAIN	106
	DO 400 I=1,NREG	MAIN	107
	WOLD = WOLD + WF (I)	MAIN	108
400	CONTINUE	MAIN	109
C	COMPARE TOTAL WITH KNOWN VALUE	MAIN	110
C	WRES IS A MEASURE OF THE PERCENT ERROR BETWEEN	MAIN	111
C	THE CALCULATED FLOW AND THE KNOWN FLOW	MAIN	112
	WRES = WOLD/WTOT - 1.0	MAIN	113
	WRES = ABS (WRES)	MAIN	114
C	TEST FOR CONVERGENCE OF TOTAL FLOW	MAIN	115
	IF (WRES.IT.E4) GO TO 500	MAIN	116
C	GUESS A NEW VALUE FOR THE PRESSURE DROP FROM PLENUM TO PLENUM	MAIN	117
	CALL GUESS	MAIN	118
C	CALCULATE NEW DISTRIBUTION AT NEW TIME LEVEL	MAIN	119
	CALL REFLOW	MAIN	120

Table A.2 (continued)

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-----
      ITER = ITER + 1                                MAIN 121
C      CHECK TO SEE IF THE MAXIMUM NUMBER OF ITERATIONS HAVE BEEN EXCEEDED MAIN 122
      IF (ITER.LE.KITER) GO TO 300                     MAIN 123
      WRITE(6,911) KITER                               MAIN 124
911  FORMAT(10X,'SOLUTION FAILED TO CONVERGE AFTER',I3,' ITERATIONS'// MAIN 125
      1 10X,'THE UNCONVERGE SOLUTION IS')             MAIN 126
      CALL OUTPUT                                     MAIN 127
      CALL OUTPT2                                     MAIN 128
      CALL OUTPT3(IQMAX)                             MAIN 129
      STOP                                             MAIN 130
C      OUTER LOOP CONVERGENCE                         MAIN 131
C      THIS LOOP CHECKS FOR CONVERGENCE BETWEEN OUTER LOOP ITERATIONS MAIN 132
C      TWO CRITERIA MUST BE MET--THE FLOWS AND TEMPERATURES CAN NOT MAIN 133
C      CHANGE BY MORE THAN SOME EPSILON BETWEEN OUTER LOOP ITERATIONS MAIN 134
C      THIS IS ANALAGOUS TO A PREDICTOR-CORRECTOR METHOD MAIN 135
C      CHECK FOR CONVERGENCE OF TEMPERATURES         MAIN 136
500  IF (ICUT.EQ.1) GO TO 620                         MAIN 137
      DO 605 I = 1,NREG                               MAIN 138
      TRESW = ABS(WF(I)/WX(I) - 1.0)                 MAIN 139
      IF (TRESW.GT.E4) GO TO 610                     MAIN 140
605  CONTINUE                                         MAIN 141
      TFESC = 0.0                                     MAIN 142
      TRESF = 0.0                                     MAIN 143
      DO 600 I=1,NREG                                 MAIN 144
      DO 595 J=1,NSEG                                 MAIN 145
      DO 590 K=1,NSUB                                 MAIN 146
      L = (J-1)*NSUB + K                             MAIN 147
      NC = L + 1                                       MAIN 148
      TEMFX = ABS(TP(I,J,K)/TFUELF(I,J,K) - 1.0)     MAIN 149
C      TRESF IS THE PERCENT ERROR IN THE FUEL TEMPERATURES BETWEEN ITERAT MAIN 150

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Table A.2 (continued)

	TRESF = IRESF + TEMPX	MAIN 151
	TEMPX = ABS(TO(I,NC)/TCOOLF(I,NC) - 1.0)	MAIN 152
C	TRESC IS THE PERCENT ERROR IN THE COCLANT TEMPERATURE	MAIN 153
C	BETWEEN OUTER LOOP ITERATIONS	MAIN 154
	TRESC = IRESC + TEMPX	MAIN 155
590	CONTINUE	MAIN 156
595	CONTINUE	MAIN 157
600	CONTINUE	MAIN 158
	IF(TRESC.GT.E5) GO TO 610	MAIN 159
	IF(TRESF.GT.E6) GO TO 610	MAIN 160
	GO TO 700	MAIN 161
C	CHECK TO SEE IF THE MAXIMUM NUMBER OF OUTER LOOP ITERATIONS	MAIN 162
C	HAS BEEN EXCEEDED	MAIN 163
610	IF(IOUT.LE.KIOUT) GO TO 620	MAIN 164
	WRITE(6,934) KIOUT	MAIN 165
934	FORMAT(10X,'THE OUTER ITERATION LOOP FAILED TO CONVERGE AFTER',	MAIN 166
	1 I3,' ITERATIONS'//10X,'THE UNCONVERGED SOLUTION IS')	MAIN 167
	GO TO 700	MAIN 168
C	STORE PREVIOUS OUTER LOOP TEMPERATURES AND FLOW RATES	MAIN 169
620	DO 650 I=1,NREG	MAIN 170
	DO 645 J=1,NSEG	MAIN 171
	DO 640 K=1,NSUB	MAIN 172
	L = (J-1)*NSUB + K	MAIN 173
	NC = L + 1	MAIN 174
	TP(I,J,K) = TFUELF(I,J,K)	MAIN 175
	TO(I,NC) = TCOOLF(I,NC)	MAIN 176
	WX(I) = WF(I)	MAIN 177
640	CONTINUE	MAIN 178
645	CONTINUE	MAIN 179
650	CONTINUE	MAIN 180

Table A.2 (continued)

	ICUT = ICUT + 1	MAIN 181
	GO TO 200	MAIN 182
C	PRINT THE CONVERGED SOLUTION AT THE NEW TIME LEVEL	MAIN 183
700	CALL OUTPUT	MAIN 184
	STORE = TIME - OLDTIME	MAIN 185
	IF (STORE.GT.0.099) GO TO 2001	MAIN 186
	GO TO 2000	MAIN 187
2001	CLDIME = TIME	MAIN 188
	CALL OUTPT2	MAIN 189
	CALL OUTPT3(IQMAX)	MAIN 190
	WRITE (12) TIME, WTOT, (WF(I), I=1, NREG)	MAIN 191
	DO 14 I=1, NREG	MAIN 192
	WRITE (12) (TCCOLF(I,L), L=1, 101)	MAIN 193
14	CONTINUE	MAIN 194
	DO 16 I=1, NREG	MAIN 195
	WRITE (12) ((TFUELF(I,J,K), K=1, NSUB), J=1, NSEG)	MAIN 196
16	CONTINUE	MAIN 197
C	CHECK TO SEE IF ALL TIME STEPS	MAIN 198
C	HAVE BEEN COMPLETE	MAIN 199
2000	NSTEP = NSTEP + 1	MAIN 200
	IF (NSTEP.LT.NSTEPS) GO TO 100	MAIN 201
	STOP	MAIN 202
	END	MAIN 203
	 SUBROUTINE INPUT	 INPT 1
C	*****	INPT 2
C	THIS SUBROUTINE READS ALL OF THE INPUT DATA AND	INPT 3
C	PACKS THE INFORMATION IN THE APPROPRIATE ARRAYS	INPT 4
C	*****	INPT 5

Table A.2 (continued)

COMMON/COERIS/ AKO (37), AKC (37), AKF (37,100), AKE1 (37),			INPT	6
1 AKE2 (37), AKE3 (37), AKG (37), AKT (37,100)			INFT	7
COMMON/OUTPT/ TIME, WTOT, WI (37), WF (37), TCOOLI (37,101),			INFT	8
1 TCOOLF (37,101), TFUELI (37,10,10), TFUELF (37,10,10),			INFT	9
2 SSPW (37,10,10)			INFT	10
COMMON/INPUT1/ AC (37), APT (37), APB1 (37), APB2 (37), APB3 (37),			INFT	11
1 WGT (37,10,10), AET (37,10,10)			INFT	12
COMMON/INPUT2/ DCS, DCL, ALCF (10), ALCT (10), DP,			INPT	13
1 DB1, DB2, DB3, DPT			INFT	14
COMMON/INPUT3/ NCOL (37), NREG, NSEG, NSUB, NCOLT, NSTEPS, IQMAX,			INPT	15
1 NSTEP			INFT	16
COMMON/INPUT4/ SP, WPER, AKOX			INPT	17
COMMON/INPUT5/ KTMX, KQMAX, KFLOW, KFRIC, KITER, KIOUT			INFT	18
COMMON/INPUT6/ E1, E2, E3, E4, E5, E6, E7, E8, E9			INPT	19
COMMON/SIGNAL/KFLAG1,KFLAG2,KFLAG3,KFLAG4,KFLAG5,KFLAG6			INFT	20
COMMON/INPUT7/ RF, TCF, F1, F2, ALIT			INPT	21
COMMON/INPUT8/ SSQT, SSWT, HECF, SSTIN, SSC, PSS, PDBA			INFT	22
COMMON/INPUT9/ PR (37), PA (10,10), PRR (37)			INPT	23
COMMON/PA2/ WOLL, TIN, DELT, SO (37)			INFT	24
COMMON/PRESBP/ ODP (37), EDP (37), CDP (37), VOL (37,10)			INPT	25
COMMON/TMPCRY/ PWR (100), TF (100), TI (100), AAT (100), AKON (100),			INFT	26
1 SUM (100), GS (100), GB (100), HTCI (37,100),			INFT	27
1 HTCF (37,100), TAU (100), G3 (100), AWGT (100), DELAY			INPT	28
COMMON/LOCATE/ NTREF, NB1REF, NB2REF, NB3REF, NADBAT			INFT	29
DIMENSION RGWGT (10), RGWGTB (10), VOLS (10), VOLB (10)			INPT	30
DIMENSION PA1 (10), PA2 (10), PA3 (10), PA4 (10), PA5 (10), PA6 (10), PA7 (10)			INFT	31
NAMELIST/CORE/ RGWGT, RGWGTB, VOLS, VOLB			INFT	32
1 /COOLN1/DCOOLS,DCOOLL,ALCF,ALCT,APTS,APTW,			INPT	33
2 APES1, APES2, APES3, APBW1, APBW2, APBW3, ALLT			INFT	34
3 /INTGR/NREG, NSEG, NSUB, NCOOLS, NCOOLI, NCLBS, NCLBL, NCOLT, NSTEP,			INPT	35

Table A.2 (continued)

3	NSIEIS, IQMAX, NTREF, NB1REF, NB2REF, NB3REF, NADBAT	INPT	36
4	/ORIFIS/SP, WPER, AKOX, OMIN	INPT	37
5	/KFLAGS/KTMAX, KQMAX, KFLOW, KFRIC, KITER, KIOUT,	INPT	38
1	KFLAG1, KFLAG2, KFLAG3, KFLAG4, KFLAG5, KFLAG6	INPT	39
6	/CONVRG/E1, E2, E3, E4, E5, E6, E7, E8, E9	INPT	40
7	/TEMP/RF, TCF, AXLS1, AXLS2, AXLS3, AXLB1, AXLB2, AXLB3	INPT	41
8	/PARM1/SSQT, SSWT, HECF, HECV, SSTIN, SSC, PSS, PDBA, DELAY	INPT	42
9	/REGN/PA1, PA2, PA3, PA4, PA5, PA6, PA7,	INPT	43
1	DPT, DB1, DB2, DB3	INPT	44
C	READ INPUT DATA	INPT	45
	READ(5, CORE)	INPT	46
	READ(5, COOLNT)	INPT	47
	READ(5, INTGF)	INPT	48
	READ(5, ORIFIS)	INPT	49
	READ(5, KFLAGS)	INPT	50
	READ(5, CONVRG)	INPT	51
	READ(5, TEMP)	INPT	52
	READ(5, PARM1)	INPT	53
	READ(5, REGN)	INPT	54
C	WRITE INPUT DATA	INPT	55
	WRITE(6, 940)	INPT	56
940	FORMAT(45X, 8('*****'))/45X, '***** LISTING OF INPUT DATA *****'	INPT	57
1	****'/45X, 8('*****')//)	INPT	58
	WRITE(6, CORE)	INPT	59
	WRITE(6, COOLNT)	INPT	60
	WRITE(6, INTGF)	INPT	61
	WRITE(6, ORIFIS)	INPT	62
	WRITE(6, KFLAGS)	INPT	63
	WRITE(6, CONVRG)	INPT	64
	WRITE(6, TEMP)	INPT	65

Table A.2 (continued)

	WRITE(6, PARM1)	INPT	66
	WRITE(6, REGN)	INPT	67
	WRITE(6, 941)	INPT	68
941	FORMAT(45X, 8('*****'))/45X, '***** END OF INPUT LISTING *****'	INPT	69
	1**'/ 45X, 8('*****'))	INPT	70
	SSQT = SSQT * 3.4138E6	INPT	71
C	CALCULATE TOTAL FLOW AREA IN TYPICAL AND BOUNDARY REFUELING REGION	INPT	72
	DCS = DCOOIS/12.0	INPT	73
	DCL = DCOOLL/12.0	INPT	74
	TAREA = (NCOCLS*3.14159*DCS*DCS)/4.0 +	INPT	75
	1 (NCOOLL*3.14159*DCL*DCL)/4.0	INPT	76
	BARFA = (NCLBS*3.14159*DCS*DCS)/4.0 +	INPT	77
	1 (NCLBL*3.14159*DCL*DCL)/4.0	INPT	78
C	LOAD AREAS INTO APPROPRIATE ARRAYS	INPT	79
	DO 23 K=1, NSUB	INPT	80
	PA(1,K) = PA1(K)	INPT	81
	PA(2,K) = PA2(K)	INPT	82
	PA(3,K) = PA3(K)	INPT	83
	PA(4,K) = PA4(K)	INPT	84
	PA(5,K) = PA5(K)	INPT	85
	PA(6,K) = PA6(K)	INPT	86
	PA(7,K) = PA7(K)	INPT	87
	PA(8,K) = PA1(K)	INPT	88
	PA(9,K) = PA1(K)	INPT	89
	PA(10,K) = PA1(K)	INPT	90
23	CONTINUE	INPT	91
	DO 110 I=1, NREG	INPT	92
	AC(I) = TAREA	INPT	93
	APT(I) = APTS	INPT	94
	APB1(I) = APES1	INPT	95

Table A.2 (continued)

	APB2(I) = APBS2	INFT	96
	APB3(I) = APBS3	INPT	97
110	CONTINUE	INFT	98
	AC(20) = BAREA	INPT	99
	AC(23) = BAREA	INFT	100
	AC(26) = BAREA	INPT	101
	AC(29) = BAREA	INFT	102
	AC(32) = BAREA	INPT	103
	AC(35) = BAREA	INFT	104
	APT(20) = APTW	INPT	105
	APT(23) = APTW	INPT	106
	APT(26) = APTW	INFT	107
	APT(29) = APTW	INPT	108
	APT(32) = APTW	INFT	109
	APT(35) = APTW	INPT	110
	DO 120 I=1,NFEG	INFT	111
	DO 119 J=1,NSEG	INFT	112
	AMASS = RGWGT(J)/NSUB	INFT	113
	DO 118 K=1,NSUB	INPT	114
	WGT(I,J,K) = AMASS	INFT	115
118	CONTINUE	INPT	116
119	CCONTINUE	INPT	117
120	CONTINUE	INFT	118
	DO 125 J=1,NSEG	INPT	119
	AMASS = RGWGT(J)/NSUB	INFT	120
	DO 124 K=1,NSUB	INPT	121
	WGT(20,J,K) = AMASS	INFT	122
	WGT(23,J,K) = AMASS	INPT	123
	WGT(26,J,K) = AMASS	INFT	124
	WGT(29,J,K) = AMASS	INFT	125

Table A.2 (continued)

	WGT (32,J,K) = AMASS	INFT 126
	WGT (35,J,K) = AMASS	INPT 127
124	CONTINUE	INFT 128
125	CONTINUE	INPT 129
	APB1(20) = APBW1	INPT 130
	APB1(23) = APBW1	INFT 131
	APB1(26) = APBW1	INPT 132
	APB1(29) = APBW1	INFT 133
	APB1(32) = APBW1	INPT 134
	APB1(35) = APBW1	INFT 135
	APB2(20) = APBW2	INPT 136
	APB2(23) = APBW2	INFT 137
	APB2(26) = APBW2	INPT 138
	APB2(29) = APBW2	INFT 139
	APB2(32) = APBW2	INPT 140
	APB2(35) = APBW2	INFT 141
	APB3(20) = APBW3	INPT 142
	APB3(26) = APBW3	INFT 143
	APB3(29) = APBW3	INPT 144
	APB3(32) = APBW3	INFT 145
	APB3(35) = APBW3	INPT 146
C	CALCULATE HEAT TRANSFER AREA OF EACH REFUELING REGION	INFT 147
	FNSUB = NSUB	INPT 148
	DO 127 J=1,NSEG	INFT 149
	ALCF(J) = ALCF(J)/FNSUB	INPT 150
	ALCT(J) = ALCT(J)/FNSUB	INPT 151
127	CONTINUE	INFT 152
	DO 130 I=1,NREG	INPT 153
	DO 129 J=1,NSEG	INFT 154
	TAHT = NCOOLS*3.14159*DCS*ALCF(J) + NCOOLL*3.14159*DCL*ALCF(J)	INFT 155

Table A.2 (continued)

	DO 128 K=1, NSUE	INPT 156
	AHT (I, J, K) = TAHT	INPT 157
128	CONTINUE	INPT 158
129	CONTINUE	INPT 159
130	CONTINUE	INPT 160
	DO 135 J=1, NSEG	INPT 161
	BAHT = NCLBS*3.14159*DCS*ALCF(J) + NCLBL*3.14159*DCL*ALCF(J)	INPT 162
	DO 134 K=1, NSUE	INPT 163
	AHT (20, J, K) = BAHT	INPT 164
	AHT (23, J, K) = BAHT	INPT 165
	AHT (26, J, K) = BAHT	INPT 166
	AHT (29, J, K) = BAHT	INPT 167
	AHT (32, J, K) = BAHT	INPT 168
	AHT (35, J, K) = BAHT	INPT 169
134	CONTINUE	INPT 170
135	CONTINUE	INPT 171
C	LOAD ARRAY CONTAINING NUMBER OF FUEL COLUMNS PER REGION	INPT 172
	DO 140 I=1, NREG	INPT 173
	NCOI (I) = 7	INPT 174
140	CONTINUE	INPT 175
	NCCI (20) = 5	INPT 176
	NCOI (23) = 5	INPT 177
	NCOI (26) = 5	INPT 178
	NCCI (29) = 5	INPT 179
	NCOI (32) = 5	INPT 180
	NCOI (35) = 5	INPT 181
	DO 210 I=1, NREG	INPT 182
	DO 205 J=1, NSEG	INPT 183
	VOL (I, J) = VOLS (J)	INPT 184
205	CONTINUE	INPT 185

Table A.2 (continued)

210	CONTINUE	INPT 186
	DO 215 J=1,NSEG	INPT 187
	VOL(20,J) = VOLB(J)	INPT 188
	VOL(23,J) = VOLB(J)	INPT 189
	VOL(26,J) = VOLB(J)	INPT 190
	VOL(32,J) = VOLB(J)	INPT 191
	VOL(35,J) = VOLB(J)	INPT 192
215	CONTINUE	INPT 193
	CALL INPT2	INPT 194
	DO 321 J=1,NSEG	INPT 195
	DO 309 K=1,NSUB	INPT 196
	L = (J-1)*NSUB + K	INPT 197
	ALNGTH = AICF(J)	INPT 198
	IF(J.EQ.1) GO TO 304	INPT 199
	IF(J.EQ.NSEG) GO TO 308	INPT 200
304	IF(K.EQ.NSUB) ALNGTH = (AICF(J) + ALCF(J+1))/2.0	INPT 201
	IF(J.GE.NSEG-1) GO TO 306	INPT 202
	GS(L) = TCF*AXLS1/(ALNGTH*2.0)	INPT 203
	GB(L) = TCF*AXLB1/(ALNGTH*2.0)	INPT 204
	GO TO 309	INPT 205
306	GS(L) = TCF*AXLS2/(ALNGTH*2.0)	INPT 206
	GB(L) = TCF*AXLB2/(ALNGTH*2.0)	INPT 207
	GO TO 309	INPT 208
308	GS(L) = TCF*AXLS3/(ALNGTH*2.0)	INPT 209
	GB(L) = TCF*AXLB3/(ALNGTH*2.0)	INPT 210
309	CONTINUE	INPT 211
321	CONTINUE	INPT 212
	RETURN	INPT 213
	END	INPT 214

SUBROUTINE INPT2

SMRY 1

Table A.2 (continued)

C	*****	SMFY	2
C	THEIS SUBROUTINE PRINTS A SUMMARY OF THE FLUID FLOW AND	SMRY	3
C	HEAT TRANSFER CHARACTERISTICS OF A REFUELING REGION	SMRY	4
C	*****	SMRY	5
	COMMON/COEFIS/ AKG(37), AKC(37), AKF(37,100), AKE1(37),	SMRY	6
	1 AKE2(37), AKE3(37), AKG(37), AKT(37,100)	SMRY	7
	COMMON/OUTPT/ TIME, WTOT, WI(37), WF(37), TCOOLI(37,101),	SMRY	8
	1 TCOOLF(37,101), TFUELI(37,10,10), TFUELF(37,10,10),	SMFY	9
	2 SSPW(37,10,10)	SMRY	10
	COMMON/INPUT1/ AC(37), APT(37), APB1(37), APB2(37), APB3(37),	SMFY	11
	1 WGT(37,10,10), AHT(37,10,10)	SMFY	12
	COMMON/INPUT2/ DCS, DCL, ALCF(10), ALCT(10), DP,	SMRY	13
	1 DPB1, DPB2, DPB3, DPT	SMFY	14
	COMMON/INPUT3/ NCOL(37), NREG, NSEG, NSUB, NCOLT, NSTEPS, IQMAX,	SMRY	15
	1 NSTEP	SMRY	16
	COMMON/INPUT4/ SP, WPEF, AKOX	SMRY	17
	COMMON/INPUT5/ KTMAX, KQMAX, KFLOW, KFRIC, KITER, KIOUT	SMFY	18
	COMMON/INPUT6/ E1, E2, E3, E4, E5, E6, E7, E8, E9	SMRY	19
	COMMON/SIGNAL/KFLAG1,KFLAG2,KFLAG3,KFLAG4,KFLAG5,KFLAG6	SMFY	20
	COMMON/INPUT7/ EF, TCF, F1, F2, ALIT	SMFY	21
	COMMON/INPUT8/ SSQT, SSWT, HECF, SSTIN, SSC, PSS, PDBA	SMFY	22
	COMMON/INPUT9/ PR(37), PA(10,10), PRF(37)	SMRY	23
	COMMON/PARM2/ WOLL, TIN, DELT, SO(37)	SMFY	24
	COMMON/PRESDP/ ODP(37), EDP(37), CDF(37), VOL(37,10)	SMFY	25
	WRITE(6,951)	SMRY	26
951	FORMAT(2H1)	SMRY	27
	WRITE(6,952)	SMRY	28
952	FORMAT(2H0 ,9X,'REFUELING REGION FLOW AND	SMRY	29
	1 HEAT TRANSFER INPUT DATA'//)	SMRY	30
	WRITE(6,953)	SMFY	31

Table A.2 (continued)

953	FORMAT (1H0,48X,'*****')	SMRY	32
	WRITE (6,954)	SMRY	33
954	FORMAT (49X,'*',22X,'*')	SMRY	34
	WRITE (6,1953)	SMRY	35
1953	FORMAT (49X,'*****')	SMRY	36
	WRITE (6,957)	SMRY	37
	WRITE (6,957)	SMRY	38
955	FORMAT (50X,'*',20X,'*')	SMRY	39
	WRITE (6,955)	SMRY	40
	ORMAX = 1.7501	SMRY	41
	WRITE (6,956) ORMAX	SMRY	42
956	FORMAT (76X,'WIDE OPEN ORIFICE'/76X,'AREA =',F7.4,' SQ FT')	SMRY	43
	WRITE (6,954)	SMRY	44
	WRITE (6,961) SP	SMRY	45
957	FORMAT (49X,'**',20X,'**')	SMRY	46
	WRITE (6,957)	SMRY	47
	WRITE (6,955)	SMRY	48
	WRITE (6,958)	SMRY	49
958	FORMAT (29X,'*****',20X,'*****')	SMRY	50
	WRITE (6,959)	SMRY	51
959	FORMAT (29X,'*',62X,'*')	SMRY	52
	WRITE (6,959)	SMRY	53
	WRITE (6,960) APT(30)	SMRY	54
960	FORMAT (29X,'*',9X,'REFUELING REGION PLENUM AREA =',	SMRY	55
	1 F7.5,' SQ FT',10X,'*')	SMRY	56
961	FORMAT (49X,'** OFIFICE CYLINDER **'/49X,'** AREA =',F6.4,	SMRY	57
	1 ' SQ FT', '**')	SMRY	58
	WRITE (6,959)	SMRY	59
	WRITE (6,959)	SMRY	60
	WRITE (6,962)	SMRY	61

Table A.2 (continued)

962	FORMAT (29X, '*****',	SMRY	62
1	1 '*****')	SMRY	63
	WRITE (6, 963)	SMRY	64
963	FORMAT (29X, '*', 20X, '*', 20X, '*', 20X, '*')	SMRY	65
	WRITE (6, 963)	SMRY	66
	WRITE (6, 963)	SMRY	67
	WRITE (6, 959)	SMRY	68
	WRITE (6, 964)	SMRY	69
964	FORMAT (29X, '*', 19X, 'T O P R E F L E C T O R', 18X, '*')	SMRY	70
	WRITE (6, 959)	SMRY	71
	WRITE (6, 965)	SMRY	72
965	FORMAT (29X, '*', 40X, 'STANDARD BOUNDARY', 2X, '*')	SMRY	73
	WRITE (6, 959)	SMRY	74
	IS = 30	SMRY	75
	IB = 23	SMRY	76
	WRITE (6, 966) NCOL (IS), NCOL (IB)	SMRY	77
966	FORMAT (29X, '*', 5X, 'REFLECTOR BLOCK COLUMNS PER REGION', 5X, I2,	SMRY	78
1	10X, I2, 4X, '*')	SMRY	79
	LSEG = 1	SMRY	80
	WRITE (6, 967) LSEG, ISEG	SMRY	81
967	FORMAT (29X, '*', 5X, 'NUMBER OF AXIAL SEGMENTS', T75, I2, 10X, I2, 4X, '*')	SMRY	82
	WRITE (6, 968) NSUB, NSUB	SMRY	83
968	FORMAT (29X, '*', 5X, 'NUMBER OF SUBDIVISIONS PER SEGMENT', T75, I2,	SMRY	84
1	10X, I2, 4X, '*')	SMRY	85
	WRITE (6, 959)	SMRY	86
	WRITE (6, 969) AC (30), AC (23)	SMRY	87
969	FORMAT (29X, '*', 5X, 'FLOW AREA (SQ FT)', T73, F7.4, 4X, F8.4, 1X, '*')	SMRY	88
	WRITE (6, 970) AHT (30, 1, 1), AHT (23, 1, 1)	SMRY	89
970	FORMAT (29X, '*', 5X, 'HEAT TRANSFER AREA PER NODE (SQ FT)',	SMRY	90
1	172, F8.4, 4X, F8.4, 1X, '*')	SMRY	91

