COBRA-WC: A Version of COBRA for Single-Phase Multiassembly Thermal Hydraulic Transient Analysis

July 1980

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

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PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
Under Contract DE-AC06-76RLO 1830

Printed in the United States of America
Available from
National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151

Price: Printed Copy \$ _____ *: Microfiche \$3.00

*Pages	NTIS
	Selling Price
001-025	\$4.00
026-050	\$4.50
051-075	\$5.25
076-100	\$6.00
101-125	\$6.50
126-150	\$7.25
151-175	\$8.00
176-200	\$9.00
201-225	\$9.25
226-250	\$9.50
251-275	\$10.75
276-300	\$11.00

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COBRA-WC: A VERSION OF
COBRA FOR SINGLE-PHASE
MULTIASSEMBLY THERMAL
HYDRAULIC TRANSIENT ANALYSIS

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SYMBOLS AND NOTATION

$$\bar{\phi}_j = \frac{\phi_j + \phi_{j-1}}{2}$$

ϕ_j^* refers to donor cell quantity, e.g., $\psi_j^* = \begin{matrix} \phi_j, & v_j \geq 0 \\ \phi_{j+1}, & v_j < 0 \end{matrix}$

ψ_i - set of gap numbers for gap which connect channel i to adjacent channels

λ_i - set of rod numbers for rods which connect to channel i

τ_i - set of wall numbers for walls which connect to channel i

γ_n - set of channel numbers for channels with a thermal connection to rod n

ξ_m - set of channel numbers for channels adjacent to wall m

e_k - multiplier (± 1) which gives the correct sign to the transverse connection terms

Ω_w - set of materials which make up wall w

SUPERSCRIPT

n - time step level

SUBSCRIPTS

c - refers to cladding

f - refers to fuel or material replacing fuel in the pin model

g - fuel - cladding gap

i - subchannel number or generalized subscript for matrix notation

j - axial level or generalized subscript for matrix notation

$\left. \begin{matrix} II \\ JJ \end{matrix} \right\}$ - refer to channel numbers on either side of a transverse gap

k - transverse gap number

m - wall number

n - rod number

w - refers to heat conducting wall

VARIABLES

- A - subchannel area (ft^2)
- A_{HTR} - effective area for heat transfer from a rod (ft^2)
- A_{HTW} - area for heat transfer from a wall (ft^2)
- A_T - area for transverse flow between channels (S x) (ft^2)
- c - fluid specific heat ($\text{Btu/lbm-}^\circ\text{F}$)
- C - axial loss coefficient
- c_c - cladding specific heat ($\text{Btu/lbm-}^\circ\text{F}$)
- c_f - fuel specific heat ($\text{Btu/lbm-}^\circ\text{F}$)
- c_w - effective wall heat capacity ($\text{Btu/lbm-}^\circ\text{F}$)
- C_T - transverse loss coefficient
- D_H - channel hydraulic diameter = $4 \times \text{AREA/WETTED PERIMETER}$
- D_w - wall width (ft)
- f - friction factor
- h - fluid enthalpy (Btu/lbm)
- H - channel film coefficient ($\text{Btu/sec-ft}^2\text{-}^\circ\text{F}$)
- H_g - fuel-cladding gap conductance ($\text{Btu/sec-ft}^2\text{-}^\circ\text{F}$)
- H_R - rod film coefficient ($\text{Btu/sec-ft}^2\text{-}^\circ\text{F}$)
- H_w - wall film coefficient ($\text{Btu/sec-ft}^2\text{-}^\circ\text{F}$)
- K - fluid conductivity ($\text{Btu/ft-}^\circ\text{F}$)
- K_f - fuel conductivity ($\text{Btu/sec-ft-}^\circ\text{F}$)
- K_w - wall conductivity ($\text{Btu/sec-}^\circ\text{F-ft}$)
- ℓ - length of transverse momentum control volume (ft)
- m - axial flow rate (lbm/sec)
- P - fluid static pressure (lb/ft^2)
- q - heat deposited in fluid (Btu/sec)
- q_f - heat generation in the fuel (Btu/sec)
- q_w - heat generation in the wall (Btu/sec)