Table A.2 (continued)

	WRITE (6, 971) WGT (30, 1, 1), WGT (23, 1, 1)	SMRY 92
971	FORMAT (29X, '*', 5X, 'MASS OF GRAPHITE PER NODE (LBM)', T72,	SMRY 93
	1 F8.2, 4X, F8.2, 1X, '*')	SMRY 94
	WRITE (6, 959)	SMRY 95
	WRITE (6, 963)	SMRY 96
	WRITE (6, 963)	SMRY 97
	WRITE (6, 963)	SMRY 98
	WRITE (6, 962)	SMRY 99
	DO 11 I=1, 3	SMRY 100
11	WRITE (6, 963)	SMRY 101
	WRITE (6, 959)	SMRY 102
	WRITE (6, 972)	SMRY 103
972	FORMAT (29X, '*', 21X, 'A C T I V E C O R E', 20X, '*')	SMRY 104
	WRITE (6, 959)	SMRY 105
	WRITE (6, 965)	SMRY 106
	WRITE (6, 959)	SMRY 107
	WRITE (6, 973) NCOL (IS), NCOL (IB)	SMRY 108
973	FORMAT (29X, '*', 5X, 'FUEL BLOCK COLUMNS PER REGION', T75, I2, 10X,	SMRY 109
	1 I2, 4X, '*')	SMRY 110
	LSEG = 6	SMRY 111
	WRITE (6, 967) LSEG, ISEG	SMRY 112
	WRITE (6, 968) NSUB, NSUB	SMRY 113
	WRITE (6, 959)	SMRY 114
	WRITE (6, 969) AC (30), AC (23)	SMRY 115
	WRITE (6, 970) AHT (30, 2, 1), AHT (23, 2, 1)	SMRY 116
	WRITE (6, 974) WGT (30, 2, 1), WGT (23, 2, 1)	SMRY 117
974	FORMAT (29X, '*', 5X, 'MASS OF CORE PER NODE (LBM)', T72, F8.2, 4X,	SMRY 118
	1 F8.2, 1X, '*')	SMRY 119
	WRITE (6, 959)	SMRY 120
	DO 12 I=1, 3	SMRY 121

Table A.2 (continued)

12	WRITE(6,963)	SMRY 122
	WRITE(6,962)	SMRY 123
	DO 13 I=1,3	SMRY 124
13	WRITE(6,963)	SMRY 125
	WRITE(6,959)	SMRY 126
	WRITE(6,975)	SMRY 127
975	FORMAT(29X,'*',15X,'B O T T O M R E F L E C T O R',16X,'*')	SMRY 128
	WRITE(6,959)	SMRY 129
	WRITE(6,965)	SMRY 130
	WRITE(6,959)	SMRY 131
	WRITE(6,966) NCOL(1S),NCOL(1B)	SMRY 132
	ISEG = 1	SMRY 133
	WRITE(6,967) ISEG,ISRG	SMRY 134
	WRITE(6,968) NSUB,NSUB	SMRY 135
	WRITE(6,959)	SMRY 136
	WRITE(6,969) AC(30),AC(23)	SMRY 137
	WRITE(6,970) AHT(30,8,1),AHT(23,8,1)	SMRY 138
	WRITE(6,971) WGT(30,8,1),WGT(23,8,1)	SMRY 139
	WRITE(6,959)	SMRY 140
	DO 14 I=1,3	SMRY 141
14	WRITE(6,963)	SMRY 142
	WRITE(6,962)	SMRY 143
	WRITE(6,963)	SMRY 144
	WRITE(6,976)	SMRY 145
976	FORMAT(29X,'*****',5X,'*****',5X,	SMRY 146
1	'*****',5X,'*****')	SMRY 147
	WRITE(6,977)	SMRY 148
977	FORMAT(29X,'*****',5X,'*****',5X,	SMRY 149
1	'*****',5X,'*****')	SMRY 150
	WRITE(6,978)	SMRY 151

Table A.2 (continued)

978	FORMAT (29X, '*****', 5X, '*****', 5X,	SMRY 152
1	'*****', 5X, '*****')	SMRY 153
	WRITE (6, 979)	SMRY 154
979	FORMAT (29X, '*****', 5X, '*****', 5X,	SMRY 155
1	'*****', 5X, '*****')	SMRY 156
	WRITE (6, 980)	SMRY 157
980	FORMAT (29X, '*****', 5X, '*****', 5X,	SMRY 158
1	'*****', 5X, '*****')	SMRY 159
	WRITE (6, 981)	SMRY 160
981	FORMAT (29X, '*****', 5X, '*****', 5X,	SMRY 161
1	'*****', 5X, '*****')	SMRY 162
	WRITE (6, 982)	SMRY 163
982	FORMAT (29X, '*****', 5X, '*****', 5X,	SMRY 164
1	'*****', 5X, '*****')	SMRY 165
	WRITE (6, 983)	SMRY 166
983	FORMAT (29X, '*****', 39X, '*****')	SMRY 167
	DO 15 I=1, 10	SMRY 168
15	WRITE (6, 983)	SMRY 169
	WRITE (6, 984)	SMRY 170
984	FORMAT (2H0, 41X, 'C O R E S U P P O R T B L O C K')	SMRY 171
	WRITE (6, 1965)	SMRY 172
1965	FORMAT (2H0, 68X, 'STANDARD', 4X, 'BOUNDARY')	SMRY 173
	LSEG = 2	SMRY 174
	WRITE (6, 985) LSEG, ISEG	SMRY 175
985	FORMAT (2H0, 32X, 'NUMBER OF AXIAL SEGMENTS', I75, I2, 10X, I2)	SMRY 176
	WRITE (6, 986) NSUB, NSUB	SMRY 177
986	FORMAT (34X, 'NUMBER OF SUBDIVISIONS PER SEGMENT', T75, I2, 10X,	SMRY 178
1	I2)	SMRY 179
	WRITE (6, 987) APB1 (30), APB1 (23), APB2 (30), APB2 (23)	SMRY 180
987	FORMAT (2H0, 32X, 'FLCW AREA'/39X, 'UPPERLEVEL (SQ FT)', T72,	SMRY 181

Table A.2 (continued)

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1  F8.4,4X,F8.4/39X,'LOWER LEVEL (SQ FT)',T72,F8.4,4X,F8.4)      SMRY 182
  WRITE(6,988) AHT(30,9,1),AHT(23,9,1),AHT(30,10,1),AHT(23,10,1)  SMRY 183
988 FORMAT(34X,'HPAT TRANSFER AREA'/39X,'UPPER LEVEL (SQ FT)',T72,  SMRY 184
1  F8.4,4X,F8.4/39X,'LOWER LEVEL (SQ FT)',T72,F8.4,4X,F8.4)      SMRY 185
  WRITE(6,989) WGT(30,9,1),WGT(23,9,1),WGT(30,10,1),WGT(23,10,1)  SMRY 186
989 FORMAT(34X,'MASS OF GRAPHITE PER NODE'/39X,                     SMRY 187
1  'UPPER LEVEL (LBM)',T72,F8.2,4X,F8.2/39X,'LOWER LEVEL (LBM)',  SMRY 188
2  T72,F8.2,4X,F8.2)                                               SMRY 189
  RETURN                                                            SMRY 190
  END                                                                SMRY 191

SUBROUTINE ORSET
C *****
C THIS SUBROUTINE CALCULATES INITIAL ORIFICE SETTINGS
C AND THE INITIAL FLOW DISTRIBUTION
C *****
COMMON/CCFFIS/ AKC(37), AKC(37), AKF(37,100), AKE1(37),
1 AKE2(37), AKE3(37), DPG(37), AKT(37,100)
COMMON/OUTPT/ TIME, WTOT, WI(37), WF(37), TCOOL1(37,101),
1 TCOOL2(37,101), IFUELI(37,10,10), IFUELE(37,10,10),
2 SSPW(37,10,10)
COMMON/INPUT1/ AC(37), APT(37), APB1(37), APB2(37), APB3(37),
1 WGT(37,10,10), AHT(37,10,10)
COMMON/INPUT2/ DCS, DCL, ALCF(10), ALCT(10), DPP,
1 DPB1, DPB2, DPB3, DPT
COMMON/INPUT3/ NCCI(37), NREG, NSEG, NSUB, NCOLT, NSTEPS, IQMAX,
1 NSTEP
COMMON/INPUT4/ SP, WPEP, AKOX
COMMON/INPUT5/ KTMAX, KQMAX, KFLOW, KFRIC, KITER, KIOUT
OPFS 1
ORFS 2
CRFS 3
ORFS 4
ORFS 5
CRFS 6
ORFS 7
ORFS 8
ORFS 9
ORFS 10
ORFS 11
ORFS 12
CRFS 13
ORFS 14
ORFS 15
CRFS 16
ORFS 17
ORFS 18

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Table A.2 (continued)

	COMMON/INPUT6/ E1, E2, E3, E4, E5, E6, E7, E8, E9	ORFS	19
	COMMON/SIGNAL/KFLAG1,KFLAG2,KFLAG3,KFLAG4,KFLAG5,KFLAG6	ORFS	20
	COMMON/INPUT7/ RF, TCF, F1, F2, ALLT	CRFS	21
	COMMON/INPUT8/ SSQT, SSWT, HECF, SSTIN, SSC, PSS, PDBA	ORFS	22
	COMMON/INPUT9/ PR(37), PA(10,10), PRR(37)	ORFS	23
	COMMON/PAWM2/ WOLD, TIN, IELT, SO(37)	ORFS	24
	COMMON/PRESDE/ ODP(37), EEP(37), CDP(37), VOL(37,10)	CRFS	25
C	*****	ORFS	26
C	THIS SECTION CALCULATES THE PRESSURE DROP ACCROSS	ORFS	27
C	THE REGION WITH THE HIGHEST POWER--THE ASSUMPTION	CRFS	28
C	IS MAKE THAT THE ORIFICE IS WIDE OPEN AND NO PRESSURE	ORFS	29
C	DROP OCCURS ACCROSS THIS ORIFICE	CRFS	30
C	*****	ORFS	31
C	THUS WE ARE ABLE TO CALCULATE THE PLENUM TO PLENUM	ORFS	32
C	PRESSURE DROP USING THIS REGION	ORFS	33
C	*****	ORFS	34
	DATA CN, AKM, RK/ 2.2334E-11, 0.07, 459.67/	CRFS	35
	PRAT = PSS/PDBA	ORFS	36
	CALL CCEFIS	ORFS	37
	I = IQMAX	CRFS	38
	TR = TCOOLF(I,1) + RK	ORFS	39
	G = WF(I)/SP	CRFS	40
	TERM = (G*G*TR*CN)/PSS	ORFS	41
	DP1 = TERM*AKOX	CRFS	42
	EDP(I) = DP1	CRFS	43
	G = WF(I)/AC(I)	ORFS	44
	TERM = (G*G*TR*CN)/PSS	ORFS	45
	DP2 = TERM*AKC(I)	ORFS	46
	DPP = EP1 + DP2	CRFS	47
	DO 200 J=1,N SEG	CRFS	48

Table A.2 (continued)

IF (J.EQ.NSEG-1) G = WF(I)/APB1(I)	CRFS	49
IF (J.EQ.NSEG) G = WF(I)/APB2(I)	ORFS	50
DO 100 K=1, NSUB	CRFS	51
L = (J-1)*NSUB + K	ORFS	52
NC = L + 1	ORFS	53
TAV = (TCOOLF(I, L) + TCOOLF(I, NC))/2.0	CPFS	54
TR = TAV + RK	ORFS	55
TERM = (G*G*TR*CN)/PSS	ORFS	56
DP3 = TERM*AKF(I, L)	ORFS	57
DP4 = TERM*AKT(I, L)	ORFS	58
DPP = DPP + DP3 + DP4	CRFS	59
100 CONTINUE	ORFS	60
IF (J.EQ.NSEG-2) GO TO 175	CRFS	61
IF (J.EQ.NSEG-1) GO TO 180	ORFS	62
IF (J.EQ.NSEG) GO TO 190	ORFS	63
TR = TCOOLF(I, NC) + RK	CPFS	64
TERM = (G*G*TR*CN)/PSS	ORFS	65
DP5 = TERM*AKM	ORFS	66
DPP = DPP + DP5	ORFS	67
GO TO 200	CRFS	68
175 TR = TCOOLF(I, NC) + RK	ORFS	69
TERM = (G*G*TR*CN)/PSS	ORFS	70
DPE1 = TERM*AKE1(I)	ORFS	71
DPP = DPP + DPE1	CRFS	72
GO TO 200	ORFS	73
180 TR = TCOOLF(I, NC) + RK	ORFS	74
TERM = (G*G*TR*CN)/PSS	ORFS	75
DPE2 = TERM*AKE2(I)	CRFS	76
DPP = DPP + DPE2	ORFS	77
GO TO 200	ORFS	78

Table A.2 (continued)

190	TR = TCOOLF(I,NC) + RK	CRFS	79
	TERM = (G*G*TR*CN)/PSS	ORFS	80
	DPE3 = TERM*AKE3(I)	CPFS	81
	DPP = DPP + DPE3	ORFS	82
	CDP(I) = DPP - DP1 - DPG(I)*PRAT	CRFS	83
200	CONTINUE	ORFS	84
	DPP = DPP - DPG(I)*PRAT	ORFS	85
C	*****	ORFS	86
C	SET ORIFICES IN OTHER REGIONS BASED UPON KNOWN FLOWS	ORFS	87
C	AND THE FLENUM TO FLENUM PRESSURE DROP CALCULATED ABOVE	CRFS	88
C	*****	ORFS	89
C		CRFS	90
C	THE ORIFICE PRESSURE DROP IS OBTAINED BY	ORFS	91
C	ORIFICE DROP = (TOTAL DROP) - (CHANNEL DROP) - (ENTRANCE DROP)	ORFS	92
C	*****	ORFS	93
	DO 500 I=1,NREG	ORFS	94
	IF(I.EQ.IQMAX) GO TO 499	ORFS	95
	TR = TCOOLF(I,1) + RK	ORFS	96
	G = WF(I)/SP	ORFS	97
	TERM = (G*G*TR*CN)/PSS	CRFS	98
	DP1 = TERM*AKOX	ORFS	99
	EDP(I) = DP1	ORFS	100
	G = WF(I)/AC(I)	CRFS	101
	TERM = (G*G*TR*CN)/PSS	ORFS	102
	DP2 = TERM*AKC(I)	CRFS	103
	DP = DP1 + DP2	ORFS	104
	DO 400 J=1,NSEG	CRFS	105
	IF(J.EQ.NSEG-1) G = WF(I)/APB1(I)	CRFS	106
	IF(J.EQ.NSEG) G = WF(I)/AFB2(I)	ORFS	107
	DO 300 K=1,NSUB	ORFS	108

Table A.2 (continued)

L = (J-1)*NSUB + K	ORFS 109
NC = L + 1	CRFS 110
TAV = (TCOOLF(I,L) + TCOOLF(I,NC))/2.0	ORFS 111
TR = TAV + RK	ORFS 112
TERM = (G*G*TR*CN)/PSS	ORFS 113
DP3 = TERM*AKF(I,L)	CRFS 114
DP4 = TERM*AKT(I,L)	ORFS 115
DP = DP + DP3 + DP4	ORFS 116
300 CONTINUE	CRFS 117
IF(J.EQ.NSEG-2) GO TO 370	ORFS 118
IF(J.EQ.NSEG-1) GO TO 380	CRFS 119
IF(J.EQ.NSEG) GO TO 390	ORFS 120
TR = TCOOLF(I,NC) + RK	ORFS 121
TERM = (G*G*TR*CN)/PSS	CRFS 122
DP5 = TERM*AKM	ORFS 123
DP = DP + DP5	CRFS 124
GO TO 400	ORFS 125
370 TR = TCOOLF(I,NC) + RK	CRFS 126
TERM = (G*G*TR*CN)/PSS	ORFS 127
DPE1 = TERM*AKE1(I)	ORFS 128
DP = DP + DPE1	ORFS 129
GO TO 400	ORFS 130
380 TR = TCOOLF(I,NC) + RK	ORFS 131
TERM = (G*G*TR*CN)/PSS	ORFS 132
DPE2 = TERM*AKE2(I)	ORFS 133
DP = DP + DPE2	CRFS 134
GO TO 400	ORFS 135
390 TR = TCOOLF(I,NC) + RK	ORFS 136
TERM = (G*G*TR*CN)/PSS	ORFS 137
DPE3 = TERM*AKE3(I)	ORFS 138

Table A.2 (continued)

	DP = DP + LPE3	CRFS 139
	CDP(I) = DP - DP1 - DPG(I)*PRAT	ORFS 140
400	CONTINUE	ORFS 141
	DP = DP - DPG(I)*PRAT	CRFS 142
	CDP(I) = DDP - DP	ORFS 143
	TR = TCOOLF(I,1) + FK	CRFS 144
	ABC = (WF(I)/(SP*SSC))**2	ORFS 145
	ABC = (AEC*TR*2.2334E-11)/(PSS*ODP(I))	CPFS 146
	XB1 = (-1.0 + (1.0 + 4.0/ABC)**.5)/(2.0/ABC)	CFFS 147
	SO(I) = XB1*SP	ORFS 148
	GO TO 500	CRFS 149
499	SO(I) = SP	ORFS 150
	ODP(I) = 0.0	OPFS 151
500	CONTINUE	CRFS 152
C	*****	OFFS 153
C	CALCULATION OF ORIFICE LOSS COEFFICIENT	CRFS 154
	DO 600 I = 1,NREG	ORFS 155
	G = WF(I)/SO(I)	ORFS 156
	TR = TCOOLF(I,1) + RK	CRFS 157
	TERM = (G*G*TR*CN)/PSS	ORFS 158
	AKC(I) = ODP(I)/TERM	CRFS 159
	IF (AKC(I).LT.0.0) GO TO 170	ORFS 160
600	CONTINUE	CRFS 161
C	*****	CRFS 162
	WRITE(6,926)	ORFS 163
926	FORMAT(1H1,30X,'INITIAL ORIFICE SETTINGS'///)	CRFS 164
	WRITE(6,927)	OFFS 165
927	FORMAT(20X,'REGION',11X,'ORIFICE',12X,'RATIO OF')	ORFS 166
	WRITE(6,928)	CRFS 167
928	FORMAT(20X,'NUMBER',13X,'AREA',15X,'AREAS')	ORFS 168

Table A.2 (continued)

	DO 220 I=1,NREG	CRFS 169
	B1 = SO(I)/SP	CRFS 170
	WRITE(6,929) I,SO(I),B1	CRFS 171
220	CONTINUE	CRFS 172
929	FORMAT(22X,I2,10X,F10.4,10X,F10.6)	CRFS 173
	RETURN	CRFS 174
170	WRITE(6,941) K,AKO(K)	CRFS 175
941	FORMAT(10X,'THE FIXED INLET LOSS TERM IS GREATER THAN THE TOTAL LOSS 1SS ACCROSS THE ORIFICE'//10X,'AKO(' ,I2,') =' ,E12.5)	CRFS 176
	STOP	CRFS 178
	END	CRFS 179
	SUBROUTINE INITAL	INIT 1
C	*****	INIT 2
C	SUBROUTINE INITAL SETS THE INITIAL CONDITIONS FOR THE	INIT 3
C	NEW TIME STEP--INCLUDING TEMPERATURES, FLOWS, AND POWER	INIT 4
C	*****	INIT 5
	COMMON/COERIS/ AKO(37), AKC(37), AKF(37,100), AKE1(37),	INIT 6
1	AKE2(37), AKE3(37), AKG(37), AKT(37,100)	INIT 7
	COMMON/OUTPT/ TIME, WTOT, WI(37), WF(37), TCOOLI(37,101),	INIT 8
1	TCOOLF(37,101), TFUELI(37,10,10), TFUELF(37,10,10),	INIT 9
2	SSPW(37,10,10)	INIT 10
	COMMON/INPUT1/ AC(37), APT(37), APB1(37), APB2(37), APB3(37),	INIT 11
1	WGT(37,10,10), AHT(37,10,10)	INIT 12
	COMMON/INPUT2/ DCS, DCL, ALCF(10), ALCT(10), DP,	INIT 13
1	DPB1, DPB2, DPB3, DPT	INIT 14
	COMMON/INPUT3/ NCOL(37), NREG, NSEG, NSUB, NCOLT, NSTEPS, IQMAX,	INIT 15
1	NSTEP	INIT 16
	COMMON/INPUT4/ SP, WPER, AKOX	INIT 17

Table A.2 (continued)

	COMMON/INPUT5/ KTMAX, KQMAX, KFIOW, KFRIC, KITER, KIOUT	INIT	18
	COMMON/INPUT6/ E1, E2, E3, E4, E5, E6, E7, E8, E9	INIT	19
	COMMON/SIGNAL/KFLAG1, KFLAG2, KFLAG3, KFLAG4, KFLAG5, KFLAG6	INIT	20
	COMMON/INPUT7/ RF, TCF, F1, F2, ALLT	INIT	21
	COMMON/INPUT8/ SSQT, SSWT, HECF, SSTIN, SSC, PSS, PDBA	INIT	22
	COMMON/INPUT9/ PR(37), PA(10,10), PRR(37)	INIT	23
	COMMON/PAWM2/ WOLD, TIN, DELT, SO(37)	INIT	24
	COMMON/PRESDE/ ODP(37), EDP(37), CDP(37), VOL(37,10)	INIT	25
	COMMON/TMPORY/ PWR(100), TF(100), TI(100), AAT(100), AKON(100),	INIT	26
	1SUM(100), GS(100), GB(100), HTCI(37,100),	INIT	27
	1 HTCF(37,100), TAU(100), G3(100), AWGT(100), DELAY	INIT	28
	COMMON/LOCATE/NTREF, NB1REF, NB2REF, NB3REF, NADBAT	INIT	29
	NAMLIST/TRANS/WTCT, TIN, DELT	INIT	30
C	READ TRANSCIENT TIME STEP DATA	INIT	31
	READ(5,TRANS)	INIT	32
	WTOT = 0.965 * WTOT	INIT	33
C	INCREMENT TIME	INIT	34
	TIME = TIME + DELT	INIT	35
C	INITIALIZE TEMPERATURES	INIT	36
	DO 300 I=1, NREG	INIT	37
	DO 200 J=1, NSEG	INIT	38
	DO 100 K=1, NSUB	INIT	39
	L = (J-1)*NSUB + K	INIT	40
	NC = L + 1	INIT	41
	TCOCLI(I,NC) = TCOCLF(I,NC)	INIT	42
	TFUELI(I,J,K) = TFUELF(I,J,K)	INIT	43
	HTCI(I,L) = HTCF(I,L)	INIT	44
100	CONTINUE	INIT	45
200	CONTINUE	INIT	46
	TCOOLI(I,1) = TCOOLF(I,1)	INIT	47

Table A.2 (continued)

		TCOCLF (I,1) = TIN	INIT	48
		WI(I) = WF(I)	INIT	49
300		CONTINUE	INIT	50
		RETURN	INIT	51
		END	INIT	52
		SUBROUTINE OLDIFLW	OLDF	1
C		*****	OLIF	2
C		SUBROUTINE OLDIFLOW ESTIMATES THE FLOW DISTRIBUTION	CLDF	3
C		AT THE NEW TIME BY MULTIPLYING THE NEW TOTAL FLOW BY THE	OLDF	4
C		SAME PROPORTION CALCULATED FROM THE PREVIOUS TIME STEP	OLDF	5
C		*****	CIDF	6
		COMMON/CORRES/ AKO(37), AKC(37), AKF(37,100), AKE1(37),	OLIF	7
1		AKE2(37), AKE3(37), AKG(37), AKT(37,100)	OLDF	8
		COMMON/OUTPT/ TIME, WTOT, WI(37), WF(37), TCOOLI(37,101),	CIDF	9
1		TCOOLF(37,101), IFUELI(37,10,10), TFUELF(37,10,10),	OLDF	10
2		SSPW(37,10,10)	OLDF	11
		COMMON/INPUT1/ AC(37), APT(37), APB1(37), APB2(37), APB3(37),	OLDF	12
1		WGT(37,10,10), AET(37,10,10)	CIDF	13
		COMMON/INPUT2/ DCS, DCL, ALCF(10), AICT(10), DP,	OLDF	14
1		DPE1, DPB2, DPB3, DPT	OLDF	15
		COMMON/INPUT3/ NCOL(37), NREG, NSEG, NSUB, NCOLT, NSTEPS, IQMAX,	CIDF	16
1		NSTEP	OLDF	17
		COMMON/INPUT4/ SP, WPER, AKOX	CLDF	18
		COMMON/INPUT5/ KTMAX, KQMAX, KFIOW, KFRIC, KITER, KIDUT	OLDF	19
		COMMON/INPUT6/ E1, E2, E3, F4, E5, F6, E7, E8, E9	CIDF	20
		COMMON/SIGNAL/KFLAG1,KFLAG2,KFLAG3,KFLAG4,KFLAG5,KFLAG6	OLDF	21
		COMMON/INPUT7/ RF, TCF, F1, F2, ALLT	CIDF	22
		COMMON/INPUT8/ SSQT, SSWT, HECF, SSTIN, SSC, PSS, PDBA	OLIF	23

Table A.2 (continued)

	COMMON/INPUT9/ PR (37), PA (10,10), PRR (37)	CIDF	24
	COMMON/PAARM2/ WOLD, TIN, LEIT, SC (37)	OLCF	25
	COMMON/PRESDE/ ODP (37), HIP (37), CDP (37), VOL (37,10)	CIDF	26
	DO 100 I = 1,NREG	OLCF	27
	WF(I) = WI (I)*WTCT/WOLD	OLDF	28
100	CONTINUE	CLDF	29
	RETURN	OLCF	30
	END	CLDF	31
	SUBROUTINE SSTEMP	SSIF	1
C	*****	SSTP	2
C	THIS SUBROUTINE CALCULATES THE STEADY-STATE TEMPERATURE	SSIF	3
C	DISTRIBUTION IN THE CORE ASSUMING THE AVERAGE COOLANT	SSIF	4
C	TEMPERATURE IS KNOWN	SSTP	5
C	*****	SSTP	6
	COMMON/COERIS/ AKO (37), AKC (37), AKF (37,100), AKE1 (37),	SSTP	7
1	AKE2 (37), AKE3 (37), AKG (37), AKT (37,100)	SSTF	8
	COMMON/OUTPT/ TIME, WTOT, WI (37), WF (37), TCOOLI (37,101),	SSIF	9
1	TCOOLF (37,101), TFUELI (37,10,10), TFUELF (37,10,10),	SSTP	10
2	SSPW (37,10,10)	SSTP	11
	COMMON/INPUT1/ AC (37), APT (37), APB1 (37), APB2 (37), APB3 (37),	SSTP	12
1	WGT (37,10,10), AHT (37,10,10)	SSTP	13
	COMMON/INPUT2/ DCS, DCL, ALCF (10), ALCT (10), DP,	SSIF	14
1	DPB1, DPB2, DPB3, DPT	SSTP	15
	COMMON/INPUT3/ NCOL (37), NREG, NSEG, NSUB, NCOLT, NSTEPS, IQMAX,	SSIF	16
1	NSTEP	SSTP	17
	COMMON/INPUT4/ SP, WPER, AKOX	SSIF	18
	COMMON/INPUT5/ KTMAX, KQMAX, KFLOW, KFRIC, KITER, KIOUT	SSTP	19
	COMMON/INPUT6/ E1, E2, E3, E4, E5, E6, E7, E8, E9	SSIF	20

Table A.2 (continued)

COMMON/SIGNAL/KFLAG1,KFLAG2,KFLAG3,KFLAG4,KFLAG5,KFLAG6	SSTP	21
COMMON/INPUT7/ PF, TCF, F1, F2, ALLT	SSIF	22
COMMON/INPUT8/ SSQT, SSWT, HECF, SSTIN, SSC, PSS, PDBA	SSTP	23
COMMON/INPUT9/ PR(37), PA(10,10), PPR(37)	SSIF	24
COMMON/PARM2/ WOLD, TIN, DELT, SO(37)	SSTP	25
COMMON/PRESDE/ ODP(37), EDP(37), CDP(37), VOL(37,10)	SSIF	26
COMMON/TMPORARY/ PWR(100),TF(100),TI(100),AAT(100),AKON(100),	SSTP	27
1SUM(100),GS(100),GE(100),HTCI(37,100),	SSTP	28
1 HTCF(37,100),TAU(100),G3(100),AWGT(100),DELAY	SSIF	29
COMMON/LOCATE/NTRREF,NB1REF,NB2REF,NB3REF,NADBAT	SSTP	30
WTCT = SSWT	SSIF	31
POWER = 0.0	SSTP	32
FNSUB = NSUB	SSTP	33
FNT = NCOLT	SSTP	34
DO 40 I=1,NREG	SSIF	35
FNCOL = NCOL(I)	SSTP	36
PRF(I) = FNCCL*PR(I)/FNT	SSIF	37
WF(I) = PPR(I)*SSWT	SSTP	38
DO 30 J=1,NSIG	SSIF	39
DO 20 K=1,NSUB	SSIF	40
PEAK = (PRF(I)*PA(J,K)*.99*SSQT)/(6.0*FNSUB)	SSTP	41
POWF = PCWF + PEAK	SSIF	42
SSPW(I,J,K) = PEAK	SSIF	43
20 CONTINUE	SSTP	44
30 CONTINUE	SSIF	45
40 CONTINUE	SSTP	46
DO 300 I=1,NREG	SSIF	47
TCOOLF(I,1) = SSTIN	SSTP	48
APEA = AC(I)	SSIF	49
DIAM = DCL	SSTP	50

Table A.2 (continued)

DO 200 J=1,NSEG	SSTP	51
IF (J.EQ.NSEG-1) GO TO 45	SSTP	52
IF (J.EQ.NSEG) GO TO 46	SSTP	53
GO TO 47	SSTP	54
45 AREA = APB1(I)	SSTP	55
DIAM = DPB1	SSTP	56
GO TO 47	SSTP	57
46 AREA = APB2(I)	SSTP	58
DIAM = DPB2	SSTP	59
47 DO 100 K=1,NSUB	SSTP	60
ITER = 0	SSTP	61
L = (J-1)*NSUB + K	SSTP	62
NC = L + 1	SSTP	63
TCOOLF(I,NC) = TCOOLF(I,L) + SSPW(I,J,K)/(WF(I)*HECP)	SSTP	64
TAVG = (TCOOLF(I,L) + TCOOLF(I,NC))/2.0	SSTP	65
TFUELF(I,J,K) = TCCOLF(I,NC)	SSTP	66
50 HTCF(I,L) = OVERAL(DIAM,RF,TCF,WF(I),AREA,TFUELF(I,J,K),	SSTP	67
1 TCOOLF(I,L),TCOOLF(I,NC),PSS,ALLT)	SSTP	68
ALPHA = (HTCF(I,L)*AHT(I,J,K))/(WF(I)*HECP)	SSTP	69
ETA = (1.0 - EXP(-ALPHA))/ALPHA	SSTP	70
DELTMP = SSPW(I,J,K)/(HTCF(I,L)*AHT(I,J,K)*ETA)	SSTP	71
TRES = TFUELF(I,J,K)	SSTP	72
TFUELF(I,J,K) = DEITMP + TCOOLF(I,L)	SSTP	73
TRES = ABS(TRES/TFUELF(I,J,K) - 1.0)	SSTP	74
IF(ITER.GE.KQMAX) GO TO 1000	SSTP	75
IF(TRES.LE.E3) GO TO 100	SSTP	76
ITER = ITER + 1	SSTP	77
GO TO 50	SSTP	78
100 CONTINUE	SSTP	79
200 CONTINUE	SSTP	80

Table A.2 (continued)

300	CONTINUE	SSIF	81
	NA = NSEG*NSUB	SSTP	82
	DO 600 I=1,NFEG	SSIF	83
	DO 350 JJ=1,NSEG	SSTP	84
	DO 325 KK=1,NSUB	SSIF	85
	L = (JJ-1)*NSUB + KK	SSTP	86
	PWF(L) = SSPW(I,JJ,KK)	SSIF	87
	AAT(L) = AHT(I,JJ,KK)	SSTP	88
	TF(L) = TPUELF(I,JJ,KK)	SSIF	89
	AKON(L) = GS(L)	SSTP	90
325	CONTINUE	SSIF	91
350	CONTINUE	SSTP	92
	IF (I.EQ.20.OR.I.EQ.23.OR.I.EQ.26.OR.I.EQ.29.	SSIF	93
	1 OR.I.EQ.32.OR.I.EQ.35) GO TO 360	SSTP	94
	GO TO 370	SSTP	95
360	DO 365 LL=1,NA	SSTP	96
	AKON(LL) = GB(LL)	SSTP	97
365	CONTINUE	SSIF	98
370	ITER = 0	SSTP	99
375	IFYES = 0	SSTP	100
	ICYES = 0	SSIF	101
	IF (ITER.EQ.0) GO TO 380	SSTP	102
	GO TO 385	SSIF	103
380	ALPHA = (HTCF(I,1)*AAT(1))/(WF(I)*HFCP)	SSTP	104
	TAU(1) = EXP(-ALPHA)	SSIF	105
	ETA = (1.0 - TAU(1))/ALPHA	SSIF	106
	G3(1) = HTCF(I,1)*AAT(1)*ETA	SSTP	107
	SUM(1) = 4.0*AKON(1) + G3(1)	SSIF	108
385	TRES1 = TF(1)	SSTP	109
	TF(1) = (4.0*AKON(1)*TF(2) + G3(1)*TCOOLF(I,1) + PWR(1))/SUM(1)	SSIF	110

Table A.2 (continued)

```

RES1 = ABS (TRES1/TF (1) - 1.0)
IF (RES1.GT.E7) IFYES = 1
TRES2 = TCOOLF (I,2)
TCOOLF (I,2) = TF (1) - (TF (1) - TCOOLF (I,1)) *TAU (1)
RES2 = ABS (TRES2/TCOOLF (I,2) - 1.0)
IF (RES2.GT.E8) ICYES = 2
NF = NA -1
DO 500 M=2,NF
IF (ITER.EQ.0) GO TO 450
GO TO 455
450 ALPHA = (HTCF (I,M)*AAT (M))/(WF (I)*HECP)
TAU (M) = EXP (-ALPHA)
ETA = (1.0 - TAU (M))/ALPHA
G3 (M) = HTCF (I,M)*AAT (M)*ETA
SUM (M) = 2.0*AKON (M-1) + 2.0*AKON (M) + G3 (M)
455 TRES1 = IF (M)
TF (M) = (2.0*AKON (M-1)*TF (M-1) + 2.0*AKON (M)*TF (M+1) +
1 G3 (M)*TCOOLF (I,M) + PWR (M))/SUM (M)
RES1 = ABS (TRES1/TF (M) - 1.0)
IF (RES1.GT.E7) IFYES = M
TRES2 = TCOOLF (I,M+1)
TCOOLF (I,M+1) = TF (M) - (TF (M) - TCOOLF (I,M))*TAU (M)
RES2 = ABS (TRES2/TCOOLF (I,M+1) - 1.0)
IF (RES2.GT.E8) ICYES = M + 1
500 CONTINUE
IF (ITER.EQ.0) GO TO 550
GO TO 555
550 ALPHA = (HTCF (I,NA)*AAT (NA))/(WF (I)*HECP)
TAU (NA) = EXP (-ALPHA)
ETA = (1.0 - TAU (NA))/ALPHA

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SSIF 111
SSIF 112
SSIF 113
SSIF 114
SSIF 115
SSIF 116
SSIF 117
SSIF 118
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SSIF 124
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SSIF 126
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SSIF 131
SSIF 132
SSIF 133
SSIF 134
SSIF 135
SSIF 136
SSIF 137
SSIF 138
SSIF 139
SSIF 140

Table A.2 (continued)

```

G3(NA) = HTCF(I,NA)*AAT(NA)*ETA                      SSTF 141
SUM(NA) = 4.C*AKCN(NA-1) + G3(NA)                     SSTF 142
555 TRFS1 = TF(NA)                                     SSTF 143
TF(NA) = (4.0*AKCN(NA-1)*TF(NA-1) + G3(NA)*TCOOLF(I,NA))/SUM(NA) SSTF 144
RES1 = ABS(TRFS1/TF(NA) - 1.0)                         SSTF 145
IF(RES1.GT.E7) IFYES = NA                             SSTF 146
TPES2 = TCOOLF(I,NA+1)                                SSTF 147
TCCCLF(I,NA+1) = TF(NA) - (TF(NA) - TCOOLF(I,NA))*TAU(NA) SSTF 148
RES2 = ABS(TPES2/TCOOLF(I,NA+1) - 1.0)                 SSTF 149
IF(RES2.GT.E8) ICYES = NA + 1                         SSTF 150
ITEF = ITEF + 1                                       SSTF 151
IF(IFYES.EQ.0.AND.ICYES.EQ.0) GO TO 575                SSTF 152
IF(ITER.GE.KFLAG1) GO TO 565                          SSTF 153
GO TO 375                                              SSTF 154
565 WRITE(6,911) IFYES,ICYES,TF(IFYES),TCOOLF(I,ICYES) SSTF 155
911 FORMAT(10X,'CAUTION: MAXIMUM NUMBER OF ITERATIONS EXCEEDED'/ SSTF 156
1 10X,'STEADY STATE TEMPERATURE CALCULATION',2I5,2F15.1) SSTF 157
575 DO 585 JJ=1,NSEG                                  SSTF 158
DO 580 KK=1,NSUB                                      SSTF 159
L = (JJ-1)*NSUB + KK                                  SSTF 160
TFUELF(I,JJ,KK) = TF(L)                              SSTF 161
580 CONTINUE                                          SSTF 162
585 CONTINUE                                          SSTF 163
600 CONTINUE                                          SSTF 164
RETURN                                                SSTF 165
1000 WRITE(6,1001)                                    SSTF 166
1001 FORMAT(10X,'THE MAXIMUM NUMBER OF ITERATIONS HAS BEEN EXCEEDED IN OSSTF 167
1 RIFICE SETTING CALCULATION')                      SSTF 168
STOP                                                  SSTF 169
END                                                  SSTF 170

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Table A.2 (continued)

	SUBROUTINE TEMPCR	TEMP	1
C	*****	TEMP	2
C	THIS SUBROUTINE CALCULATES TRANSCIENT TEMPERATURES	TEMP	3
C	IN THE CORE OF THE FORT SAINT VRAIN REACTOR	TEMP	4
C	*****	TEMP	5
	COMMON/COEFIS/ AKO(37), AKC(37), AKF(37,100), AKE1(37),	TEMP	6
	1 AKE2(37), AKE3(37), AKG(37), AKT(37,100)	TEMP	7
	COMMON/OUTPT/ TIME, WTOT, WI(37), WF(37), TCOOLI(37,101),	TEMP	8
	1 TCOOLF(37,101), TFUELI(37,10,10), TFUELF(37,10,10),	TEMP	9
	2 SSPW(37,10,10)	TEMP	10
	COMMON/INPUT1/ AC(37), APT(37), APB1(37), APB2(37), APB3(37),	TEMP	11
	1 WGT(37,10,10), AHT(37,10,10)	TEMP	12
	COMMON/INPUT2/ DCS, DCL, ALCF(10), AICT(10), DP,	TEMP	13
	1 DPE1, DPB2, DPB3, DPT	TEMP	14
	COMMON/INPUT3/ NCOL(37), NREG, NSEG, NSUB, NCOLT, NSTEPS, IQMAX,	TEMP	15
	1 NSTEP	TEMP	16
	COMMON/INPUT4/ SP, WPER, AKOX	TEMP	17
	COMMON/INPUT5/ KTMAX, KQMAX, KFLOW, KFRIC, KITER, KIOUT	TEMP	18
	COMMON/INPUT6/ E1, E2, E3, E4, E5, E6, E7, E8, E9	TEMP	19
	COMMON/SIGNAL/KFLAG1,KFLAG2,KFLAG3,KFLAG4,KFLAG5,KFLAG6	TEMP	20
	COMMON/INPUT7/ RF, TCF, F1, F2, ALLT	TEMP	21
	COMMON/INPUT8/ SSQT, SSWT, HECF, SSTIN, SSC, PSS, PDBA	TEMP	22
	COMMON/INPUT9/ PR(37), PA(10,10), PRR(37)	TEMP	23
	COMMON/PRM2/ WOLD, TIN, DELT, SO(37)	TEMP	24
	COMMON/PRESDE/ ODF(37), EDP(37), CDP(37), VOL(37,10)	TEMP	25
	COMMON/TMPORY/ PWR(100), TF(100), TI(100), AAT(100), AKON(100),	TEMP	26
	1SUM(100), GS(100), GE(100), HTCI(37,100),	TEMP	27
	1 HTCF(37,100), TAU(100), G3(100), AWGT(100), DELAY	TEMP	28

Table A.2 (continued)

COMMON/LOCATE/NREF,NB1REF,NB2REF,NB3REF,NADBAT		TEMP	29
PFRAC = PWRAC(TIME,DELT)		TEMP	30
NA = NSEG*NSUB		TEMP	31
DO 600 I=1,NREG		TEMP	32
DO 350 JJ=1, NSEG		TEMP	33
DO 325 KK=1, NSUB		TEMP	34
L = (JJ-1)*NSUB + KK		TEMP	35
PWR(L) = SSPW(I,JJ,KK)*PFRAC		TEMP	36
AAT(L) = AHT(I,JJ,KK)		TEMP	37
TI(L) = TFUEII(I,JJ,KK)		TEMP	38
TF(L) = TFUEIF(I,JJ,KK)		TEMP	39
AWGT(L) = WGT(I,JJ,KK)		TEMP	40
AKON(L) = GS(L)		TEMP	41
325	CONTINUE	TEMP	42
350	CONTINUE	TEMP	43
IF(I.EQ.20.OR.I.EQ.23.OR.I.EQ.26.OR.I.EQ.29.		TEMP	44
1	CR.I.EQ.32.OR.I.EQ.35) GO TO 360	TEMP	45
GO TO 370		TEMP	46
360	DO 365 LL=1,NA	TEMP	47
AKON(LL) = GB(LL)		TEMP	48
365	CONTINUE	TEMP	49
370	ITER = 0	TEMP	50
375	IFYES = 0	TEMP	51
IF(ITER.EQ.0) GO TO 380		TEMP	52
GO TO 385		TEMP	53
380	TAVG = (TF(1) + TI(1))/2.0	TEMP	54
CP = HEATCF(TAVG,0)		TEMP	55
CAPC = (AWGT(1)*CP)/DELT		TEMP	56
HTC = CVERAL(DCL,RI,TCF,WF(I),AC(I),TF(1),TCOOLF(I,1),		TEMP	57
1	TCOOLF(I,2),FDBA,ALLT)	TEMP	58

Table A.2 (continued)

```

ALPHA = (HTC*AAT(1))/(WF(I)*HECP)
TAU(1) = EXP(-ALPHA)
ETA = (1.0 - TAU(1))/ALPHA
HTCF(I,1) = HTC*ETA
G3(1) = HTCF(I,1)*AAT(1)/2.0
PWR(1) = PWR(1) + 2.0*AKON(1)*(TI(2)-TI(1)) -
1 HTCI(I,1)*AAT(1)*(TI(1)-TCOOLI(I,1))/2.0 + CAPC*TI(1)
SUM(1) = 2.0*AKON(1) + G3(1) + CAPC
385 TRES1 = TF(1)
TF(1) = (2.0*AKON(1)*TF(2) + G3(1)*TCOOLF(I,1) + PWR(1))/SUM(1)
RES1 = ABS(TRES1/TF(1) - 1.0)
IF(RES1.GT.E9) IFYES=1
TRES2 = TCOOLF(I,2)
TCOOLF(I,2) = TF(1) - (TF(1) - TCOOLF(I,1))*TAU(1)
RES2 = ABS(TRES2/TCOOLF(I,2) - 1.0)
IF(RES2.GT.E9) ICYES = 2
NF = NA - 1
DO 500 M=2,NF
IF(ITER.EQ.0) GO TO 450
GO TO 455
450 TAVG = (TF(M) + TI(M))/2.0
IF(M.LE.NTREF.OR.M.GE.NB1REF) GO TO 451
CP = HEATCP(TAVG,1)
HTC = OVERAL(DCL,RF,TCF,WF(I),AC(I),TF(M),TCOOLF(I,M),
1 TCOOLF(I,M+1),PDBA,ALLT)
GO TO 454
451 CP = HEATCP(TAVG,0)
IF(M.GE.NB2REF) GO TO 452
HTC = OVERAL(DCL,RF,TCF,WF(I),AC(I),TF(M),TCOOLF(I,M),
1 TCOOLF(I,M+1),PDBA,ALLT)

```

TEMP 59
TEMP 60
TEMP 61
TEMP 62
TEMP 63
TEMP 64
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TEMP 66
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TEMP 68
TEMP 69
TEMP 70
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TEMP 72
TEMP 73
TEMP 74
TEMP 75
TEMP 76
TEMP 77
TEMP 78
TEMP 79
TEMP 80
TEMP 81
TEMP 82
TEMP 83
TEMP 84
TEMP 85
TEMP 86
TEMP 87
TEMP 88

Table A.2 (continued)

GO TO 454	TEMP 89
452 IF (M.GE.NB3PEF) GO TO 453	TEMP 90
HTC = OVERAL (DPB1, RF, TCF, WF (I), APB1 (I), TF (M), TCOOLF (I, M),	TEMP 91
1 TCOOLF (I, M+1), FDBA, ALLT)	TEMP 92
GO TO 454	TEMP 93
453 HTC = OVERAL (DPB2, RF, TCF, WF (I), APB2 (I), TF (M), TCOOLF (I, M),	TEMP 94
1 TCOOLF (I, M+1), FDBA, ALLT)	TEMP 95
454 CAPC = (AWGT (M) * CP) / DELT	TEMP 96
ALPHA = (HTC * AAT (M)) / (WF (I) * HECP)	TEMP 97
TAU (M) = EXP (-ALPHA)	TEMP 98
ETA = (1.0 - TAU (M)) / ALPHA	TEMP 99
HTCF (I, M) = HTC * ETA	TEMP 100
G3 (M) = HTCF (I, M) * AAT (M) / 2.0	TEMP 101
PWR (M) = PWR (M) + AKON (M-1) * (TI (M-1) - TI (M)) + AKON (M) * (TI (M+1)	TEMP 102
1 - TI (M)) - HTCI (I, M) * AAT (M) * (TI (M) - TCOOLI (I, M)) / 2.0	TEMP 103
2 + CAPC * TI (M)	TEMP 104
SUM (M) = AKON (M-1) + AKON (M) + G3 (M) + CAPC	TEMP 105
455 TRES1 = TF (M)	TEMP 106
TF (M) = (AKON (M-1) * TF (M-1) + AKON (M) * TF (M+1) +	TEMP 107
1 G3 (M) * TCOOLF (I, M) + PWR (M)) / SUM (M)	TEMP 108
RES1 = ABS (TRES1 / TF (M) - 1.0)	TEMP 109
IF (RES1.GT.E9) IFYES = M	TEMP 110
TRES2 = TCOOLF (I, M+1)	TEMP 111
TCOOLF (I, M+1) = TF (M) - (TF (M) - TCOOLF (I, M)) * TAU (M)	TEMP 112
RES2 = ABS (TRES2 / TCOOLF (I, M) - 1.0)	TEMP 113
IF (RES2.GT.E9) ICYES = M+1	TEMP 114
500 CONTINUE	TEMP 115
IF (ITER.EQ.0) GO TO 550	TEMP 116
GO TO 555	TEMP 117
550 TAVG = (TF (NA) + TI (NA)) / 2.0	TEMP 118

Table A.2 (continued)

```

CP = HEATCP(TAVG,0)
CAPC = (AWGT(M)*CF)/DELT
HTC = OVERAL(DPB2,RF,TCF,WF(I),APB2(I),TF(NA),TCOOLF(I,NA),
1      TCOOLF(I,NA+1),PDBA,ALLT)
ALPHA = (HTC*AAT(NA))/(WF(I)*HECP)
TAU(NA) = EXP(-ALPHA)
ETA = (1.0 - TAU(NA))/ALPHA
HTCF(I,NA) = HTC*ETA
G3(NA) = HTCF(I,NA)*AAT(NA)/2.0
PWR(NA) = PWR(NA) + 2.0*AKON(NA-1)*(TI(NA-1)-TI(NA))
1      -HTCI(I,NA)*AAT(NA)*(TI(NA)-TCOOLI(I,NA))/2.0
2      + CAPC*TI(NA)
SUM(NA) = 2.0*AKON(NA-1) + G3(NA) + CAPC
555 TRES1 = TF(NA)
TF(NA) = (2.0*AKON(NA-1)*TF(NA-1) + G3(NA)*TCOOLF(I,NA)
1      +PWR(NA))/SUM(NA)
RES1 = ABS(TRES1/TF(NA) - 1.0)
IF(RES1.GT.E9) IFYES = NA
TRES2 = TCOOLF(I,NA+1)
TCOOLF(I,NA+1) = TF(NA) - (TF(NA) - TCOOLF(I,NA))*TAU(NA)
RES2 = ABS(TRES2/TCOOLF(I,NA+1) - 1.0)
IF(RES2.GT.E9) ICYES = NA+1
ITER = ITER + 1
IF(IFYES.EQ.0.AND.ICYES.EQ.0) GO TO 575
IF(ITER.GE.KFLAG1) GO TO 575
GO TO 375
575 DO 585 JJ=1,NSEG
DO 580 KK=1,NSUB
L = (JJ-1)*NSUB + KK
TFUELF(I,JJ,KK) = TF(L)

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TEMP 119
TEMP 120
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TEMP 134
TEMP 135
TEMP 136
TEMP 137
TEMP 138
TEMP 139
TEMP 140
TEMP 141
TEMP 142
TEMP 143
TEMP 144
TEMP 145
TEMP 146
TEMP 147
TEMP 148

Table A.2 (continued)

580	CONTINUE	TEMP	149
585	CONTINUE	TEMP	150
600	CONTINUE	TEMP	151
	RETURN	TEMP	152
	END	TEMP	153
	SUBROUTINE COEFIS	COFS	1
C	*****	COFS	2
C	SUBROUTINE COEFIS CALCULATES LOSS COEFFICIENTS GIVEN	COFS	3
C	TEMPERATURES AND FLOWS	COFS	4
C	*****	COFS	5
	COMMON/COEFIS/ AKO(37), AKC(37), AKF(37,100), AKE1(37),	COFS	6
	1 AKE2(37), AKE3(37), AKG(37), AKT(37,100)	COFS	7
	COMMON/OUTPUT/ TIME, WTOT, WI(37), WF(37), TCOOLI(37,101),	COFS	8
	1 TCOOLF(37,101), TFUELI(37,10,10), TFUELF(37,10,10),	COFS	9
	2 SSPW(37,10,10)	COFS	10
	COMMON/INPUT1/ AC(37), APT(37), APB1(37), APB2(37), APB3(37),	COFS	11
	1 WGT(37,10,10), AHT(37,10,10)	COFS	12
	COMMON/INPUT2/ DCS, DCL, ALCP(10), AICT(10), DF,	COFS	13
	1 DB1, DB2, DB3, DPT	COFS	14
	COMMON/INPUT3/ NCCI(37), NPEG, NSEG, NSUB, NCOLT, NSTEPS, IQMAX,	COFS	15
	1 NSTEP	COFS	16
	COMMON/INPUT4/ SF, WPER, AKOX	COFS	17
	COMMON/INPUT5/ KTMAX, KQMAX, KFLOW, KFRIC, KITER, KICUT	COFS	18
	COMMON/INPUT6/ E1, E2, F3, E4, E5, E6, E7, E8, E9	COFS	19
	COMMON/SIGNAL/ KFLAG1, KFLAG2, KFLAG3, KFLAG4, KFLAG5, KFLAG6	COFS	20
	COMMON/INPUT7/ RF, TCF, F1, F2, AILT	COFS	21
	COMMON/INPUT8/ SSQT, SSWT, HECF, SSTIN, SSC, PSS, PDBA	COFS	22
	COMMON/INPUT9/ FR(37), PA(10,10), PER(37)	COFS	23

Table A.2 (continued)

COMMON/PARM2/ WOLL, TIN, DELT, SO(37)	COFS	24
COMMON/PRESBP/ GDP(37), EDP(37), CDP(37), VOL(37,10)	COFS	25
DATA CG/0.00259/	COFS	26
DO 300 I=1,NREG	COFS	27
DPG = 0.0	COFS	28
RENC = RENUM(WF(I),AC(I),TCOOLF(I,1),DCL,1.0,1)	COFS	29
AKC(I) = CONTRC(RENO,AC(I),APT(I))	COFS	30
NC = (NSEG-2)*NSUB + 1	COFS	31
RENO = RENUM(WF(I),AC(I),TCOOLF(I,NC),DCL,1.0,1)	COFS	32
AKE1(I) = EXPANS(RENO,AC(I),APB1(I))	COFS	33
NC = (NSEG-1)*NSUB + 1	COFS	34
RENO = RENUM(WF(I),APB1(I),TCOOLF(I,NC),DE1,1.0,1)	COFS	35
AKE2(I) = EXPANS(RENO,APB1(I),APB2(I))	COFS	36
NC = NSEG*NSUB + 1	COFS	37
RENO = RENUM(WF(I),APB2(I),TCOOLF(I,NC),DE2,1.0,1)	COFS	38
AKE3(I) = EXPANS(RENO,APB2(I),APB3(I))	COFS	39
AREA = AC(I)	COFS	40
DIAM = DCL	COFS	41
DO 200 J=1,NSEG	COFS	42
IF(J.EQ.NSEG-1) GO TO 40	COFS	43
IF(J.EQ.NSEG) GO TO 45	COFS	44
GO TO 50	COFS	45
40 AREA = APB1(I)	COFS	46
DIAM = DB1	COFS	47
GO TO 50	COFS	48
45 AREA = APB2(I)	COFS	49
DIAM = DE2	COFS	50
50 DO 100 K=1,NSUB	COFS	51
L = (J-1)*NSUB + K	COFS	52
NC = L + 1	COFS	53

Table A.2 (continued)

	TAV = (TCOOLF(I,L) + TCOOLF(I,NC))/2.0	COFS	54
	TFILM = TAV	COFS	55
	RENO = RENUM(WF(I),AREA,TFILM,DIAM,1.0,1)	COFS	56
	AKF(I,L) = (4.0*ALCT(J)/DIAM)*FRICTN(RENO)	COFS	57
	TR = TAV + 459.67	COFS	58
	AKT(I,L) = (2.0/TR)*(TCOOLF(I,NC) - TCOOLF(I,L))	COFS	59
	DPG = DPG + CG*PDBA*ALCF(J)/TR	COFS	60
100	CONTINUE	COFS	61
200	CONTINUE	COFS	62
	AKG(I) = DPG	COFS	63
300	CONTINUE	COFS	64
	RETURN	COFS	65
	END	COFS	66
	SUBROUTINE GUESS	GUES	1
C	*****	GUES	2
C	SUBROUTINE GUESS CALCULATES A NEW GUESS FOR THE PLENUM	GUES	3
C	TO PLENUM PRESSURE DROP BASED ON KNOWN AND ITERATIVE	GUES	4
C	VALUES OF THE TOTAL FLOW	GUES	5
C	*****	GUES	6
	COMMON/COFRI/ AKO(37), AKC(37), AKF(37,100), AKE1(37),	GUES	7
1	AKE2(37), AKE3(37), AKG(37), AKT(37,100)	GUES	8
	COMMON/OUTPT/ TIME, WTOT, WI(37), WF(37), TCOOLI(37,101),	GUES	9
1	TCOOLF(37,101), TFUELI(37,10,10), TFUELF(37,10,10),	GUES	10
2	SSPW(37,10,10)	GUES	11
	COMMON/INPUT1/ AC(37), APT(37), APB1(37), APB2(37), APB3(37),	GUES	12
1	WGT(37,10,10), AHT(37,10,10)	GUES	13
	COMMON/INPUT2/ DCS, DCL, ALCF(10), ALCT(10), DP,	GUES	14
1	DPB1, DPB2, DPB3, DPT	GUES	15

Table A.2 (continued)

	COMMON/INPUT 3/ NCCI(37), NREG, NSEG, NSUB, NCOLT, NSTEPS, IQMAX,	GUES	16
1	NSTEP	GUES	17
	COMMON/INPUT 4/ SP, WPER, AKOX	GUES	18
	COMMON/INPUT 5/ KTMAY, KQMAX, KFIOW, KFRIC, KITER, KIOU	GUES	19
	COMMON/INPUT 6/ E1, E2, E3, E4, E5, E6, E7, E8, E9	GUES	20
	COMMON/SIGNAL/KFLAG1, KFLAG2, KFLAG3, KFLAG4, KFLAG5, KFLAG6	GUES	21
	COMMON/INPUT 7/ RF, TCF, F1, F2, ALLT	GUES	22
	COMMON/INPUT 8/ SSQT, SSWT, HECF, SSTIN, SSC, PSS, PDBA	GUES	23
	COMMON/INPUT 9/ PR(37), PA(10,10), PRR(37)	GUES	24
	COMMON/PAIM2/ WOLD, TIN, DEIT, SC(37)	GUES	25
	COMMON/PRESDF/ ODP(37), IDP(37), CDP(37), VOL(37,10)	GUES	26
	DATA DD, AA, XMU/0.05208, 54.0, 0.1/	GUES	27
	RENO = DD*WTOT/(XMU*AA)	GUES	28
	IF (RENC.IT.2100.0) GO TO 100	GUES	29
	DP = DP* (WTOT/WOLD)**1.68	GUES	30
	RETURN	GUES	31
100	DP = DP* (WTOT/WOLD)	GUES	32
	RETURN	GUES	33
	END	GUES	34
	SUBROUTINE REFLOW	REFI	1
C	*****	REFL	2
C	SUBROUTINE REFLOW CALCULATES THE REGIONWISE FLOW DISTRIBUTION	REFI	3
C	AT THE NEW TIME LEVEL GIVEN TEMPERATURES AND LOSS COEFFICIENTS	REFI	4
C	*****	REFL	5
	COMMON/COERIS/ AKC(37), AKC(37), AKF(37,100), AKE1(37),	REFI	6
1	AKE2(37), AKE3(37), DPG(37), AKT(37,100)	REFL	7
	COMMON/OUTPT/ TIME, WTOT, WI(37), WF(37), TCOOLI(37,101),	REFI	8
1	TCOOLF(37,101), TFUELI(37,10,10), TFUELF(37,10,10),	REFL	9

Table A.2 (continued)

2	SSPW (37, 10, 10)	REFL	10
	COMMON/INPUT 1/ AC (37), APT (37), APB1 (37), APB2 (37), APB3 (37),	REFL	11
1	WGT (37, 10, 10), AHT (37, 10, 10)	REFL	12
	COMMON/INPUT 2/ DCS, DCL, ALCF (10), ALCT (10), DP,	REFL	13
1	DPB1, DPB2, DPB3, DPT	REFL	14
	COMMON/INPUT 3/ NCOL (37), NREG, NSEG, NSUB, NCOLT, NSTEPS, IQMAX,	REFL	15
1	NSTEP	REFL	16
	COMMON/INPUT 4/ SP, WPER, AKOX	REFL	17
	COMMON/INPUT 5/ KTMAX, KQMAX, KFLOW, KFRIC, KITER, KIOU	REFL	18
	COMMON/INPUT 6/ E1, E2, E3, E4, E5, E6, E7, E8, E9	REFL	19
	COMMON/SIGNAL/KFLAG1, KFLAG2, KFLAG3, KFLAG4, KFLAG5, KFLAG6	REFL	20
	COMMON/INPUT 7/ RF, TCF, F1, F2, ALIT	REFL	21
	COMMON/INPUT 8/ SSQT, SSWT, HECF, SSTIN, SSC, PSS, PDBA	REFL	22
	COMMON/INPUT 9/ PR (37), PA (10, 10), PRE (37)	REFL	23
	COMMON/PARM2/ WOLF, TIN, DELT, SO (37)	REFL	24
	COMMON/PRES DP/ ODE (37), EDP (37), CDP (37), VOL (37, 10)	REFL	25
	DATA CN, AKM, PK/ 2.2334E-11, 0.001, 459.67/	REFL	26
	DO 300 I=1, NREG	REFL	27
	TR = TCOOLF (I, 1) + PK	REFL	28
	TERM1 = ((TR*CN)/(PDBA*SO (I)*SO (I))) *AKO (I)	REFL	29
	TERM2 = ((TR*CN)/(PDBA*SP*SP)) *AKOX	REFL	30
	TERM3 = ((TR*CN)/(PDBA*AC (I)*AC (I))) *AKC (I)	REFL	31
	TERM = TERM1 + TERM2 + TERM3	REFL	32
	AREA = AC (I)	REFL	33
	DO 200 J=1, NSEG	REFL	34
	IF (J.EQ.NSEG-1) GO TO 40	REFL	35
	IF (J.EQ.NSEG) GO TO 45	REFL	36
	GO TO 50	REFL	37
40	AREA = APB1 (I)	REFL	38
	GO TO 50	REFL	39

Table A.2 (continued)

45	AREA = APB2(I)	REFL	40
50	DO 100 K=1, NSUB	REFL	41
	I = (J-1)*NSUB + K	REFI	42
	NC = L + 1	REFL	43
	TR = (TCOOLF(I,L) + TCOOLF(I,NC))/2.0 + RK	REFI	44
	FACT = ((TR*CN)/(PDBA*AREA*AREA))	REFL	45
	TERM5 = FACT*AKF(I,L)	REFI	46
	TERM6 = FACT*AKT(I,L)	REFL	47
	TERM = TERM + TERM5 + TERM6	REFL	48
100	CONTINUE	REFI	49
	IF(J.EQ.NSEG-2) GO TO 170	REFL	50
	IF(J.EQ.NSEG-1) GO TO 180	REFI	51
	IF(J.EQ.NSEG) GO TO 190	REFI	52
	TR = TCOOLF(I,NC) + RK	REFL	53
	TERM4 = ((TR*CN)/(PDBA*AC(I)*AC(I))) *AKM	REFI	54
	TERM = TERM + TERM4	REFL	55
	GO TO 200	REFI	56
170	TR = TCOOLF(I,NC) + RK	REFL	57
	TERM7 = ((TR*CN)/(PDBA*AC(I)*AC(I))) *AKE1(I)	REFI	58
	TERM = TERM + TERM7	REFL	59
	GO TO 200	REFL	60
180	TR = TCOOLF(I,NC) + RK	REFI	61
	TERM7 = ((TR*CN)/(PDBA*APB1(I)*APB1(I))) *AKE2(I)	REFL	62
	TERM = TERM + TERM7	REFI	63
	GOTO 200	REFL	64
190	TR = TCOOLF(I,NC) + RK	REFI	65
	TERM7 = ((TR*CN)/(PDBA*APB2(I)*APB2(I))) *AKE3(I)	REFL	66
	TERM = TERM + TERM7	REFL	67
200	CONTINUE	REFI	68
	WF(I) = ((DP + DPG(I))/TERM)**0.5	REFL	69

Table A.2 (continued)

	ODF(I) = TERM1*WF(I)*WF(I)	REFI	70
	EDP(I) = TERM2*WF(I)*WF(I)	REFL	71
	TEPMC = TERM - TERM1 - TERM2	REFL	72
	CDP(I) = TERMC*WF(I)*WF(I) - DPG(I)	REFI	73
300	CONTINUE	REFL	74
	RETURN	PEFI	75
	END	REFL	76
	SUBROUTINE NCFLOW	NOFL	1
C	*****	NCFI	2
C	THIS SUBROUTINE CALCULATES CORE AND HELIUM TEMPERATURES	NOFI	3
C	ASSUMING THERE IS A DELAY IN THE START-UP OF FORCED	NOFI	4
C	CONVECTION--THE CORE IS ASSUMED TO HEAT UP ADIABATICALLY	NOFL	5
C	WHILE THE COLLANT IS ASSUMED TO BE AT THE SAME TEMPERATURE	NOFI	6
C	AS THE GRAPHITE	NOFL	7
C	*****	NOFI	8
	COMMON/COERIS/ AKO(37), AKC(37), AKF(37,100), AKE1(37),	NCFI	9
	1 AKE2(37), AKE3(37), AKG(37), AKT(37,100)	NOFL	10
	COMMON/OUTFI/ TIME, WTOT, WI(37), WF(37), TCOOLI(37,101),	NOFI	11
	1 TCOOLF(37,101), IFUELI(37,10,10), TFUELF(37,10,10),	NOFL	12
	2 SSPW(37,10,10)	NOFI	13
	COMMON/INPUT1/ AC(37), APT(37), APB1(37), APB2(37), APB3(37),	NOFL	14
	1 WGT(37,10,10), AHT(37,10,10)	NOFL	15
	COMMON/INPUT2/ DCS, DCL, ALCF(10), ALCT(10), DP,	NOFI	16
	1 DPB1, DPB2, DPB3, DPT	NOFL	17
	COMMON/INPUT3/ NCCI(37), NREG, NSEG, NSUB, NCOLT, NSTEPS, IQMAX,	NOFI	18
	1 NSTEP	NOFI	19
	COMMON/INPUT4/ SP, WPER, AKOX	NOFL	20
	COMMON/INPUT5/ KTHAX, KQMAX, KFLOW, KFRIC, KITER, KIOUT	NCFI	21

Table A.2 (continued)

COMMON/INPUT6/ E1, E2, E3, E4, E5, E6, E7, E8, E9	NOFL	22
COMMON/SIGNAL/KFLAG1,KFLAG2,KFLAG3,KFLAG4,KFLAG5,KFLAG6	NOFL	23
COMMON/INPUT7/ RF, TCF, F1, F2, ALIT	NOFL	24
COMMON/INPUT8/ SSQT, SSWT, HECF, SSTIN, SSC, PSS, PDBA	NOFL	25
COMMON/INPUT9/ PR(37), PA(10,10), FRR(37)	NOFL	26
COMMON/PAFM2/ WOLD, TIN, DELT, SO(37)	NOFL	27
COMMON/PRESDF/ ODP(37), EDP(37), CDP(37), VOL(37,10)	NOFL	28
COMMON/TMPORY/ PWR(100), TF(100), TI(100), AAT(100), AKON(100),	NOFL	29
1SUM(100), GS(100), GE(100), HTCI(37,100),	NOFL	30
1 HTCF(37,100), TAU(100), G3(100), AWGT(100), DELAY	NOFL	31
COMMON/LCCATE/NTREF,NB1REF,NB2REF,NB3REF,NADBAT	NOFL	32
PFRAC = PWFRAC(TIME,DELT)	NOFL	33
NA = NSEG*NSUB	NOFL	34
DO 600 I=1,NREG	NOFL	35
DO 350 JJ=1,NSSEG	NOFL	36
DO 325 KK=1,NSUB	NOFL	37
L = (JJ-1)*NSUB + KK	NOFL	38
PWR(L) = SSPW(I,JJ,KK)*PFRAC	NOFL	39
AAT(L) = AHT(I,JJ,KK)	NOFL	40
TF(L) = TFUEIF(I,JJ,KK)	NOFL	41
TI(L) = TFUEII(I,JJ,KK)	NOFL	42
AWGT(L) = WGT(I,JJ,KK)	NOFL	43
AKON(L) = GS(L)	NOFL	44
325 CONTINUE	NOFL	45
350 CONTINUE	NOFL	46
IF(I.EQ.20.OR.I.EQ.23.OR.I.EQ.26.OR.I.EQ.29.	NOFL	47
1 OR.I.EQ.32.OR.I.EQ.35) GO TO 360	NOFL	48
GO TO 370	NOFL	49
360 DO 365 LL=1,NA	NOFL	50
AKON(LL) = GE(LL)	NOFL	51

Table A.2 (continued)

365	CONTINUE	NOFL	52
370	ITER = 0	NOFL	53
375	IFYES = 0	NOFL	54
	IF(ITER.EQ.0) GO TC 380	NOFL	55
	GO TO 385	NOFL	56
380	TAVG= (TF(1) + TI(1))/2.0	NOFL	57
	CP = HEATCP(TAVG,0)	NOFL	58
	CAPC = (AWGT(1)*CP)/DELT	NOFL	59
	PWR(1) = PWR(1) + 2.0*AKON(1)*(TI(2)-TI(1)) + CAPC*TI(1)	NOFL	60
	SUM(1) = 2.0*AKON(1) + CAPC	NOFL	61
385	TRES1 = TF(1)	NOFL	62
	TF(1) = (2.0*AKON(1)*TF(2) + PWR(1))/SUM(1)	NOFL	63
	RES1 = ABS(TRES1/TF(1) - 1.0)	NOFL	64
	IF(RES1.GT.E9) IFYES = 1	NOFL	65
	NF = NA - 1	NOFL	66
	DO 500 M=2,NF	NOFL	67
	IF(ITER.EQ.0) GO TC 450	NOFL	68
	GO TO 455	NOFL	69
450	TAVG = (TF(M) + TI(M))/2.0	NOFL	70
	IF(M.LE.NTREF.OR.M.GE.NB1REF) GO TC 452	NOFL	71
	CP = HEATCP(TAVG,1)	NOFL	72
	GO TO 453	NOFL	73
452	CP = HEATCP(TAVG,0)	NOFL	74
453	CAPC = (AWGT(M)*CP)/DELT	NOFL	75
	PWR(M) = PWR(M) + AKON(M-1)*(TI(M-1)-TI(M)) + AKON(M)*	NOFL	76
1	(TI(M+1)-TI(M)) + CAPC*TI(M)	NOFL	77
	SUM(M) = AKON(M-1) + AKON(M) + CAPC	NOFL	78
455	TRES1 = TF(M)	NOFL	79
	TF(M) = (AKON(M-1)*TF(M-1) + AKON(M)*TF(M+1) + PWR(M))/SUM(M)	NOFL	80
	RES1 = ABS(TRES1/TF(M) - 1.0)	NOFL	81

Table A.2 (continued)

	IF (RES1.GT.E9) IFYES = M	NOFL	82
500	CONTINUE	NOFL	83
	IF (ITER.EQ.0) GO TO 550	NOFL	84
	GO TO 555	NOFL	85
550	TAVG = (TF (NA) + TI (NA)) / 2.0	NOFL	86
	CP = HEATCP (TAVG, 0)	NOFL	87
	CAPC = (AWGT (NA) * CP) / DELT	NOFL	88
	PWR (NA) = PWR (NA) + 2.0 * AKON (NA-1) * (TI (NA-1) - TI (NA)) +	NOFL	89
	1 CAPC * TI (NA)	NOFL	90
	SUM (NA) = 2.0 * AKON (NA-1) + CAPC	NOFL	91
555	TRES1 = TF (NA)	NOFL	92
	TF (NA) = (2.0 * AKON (NA-1) * TF (NA-1) + PWR (NA)) / SUM (NA)	NOFL	93
	RES1 = ABS (TRES1 / TF (NA) - 1.0)	NOFL	94
	IF (RES1.GT.E9) IFYES=NA	NOFL	95
	ITER = ITER + 1	NOFL	96
	IF (IFYES.EQ.0) GO TO 575	NOFL	97
	IF (ITER.GE.KFLAG1) GO TO 565	NOFL	98
	GO TO 375	NOFL	99
565	WRITE (6, 911) IFYES, TF (IFYES)	NOFL	100
911	FORMAT (10X, 'CAUTION: MAXIMUM NUMBER OF ITERATIONS EXCEEDED' /	NOFL	101
	1 10X, 'IN NO FLOW TEMPERATURE CALCULATIONS', I5, F15.2)	NOFL	102
575	DO 585 JJ=1, NSEG	NOFL	103
	DO 580 KK=1, NSUB	NOFL	104
	L = (JJ-1) * NSUB + KK	NOFL	105
	TFUELF (I, JJ, KK) = TF (L)	NOFL	106
	TFUELI (I, JJ, KK) = TF (L)	NOFL	107
	TCOOLF (I, L+1) = TF (L)	NOFL	108
	HTCF (I, L) = 0.0	NOFL	109
580	CONTINUE	NOFL	110
585	CONTINUE	NOFL	111

Table A.2 (continued)

	600 CONTINUE		NOFL 112
	RETURN		NOFL 113
	END		NOFL 114
	SUBROUTINE OUTPT2	PSDF	1
C	*****	PSDF	2
C	THIS SUBROUTINE LISTS THE OUTPT SUMMARY OF THE PRESSURE	PSDF	3
C	DROPS AND REGION FLOWS	PSDF	4
C	*****	PSDF	5
	COMMON/CCEBIS/ AKC(37), AKC(37), AKF(37,100), AKE1(37),	PSDF	6
	1 AKE2(37), AKE3(37), AKG(37), AKT(37,100)	PSDF	7
	COMMON/OUTPT/ TIME, WTOT, WI(37), WF(37), TCOOLI(37,101),	PSDF	8
	1 TCOOLF(37,101), TFUELI(37,10,10), TFUELF(37,10,10),	PSDF	9
	2 SSPW(37,10,10)	PSDF	10
	COMMON/INPUT1/ AC(37), APF(37), APB1(37), APB2(37), APB3(37),	PSDF	11
	1 WGT(37,10,10), AHT(37,10,10)	PSDF	12
	COMMON/INPUT2/ DCS, DCL, ALCF(10), ALCT(10), DP,	PSDF	13
	1 DPB1, DPB2, DPB3, DPT	PSDF	14
	COMMON/INPUT3/ NCOL(37), NREG, NSEG, NSUB, NCOLT, NSTEPS, IQMAX,	PSDF	15
	1 NSTEP	PSDF	16
	COMMON/INPUT4/ SP, WPER, AKOX	PSDF	17
	COMMON/INPUT5/ KTMAX, KQMAX, KFLOW, KFRIC, KITER, KIOUT	PSDF	18
	COMMON/INPUT6/ E1, E2, E3, E4, E5, E6, E7, E8, E9	PSDF	19
	COMMON/SIGNAL/ KFLAG1, KFLAG2, KFLAG3, KFLAG4, KFLAG5, KFLAG6	PSDF	20
	COMMON/INPUT7/ RF, TCF, F1, F2, ALLT	PSDF	21
	COMMON/INPUT8/ SSQT, SSWT, HECF, SSTIN, SSC, PSS, PDBA	PSDF	22
	COMMON/INPUT9/ PF(37), PA(10,10), PFR(37)	PSDF	23
	COMMON/FARM2/ WOLL, TIN, DELT, SO(37)	PSDF	24
	COMMON/PRESDF/ ODP(37), EDP(37), CDP(37), VOL(37,10)	PSDF	25

Table A.2 (continued)

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WRITE(6,901)
901 FORMAT(2H1 , 25X,'R E G I O N   F L O W   A N D   P R E S S U
1 R E   D R O P   S U M M A R Y'//)
WRITE(6,902) TIME,WTOT,DP
902 FORMAT(6X,'TIME =',F8.5,' HOURS',9X,'TOTAL FLOW =',F11.1,
1 ' LB/HR',9X,'PLENUM TO PLENUM PRESSURE DROP =',F8.5,' PSIA'//)
WRITE(6,903)
903 FORMAT(2H0 ,30X,'REGION FLOW INFORMATION',20X,
1 'PRESSURE DROP INFORMATION'//)
WRITE(6,904)
904 FORMAT(2H0 ,6X,'REGION',3X,'RADIAL',7X,'REGION',3X,'RATIO TC',
1 3X,'% CF',10X,'CRIFICE',2X,'% OF',5X,'ENTRANCE',2X,
2 '% OF',5X,'CHANNEL',3X,'% OF')
WRITE(6,905)
905 FORMAT(17X,'PEAKING',6X,'FLOW',5X,'AVERAGE',4X,'TOTAL',11X,'DROP',
1 3X,'TOTAL',6X,'DROP',4X,'TOTAL',5X,'DROP',5X,'TOTAL')
WRITE(6,906)
906 FORMAT(17X,'FACTOR',6X,'(LB/HR)',5X,'FLOW',5X,'FLOW',11X,'(PSIA)',
1 2X,'DROP',6X,'(PSIA)',3X,'DROP',6X,'(PSIA)',3X,'DROP'//)
FNC = NCCLT
WAVG = WTOT/FNC
DC 100 I=1, NREG
FNC = NCCL(I)
WRAT = WF(I)/(WAVG*FNC)
WPER = 100.0*WF(I)/WTOT
ODPPER = (ODP(I)/DP)*100.0
EDPPER = (EDP(I)/DP)*100.0
CDPPER = (CDF(I)/DE)*100.0
WRITE(6,907) I,PR(I),WF(I),WRAT,WPER,ODP(I),ODPPER,EDP(I),EDPPER,
1 CDP(I),CDPPER

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Table A.2 (continued)

	100 CONTINUE	PSDP	56
	907 FORMAT (9X, I2, 5X, F7.5, 6X, F8.1, 2X, F8.4, 3X, F3.1, 10X, F8.5,	PSDP	57
	1 2X, F4.1, 6X, F7.5, 2X, F4.1, 6X, F7.5, 2X, F4.1)	FSDP	58
	RETURN	PSDP	59
	END	PSLP	60
	 SUBROUTINE OUTPT3(I)	HOTS	1
C	*****	HOTS	2
C	THE SUBROUTINE LISTS THE DETAILED TEMPERATURE DISTRIBUTION	HOTS	3
C	FOR A GIVEN REFUELING REGION	HOTS	4
C	*****	HOTS	5
	COMMON/COFRIS/ AKC(37), AKC(37), AKF(37,100), AKE1(37),	HOTS	6
	1 AKE2(37), AKE3(37), AKG(37), AKT(37,100)	HOTS	7
	COMMON/OUTPT/ TIME, WTOT, WI(37), WF(37), TCOOLI(37,101),	HOTS	8
	1 TCOOLF(37,101), TFUELI(37,10,10), TFUELF(37,10,10),	HOTS	9
	2 SSPW(37,10,10)	HOTS	10
	COMMON/INPUT1/ AC(37), API(37), APB1(37), APB2(37), APB3(37),	HOTS	11
	1 WGT(37,10,10), AHT(37,10,10)	HOTS	12
	COMMON/INPUT2/ DCS, DCL, ALCF(10), ALCT(10), DP,	HOTS	13
	1 DPB1, DPB2, DPB3, DPT	HOTS	14
	COMMON/INPUT3/ NCOL(37), NREG, NSEG, NSUB, NCOLT, NSTEPS, IQMAX,	HOTS	15
	1 NSTEP	HOTS	16
	COMMON/INPUT4/ SP, WPER, AKOX	HOTS	17
	COMMON/INPUT5/ KTMAX, KQMAX, KFLOW, KFRIC, KITER, KIOUT	HOTS	18
	COMMON/INPUT6/ E1, E2, E3, E4, E5, E6, E7, E8, E9	HOTS	19
	COMMON/SIGNAL/ KFLAG1, KFLAG2, KFLAG3, KFLAG4, KFLAG5, KFLAG6	HOTS	20
	COMMON/INPUT7/ FF, TCF, F1, F2, ALIT	HOTS	21
	COMMON/INPUT8/ SSQT, SSWT, HECF, SSTIN, SSC, PSS, PDBA	HOTS	22
	COMMON/INPUT9/ PR(37), PA(10,10), PRR(37)	HOTS	23

Table A.2 (continued)

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COMMON/ Parm2/ WOLD, TIN, DELT, SO (37)
DIMENSION XC (101)
WRITE (6, 900)
900 FORMAT (2H1 )
WRITE (6, 901)
901 FORMAT (15X, 'TEMPERATURE DISTRIBUTION F 0
1R HCT REFUELING REGION' /)
FNC = NCOLT
WAVG = WTOT / FNC
FNC = NCOL (I)
IF (WAVG.LT.1.0) GO TO 75
WNORM = WF (I) / (WAVG * FNC)
GO TO 80
75 WNCFM = 0.0
80 WRITE (6, 909) TIME, I, WF (I), I, WNORM
909 FORMAT (2H0 ,6X, 'TIME =', F8.5, ' HRS', 5X, 'REGION =', I3, 5X,
1 'REGION FLOW =', F8.1, ' 1B/HR', 5X,
2 'NORMALIZED FLOW (WF(', I2, ') / WAVG) =', F8.4 //)
WRITE (6, 902)
902 FORMAT (2 (8X, '* NODE * DISTANCE *', 12X, '* FUEL AND/OR*'))
WRITE (6, 903)
903 FORMAT (2 (8X, '* LOCATION*FROM CHANNEL* COOLANT * MODERATOR *'))
WRITE (6, 904)
904 FORMAT (2 (8X, '* (SEGMENT,* ENTRANCE * TEMPERATURE* TEMPERATURE*'))
WRITE (6, 905)
905 FORMAT (2 (8X, '* POSITION) * (FEET) * (DEG F) * (DEG F) *'))
WRITE (6, 907)
907 FORMAT (2 (8X, '*****'))
WRITE (6, 906)
906 FORMAT (2 (8X, '*', 9X, '*', 12X, '*', 12X, '*', 12X, '*'))

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HOTS 24
HOTS 25
HOTS 26
HOTS 27
HOTS 28
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HOTS 46
HOTS 47
HOTS 48
HOTS 49
HOTS 50
HOTS 51
HOTS 52
HOTS 53

Table A.2 (continued)

	XCT = 0.0	HOTS	54
	XC(1) = XCT	HOTS	55
	DO 200 J=1,NSEG	HOTS	56
	DELX = AICF(J)	HOTS	57
	DO 100 K=1,NSUB	HOTS	58
	I = (J-1)*NSUB + K + 1	HOTS	59
	XC(I) = XCT + DELX	HOTS	60
	XCT = XCT + DELX	HOTS	61
100	CONTINUE	HOTS	62
200	CONTINUE	HOTS	63
	N1 = NSEG/2	HOTS	64
	IDUM = N1*NSUB + 1	HOTS	65
	WRITE(6,911) XC(1),TCOOLF(I,1),XC(IDUM),TCOOLF(I,IDUM)	HOTS	66
	DO 400 J=1,N1	HOTS	67
	NJ = J + N1	HOTS	68
	DO 300 K=1,NSUB	HOTS	69
	L1 = (J-1)*NSUB + K	HOTS	70
	NC1 = L1 + 1	HOTS	71
	L2 = (NJ-1)*NSUB + K	HOTS	72
	NC2 = L2 + 1	HOTS	73
	WRITE(6,910) J,K,TFUELF(I,J,K),NJ,K,TFUELF(I,NJ,K)	HOTS	74
	WRITE(6,911) XC(NC1),TCOOLF(I,NC1),XC(NC2),TCOOLF(I,NC2)	HOTS	75
300	CONTINUE	HOTS	76
400	CONTINUE	HOTS	77
911	FORMAT(2(8X,'*',9X,'*',2X,F8.5,2X,'*',2X,F7.1,3X,'*',12X,'*'))	HOTS	78
910	FORMAT(2(8X,'*(' ,I2,' ',I2,' ') ', '*',12X,	HOTS	79
1	'*',12X,'*',2X,F7.1,3X,'*'))	HOTS	80
	RETURN	HOTS	81
	END	HOTS	82

SUBROUTINE OUTPUT

CUTF 1

Table A.2 (continued)

```

C *****
C THIS OUTPUT SUBROUTINE PRINTS TEMPERATURES AND FLOWS
C IN A PATTERN SIMULATING THE FACE OF THE FORT SAINT
C VRAIN REACTOR--OTHER PERTINENT PARAMETERS MAY BE
C PRINTED BY CHANGING VARIABLES TRANSFER THROUGH COMMON
C *****
COMMON/OUTPT/ TIME, WTOT, WI(37), WF(37), TCOOLI(37,101),
1 TCOOLF(37,101), TFUELI(37,10,10), TFUELF(37,10,10),
2 SSPW(37,10,10)
COMMON/INPUT3/ NCCL(37), NREG, NSEG, NSUB, NCOLT, NSTEPS, IQMAX,
1 NSTEP
DIMENSION IJ(37), IK(37), TF(37), TO(37)
WRITE(6,45)
45 FORMAT(1H1,10X,' ')
WRITE(6,50)
50 FORMAT(30X,'F O R T   S A I N T   V R A I N   F L O W   R E D I S
1 T R I E U T I O N'//35X,'A F T E R   D E P R E S S U R I Z A T I O
2 N   A C C I D E N T'//)
IF(WTOT.LT.1.0) GO TO 47
N11 = NSEG*NSUB + 1
SUMM = 0.0
DO 2001 I=1,NREG
FFF1 = WF(I)*TCOOLF(I,N11)
SUMM = SUMM + FFF1
2001 CONTINUE
TMM = SUMM/WTOT
47 WRITE(6,51) TIME,WTOT,TCOOLF(1,1),TMM
51 FORMAT(2X,'TIME =',F8.5,' (HOURS)',4X,'TOTAL FLOW =',F11.1,
1 ' (LB/HR)',4X,'INLET TEMPERATURE =',F6.0,' DEG F',
2 4X,'MIXED MEAN OUT =',F6.0,' DEG F'//)

```

```

OUTP  2
CUTF  3
CUTF  4
OUTP  5
CUTF  6
OUTP  7
OUTF  8
CUTF  9
OUTP 10
CUTF 11
OUTP 12
CUTF 13
OUTP 14
OUTP 15
CUTF 16
OUTP 17
OUTF 18
OUTP 19
OUTP 20
OUTP 21
OUTP 22
CUTF 23
OUTP 24
OUTP 25
CUTF 26
OUTP 27
CUTF 28
OUTP 29
CUTF 30
OUTP 31

```

Table A.2 (continued)

NC = NSUB*NSEG + 1	OUTP	32
DO 60 I=1,NSEG	OUTP	33
TFMAX = TFUELF(I,1,1)	CUTP	34
DO 59 J=1,NSEG	OUTP	35
DO 58 K=1,NSUB	OUTP	36
IF(TFUELF(I,J,K).GT.TFMAX) GO TO 56	OUTP	37
GO TO 58	CUTP	38
56 TFMAX = TFUELF(I,J,K)	OUTP	39
IJ(I) = J	OUTP	40
IK(I) = K	CUTP	41
58 CONTINUE	OUTP	42
59 CONTINUE	OUTP	43
TF(I) = TFMAX	OUTP	44
TO(I) = TCCOLF(I,NC)	CUTP	45
60 CONTINUE	OUTP	46
IREG = 1	OUTP	47
I1 = 35	OUTP	48
I2 = 36	CUTP	49
I3 = 37	OUTP	50
I4 = 20	OUTP	51
GO TO 100	OUTP	52
75 I1 = 29	OUTP	53
I2 = 28	CUTP	54
I3 = 27	CUTP	55
I4 = 26	OUTP	56
100 WRITE(6,101) I1,I2,I3,I4	OUTP	57
101 FORMAT(27X,4(4X,'REGION ',I2,5X))	OUTP	58
WRITE(6,102) WF(I1),WF(I2),WF(I3),WF(I4)	CUTP	59
102 FORMAT(29X,4('FLOW =',F9.2,3X))	CUTP	60
104 FORMAT(29X,4('HE CUT=',F6.0,5X)///)	OUTP	61

Table A.2 (continued)

	WRITE(6,103) IJ(I1),IK(I1),IJ(I2),IK(I2),IJ(I3),IK(I3),	CUTF	62
	1 IJ(I4),IK(I4)	OUTP	63
103	FORMAT(29X,4('LOCATION',2X,I2,',',I2,3X))	OUTP	64
	WRITE(6,105) TF(I1),TF(I2),TF(I3),TF(I4)	CUTF	65
105	FORMAT(29X,4('FUEL =',F6.0,5X))	OUTP	66
	WRITE(6,104) TO(I1),TO(I2),TO(I3),TO(I4)	CUTF	67
	IF(IREG.EQ.1) GO TO 125	OUTF	68
	RETURN	OUTP	69
125	I1 = 34	CUTF	70
	I2 = 18	OUTP	71
	I3 = 19	CUTP	72
	I4 = 8	CUTF	73
	I5 = 21	OUTP	74
	GO TO 200	OUTF	75
150	I1 = 30	OUTP	76
	I2 = 14	CUTF	77
	I3 = 13	OUTP	78
	I4 = 12	OUTP	79
	I5 = 25	OUTP	80
200	WRITE(6,201) I1,I2,I3,I4,I5	OUTP	81
201	FORMAT(18X,5(4X,'REGION ',I2,5X))	CUTP	82
	WRITE(6,202) WF(I1),WF(I2),WF(I3),WF(I4),WF(I5)	OUTP	83
202	FORMAT(20X,5('FLOW =',F9.2,3X))	CUTF	84
204	FORMAT(20X,5('HE OUT=',F6.0,5X)///)	OUTP	85
	WRITE(6,203) IJ(I1),IK(I1),IJ(I2),IK(I2),IJ(I3),IK(I3),	OUTP	86
	1 IJ(I4),IK(I4),IJ(I5),IK(I5)	CUTF	87
203	FORMAT(20X,5('LOCATION',2X,I2,',',I2,3X))	OUTP	88
	WRITE(6,205) TF(I1),TF(I2),TF(I3),TF(I4),TF(I5)	OUTF	89
205	FORMAT(20X,5('FUEL =',F6.0,5X))	CUTF	90
	WRITE(6,204) TO(I1),TO(I2),TO(I3),TO(I4),TO(I5)	OUTP	91

Table A.2 (continued)

	IF (IREG.EQ.1) GO TC 225	CUTP	92
	IF (IREG.EQ.2) GO TO 75	OUTP	93
	STOP	OUTP	94
225	I1 = 33	CUTP	95
	I2 = 17	OUTP	96
	I3 = 7	CUTP	97
	I4 = 2	CUTP	98
	I5 = 9	OUTP	99
	I6 = 22	OUTP	100
	GO TO 300	OUTP	101
250	I1 = 31	CUTP	102
	I2 = 15	OUTP	103
	I3 = 5	OUTP	104
	I4 = 4	CUTP	105
	I5 = 11	OUTP	106
	I6 = 24	OUTP	107
300	WRITE(6,301) I1,I2,I3,I4,I5,I6	OUTP	108
301	FORMAT (9X,6 (4X,'REGION ',I2,5X))	CUTP	109
	WRITE(6,302) WF(I1),WF(I2),WF(I3),WF(I4),WF(I5),WF(I6)	OUTP	110
302	FORMAT(11X,6 ('FLCW =',F9.2,3X))	OUTP	111
304	FORMAT(11X,6 ('HE CUT=',F6.0,5X))//)	CUTP	112
	WRITE(6,303) IJ(I1),IK(I1),IJ(I2),IK(I2),IJ(I3),IK(I3),	OUTP	113
1	IJ(I4),IK(I4),IJ(I5),IK(I5),IJ(I6),IK(I6)	OUTP	114
303	FORMAT(11X,6 ('LOCATION',2X,I2,',',I2,3X))	CUTP	115
	WRITE(6,305) TF(I1),TF(I2),TF(I3),TF(I4),TF(I5),TF(I6)	OUTP	116
305	FORMAT(11X,6 ('FUEL =',F6.0,5X))	OUTP	117
	WRITE(6,304) TO(I1),TO(I2),TO(I3),TO(I4),TO(I5),TO(I6)	OUTP	118
	IF (IREG.EQ.1) GO TC 350	OUTP	119
	IF (IREG.EQ.2) GO TC 150	OUTP	120
	STOP	OUTP	121

Table A.2 (continued)

350	I1 = 32	CUTF 122
	I2 = 16	OUTP 123
	I3 = 6	CUTF 124
	I4 = 1	OUTP 125
	I5 = 3	OUTP 126
	I6 = 10	CUTF 127
	I7 = 23	OUTP 128
400	WRITE(6,401) I1,I2,I3,I4,I5,I6,I7	OUTP 129
401	FORMAT(7(4X,'REGION ',I2,5X))	OUTP 130
	WRITE(6,402) WF(I1),WF(I2),WF(I3),WF(I4),WF(I5),WF(I6),WF(I7)	CUTF 131
402	FORMAT(2X,7('FLOW =',F9.2,3X))	CUTF 132
404	FORMAT(2X,7('HE OUT=',F6.0,5X)///)	OUTP 133
	WRITE(6,403) IJ(I1),IK(I1),IJ(I2),IK(I2),IJ(I3),IK(I3),	CUTF 134
	1 IJ(I4),IK(I4),IJ(I5),IK(I5),IJ(I6),IK(I6),IJ(I7),IK(I7)	OUTP 135
403	FORMAT(2X,7('LOCATION',2X,I2,',',I2,3X))	OUTP 136
	WRITE(6,405) TF(I1),TF(I2),TF(I3),TF(I4),TF(I5),TF(I6),TF(I7)	CUTF 137
405	FORMAT(2X,7('FUEL =',F6.0,5X))	OUTP 138
	WRITE(6,404) TO(I1),TO(I2),TO(I3),TO(I4),TO(I5),TO(I6),TO(I7)	CUTF 139
	IREG = IREG + 1	OUTP 140
	IF(IREG.EQ.2) GO TO 250	OUTP 141
	STOP	OUTP 142
	END	OUTP 143
	FUNCTION HEATCP(TF,IFLAG)	CAPC 1
C	*****	CAPC 2
C	FUNCTION HEATCP CALCULATES THE HEAT CAPACITY OF PURE	CAPC 3
C	GRAPHITE AND OF THE COMPOSITE CORE	CAPC 4
C	*****	CAPC 5
	DATA A,B,C,D/-0.103,6.472E-4,-2.667E-7,3.97E-11/	CAPC 6

Table A.2 (continued)

	DATA E,F,G,H/3.38,2.74E-2,-4.88E-6,-0.146E6/	CAFC	7
	DATA DENS G,DENS F,VOL G,VOL F/107.0,107.0,12.532,4.8956/	CAPC	8
	T = TF + 459.67	CAFC	9
	AGCP = A + B*T + C*T*T + D*T*T*T	CAPC	10
	IF (IFLAG.EQ.0) GO TO 50	CAFC	11
	ROWCPF = E + F*T + G*T*T + H/(T*T)	CAFC	12
	GMASS = DENS G*VOL G	CAPC	13
	FMASS = DENS F*VOL F	CAPC	14
	HEATCP = (GMASS*AGCP + ROWCPF*VOL F)/(GMASS + FMASS)	CAPC	15
	RETURN	CAFC	16
50	HEATCP = AGCP	CAFC	17
	RETURN	CAPC	18
	END	CAFC	19
	FUNCTION PWFRAC (TIME,DELT)	PWFR	1
C	*****	PWFR	2
C	FUNCTION PWFRAC CALCULATES THE AVERAGE FRACTIONAL	PWFR	3
C	POWER REMAINING BETWEEN THE GIVEN BOUNDING TIMES	PWFR	4
C	*****	PWFR	5
	DATA A,B,C/0.128,0.0003796,0.739/	PWFR	6
	T2 = TIME*3600.0	PWFR	7
	T1 = T2 - DELT*3600.0	PWFR	8
	S1 = (T1 + B)**C	PWFR	9
	S2 = (T2 + B)**C	PWFR	10
	PWFRAC = (A*(S2-S1))/((T2-T1)*C)	PWFR	11
	RETURN	PWFR	12
	END	PWFR	13
	FUNCTION HEHTC (W,A,TF,TIN,TOUT,P,D,AL)	HTCS	1

Table A.2 (continued)

C	*****	HTCS	2
C	FUNCTION HEHTC CALCULATES A HELIUM HEAT TRANSFER COEFFICIENT	HTCS	3
C		HTCS	4
C	THREE HEAT TRANSFER REGIMES ARE IDENTIFIED DEPENDING ON	HTCS	5
C	THE VALUE OF THE REYNOLDS NUMBER--THE REGIMES ARE TURBULENT,	HTCS	6
C	TRANSITIONAL, AND LAMINAR	HTCS	7
C	*****	HTCS	8
	G = W/A	HTCS	9
	TA = (TIN + TOUT) / 2.0	HTCS	10
	TW = (TA + TF) / 2.0	HTCS	11
	XMU = VIS(TA)	HTCS	12
	XMUW = VIS(TW)	HTCS	13
	XK = HEHTC(TA, F)	HTCS	14
	RENO = D * G / XMU	HTCS	15
	IF (RENO .GE. 10000.0 .AND. RENO .LE. 2000000.0) GO TO 10	HTCS	16
	IF (RENO .LE. 2100.0) GO TO 20	HTCS	17
	IF (RENO .GT. 2100.0 .AND. RENO .LT. 10000.0) GO TO 30	HTCS	18
	WRITE(6, 972) RENO	HTCS	19
972	FORMAT(10X, 'THE REYNOLDS NUMBER(' , E12.5, ' IS OUTSIDE RANGE FOR HEHTC	HTCS	20
	1 CALCULATION' / 10X, 'WARNING---DITTUS-BOELTER RELATION IS USED')	HTCS	21
10	HEHTC = TURBLT(RENO, XMU, XMUW, XK, D)	HTCS	22
	RETURN	HTCS	23
20	HEHTC = SAMINR(XK, XMU, XMUW, A1, D, G)	HTCS	24
	RETURN	HTCS	25
30	H1 = TURBLT(10000.0, XMU, XMUW, XK, D)	HTCS	26
	G = 2100.0 * XMU / D	HTCS	27
	H2 = SAMINR(XK, XMU, XMUW, A1, D, G)	HTCS	28
	M = (H1 - H2) / 0.677781	HTCS	29
	B = H2 - (M * 3.32222)	HTCS	30
	HEHTC = M * ALOG10(RENO) + B	HTCS	31

Table A.2 (continued)

	RETURN	HTCS	32
	END	HTCS	33
	FUNCTION TURELT(RENO,XMU,XMUW,XK,D)	TURB	1
C	*****	TURB	2
C	FUNCTION TURBLT CALCULATES A HELIUM HEAT TRANSFER COEFFICIENT	TURE	3
C	BASED CN THE DITTUS-BOELTER CORRELATION	TURB	4
C	*****	TURB	5
	PRNO = 1.2425*XMU/XK	TURE	6
	R = RENO**0.8	TURB	7
	S = PRNO**0.333333	TURE	8
	T = (XMU/XMUW)**0.14	TURB	9
	XNUNO = 0.023*R*S*T	TURE	10
	TURBLT = XK*XNUNO/I	TURB	11
	RETURN	TURE	12
	END	TURB	13
C		TURB	14
	FUNCTION SAMINR(XK,XMU,XMUW,AL,D,G)	LAMR	1
C	*****	LAMR	2
C	FUNCTION SAMINR CALCULATES LAMINAR HEAT TRANSFER	LAMR	3
C	COEFFICIENTS BASED ON A GRAETZ NUMBER CORRELATION	LAMR	4
C	*****	LAMR	5
	W = 0.7854*D*D*G	LAMR	6
	GZ = (W*1.2425)/(XK*AL)	LAMR	7
	R = GZ**0.333333	LAMR	8
	S = 2.0*(XMU/XMUW)**0.14	LAMR	9
	XNUNO = R*S	LAMR	10

Table A.2 (continued)

	SAMINR = XK*XNUNO/I	LAMR	11
	RETURN	LAMR	12
	END	LAMR	13
	FUNCTION HETC(T,P)	HETC	1
C	*****	HETC	2
C	FUNCTION HETC CALCULATES THE THERMAL CONDUCTIVITY	HETC	3
C	OF HELIUM AT PRESSURES BETWEEN 0.0 TO 2000.0 PSIA	HETC	4
C	*****	HETC	5
	IF (P.GT.0.0.AND.P.LE.14.7) GO TO 10	HETC	6
	IF (P.GT.14.7.AND.P.LE.100.0) GO TO 20	HETC	7
	IF (P.GT.100.0.AND.P.LE.1000.0) GO TO 30	HETC	8
	IF (P.GT.1000.0.AND.P.LE.2000.0) GO TO 40	HETC	9
	WRITE(6,985) P	HETC	10
985	FORMAT(10X,'THE PRESSURE(' ,E12.5,' PSIA) IS OUTSIDE RANGE FOR CALCULATING THE THERMAL CONDUCTIVITY OF HELIUM'/10X,'WARNING---THE CORRELATION FOR P = 2000.0 PSIA IS USED')	HETC	11
	HETC = P4(T)	HETC	12
	RETURN	HETC	13
10	HETC = P1(T)	HETC	14
	RETURN	HETC	15
20	A = P1(T)	HETC	16
	B = P2(T)	HETC	17
	HETC = A + (B-A) * (P-14.7) / 85.3	HETC	18
	RETURN	HETC	19
30	A = P2(T)	HETC	20
	B = P3(T)	HETC	21
	HETC = A + (B-A) * (P-100.0) / 900.0	HETC	22
	RETURN	HETC	23
		HETC	24
		HETC	25

Table A.2 (continued)

40	A = P3 (T)	HETC	26
	B = P4 (T)	HETC	27
	HETC = A + (E-A) * (E-1000.0) / 1000.0	HETC	28
	RETURN	HETC	29
	END	HETC	30
	FUNCTION P1(T)	K1FS	1
C	*****	K1FS	2
C	FUNCTION P1 CALCULATES HELIUM THERMAL CONDUCTIVITY	K1PS	3
C	AT 14.7 PSIA	K1FS	4
C	*****	K1PS	5
	P1 = .0809175 + 9.9936E-5*T - 1.10025E-8*T*T	K1FS	6
	RETURN	K1FS	7
	END	K1PS	8
	FUNCTION P2(T)	K2FS	1
C	*****	K2PS	2
C	FUNCTION P2 CALCULATES HELIUM THERMAL CONDUCTIVITY	K2PS	3
C	AT 100.0 PSIA	K2FS	4
C	*****	K2PS	5
	P2 = .0834957 + 1.00842E-4*T - 1.13598E-8*T*T	K2FS	6
	RETURN	K2FS	7
	END	K2PS	8
	FUNCTION P3(T)	K3PS	1
C	*****	K3FS	2
C	FUNCTION P3 CALCULATES HELIUM THERMAL CONDUCTIVITY	K3PS	3

Table A.2 (continued)

C	AT 1000.0 PSIA	K3PS	4
C	*****	K3PS	5
	P3 = .0863791 + 1.01611E-4*T - 1.20405E-8*T*T	K3PS	6
	RETURN	K3PS	7
	END	K3PS	8
	FUNCTION P4(T)	K4PS	1
C	*****	K4PS	2
C	FUNCTION P4 CALCULATES HELIUM THERMAL CONDUCTIVITY	K4PS	3
C	AT 2000.0 PSIA	K4PS	4
C	*****	K4PS	5
	P4 = .0869068 + 1.03092E-4*T - 1.27824E-8*T*T	K4PS	6
	RETURN	K4PS	7
	END	K4PS	8
	FUNCTION RENUM(W,A,T,D,P,N)	RENO	1
C	*****	RENO	2
C	FUNCTION RENUM CALCULATES A REYNOLDS NUMBER FOR A	RENC	3
C	ARBITRARILY SHAPED DUCT	RENO	4
C	*****	RENO	5
C	CALCULATE REYNOLDS NUMBER FOR CIRCULAR (N=1, DEFAULT) AND	RENC	6
C	NON-CIRCULAR (N=0) CHANNELS	RENO	7
	IF (N.NE.0) GC TO 10	RENC	8
	DE = 4*A/P	RENO	9
	GO TO 20	RENC	10
10	DE = D	RENO	11
20	G = W/A	RENO	12
	V = VIS(T)	RENC	13

Table A.2 (continued)

	RENUM =(DF * G)/V	FENO	14
	RETURN	RENC	15
	END	RENO	16
	FUNCTION HEDEN(T,P)	DENS	1
C	*****	DENS	2
C	FUNCTION HEDEN CALCULATES THE DENSITY OF HELIUM (LB/CU FT)	DENS	3
C	USING THE IDEAL GAS LAW	DENS	4
C	*****	DENS	5
	TR = T + 459.67	DENS	6
	IF(P.GT.0.0.AND.P.LE.1000.0) GO TO 10	DENS	7
	WRITE(6,909) P	DENS	8
909	FORMAT(10X,'THE PRESSURE (' ,E12.5,') IS OUTSIDE RANGE OF APPLICAB	DENS	9
	ILITY OF '/10X,'IDEAL GAS LAW WHEN CALCULATING THE DENSITY OF HELI	DENS	10
	2UM'//10X,'CAUTION- THE IDEAL GAS LAW IS USED')	DENS	11
10	IF(T.GT.0.0.AND.T.LE.1600.0) GO TO 20	DENS	12
20	HEDEN = 0.37303 * P/TR	DENS	13
	RETURN	DENS	14
	END	DENS	15
	FUNCTION FRICTN(FENO)	FRIC	1
C	*****	FRIC	2
C	FUNCTION FRICTN CALCULATES THE FRICTION LOSS COEFFICIENT	FRIC	3
C	BASED ON THE FLOW REGIME	FRIC	4
C	*****	FRIC	5
	IF(RENC.GT.0.0.AND.RENO.LE.1600.0) GO TO 10	FRIC	6
	IF(FENO.GT.1600.0.AND.FENO.LT.4290.8) GO TO 20	FRIC	7
	IF(FENO.GE.4290.8.AND.FENO.LT.1.0E8) GO TO 30	FRIC	8

Table A.2 (continued)

WRITE(6,903) RENO	FRIC 9
STOP	FRIC 10
903 FORMAT(10X,'THE REYNOLDS NUMBER (' ,E12.5,') IS OUT OF RANGE FOR THE FRICTION FACTOR CALCULATION')	FRIC 11
10 FRICTN = 16.0/RENC	FRIC 12
RETURN	FRIC 13
20 FRICTN = 0.01	FRIC 14
RETURN	FRIC 15
30 FRICTN = 0.00140 + 0.125/(RENO**.32)	FRIC 16
RETURN	FRIC 17
END	FRIC 18
	FRIC 19
FUNCTION CCNTRC(RENO,SA,SE)	CNTR 1
DIMENSION X(11),Y(11)	CNTR 2
DATA X/0.0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0/	CNTR 3
DATA Y/0.611,0.612,0.616,0.622,0.631,0.644,0.662,0.687,0.722,	CNTR 4
1 0.781,1.00/	CNTR 5
SIGMA = SA/SB	CNTR 6
S2 = SIGMA*SIGMA	CNTR 7
DO 5 I=1,11	CNTR 8
IF(X(I).LE.SIGMA) MIN = I	CNTR 9
IF(X(I).GT.SIGMA) GO TO 8	CNTR 10
5 CONTINUE	CNTR 11
8 MAX = MIN + 1	CNTR 12
DELY = Y(MAX) - Y(MIN)	CNTR 13
DELX = X(MAX) - X(MIN)	CNTR 14
CJ = Y(MIN) + DELY*(SIGMA - X(MIN))/DELX	CNTR 15
CJ2 = CJ*CJ	CNTR 16
IF(RENO.GT.0.0.AND.RENO.LE.2100.0) GO TO 10	CNTR 17

Table A.2 (continued)

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IF (RENO.GT.2100.0.AND.RENO.LT.1.0E8) GO TO 20          CNTR  18
WRITE(6,904) RENO,SA,SB                                CNTR  19
904 FORMAT(10X,'THE REYNOLDS NUMBER (' ,F12.5,' ) IS OUTSIDE OF THE RAN CNTR  20
1GE FOR CONTRACTION LOSS',2E10.3)                     CNTR  21
STOP                                                    CNTR  22
10 BETA = 1.33                                          CNTR  23
   XLAM = 1.00                                          CNTR  24
   GO TO 30                                             CNTR  25
20 BETA = 1.00                                          CNTR  26
   XLAM = 1.00                                          CNTR  27
30 CONTRC = ((1.0 - XLAM*S2*CJ2 - 2.0*CJ + 2.0*BETA*CJ2)/CJ2) - CNTR  28
1   (1 - S2)                                           CNTR  29
RETURN                                                  CNTR  30
END                                                    CNTR  31
END                                                    CNTR  32

FUNCTION EXPANS(RENO,SA,SB)                             EXPN  1
C *****                                             EXPN  2
C FUNCTION EXPANS CALCULATES AN EXPANSION LOSS COEFFICIENT EXPN  3
C FOR TWO FLOW REGIMES DEPENDING ON THE REYNOLDS NUMBER EXPN  4
C *****                                             EXPN  5
IF (SA.GT.SB) GO TO 10                                EXPN  6
IF (RENO.GT.0.0.AND.RENO.LE.2100.0) GO TO 20          EXPN  7
IF (RENO.GT.2100.0.AND.RENO.LT.1.0E8) GO TO 30        EXPN  8
10 WRITE(6,905) RENO,SA,SB                             EXPN  9
STOP                                                    EXPN 10
905 FORMAT(10X,'THE REYNOLDS NUMBER (' ,F12.5,' ) IS OUTSIDE RANGE FOR EXPN 11
1EXPANSION LOSS'/10X,'OR SA ',E12.5,' IS LARGER THAN SB ',E12.5) EXPN 12
20 EXPANS = 1.0 - 2.667*(SA/SB) + (SA/SB)**2          EXPN 13

```

Table A.2 (continued)

	RETURN	EXFN	14
30	EXPANS = (1.0 - SA/SB)**2	EXFN	15
	RETURN	EXFN	16
	END	EXFN	17
	FUNCTION ORIFIS (RENO,SA,SB)	CECC	1
C	*****	ORCO	2
C	FUNCTION ORIFIS CALCULATES AN ORIFICE LOSS COEFFICIENT	CRCC	3
C	AS A FUNCTION OF THE REYNOLDS NUMBER AND ORIFICE AREA	CRCC	4
C	*****	OECC	5
	BETA = (SA/SB)**.5	CECC	6
	IF (BETA.GT.0.0.AND.BETA.LE.1.0) GO TO 10	ORCO	7
	WRITE (6,906) BETA	ORCC	8
906	FORMAT (10X,'THE VALUE OF BETA (' ,E12.5,') IS OUTSIDE RANGE FOR ORORCO	ORCO	9
	1IFICE LOSS CALCULATION')	ORCO	10
10	ORIFIS = 1.0 - BETA*BETA	CRCC	11
	CD = FLOWCD (RENO,BETA)	ORCO	12
	ORIFIS = ORIFIS / (CI*CD)	OFCC	13
	RETURN	ORCO	14
	END	CRCC	15
	FUNCTION FLOWCD (RENO,B)	CODES	1
C	*****	CODES	2
C	FUNCTION FLOWCD CALCULATES THE COEFFICIENT OF DISCHARGE	CODES	3
C	FOR THE ORIFICES AS A FUNCTION OF THE REYNOLDS NUMBER	CODES	4
C	AND THE ORIFICE AREA	CODES	5
C	*****	CODES	6
	IF (RENO.GE.3.0.AND.RENO.LE.40.0) GO TO 30	CODES	7

Table A.2 (continued)

IF (RENO.GE.40.0.AND.RENO.LE.100.0) GO TO 40	COIS	8
IF (RENO.GE.100.0.AND.RENO.LE.400.0) GO TO 50	CODS	9
IF (RENO.GE.400.0.AND.RENO.LE.1000.0) GO TO 60	COIS	10
IF (RENO.GE.1000.0.AND.RENO.LE.2000.0) GO TO 70	CODS	11
IF (RENO.GE.2000.0.AND.RENO.LE.4000.0) GO TO 80	CODS	12
IF (RENO.GE.4000.0.AND.RENO.LE.10000.0) GO TO 90	COIS	13
IF (RENO.GE.10000.0.AND.RENO.LE.1.0E8) GO TO 100	COIS	14
WRITE (6,907) REFC	CODS	15
907 FORMAT(10X,'THE REYNOLDS NUMBER ('E12.5,') IS OUTSIDE RANGE FOR	COIS	16
1 FLOW COEFFICIENT CALCULATION')	CODS	17
STOP	CODS	18
30 FLOWCD = CD1 (R) + (CD2 (R) - CD1 (R)) * (RENO - 3.0) / 37.0	COIS	19
RETURN	CODS	20
40 FLOWCD = CD2 (R) + (CD3 (R) - CD2 (R)) * (RENO - 40.) / 60.0	CODS	21
RETURN	CODS	22
50 FLOWCD = CD3 (R) + (CD4 (R) - CD3 (R)) * (RENO - 100.) / 300.	CODS	23
RETURN	COIS	24
60 FLOWCD = CD4 (R) + (CD5 (R) - CD4 (R)) * (RENO - 400.) / 600.	CODS	25
RETURN	COIS	26
70 FLOWCD = CD5 (R) + (CD6 (R) - CD5 (R)) * (RENO - 1000.) / 1000.	CODS	27
RETURN	CODS	28
80 FLOWCD = CD6 (R) + (CD7 (R) - CD6 (R)) * (RENO - 2000.) / 2000.	COIS	29
RETURN	CODS	30
90 FLOWCD = CD7 (R) + (CD8 (R) - CD7 (R)) * (RENO - 4000.) / 6000.	COIS	31
RETURN	CODS	32
100 FLOWCD = CD8 (R) + (CD9 (R) - CD8 (R)) * (RENO - 1.0E4) / 9.999E7	CODS	33
RETURN	CODS	34
END	CODS	35
 FUNCTION CD1 (R)	 COIS	 1

Table A.2 (continued)

C	*****	C1IS	2
C	FUNCTION CD1 CALCULATES THE COEFFICIENT OF DISCHARGE	C1DS	3
C	AT REYNOLDS = 3.0	C1DS	4
C	*****	C1DS	5
	CD1 = .543653 - .161026*B - .221394*B*B	C1DS	6
	RETURN	C1DS	7
	END	C1DS	8
	FUNCTION CD2 (B)	C2DS	1
C	*****	C2DS	2
C	FUNCTION CD2 CALCULATES THE COEFFICIENT OF DISCHARGE	C2DS	3
C	AT REYNOLDS = 40.0	C2IS	4
C	*****	C2DS	5
	CD2 = .713844 - .257462*B + .531716*B*B	C2DS	6
	RETURN	C2IS	7
	END	C2DS	8
	FUNCTION CD3 (B)	C3DS	1
C	*****	C3IS	2
C	FUNCTION CD3 CALCULATES THE COEFFICIENT OF DISCHARGE	C3DS	3
C	AT REYNOLDS = 100.0	C3DS	4
C	*****	C3IS	5
	CD3 = .698708 - .36874*B + .968407*B*B	C3DS	6
	RETURN	C3DS	7
	END	C3DS	8
	FUNCTION CD4 (B)	C4DS	1

Table A.2 (continued)

C	*****	C4DS	2
C	FUNCTION CD4 CALCULATES THE COEFFICIENT OF DISCHARGE	C4DS	3
C	AT REYNOLDS = 400.0	C4IS	4
C	*****	C4DS	5
	CD4 = .649126 - .583087*B + 1.51107*B*B	C4DS	6
	RETURN	C4IS	7
	END	C4DS	8
	FUNCTION CD5 (B)	C5DS	1
C	*****	C5DS	2
C	FUNCTION CD5 CALCULATES THE COEFFICIENT OF DISCHARGE	C5DS	3
C	AT REYNOLDS = 1000.0	C5IS	4
C	*****	C5DS	5
	CD5 = .635092 - .7278*B + 1.72979*B*B	C5IS	6
	RETURN	C5DS	7
	END	C5DS	8
	FUNCTION CD6 (B)	C6IS	1
C	*****	C6DS	2
C	FUNCTION CD6 CALCULATES THE COEFFICIENT OF DISCHARGE	C6DS	3
C	AT REYNOLDS = 2000.0	C6DS	4
C	*****	C6DS	5
	CD6 = .644642 - .792987*B + 1.70455*B*B	C6IS	6
	RETURN	C6DS	7
	END	C6IS	8
	FUNCTION CI7 (B)	C7IS	1

Table A.2 (continued)

C	*****	C7DS	2
C	FUNCTION CD7 CALCULATES THE COEFFICIENT OF DISCHARGE	C7IS	3
C	AT REYNOLDS = 4000.0	C7DS	4
C	*****	C7DS	5
	CD7 = .605351 - .342319*B + .893482*B*B	C7IS	6
	RETURN	C7DS	7
	END	C7DS	8
	FUNCTION CD8 (B)	C8IS	1
C	*****	C8DS	2
C	FUNCTION CD8 CALCULATES THE COEFFICIENT OF DISCHARGE	C8DS	3
C	AT REYNOLDS = 10000.0	C8IS	4
C	*****	C8DS	5
	CD8 = .599747 - .225927*B + .620089*B*B	C8IS	6
	RETURN	C8IS	7
	END	C8DS	8
	FUNCTION CD9 (B)	C9DS	1
C	*****	C9IS	2
C	FUNCTION CD9 CALCULATES THE COEFFICIENT OF DISCHARGE	C9DS	3
C	AT REYNOLDS = 1.0E8	C9DS	4
C	*****	C9IS	5
	CD9 = .61	C9DS	6
	RETURN	C9DS	7
	END	C9DS	8
	FUNCTION VIS (T)	VISC	1

Table A.2 (continued)

C	*****	VISC	2
C	FUNCTION VIS CALCULATES THE VISCOSITY OF HELIUM IN	VISC	3
C	THE TEMPERATURE RANGE 0.0 TO 1600.0 DEG F	VISC	4
C	*****	VISC	5
	TR = T + 459.67	VISC	6
	IF (T.GT.0.0.AND.T.LE.1600.0) GO TO 10	VISC	7
10	VIS = 6.7E-4 * TR**0.68	VISC	8
	RETURN	VISC	9
	END	VISC	10
	FUNCTION OVERAL(DC,RF,TCF,W,A,TF,TIN,TOUT,P,AL)	OVRL	1
C	*****	OVRL	2
C	FUNCTION OVERAL CALCULATES AN OVERALL HEAT TRANSFER COEFFICIENT	OVRL	3
C	FROM THE CENTER OF THE FUEL STICK TO THE COOLANT CHANNEL	OVRL	4
C	*****	OVRL	5
	RC = DC/2.0	OVRL	6
	HTC = HEHTC(W,A,TF,TIN,TOUT,P,DC,AL)	OVRL	7
	IF (RC.GT.RF) GO TO 10	OVRL	8
	HTC = 1.0/(RC*HTC)	OVRL	9
	CONDTR = (ALOG(RF/RC))/TCF	OVRL	10
	OVERAL = 1.0/(RC*(HTC + CONDTR))	OVRL	11
	RETURN	OVRL	12
10	OVERAL = HTC	OVRL	13
	RETURN	OVRL	14
	END	OVRL	15

Table A.3. Listing of FLODIS Input Data For a DEDA

&CORE	DATA	1
RGWGTS=2990.0,6*1995.0,2737.0,451.1,792.0,	DATA	2
RGWGTB=2140.0,6*1409.0,1917.0,451.1,792.0,	DATA	3
VOLS=5.8987,6*3.9408,5.8987,0.4256,0.7479,	DATA	4
VOLB=4.1976,6*2.8042,4.1976,0.4256,0.7479,	DATA	5
&END	DATA	6
&COOLNT	DATA	7
DCOOLS=.500,	DATA	8
DCOOLL=.625,	DATA	9
ALCF=3.9,6*2.602,3.9,0.667,1.25,	DATA	10
ALCT=3.9,6*2.602,3.9,0.667,1.25,	DATA	11
APTS=8.07294,	DATA	12
APTW=5.70085,	DATA	13
APBS1=1.8654,	DATA	14
APBS2=2.405,	DATA	15
APBS3=8.3898,	DATA	16
APBW1=1.2436,	DATA	17
APBW2=2.405,	DATA	18
APBW3=8.3898,	DATA	19
ALLT=23.42,	DATA	20
&END	DATA	21
&INTGR	DATA	22
NREG=37,	DATA	23
NSEG=10,	DATA	24
NSUB=10,	DATA	25
NCOOLS=41,	DATA	26
NCOOLL=661,	DATA	27
NCLBS=29,	DATA	28
NCLBL=460,	DATA	29
NCOLT=247,	DATA	30

Table A.3 (continued)

NSTEP=1,	DATA 31
NSTEPS=148,	DATA 32
IQMAX=30,	DATA 33
NTREF=10,	DATA 34
NB1REF=71,	DATA 35
NB2REF=81,	DATA 36
NB3REF=91,	DATA 37
NADEAT=10,	DATA 38
&END	DATA 39
&ORIFIS	DATA 40
SP=1.1469,	DATA 41
WPER=7.36023,	DATA 42
AKOX=.98,	DATA 43
OMIN=0.01,	DATA 44
&END	DATA 45
&KFLAGS	DATA 46
KTMAX=30	DATA 47
KQMAX=30,	DATA 48
KFLCW=1,	DATA 49
KFRIC=1,	DATA 50
KITER=15,	DATA 51
KIOUT=15,	DATA 52
KFLAG1=20,	DATA 53
KFLAG2=0,	DATA 54
KFLAG3=0,	DATA 55
KFLAG4=0,	DATA 56
KFLAG5=0,	DATA 57
KFLAG6=0,	DATA 58
&END	DATA 59
&CONV RG	DATA 60

Table A.3 (continued)

E1=.0001,	DATA 61
E2=.0001,	DATA 62
E3=.0001,	DATA 63
E4=.0001,	DATA 64
E5=15.,	DATA 65
E6=15.,	DATA 66
E7=0.0001,	DATA 67
E8=0.0001,	DATA 68
E9=0.0001,	DATA 69
&END	DATA 70
&TEMP	DATA 71
RF=.033,	DATA 72
TCF=10.0,	DATA 73
AXLS1=6.660,	DATA 74
AXLS2=6.589,	DATA 75
AXLS3=6.050,	DATA 76
AXLB1=4.716,	DATA 77
AXLB2=4.706,	DATA 78
AXLB3=4.321,	DATA 79
&END	DATA 80
&PARM1	DATA 81
SSQT=879.0,	DATA 82
SSWT=3.4354E6,	DATA 83
HECP=1.2425,	DATA 84
HECV=.7460,	DATA 85
SSTIN=773.0,	DATA 86
SSC=.61,	DATA 87
PSS=706.0,	DATA 88
PDBA=12.7,	DATA 89
DELAY=4.8786,	DATA 90

Table A.3 (continued)

&END	DATA 91
®N	DATA 92
PR(1)=0.3383, 1.1274, 1.1660, 1.0785, 0.7964, 0.7131, 1.0140, 0.9952,	DATA 93
PR(9)=0.9567, 0.7714, 1.4835, 1.0275, 1.2336, 1.2378, 1.2492, 1.5397,	DATA 94
PR(17)=0.8901, 1.1243, 0.8547, 0.4495, 0.5205, 0.5372, 0.4949, 0.8016,	DATA 95
PR(25)=1.5261, 1.1140, 1.2388, 0.5569, 0.8656, 1.7843, 1.1129, 0.8595,	DATA 96
PR(33)=1.3544, 0.7808, 0.4272, 1.0629, 1.4043,	DATA 97
PA1(1)=10*0.0,	DATA 98
PA2(1)=0.75, 0.72, 0.71, 0.72, 0.75, 0.80, 0.85, 0.89, 0.94, 0.98,	DATA 99
PA3(1)=1.02, 1.05, 1.08, 1.11, 1.14, 1.17, 1.20, 1.23, 1.25, 1.27,	DATA 100
PA4(1)=1.28, 1.29, 1.30, 1.31, 1.32, 1.33, 1.34, 1.35, 1.36, 1.38,	DATA 101
PA5(1)=1.08, 1.10, 1.12, 1.11, 1.10, 1.09, 1.07, 1.06, 1.04, 1.03,	DATA 102
PA6(1)=1.01, 0.99, 0.97, 0.95, 0.93, 0.91, 0.89, 0.86, 0.84, 0.82,	DATA 103
PA7(1)=0.79, 0.77, 0.74, 0.72, 0.69, 0.67, 0.66, 0.67, 0.69, 0.74,	DATA 104
DPT=3.5425,	DATA 105
DB1=0.6292,	DATA 106
DB2=1.75,	DATA 107
DB3=3.5425,	DATA 108
&END	DATA 109
&TRANS	DATA 110
WTOT = 0.0,	DATA 111
TIN=734.0,	DATA 112
DELT = .08131,	DATA 113
&END	DATA 114
&TRANS	DATA 115
WTOT=13070.,	DATA 116
TIN=734.,	DATA 117
DELT=.00199,	DATA 118
&END	DATA 119
&TRANS	DATA 120

Table A.3 (continued)

WTOT=18528.,	DATA 121
TIN=702.5,	DATA 122
DELT=.00199,	DATA 123
&END	DATA 124
&TRANS	DATA 125
WTOT=18985.,	DATA 126
TIN=671.0,	DATA 127
DELT=.00199,	DATA 128
&END	DATA 129
&TRANS	DATA 130
WTOT=19443.,	DATA 131
TIN=639.5,	DATA 132
DELT=.00199,	DATA 133
&END	DATA 134
&TRANS	DATA 135
WTOT=19901.,	DATA 136
TIN=608.0,	DATA 137
DELT=.00199,	DATA 138
&END	DATA 139
&TRANS	DATA 140
WTOT=20358.,	DATA 141
TIN=576.5,	DATA 142
DELT=.00199,	DATA 143
&END	DATA 144
&TRANS	DATA 145
WTOT=20816.,	DATA 146
TIN=545.0,	DATA 147
DELT=.00199,	DATA 148
&END	DATA 149
&TRANS	DATA 150

APPENDIX B

This appendix contains selected computer output from the FLODIS code. The output represents the rapid depressurization accident described in the main body of this report. The first page is a listing of the input data for the code. The next page gives a summary of the flow and heat transfer input data along with nodal point information. At time zero (steady-state conditions) a reactor core map gives useful information about each refueling region. A detailed temperature distribution for the hottest refueling region is presented on the following page. Also at steady-state, a separate table is shown which summarizes the flow and pressure drop output. Transient information has been printed every hour thereafter; ending at 10 hr into the accident.

 ***** LISTING OF INPUT DATA *****

```

&CURE
RGWGT= 2990.0000 , 1995.0000 , 1995.0000 , 1995.0000 , 1995.0000 , 1995.0000 , 1995.0000 , 1995.0000 ,
2737.0000 , 451.09985 , 792.00000 , RGWGT= 2140.0000 , 1409.0000 , 1407.0000 , 1409.0000 ,
1409.0000 , 1409.0000 , 1409.0000 , 1917.0000 , 451.09985 , 792.00000 , VOLS= 5.8986998 ,
3.9407997 , 3.9407997 , 3.9407997 , 3.9407997 , 3.9407997 , 3.9407997 , 5.8986998 , 0.4255999 ,
0.7478999 , VOLS= 4.1975994 , 2.8041992 , 2.8041992 , 2.8041992 , 2.8041992 , 2.8041992 , 2.8041992 ,
2.8041992 , 4.1975994 , 0.4255999 , 0.7478999
&END
&CCOLNT
CCOLLS= 0.50000000 , CCCCC= 0.62500000 , ALCT= 3.8999999 , 2.6019993 , 2.6019993 , 2.6019993 , 2.6019993 ,
2.6019993 , 2.6019993 , 3.8999999 , 0.66700000 , 1.2500000 , ALCT= 3.8999999 , 2.6019993 ,
2.6019993 , 2.6019993 , 2.6019993 , 2.6019993 , 3.8999999 , 0.66700000 , 1.2500000 ,
APTS= 8.0729399 , APTW= 5.7003495 , APBS1= 1.8653994 , APBS2= 2.4044997 , APBS3= 8.3697991 , APBW1= 1.2435999 ,
APBW2= 2.4044997 , APBW3= 8.3697991 , ALLI= 23.41998
&END
&INTGR
NRLG= 37, NSEG= 10, NSUB= 1, NCOLLS= 41, NCOLL= 661, NCLBS= 29, NCLBL= 400, NCOLT=
247, NSTEP= 1, NSILPS= 140, EQMAX= 30, NTRF= 10, NBLRKF= 71, NBLREF= 81, NBLREF=
91, NBLREF=
&END
&CURFIS
SP= 1.1468992 , WPER= 7.3602295 , AKUX= 0.9999999 , UMIN= 0.999999999-02
&END
&KFLAGS
KIMAX= 30, KUMAX= 30, KFLUX= 1, KFRIC= 1, KITER= 15, KIOUT= 15, KFLAG1= 20,
KFLAG2= 0, KFLAG3= 0, KFLAG4= 0, KFLAG5= 0, KFLAG6= 0
&END
&CUNVRG
E1= 0.999999999-04, E2= 0.999999999-04, E3= 0.999999999-04, E4= 0.999999999-04, E5= 15.000000 , E6= 15.000000 , E7=
0.999999999-04, E8= 0.999999999-04, E9= 0.999999999-04
&END
&TEMP
RF= 0.330000000-01, TCF= 10.000000 , AXLS1= 6.5599999 , AXLS2= 6.5599999 , AXLS3= 6.0499992 , AXLS4= 4.7159996 ,
AXLS5= 4.7059994 , AXLS6= 4.3209991
&END
&PARAM
SSQT= 879.00000 , SSWT= 3435400.0 , HECF= 1.2424994 , HECV= 0.7459999 , SSFIN= 773.00000 , SSC= 0.6099999 , PSS=
706.00000 , PD8A= 12.70000 , DELAY= 4.6755992
&END
&REGN
PR= 0.33829999 , 1.1273994 , 1.1659994 , 1.0784996 , 0.79639995 , 0.71309996 , 1.0139999 , 0.99519998 ,
0.95669997 , 0.77139997 , 1.4634995 , 1.0274992 , 1.2335997 , 1.2377996 , 1.2491999 , 1.5396996 ,
0.89009994 , 1.1242990 , 0.85469997 , 0.44949996 , 0.52049994 , 0.53719997 , 0.49489999 , 0.80159998 ,
1.5260992 , 1.1139994 , 1.2387991 , 0.55089996 , 0.86559999 , 1.7842999 , 1.1128998 , 0.85349999 ,
1.3543997 , 0.78079998 , 0.42719996 , 1.0626996 , 1.4042997 , PA1= 0.0 , 0.0 , 0.0 ,
0.0 , 0.0 , 0.0 , 0.0 , 0.0 , 0.0 , PA2= 0.75000000 ,
0.71999997 , 0.70799998 , 0.71999997 , 0.75000000 , 0.79999995 , 0.84599996 , 0.88999999 , 0.94000000 ,
0.97999996 , PA3= 1.0199995 , 1.0499992 , 1.0799999 , 1.1099997 , 1.1399994 , 1.1699991 , 1.1999996 ,
1.2299995 , 1.2500000 , 1.2655995 , PA4= 1.2799997 , 1.2900000 , 1.2999992 , 1.3099995 , 1.3199997 ,
1.3299999 , 1.3399992 , 1.3499994 , 1.3599997 , 1.3799992 , PA5= 1.0799999 , 1.0999994 , 1.1199999 ,
1.1099997 , 1.0999994 , 1.0899992 , 1.0699997 , 1.0599995 , 1.0400000 , 1.0299997 , PA6= 1.0399993 ,
0.98999995 , 0.96999997 , 0.94999999 , 0.92999995 , 0.90999997 , 0.88999999 , 0.85999995 , 0.83999997 ,
0.81999999 , PA7= 0.78999996 , 0.76999998 , 0.73999995 , 0.71999997 , 0.69000000 , 0.66999996 , 0.65999997 ,
0.66999996 , 0.69000000 , 0.73999995 , 0.71999997 , 0.69199998 , 0.62999999 , 0.62999999 , 0.63999999 ,
&END
  
```

```

*****
** ORIFICE CYLINDER **
** AREA = 1.1469 SQ FT **
*****

REFUELING REGION PLENUM AREA = 8.07294 SQ FT

*****
TOP REFLECTOR
*****
                STANDARD      BOUNDARY
REFLECTOR BLOCK COLUMNS PER REGION          7           5
NUMBER OF AXIAL SEGMENTS                     1           1
NUMBER OF SUBDIVISIONS PER SEGMENT            10          10
FLOW AREA (SQ FT)                           1.4642       1.0196
HEAT TRANSFER AREA PER NODE (SQ FT)         44.2738     30.8347
MASS OF GRAPHITE PER NODE (LBM)              299.00      214.00

*****
ACTIVE CORE
*****
                STANDARD      BOUNDARY
FUEL BLOCK COLUMNS PER REGION               7           5
NUMBER OF AXIAL SEGMENTS                    10           6
NUMBER OF SUBDIVISIONS PER SEGMENT           10           10
FLOW AREA (SQ FT)                          1.4642       1.0196
HEAT TRANSFER AREA PER NODE (SQ FT)        29.5386     20.5723
MASS OF CORE PER NODE (LBM)                 199.50      140.90

*****
BOTTOM REFLECTOR
*****
                STANDARD      BOUNDARY
REFLECTOR BLOCK COLUMNS PER REGION          7           5
NUMBER OF AXIAL SEGMENTS                     1           1
NUMBER OF SUBDIVISIONS PER SEGMENT            10          10
FLOW AREA (SQ FT)                           1.4642       1.0196
HEAT TRANSFER AREA PER NODE (SQ FT)         44.2738     30.8347
MASS OF GRAPHITE PER NODE (LBM)              273.70      191.70

*****
CORE SUPPORT BLOCK
*****
                STANDARD      BOUNDARY
NUMBER OF AXIAL SEGMENTS                     2           2
NUMBER OF SUBDIVISIONS PER SEGMENT           10           10
FLOW AREA
UPPER LEVEL (SQ FT)                         1.8654       1.2436
LOWER LEVEL (SQ FT)                       2.4050       2.4050
HEAT TRANSFER AREA
UPPER LEVEL (SQ FT)                        7.5720       5.2735
LOWER LEVEL (SQ FT)                      14.1903      9.8829
MASS OF GRAPHITE PER NODE
UPPER LEVEL (LBM)                         45.11        45.11
LOWER LEVEL (LBM)                        79.20       79.20

```

FORI SAINT VRAIN FLOW REDISTRIBUTION

AFTER DEPRESSURIZATION ACCIDENT

TIME = 0.0 (HOURS) TOTAL FLOW = 3435400.0 (LB/HR) INLET TEMPERATURE = 773. DEG F MIXED MEAN OUT = 1469. DEG F

REGION 35	REGION 36	REGION 37	REGION 20
FLOW = 25708.55	FLOW = 103483.38	FLOW = 136721.88	FLOW = 31259.34
LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10
FUEL = 1565.	FUEL = 1599.	FUEL = 1613.	FUEL = 1567.
HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.

REGION 34	REGION 18	REGION 19	REGION 8	REGION 21
FLOW = 76018.25	FLOW = 109461.19	FLOW = 83213.13	FLOW = 96892.13	FLOW = 50675.61
LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10
FUEL = 1535.	FUEL = 1601.	FUEL = 1589.	FUEL = 1596.	FUEL = 1571.
HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.

REGION 33	REGION 17	REGION 7	REGION 2	REGION 9	REGION 22
FLOW = 131863.63	FLOW = 86059.69	FLOW = 98722.50	FLOW = 109763.00	FLOW = 93143.81	FLOW = 32361.52
LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10
FUEL = 1611.	FUEL = 1591.	FUEL = 1596.	FUEL = 1602.	FUEL = 1574.	FUEL = 1572.
HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.

REGION 32	REGION 16	REGION 6	REGION 1	REGION 3	REGION 10	REGION 23
FLOW = 59771.77	FLOW = 149904.38	FLOW = 69427.00	FLOW = 32936.70	FLOW = 113521.13	FLOW = 75103.06	FLOW = 34416.57
LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10
FUEL = 1590.	FUEL = 1618.	FUEL = 1582.	FUEL = 1557.	FUEL = 1603.	FUEL = 1585.	FUEL = 1570.
HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.

REGION 31	REGION 15	REGION 5	REGION 4	REGION 11	REGION 24
FLOW = 108351.31	FLOW = 121621.44	FLOW = 77537.06	FLOW = 105002.19	FLOW = 144432.75	FLOW = 78043.31
LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10
FUEL = 1601.	FUEL = 1607.	FUEL = 1586.	FUEL = 1599.	FUEL = 1616.	FUEL = 1586.
HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.

REGION 30	REGION 14	REGION 13	REGION 12	REGION 25
FLOW = 173718.50	FLOW = 120511.56	FLOW = 120102.63	FLOW = 100036.81	FLOW = 148580.25
LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10
FUEL = 1627.	FUEL = 1606.	FUEL = 1606.	FUEL = 1597.	FUEL = 1618.
HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.

REGION 29	REGION 28	REGION 27	REGION 26
FLOW = 60195.97	FLOW = 54219.50	FLOW = 120608.81	FLOW = 77470.25
LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10
FUEL = 1590.	FUEL = 1573.	FUEL = 1606.	FUEL = 1602.
HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.	HE OUT= 1469.

TEMPERATURE DISTRIBUTION FOR HOT REFUELING REGION

TIME = 0.0 HRS REGION = 30 REGION FLOW = 173718.5 LB/HR NORMALIZED FLOW (WF(30)/WAVG) = 1.7843

* NODE * LOCATION * (SEGMENT * POSITION)	* DISTANCE * FROM CHANNEL * ENTRANCE * (FEET)	* COOLANT * TEMPERATURE * (DEG F)	* FUEL AND/OR * MODERATOR * TEMPERATURE * (DEG F)	* NODE * LOCATION * (SEGMENT * POSITION)	* DISTANCE * FROM CHANNEL * ENTRANCE * (FEET)	* COOLANT * TEMPERATURE * (DEG F)	* FUEL AND/OR * MODERATOR * TEMPERATURE * (DEG F)
(1, 1)	0.0	773.0	773.0	(6, 1)	14.30798	1279.8	1514.3
(1, 2)	0.39000	773.0	773.0	(6, 2)	14.56818	1291.5	1521.2
(1, 3)	0.78000	773.0	773.0	(6, 3)	14.82838	1303.0	1527.9
(1, 4)	1.17000	773.0	773.0	(6, 4)	15.08858	1314.2	1534.4
(1, 5)	1.56000	773.0	773.0	(6, 5)	15.34877	1325.3	1540.7
(1, 6)	1.95000	773.0	773.0	(6, 6)	15.60897	1336.0	1546.7
(1, 7)	2.34000	773.0	773.0	(6, 7)	15.86917	1346.6	1552.5
(1, 8)	2.73000	773.0	773.0	(6, 8)	16.12936	1356.9	1555.8
(1, 9)	3.12000	773.0	773.0	(6, 9)	16.38956	1366.9	1561.0
(1, 10)	3.51000	773.0	775.3	(6, 10)	16.64975	1376.6	1566.0
(2, 1)	3.89999	773.2	949.3	(7, 1)	16.90994	1386.1	1568.6
(2, 2)	4.16019	781.7	953.8	(7, 2)	17.17014	1395.3	1573.0
(2, 3)	4.42039	790.1	959.7	(7, 3)	17.43033	1404.2	1575.0
(2, 4)	4.68059	798.3	970.3	(7, 4)	17.69052	1412.8	1578.8
(2, 5)	4.94079	806.7	985.7	(7, 5)	17.95071	1421.2	1580.2
(2, 6)	5.20099	815.4	1006.2	(7, 6)	18.21091	1429.2	1583.6
(2, 7)	5.46119	824.6	1027.2	(7, 7)	18.47110	1437.0	1589.1
(2, 8)	5.72139	834.5	1046.6	(7, 8)	18.73129	1444.6	1598.9
(2, 9)	5.98159	844.8	1068.7	(7, 9)	18.99149	1452.4	1611.3
(2, 10)	6.24179	855.7	1089.0	(7, 10)	19.25168	1460.4	1627.4
(3, 1)	6.50199	867.1	1109.7	(8, 1)	19.51187	1468.8	1470.8
(3, 2)	6.76219	878.9	1128.5	(8, 2)	19.90187	1469.0	1469.0
(3, 3)	7.02239	891.1	1147.7	(8, 3)	20.29187	1469.0	1469.0
(3, 4)	7.28259	903.6	1167.1	(8, 4)	20.68187	1469.0	1469.0
(3, 5)	7.54279	916.5	1186.9	(8, 5)	21.07187	1469.0	1469.0
(3, 6)	7.80299	929.7	1207.1	(8, 6)	21.46187	1469.0	1469.0
(3, 7)	8.06319	943.3	1227.5	(8, 7)	21.85187	1469.0	1469.0
(3, 8)	8.32339	957.2	1248.3	(8, 8)	22.24187	1469.0	1469.0
(3, 9)	8.58359	971.5	1267.1	(8, 9)	22.63187	1469.0	1469.0
(3, 10)	8.84379	986.0	1286.0	(8, 10)	23.02187	1469.0	1469.0
(4, 1)	9.10399	1000.7	1302.9	(9, 1)	23.41187	1469.0	1469.0
(4, 2)	9.36419	1015.6	1319.8	(9, 2)	23.47856	1469.0	1469.0
(4, 3)	9.62438	1030.5	1336.9	(9, 3)	23.54526	1469.0	1469.0
(4, 4)	9.88458	1045.6	1354.0	(9, 4)	23.61195	1469.0	1469.0
(4, 5)	10.14478	1060.8	1371.3	(9, 5)	23.67865	1469.0	1469.0
(4, 6)	10.40498	1076.1	1388.7	(9, 6)	23.74535	1469.0	1469.0
(4, 7)	10.66518	1091.5	1406.2	(9, 7)	23.81204	1469.0	1469.0
(4, 8)	10.92538	1107.1	1423.8	(9, 8)	23.87874	1469.0	1469.0
(4, 9)	11.18558	1122.7	1441.6	(9, 9)	23.94543	1469.0	1469.0
(4, 10)	11.44578	1138.5	1460.1	(9, 10)	24.01213	1469.0	1469.0
(5, 1)	11.70598	1154.4	1408.5	(10, 1)	24.07883	1469.0	1469.0
(5, 2)	11.96618	1167.1	1424.0	(10, 2)	24.20383	1469.0	1469.0
(5, 3)	12.22638	1179.8	1441.1	(10, 3)	24.32883	1469.0	1469.0
(5, 4)	12.48658	1192.8	1451.7	(10, 4)	24.45383	1469.0	1469.0
(5, 5)	12.74678	1205.7	1462.1	(10, 5)	24.57883	1469.0	1469.0
(5, 6)	13.00698	1218.4	1472.3	(10, 6)	24.70383	1469.0	1469.0
(5, 7)	13.26718	1231.1	1480.2	(10, 7)	24.82883	1469.0	1469.0
(5, 8)	13.52738	1243.5	1490.0	(10, 8)	24.95383	1469.0	1469.0
(5, 9)	13.78758	1255.8	1497.6	(10, 9)	25.07883	1469.0	1469.0
(5, 10)	14.04778	1267.8	1507.1	(10, 10)	25.20383	1469.0	1469.0
	14.30798	1279.8			25.32883	1469.0	

REGION FLOW AND PRESSURE DROP SUMMARY

TIME = 0.0 HOURS

TOTAL FLOW = 3435400.0 LB/HR

PLENUM TO PLENUM PRESSURE DROP = 9.80071 PSIA

REGION FLOW INFORMATION

PRESSURE DROP INFORMATION

REGION	RADIAL PEAKING FACTOR	REGION FLOW (LB/HR)	RATIO TO AVERAGE FLOW	% OF TOTAL FLOW	ORIFICE DROP (PSIA)	% OF TOTAL DROP	ENTRANCE DROP (PSIA)	% OF TOTAL DROP	CHANNEL DROP (PSIA)	% OF TOTAL DROP
1	0.33830	32936.7	0.3383	1.0	9.35815	95.5	0.03152	0.3	0.41104	4.2
2	1.12740	109763.0	1.1274	3.2	5.60915	57.2	0.35002	3.6	3.84154	39.2
3	1.16600	113521.1	1.1660	3.3	5.34002	54.5	0.37440	3.8	4.08029	41.7
4	1.07850	105002.2	1.0785	3.1	5.33899	60.6	0.32032	3.3	3.54140	36.1
5	0.79640	77537.1	0.7964	2.3	7.59645	77.5	0.17466	1.8	2.02959	20.7
6	0.71310	69427.0	0.7131	2.0	3.00437	81.7	0.14004	1.4	1.65631	16.9
7	1.01400	98722.5	1.0140	2.9	6.35501	64.8	0.28315	2.9	3.16255	32.3
8	0.99520	96892.1	0.9952	2.8	6.47216	66.0	0.27275	2.8	3.05579	31.2
9	0.95670	93143.8	0.9567	2.7	6.70629	68.4	0.25205	2.6	2.84237	29.0
10	0.77140	75103.1	0.7714	2.2	7.72284	78.8	0.16387	1.7	1.91400	19.5
11	1.48350	144432.8	1.4835	4.2	2.83752	29.0	0.60606	6.2	6.35713	64.9
12	1.02750	100036.8	1.0275	2.9	6.26973	64.0	0.29074	3.0	3.24024	33.1
13	1.23360	120162.6	1.2336	3.5	4.85024	49.5	0.41907	4.3	4.53139	46.2
14	1.23780	120511.6	1.2378	3.5	4.91904	49.2	0.42193	4.3	4.55974	46.5
15	1.24920	121621.4	1.2492	3.5	4.73388	48.3	0.42974	4.4	4.63709	47.3
16	1.53970	149954.4	1.5397	4.4	2.34154	23.9	0.65285	6.7	6.80032	69.4
17	0.89010	86659.7	0.8901	2.5	7.09277	72.4	0.21818	2.2	2.48975	25.4
18	1.12430	109461.2	1.1243	3.2	5.63043	57.4	0.34810	3.6	3.82218	39.0
19	0.85470	83213.1	0.8547	2.4	7.28861	74.4	0.20117	2.1	2.31093	23.6
20	0.44950	31259.3	0.4495	0.9	9.03322	92.2	0.02839	0.3	0.73910	7.5
21	0.52050	50675.6	0.5205	1.5	8.80068	89.8	0.07461	0.8	0.92543	9.4
22	0.53720	52301.5	0.5372	1.5	8.73989	89.2	0.07947	0.8	0.98135	10.0
23	0.49490	34416.6	0.4949	1.0	8.88185	90.6	0.03441	0.4	0.88444	9.0
24	0.80160	78043.3	0.8016	2.3	7.56974	77.2	0.17695	1.8	2.05402	21.0
25	1.52610	148580.3	1.5261	4.3	2.46300	25.1	0.64137	6.5	6.69634	68.3
26	1.11400	77470.3	1.1140	2.3	5.68326	58.0	0.17436	1.8	3.94307	40.2
27	1.23880	120608.8	1.2388	3.5	4.81161	49.1	0.42261	4.3	4.56049	46.6
28	0.55690	54219.5	0.5569	1.6	8.66615	88.4	0.08541	0.9	1.04916	10.7
29	0.86560	60196.0	0.8656	1.8	7.21374	73.6	0.10527	1.1	2.48169	25.3
30	1.78430	173718.5	1.7843	5.1	0.0	0.0	0.87675	8.9	8.92396	91.1
31	1.11290	108351.3	1.1129	3.2	5.70825	58.2	0.34108	3.5	3.75139	38.3
32	0.85950	59771.8	0.8595	1.7	7.24725	73.9	0.10379	1.1	2.44967	25.0
33	1.35440	131863.6	1.3544	3.8	3.91681	40.0	0.50517	5.2	5.37874	54.9
34	0.78080	76018.3	0.7808	2.2	7.67572	78.3	0.16789	1.7	1.95710	20.0
35	0.42720	29706.5	0.4272	0.9	9.10318	92.9	0.02564	0.3	0.67189	6.9
36	1.06290	103483.4	1.0629	3.0	6.04160	61.6	0.31112	3.2	3.44799	35.2
37	1.40430	136721.9	1.4043	4.0	3.50960	35.8	0.54307	5.5	5.74803	58.6

PORT SAINT VRAIN FLOW REDISTRIBUTION

AFTER DEPRESSURIZATION ACCIDENT

TIME = 1.00000 (HOURS) TOTAL FLOW = 33526.9 (LB/HR) INLET TEMPERATURE = 249. DEG F MIXED MEAN OUT = 1546. DEG F

REGION 35	REGION 36	REGION 37	REGION 20
FLOW = 472.40	FLOW = 1023.96	FLOW = 1030.32	FLOW = 488.36
LOCATION 7, 8	LOCATION 7, 7	LOCATION 7, 2	LOCATION 7, 8
FUEL = 1588.	FUEL = 1753.	FUEL = 1861.	FUEL = 1593.
HE OUT= 1493.	HE OUT= 1550.	HE OUT= 1581.	HE OUT= 1495.

REGION 34	REGION 18	REGION 19	REGION 8	REGION 21
FLOW = 936.55	FLOW = 1031.58	FLOW = 968.86	FLOW = 1011.33	FLOW = 758.08
LOCATION 7, 8	LOCATION 7, 7	LOCATION 7, 8	LOCATION 7, 8	LOCATION 7, 8
FUEL = 1673.	FUEL = 1771.	FUEL = 1694.	FUEL = 1733.	FUEL = 1608.
HE OUT= 1522.	HE OUT= 1556.	HE OUT= 1529.	HE OUT= 1543.	HE OUT= 1499.

REGION 33	REGION 17	REGION 7	REGION 2	REGION 9	REGION 22
FLOW = 1034.04	FLOW = 981.80	FLOW = 1015.31	FLOW = 1031.88	FLOW = 1001.99	FLOW = 772.85
LOCATION 7, 3	LOCATION 7, 8	LOCATION 7, 8	LOCATION 7, 7	LOCATION 7, 8	LOCATION 7, 8
FUEL = 1844.	FUEL = 1703.	FUEL = 1739.	FUEL = 1772.	FUEL = 1722.	FUEL = 1612.
HE OUT= 1576.	HE OUT= 1533.	HE OUT= 1545.	HE OUT= 1556.	HE OUT= 1539.	HE OUT= 1500.

REGION 32	REGION 16	REGION 6	REGION 1	REGION 3	REGION 10	REGION 23
FLOW = 681.59	FLOW = 1014.91	FLOW = 900.25	FLOW = 563.76	FLOW = 1034.87	FLOW = 931.91	FLOW = 519.60
LOCATION 7, 8	LOCATION 6, 10	LOCATION 7, 8	LOCATION 7, 8	LOCATION 7, 7	LOCATION 7, 8	LOCATION 7, 8
FUEL = 1659.	FUEL = 1909.	FUEL = 1656.	FUEL = 1567.	FUEL = 1784.	FUEL = 1671.	FUEL = 1604.
HE OUT= 1528.	HE OUT= 1591.	HE OUT= 1516.	HE OUT= 1484.	HE OUT= 1559.	HE OUT= 1521.	HE OUT= 1498.

REGION 31	REGION 15	REGION 5	REGION 4	REGION 11	REGION 24
FLOW = 1030.42	FLOW = 1037.40	FLOW = 943.99	FLOW = 1026.23	FLOW = 1022.14	FLOW = 946.40
LOCATION 7, 7	LOCATION 7, 7	LOCATION 7, 8	LOCATION 7, 7	LOCATION 7, 1	LOCATION 7, 8
FUEL = 1768.	FUEL = 1810.	FUEL = 1678.	FUEL = 1758.	FUEL = 1889.	FUEL = 1679.
HE OUT= 1554.	HE OUT= 1567.	HE OUT= 1524.	HE OUT= 1551.	HE OUT= 1587.	HE OUT= 1524.

REGION 30	REGION 14	REGION 13	REGION 12	REGION 25
FLOW = 974.09	FLOW = 1037.35	FLOW = 1037.30	FLOW = 1017.94	FLOW = 1016.76
LOCATION 6, 8	LOCATION 7, 7	LOCATION 7, 7	LOCATION 7, 8	LOCATION 7, 1
FUEL = 2001.	FUEL = 1806.	FUEL = 1805.	FUEL = 1743.	FUEL = 1904.
HE OUT= 1609.	HE OUT= 1566.	HE OUT= 1566.	HE OUT= 1546.	HE OUT= 1590.

REGION 29	REGION 28	REGION 27	REGION 26
FLOW = 683.12	FLOW = 789.65	FLOW = 1037.35	FLOW = 719.82
LOCATION 7, 8	LOCATION 7, 8	LOCATION 7, 7	LOCATION 7, 7
FUEL = 1700.	FUEL = 1617.	FUEL = 1807.	FUEL = 1774.
HE OUT= 1529.	HE OUT= 1502.	HE OUT= 1566.	HE OUT= 1551.

PORT SAINT VRAIN FLOW REDISTRIBUTION

AFTER DEPRESSURIZATION ACCIDENT

TIME = 2.00000 (HOURS) TOTAL FLOW = 34169.9 (LB/HR) INLET TEMPERATURE = 235. DEG F MIXED MEAN OUT = 1655. DEG F

REGION 35	REGION 36	REGION 37	REGION 20
FLOW = 475.54	FLOW = 1059.38	FLOW = 1027.80	FLOW = 492.53
LOCATION 7, 9	LOCATION 7, 9	LOCATION 7, 8	LOCATION 7, 9
FUEL = 1587.	FUEL = 1797.	FUEL = 1976.	FUEL = 1592.
HE OUT= 1519.	HE OUT= 1662.	HE OUT= 1751.	HE OUT= 1522.

REGION 34	REGION 18	REGION 19	REGION 8	REGION 21
FLOW = 968.39	FLOW = 1063.36	FLOW = 1004.52	FLOW = 1048.84	FLOW = 769.17
LOCATION 7, 9	LOCATION 7, 9	LOCATION 7, 9	LOCATION 7, 9	LOCATION 7, 9
FUEL = 1683.	FUEL = 1827.	FUEL = 1709.	FUEL = 1767.	FUEL = 1607.
HE OUT= 1592.	HE OUT= 1678.	HE OUT= 1609.	HE OUT= 1644.	HE OUT= 1538.

REGION 33	REGION 17	REGION 7	REGION 2	REGION 9	REGION 22
FLOW = 1039.27	FLOW = 1018.65	FLOW = 1052.45	FLOW = 1063.43	FLOW = 1039.79	FLOW = 785.31
LOCATION 7, 8	LOCATION 7, 9	LOCATION 7, 9	LOCATION 7, 9	LOCATION 7, 9	LOCATION 7, 9
FUEL = 1948.	FUEL = 1723.	FUEL = 1775.	FUEL = 1828.	FUEL = 1750.	FUEL = 1611.
HE OUT= 1738.	HE OUT= 1618.	HE OUT= 1649.	HE OUT= 1679.	HE OUT= 1634.	HE OUT= 1541.

REGION 32	REGION 16	REGION 6	REGION 1	REGION 3	REGION 10	REGION 23
FLOW = 705.91	FLOW = 989.60	FLOW = 927.36	FLOW = 563.09	FLOW = 1063.26	FLOW = 963.15	FLOW = 526.15
LOCATION 7, 9	LOCATION 7, 8	LOCATION 7, 9	LOCATION 7, 9	LOCATION 7, 9	LOCATION 7, 9	LOCATION 7, 9
FUEL = 1719.	FUEL = 2055.	FUEL = 1661.	FUEL = 1565.	FUEL = 1847.	FUEL = 1680.	FUEL = 1604.
HE OUT= 1599.	HE OUT= 1783.	HE OUT= 1577.	HE OUT= 1506.	HE OUT= 1689.	HE OUT= 1589.	HE OUT= 1529.

REGION 31	REGION 15	REGION 5	REGION 4	REGION 11	REGION 24
FLOW = 1063.01	FLOW = 1056.98	FLOW = 976.76	FLOW = 1060.88	FLOW = 1006.50	FLOW = 979.47
LOCATION 7, 9	LOCATION 7, 8	LOCATION 7, 9	LOCATION 7, 9	LOCATION 7, 8	LOCATION 7, 9
FUEL = 1821.	FUEL = 1890.	FUEL = 1688.	FUEL = 1805.	FUEL = 2022.	FUEL = 1690.
HE OUT= 1675.	HE OUT= 1711.	HE OUT= 1595.	HE OUT= 1666.	HE OUT= 1770.	HE OUT= 1596.

REGION 30	REGION 14	REGION 13	REGION 12	REGION 25
FLOW = 907.31	FLOW = 1058.29	FLOW = 1058.73	FLOW = 1054.71	FLOW = 993.81
LOCATION 7, 5	LOCATION 7, 8	LOCATION 7, 8	LOCATION 7, 9	LOCATION 7, 8
FUEL = 2201.	FUEL = 1884.	FUEL = 1882.	FUEL = 1781.	FUEL = 2047.
HE OUT= 1835.	HE OUT= 1768.	HE OUT= 1707.	HE OUT= 1653.	HE OUT= 1780.

REGION 29	REGION 28	REGION 27	REGION 26
FLOW = 707.56	FLOW = 803.75	FLOW = 1058.18	FLOW = 739.66
LOCATION 7, 9	LOCATION 7, 9	LOCATION 7, 8	LOCATION 7, 9
FUEL = 1721.	FUEL = 1616.	FUEL = 1885.	FUEL = 1833.
HE OUT= 1601.	HE OUT= 1545.	HE OUT= 1708.	HE OUT= 1660.

PORT SAINT VRAIN FLOW REDISTRIBUTION

AFTER DEPRESSURIZATION ACCIDENT

TIME = 3.00000 (HOURS) TOTAL FLOW = 34618.8 (LE/HR) INLET TEMPERATURE = 227. DEG F MIXED MEAN OUT = 1700. DEG F

REGION 35	REGION 36	REGION 37	REGION 20
FLOW = 465.85	FLOW = 1093.01	FLOW = 1030.84	FLOW = 484.10
LOCATION 7,10	LOCATION 7,10	LOCATION 7, 9	LOCATION 7,10
FUEL = 1549.	FUEL = 1712.	FUEL = 1961.	FUEL = 1550.
HE OUT= 1528.	HE OUT= 1693.	HE OUT= 1855.	HE OUT= 1531.

REGION 34	REGION 18	REGION 19	REGION 8	REGION 21
FLOW = 984.66	FLOW = 1096.07	FLOW = 1027.74	FLOW = 1081.12	FLOW = 760.77
LOCATION 10,10	LOCATION 7,10	LOCATION 10,10	LOCATION 7,10	LOCATION 8, 8
FUEL = 1602.	FUEL = 1749.	FUEL = 1622.	FUEL = 1676.	FUEL = 1553.
HE OUT= 1598.	HE OUT= 1720.	HE OUT= 1619.	HE OUT= 1666.	HE OUT= 1548.

REGION 33	REGION 17	REGION 7	REGION 2	REGION 9	REGION 22
FLOW = 1050.16	FLOW = 1044.78	FLOW = 1085.33	FLOW = 1096.04	FLOW = 1070.32	FLOW = 778.18
LOCATION 7, 9	LOCATION 10,10	LOCATION 7,10	LOCATION 7,10	LOCATION 7,10	LOCATION 8, 8
FUEL = 1919.	FUEL = 1632.	FUEL = 1685.	FUEL = 1750.	FUEL = 1657.	FUEL = 1555.
HE OUT= 1830.	HE OUT= 1629.	HE OUT= 1673.	HE OUT= 1721.	HE OUT= 1652.	HE OUT= 1551.

REGION 32	REGION 16	REGION 6	REGION 1	REGION 3	REGION 10	REGION 23
FLOW = 722.11	FLOW = 968.67	FLOW = 936.76	FLOW = 546.62	FLOW = 1094.12	FLOW = 978.49	FLOW = 519.18
LOCATION 7,10	LOCATION 7, 9	LOCATION 10,10	LOCATION 7,10	LOCATION 7, 9	LOCATION 10,10	LOCATION 7,10
FUEL = 1630.	FUEL = 2080.	FUEL = 1586.	FUEL = 1542.	FUEL = 1776.	FUEL = 1599.	FUEL = 1554.
HE OUT= 1615.	HE OUT= 1920.	HE OUT= 1583.	HE OUT= 1520.	HE OUT= 1739.	HE OUT= 1596.	HE OUT= 1538.

REGION 31	REGION 15	REGION 5	REGION 4	REGION 11	REGION 24
FLOW = 1096.05	FLOW = 1081.23	FLOW = 994.58	FLOW = 1094.47	FLOW = 995.82	FLOW = 997.79
LOCATION 7,10	LOCATION 7, 9	LOCATION 10,10	LOCATION 7,10	LOCATION 7, 9	LOCATION 10,10
FUEL = 1741.	FUEL = 1835.	FUEL = 1606.	FUEL = 1721.	FUEL = 2030.	FUEL = 1607.
HE OUT= 1715.	HE OUT= 1778.	HE OUT= 1602.	HE OUT= 1700.	HE OUT= 1894.	HE OUT= 1604.

REGION 30	REGION 14	REGION 13	REGION 12	REGION 25
FLOW = 847.71	FLOW = 1083.66	FLOW = 1084.51	FLOW = 1087.91	FLOW = 975.37
LOCATION 7, 8	LOCATION 7, 9	LOCATION 7, 9	LOCATION 7,10	LOCATION 7, 9
FUEL = 2304.	FUEL = 1827.	FUEL = 1824.	FUEL = 1692.	FUEL = 2068.
HE OUT= 2025.	HE OUT= 1773.	HE OUT= 1771.	HE OUT= 1679.	HE OUT= 1914.

REGION 29	REGION 28	REGION 27	REGION 26
FLOW = 724.09	FLOW = 798.21	FLOW = 1083.46	FLOW = 759.88
LOCATION 7,10	LOCATION 8, 8	LOCATION 7, 9	LOCATION 7, 9
FUEL = 1633.	FUEL = 1558.	FUEL = 1828.	FUEL = 1763.
HE OUT= 1617.	HE OUT= 1554.	HE OUT= 1773.	HE OUT= 1708.

PORT SAINT VRAIN FLOW REDISTRIBUTION

AFTER DEPRESSURIZATION ACCIDENT

TIME = 4.00000 (HOURS) TOTAL FLCW = 34949.6 (LB/HR) INLET TEMPERATURE = 221. DEG F MIXED MEAN OUT = 1644. DEG F

REGION 35	REGION 36	REGION 37	REGION 20
FLOW = 451.43	FLOW = 1123.06	FLOW = 1040.97	FLOW = 470.24
LOCATION 9, 5	LOCATION 10,10	LOCATION 10,10	LOCATION 9, 6
FUEL = 1523.	FUEL = 1612.	FUEL = 1853.	FUEL = 1524.
HE OUT= 1510.	HE OUT= 1604.	HE OUT= 1847.	HE OUT= 1510.

REGION 34	REGION 18	REGION 19	REGION 8	REGION 21
FLOW = 990.02	FLOW = 1128.08	FLOW = 1040.65	FLOW = 1106.93	FLOW = 744.19
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1526.	FUEL = 1646.	FUEL = 1537.	FUEL = 1580.	FUEL = 1523.
HE OUT= 1514.	HE OUT= 1639.	HE OUT= 1527.	HE OUT= 1572.	HE OUT= 1511.

REGION 33	REGION 17	REGION 7	REGION 2	REGION 9	REGION 22
FLOW = 1067.84	FLOW = 1061.25	FLOW = 1112.50	FLOW = 1128.09	FLOW = 1093.01	FLOW = 762.59
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1812.	FUEL = 1545.	FUEL = 1588.	FUEL = 1648.	FUEL = 1566.	FUEL = 1523.
HE OUT= 1806.	HE OUT= 1536.	HE OUT= 1580.	HE OUT= 1641.	HE OUT= 1557.	HE OUT= 1510.

REGION 32	REGION 16	REGION 6	REGION 1	REGION 3	REGION 10	REGION 23
FLOW = 731.79	FLOW = 953.76	FLOW = 935.39	FLOW = 524.82	FLOW = 1126.20	FLOW = 982.88	FLOW = 506.73
LOCATION 10,10	LOCATION 7,10	LOCATION 10,10	LOCATION 9, 4	LOCATION 10,10	LOCATION 10,10	LOCATION 9, 8
FUEL = 1575.	FUEL = 1998.	FUEL = 1520.	FUEL = 1521.	FUEL = 1672.	FUEL = 1525.	FUEL = 1527.
HE OUT= 1542.	HE OUT= 1960.	HE OUT= 1508.	HE OUT= 1517.	HE OUT= 1665.	HE OUT= 1513.	HE OUT= 1509.

REGION 31	REGION 15	REGION 5	REGION 4	REGION 11	REGION 24
FLOW = 1127.85	FLOW = 1109.96	FLOW = 1001.52	FLOW = 1125.21	FLOW = 991.82	FLOW = 1005.26
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 7,10	LOCATION 10,10
FUEL = 1639.	FUEL = 1731.	FUEL = 1527.	FUEL = 1620.	FUEL = 1928.	FUEL = 1528.
HE OUT= 1632.	HE OUT= 1723.	HE OUT= 1516.	HE OUT= 1612.	HE OUT= 1914.	HE OUT= 1517.

REGION 30	REGION 14	REGION 13	REGION 12	REGION 25
FLOW = 789.36	FLOW = 1113.13	FLOW = 1114.23	FLOW = 1115.98	FLOW = 963.14
LOCATION 7, 9	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 7,10
FUEL = 2319.	FUEL = 1722.	FUEL = 1719.	FUEL = 1594.	FUEL = 1981.
HE OUT= 2143.	HE OUT= 1715.	HE OUT= 1712.	HE OUT= 1586.	HE OUT= 1949.

REGION 29	REGION 28	REGION 27	REGION 26
FLOW = 734.17	FLOW = 783.89	FLOW = 1112.87	FLOW = 780.18
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1577.	FUEL = 1522.	FUEL = 1723.	FUEL = 1680.
HE OUT= 1544.	HE OUT= 1509.	HE OUT= 1716.	HE OUT= 1654.

PORT SAINT VRAIN FLOW REDISTRIBUTION

AFTER DEPRESSURIZATION ACCIDENT

TIME = 5.00000 (HOURS) TOTAL FLOW = 34982.7 (LB/HR) INLET TEMPERATURE = 220. DEG F MIXED MEAN OUT = 1500. DEG F

REGION 35	REGION 36	REGION 37	REGION 20
FLOW = 435.76	FLOW = 1137.74	FLOW = 1052.69	FLOW = 454.82
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1500.	FUEL = 1436.	FUEL = 1752.	FUEL = 1496.
HE OUT= 1461.	HE OUT= 1412.	HE OUT= 1739.	HE OUT= 1452.

REGION 34	REGION 18	REGION 19	REGION 8	REGION 21
FLOW = 982.18	FLOW = 1146.94	FLOW = 1038.16	FLOW = 1116.07	FLOW = 723.76
LOCATION 10,10	LOCATION 9, 4	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1389.	FUEL = 1467.	FUEL = 1388.	FUEL = 1414.	FUEL = 1451.
HE OUT= 1353.	HE OUT= 1455.	HE OUT= 1354.	HE OUT= 1385.	HE OUT= 1420.

REGION 33	REGION 17	REGION 7	REGION 2	REGION 9	REGION 22
FLOW = 1085.00	FLOW = 1061.55	FLOW = 1123.22	FLOW = 1147.13	FLOW = 1098.86	FLOW = 742.67
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 9, 4	LOCATION 10,10	LOCATION 10,10
FUEL = 1692.	FUEL = 1391.	FUEL = 1419.	FUEL = 1469.	FUEL = 1404.	FUEL = 1446.
HE OUT= 1680.	HE OUT= 1358.	HE OUT= 1391.	HE OUT= 1457.	HE OUT= 1373.	HE OUT= 1413.

REGION 32	REGION 16	REGION 6	REGION 1	REGION 3	REGION 10	REGION 23
FLOW = 731.24	FLOW = 943.34	FLOW = 923.34	FLOW = 502.37	FLOW = 1147.09	FLOW = 974.42	FLOW = 492.04
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1462.	FUEL = 1921.	FUEL = 1397.	FUEL = 1506.	FUEL = 1503.	FUEL = 1389.	FUEL = 1489.
HE OUT= 1386.	HE OUT= 1909.	HE OUT= 1361.	HE OUT= 1493.	HE OUT= 1495.	HE OUT= 1354.	HE OUT= 1435.

REGION 31	REGION 15	REGION 5	REGION 4	REGION 11	REGION 24
FLOW = 1146.12	FLOW = 1132.30	FLOW = 994.75	FLOW = 1141.07	FLOW = 991.57	FLOW = 598.86
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1462.	FUEL = 1577.	FUEL = 1388.	FUEL = 1445.	FUEL = 1850.	FUEL = 1387.
HE OUT= 1437.	HE OUT= 1568.	HE OUT= 1353.	HE OUT= 1420.	HE OUT= 1838.	HE OUT= 1353.

REGION 30	REGION 14	REGION 13	REGION 12	REGION 25
FLOW = 736.82	FLOW = 1135.54	FLOW = 1136.64	FLOW = 1127.83	FLOW = 955.26
LOCATION 7,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 2277.	FUEL = 1566.	FUEL = 1562.	FUEL = 1424.	FUEL = 1904.
HE OUT= 2196.	HE OUT= 1557.	HE OUT= 1553.	HE OUT= 1396.	HE OUT= 1892.

REGION 29	REGION 28	REGION 27	REGION 26
FLOW = 733.94	FLOW = 764.63	FLOW = 1135.27	FLOW = 792.87
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1462.	FUEL = 1440.	FUEL = 1567.	FUEL = 1560.
HE OUT= 1387.	HE OUT= 1406.	HE OUT= 1558.	HE OUT= 1510.

PORT SAINT VRAIN FLOW REDISTRIBUTION

AFTER DEPRESSURIZATION ACCIDENT

TIME = 6.00000 (HOURS) TOTAL FLOW = 34982.7 (LB/HR) INLET TEMPERATURE = 220. DEG F MIXED MEAN OUT = 1335. DEG F

REGION 35	REGION 36	REGION 37	REGION 20
FLOW = 424.94	FLOW = 1142.90	FLOW = 1072.23	FLOW = 444.14
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1456.	FUEL = 1258.	FUEL = 1587.	FUEL = 1446.
HE OUT= 1381.	HE OUT= 1228.	HE OUT= 1575.	HE OUT= 1365.

REGION 34	REGION 18	REGION 19	REGION 8	REGION 21
FLOW = 971.83	FLOW = 1157.18	FLOW = 1030.46	FLOW = 1116.20	FLOW = 709.00
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1220.	FUEL = 1294.	FUEL = 1211.	FUEL = 1231.	FUEL = 1351.
HE OUT= 1182.	HE OUT= 1264.	HE OUT= 1175.	HE OUT= 1199.	HE OUT= 1305.

REGION 33	REGION 17	REGION 7	REGION 2	REGION 9	REGION 22
FLOW = 1106.54	FLOW = 1055.47	FLOW = 1124.67	FLOW = 1157.62	FLOW = 1096.46	FLOW = 728.07
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1513.	FUEL = 1211.	FUEL = 1237.	FUEL = 1296.	FUEL = 1220.	FUEL = 1339.
HE OUT= 1503.	HE OUT= 1177.	HE OUT= 1206.	HE OUT= 1266.	HE OUT= 1188.	HE OUT= 1293.

REGION 32	REGION 16	REGION 6	REGION 1	REGION 3	REGION 10	REGION 23
FLOW = 727.22	FLOW = 947.07	FLOW = 911.28	FLOW = 486.67	FLOW = 1160.82	FLOW = 963.80	FLOW = 481.70
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1312.	FUEL = 1815.	FUEL = 1240.	FUEL = 1472.	FUEL = 1324.	FUEL = 1222.	FUEL = 1424.
HE OUT= 1220.	HE OUT= 1798.	HE OUT= 1199.	HE OUT= 1446.	HE OUT= 1294.	HE OUT= 1183.	HE OUT= 1336.

REGION 31	REGION 15	REGION 5	REGION 4	REGION 11	REGION 24
FLOW = 1155.31	FLOW = 1151.77	FLOW = 984.90	FLOW = 1147.48	FLOW = 1003.48	FLOW = 989.16
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1287.	FUEL = 1395.	FUEL = 1217.	FUEL = 1267.	FUEL = 1718.	FUEL = 1216.
HE OUT= 1257.	HE OUT= 1367.	HE OUT= 1179.	HE OUT= 1236.	HE OUT= 1702.	HE OUT= 1179.

REGION 30	REGION 14	REGION 13	REGION 12	REGION 25
FLOW = 700.76	FLOW = 1154.36	FLOW = 1155.20	FLOW = 1130.27	FLOW = 961.13
LOCATION 7,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 2213.	FUEL = 1385.	FUEL = 1381.	FUEL = 1242.	FUEL = 1791.
HE OUT= 2200.	HE OUT= 1356.	HE OUT= 1352.	HE OUT= 1212.	HE OUT= 1774.

REGION 29	REGION 28	REGION 27	REGION 26
FLOW = 730.16	FLOW = 750.24	FLOW = 1154.15	FLOW = 801.39
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1312.	FUEL = 1325.	FUEL = 1385.	FUEL = 1402.
HE OUT= 1220.	HE OUT= 1279.	HE OUT= 1357.	HE OUT= 1319.

PORT SAINT VRAIN FLOW BED DISTRIBUTION

AFTER DEPRESSURIZATION ACCIDENT

TIME = 7.00000 (HOURS) TOTAL FLOW = 34982.7 (LB/HR) INLET TEMPERATURE = 220. DEG F MIXED MEAN OUT = 1181. DEG F

REGION 35	REGION 36	REGION 37	REGION 20
FLOW = 418.88	FLOW = 1141.59	FLOW = 1096.05	FLOW = 437.67
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1389.	FUEL = 1085.	FUEL = 1421.	FUEL = 1369.
HE OUT= 1283.	HE OUT= 1063.	HE OUT= 1395.	HE OUT= 1261.

REGION 34	REGION 18	REGION 19	REGION 8	REGION 21
FLOW = 961.75	FLOW = 1160.33	FLOW = 1021.09	FLOW = 1111.10	FLOW = 699.98
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1055.	FUEL = 1118.	FUEL = 1044.	FUEL = 1060.	FUEL = 1223.
HE OUT= 1025.	HE OUT= 1096.	HE OUT= 1017.	HE OUT= 1037.	HE OUT= 1172.

REGION 33	REGION 17	REGION 7	REGION 2	REGION 9	REGION 22
FLOW = 1128.74	FLOW = 1046.77	FLOW = 1120.51	FLOW = 1161.02	FLOW = 1089.75	FLOW = 718.96
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1351.	FUEL = 1044.	FUEL = 1066.	FUEL = 1120.	FUEL = 1051.	FUEL = 1206.
HE OUT= 1324.	HE OUT= 1018.	HE OUT= 1043.	HE OUT= 1098.	HE OUT= 1028.	HE OUT= 1156.

REGION 32	REGION 16	REGION 6	REGION 1	REGION 3	REGION 10	REGION 23
FLOW = 721.93	FLOW = 963.28	FLOW = 901.14	FLOW = 477.69	FLOW = 1167.47	FLOW = 953.67	FLOW = 475.64
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1146.	FUEL = 1676.	FUEL = 1079.	FUEL = 1423.	FUEL = 1147.	FUEL = 1058.	FUEL = 1330.
HE OUT= 1064.	HE OUT= 1659.	HE OUT= 1044.	HE OUT= 1380.	HE OUT= 1124.	HE OUT= 1027.	HE OUT= 1219.

REGION 31	REGION 15	REGION 5	REGION 4	REGION 11	REGION 24
FLOW = 1157.56	FLOW = 1165.93	FLOW = 974.89	FLOW = 1147.21	FLOW = 1024.98	FLOW = 579.19
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1111.	FUEL = 1222.	FUEL = 1052.	FUEL = 1092.	FUEL = 1558.	FUEL = 1051.
HE OUT= 1089.	HE OUT= 1198.	HE OUT= 1022.	HE OUT= 1070.	HE OUT= 1545.	HE OUT= 1021.

REGION 30	REGION 14	REGION 13	REGION 12	REGION 25
FLOW = 680.31	FLOW = 1167.51	FLOW = 1167.97	FLOW = 1126.83	FLOW = 978.28
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 2183.	FUEL = 1211.	FUEL = 1206.	FUEL = 1070.	FUEL = 1646.
HE OUT= 2172.	HE OUT= 1186.	HE OUT= 1182.	HE OUT= 1048.	HE OUT= 1630.

REGION 29	REGION 28	REGION 27	REGION 26
FLOW = 724.98	FLOW = 741.01	FLOW = 1167.39	FLOW = 905.74
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1146.	FUEL = 1187.	FUEL = 1212.	FUEL = 1231.
HE OUT= 1064.	HE OUT= 1139.	HE OUT= 1187.	HE OUT= 1154.

F O R T S A I N T V R A I N F L O W R E D I S T R I B U T I O N

A F T E R D E P R E S S U R I Z A T I O N A C C I D E N T

TIME = 8.00000 (HOURS) TOTAL FLOW = 34982.7 (LB/HR) INLET TEMPERATURE = 220. DEG F MIXED MEAN OUT = 1058. DEG F

REGION 35	REGION 36	REGION 37	REGION 20
FLOW = 415.53	FLOW = 1136.81	FLOW = 1119.69	FLOW = 434.56
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1299.	FUEL = 958.	FUEL = 1277.	FUEL = 1272.
HE OUT= 1175.	HE OUT= 944.	HE OUT= 1254.	HE OUT= 1149.

REGION 34	REGION 18	REGION 19	REGION 8	REGION 21
FLOW = 952.69	FLOW = 1158.93	FLOW = 1011.81	FLOW = 1103.79	FLOW = 694.54
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 924.	FUEL = 988.	FUEL = 917.	FUEL = 935.	FUEL = 1088.
HE OUT= 903.	HE OUT= 974.	HE OUT= 900.	HE OUT= 921.	HE OUT= 1041.

REGION 33	REGION 17	REGION 7	REGION 2	REGION 9	REGION 22
FLOW = 1148.32	FLOW = 1037.65	FLOW = 1113.78	FLOW = 1159.83	FLOW = 1081.51	FLOW = 713.28
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1201.	FUEL = 918.	FUEL = 941.	FUEL = 989.	FUEL = 926.	FUEL = 1069.
HE OUT= 1181.	HE OUT= 902.	HE OUT= 927.	HE OUT= 975.	HE OUT= 912.	HE OUT= 1024.

REGION 32	REGION 16	REGION 6	REGION 1	REGION 3	REGION 10	REGION 23
FLOW = 716.44	FLOW = 987.81	FLOW = 892.76	FLOW = 473.38	FLOW = 1169.05	FLOW = 944.69	FLOW = 472.25
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1002.	FUEL = 1532.	FUEL = 943.	FUEL = 1353.	FUEL = 1013.	FUEL = 926.	FUEL = 1218.
HE OUT= 940.	HE OUT= 1519.	HE OUT= 918.	HE OUT= 1297.	HE OUT= 998.	HE OUT= 905.	HE OUT= 1099.

REGION 31	REGION 15	REGION 5	REGION 4	REGION 11	REGION 24
FLOW = 1155.45	FLOW = 1174.93	FLOW = 965.73	FLOW = 1143.19	FLOW = 1051.61	FLOW = 570.02
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 982.	FUEL = 1079.	FUEL = 922.	FUEL = 965.	FUEL = 1416.	FUEL = 921.
HE OUT= 968.	HE OUT= 1063.	HE OUT= 902.	HE OUT= 951.	HE OUT= 1392.	HE OUT= 901.

REGION 30	REGION 14	REGION 13	REGION 12	REGION 25
FLOW = 671.89	FLOW = 1175.39	FLOW = 1175.44	FLOW = 1120.58	FLOW = 1004.23
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 2143.	FUEL = 1069.	FUEL = 1065.	FUEL = 945.	FUEL = 1500.
HE OUT= 2124.	HE OUT= 1053.	HE OUT= 1049.	HE OUT= 931.	HE OUT= 1488.

REGION 29	REGION 28	REGION 27	REGION 26
FLOW = 719.53	FLOW = 735.01	FLOW = 1175.36	FLOW = 806.97
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1001.	FUEL = 1048.	FUEL = 1070.	FUEL = 1079.
HE OUT= 940.	HE OUT= 1006.	HE OUT= 1053.	HE OUT= 1023.

PORT SAINT VRAIN FLOW REDISTRIBUTION

AFTER DEPRESSURIZATION ACCIDENT

TIME = 9.00000 (HOURS) TOTAL FLOW = 34982.7 (LB/HR) INLET TEMPERATURE = 220. DEG F MIXED MEAN OUT = 968. DEG F

REGION 35	REGION 36	REGION 37	REGION 20
FLOW = 414.00	FLOW = 1130.88	FLOW = 1140.85	FLOW = 432.84
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1197.	FUEL = 876.	FUEL = 1154.	FUEL = 1163.
HE OUT= 1068.	HE OUT= 868.	HE OUT= 1138.	HE OUT= 1039.

REGION 34	REGION 18	REGION 19	REGION 8	REGION 21
FLOW = 944.80	FLOW = 1155.44	FLOW = 1003.44	FLOW = 1096.24	FLOW = 690.78
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 834.	FUEL = 901.	FUEL = 833.	FUEL = 855.	FUEL = 963.
HE OUT= 821.	HE OUT= 893.	HE OUT= 822.	HE OUT= 846.	HE OUT= 926.

REGION 33	REGION 17	REGION 7	REGION 2	REGION 9	REGION 22
FLOW = 1164.07	FLOW = 1029.23	FLOW = 1106.59	FLOW = 1156.48	FLOW = 1073.44	FLOW = 709.22
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 1085.	FUEL = 836.	FUEL = 860.	FUEL = 903.	FUEL = 846.	FUEL = 946.
HE OUT= 1072.	HE OUT= 826.	HE OUT= 852.	HE OUT= 895.	HE OUT= 837.	HE OUT= 910.

REGION 32	REGION 16	REGION 6	REGION 1	REGION 3	REGION 10	REGION 23
FLOW = 711.28	FLOW = 1016.61	FLOW = 885.69	FLOW = 471.67	FLOW = 1167.83	FLOW = 936.90	FLOW = 470.07
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 893.	FUEL = 1412.	FUEL = 844.	FUEL = 1266.	FUEL = 923.	FUEL = 834.	FUEL = 1098.
HE OUT= 853.	HE OUT= 1390.	HE OUT= 828.	HE OUT= 1201.	HE OUT= 914.	HE OUT= 821.	HE OUT= 986.

REGION 31	REGION 15	REGION 5	REGION 4	REGION 11	REGION 24
FLOW = 1151.42	FLOW = 1179.94	FLOW = 957.70	FLOW = 1137.77	FLOW = 1079.18	FLOW = 961.94
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 896.	FUEL = 980.	FUEL = 833.	FUEL = 862.	FUEL = 1294.	FUEL = 832.
HE OUT= 888.	HE OUT= 969.	HE OUT= 820.	HE OUT= 874.	HE OUT= 1273.	HE OUT= 820.

REGION 30	REGION 14	REGION 13	REGION 12	REGION 25
FLOW = 672.05	FLOW = 1179.40	FLOW = 1179.11	FLOW = 1113.68	FLOW = 1033.08
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 2089.	FUEL = 971.	FUEL = 968.	FUEL = 864.	FUEL = 1384.
HE OUT= 2068.	HE OUT= 961.	HE OUT= 958.	HE OUT= 856.	HE OUT= 1360.

REGION 29	REGION 28	REGION 27	REGION 26
FLOW = 714.38	FLOW = 730.60	FLOW = 1179.46	FLOW = 806.36
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10
FUEL = 894.	FUEL = 927.	FUEL = 971.	FUEL = 966.
HE OUT= 853.	HE OUT= 895.	HE OUT= 962.	HE OUT= 929.

PORT SAINT VRAIN FLOW REDISTRIBUTION

AFTER DEPRESSURIZATION ACCIDENT

TIME =10.00000 (HOURS) TOTAL FLCW = 34982.7 (LB/HR) INLET TEMPERATURE = 220. DEG F MIXED MEAN OUT = 906. DEG F

REGION 35	REGION 36	REGION 37	REGION 20
FLOW = 412.91	FLOW = 1125.03	FLOW = 1158.46	FLOW = 431.53
LOCATION 10,10	LOCATION 7, 9	LOCATION 10,10	LOCATION 10,10
FUEL = 1089.	FUEL = 835.	FUEL = 1063.	FUEL = 1052.
HE OUT= 967.	HE OUT= 820.	HE OUT= 1052.	HE OUT= 939.

REGION 34	REGION 18	REGION 19	REGION 8	REGION 21
FLOW = 938.00	FLOW = 1151.30	FLOW = 996.18	FLOW = 1089.35	FLOW = 687.57
LOCATION 10,10	LOCATION 7, 9	LOCATION 10,10	LOCATION 7, 9	LOCATION 10,10
FUEL = 779.	FUEL = 858.	FUEL = 781.	FUEL = 813.	FUEL = 861.
HE OUT= 765.	HE OUT= 843.	HE OUT= 771.	HE OUT= 800.	HE OUT= 834.

REGION 33	REGION 17	REGION 7	REGION 2	REGION 9	REGION 22
FLOW = 1176.06	FLOW = 1021.89	FLOW = 1099.91	FLOW = 1152.46	FLOW = 1066.24	FLOW = 705.73
LOCATION 10,10	LOCATION 7, 9	LOCATION 7, 9	LOCATION 7, 9	LOCATION 7, 9	LOCATION 10,10
FUEL = 1003.	FUEL = 785.	FUEL = 819.	FUEL = 859.	FUEL = 802.	FUEL = 847.
HE OUT= 995.	HE OUT= 776.	HE OUT= 805.	HE OUT= 844.	HE OUT= 791.	HE OUT= 822.

REGION 32	REGION 16	REGION 6	REGION 1	REGION 3	REGION 10	REGION 23
FLOW = 706.66	FLOW = 1046.46	FLOW = 879.58	FLOW = 471.02	FLOW = 1165.35	FLOW = 930.18	FLOW = 468.25
LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 10,10	LOCATION 7, 9	LOCATION 10,10	LOCATION 10,10
FUEL = 821.	FUEL = 1308.	FUEL = 781.	FUEL = 1167.	FUEL = 876.	FUEL = 779.	FUEL = 985.
HE OUT= 796.	HE OUT= 1288.	HE OUT= 765.	HE OUT= 1100.	HE OUT= 861.	HE OUT= 765.	HE OUT= 890.

REGION 31	REGION 15	REGION 5	REGION 4	REGION 11	REGION 24
FLOW = 1146.90	FLOW = 1182.35	FLOW = 950.78	FLOW = 1132.29	FLOW = 1105.36	FLOW = 954.98
LOCATION 7, 9	LOCATION 7, 9	LOCATION 10,10	LOCATION 7, 9	LOCATION 10,10	LOCATION 10,10
FUEL = 853.	FUEL = 920.	FUEL = 779.	FUEL = 840.	FUEL = 1190.	FUEL = 779.
HE OUT= 838.	HE OUT= 908.	HE OUT= 766.	HE OUT= 825.	HE OUT= 1174.	HE OUT= 766.

REGION 30	REGION 14	REGION 13	REGION 12	REGION 25
FLOW = 678.37	FLOW = 1181.00	FLOW = 1180.42	FLOW = 1107.20	FLOW = 1062.36
LOCATION 10,10	LOCATION 7, 9	LOCATION 7, 9	LOCATION 7, 9	LOCATION 10,10
FUEL = 2030.	FUEL = 913.	FUEL = 911.	FUEL = 823.	FUEL = 1277.
HE OUT= 2009.	HE OUT= 900.	HE OUT= 898.	HE OUT= 809.	HE OUT= 1259.

REGION 29	REGION 28	REGION 27	REGION 26
FLOW = 709.76	FLOW = 726.77	FLOW = 1181.13	FLOW = 804.82
LOCATION 10,10	LOCATION 10,10	LOCATION 7, 9	LOCATION 10,10
FUEL = 821.	FUEL = 833.	FUEL = 914.	FUEL = 891.
HE OUT= 796.	HE OUT= 810.	HE OUT= 901.	HE OUT= 869.

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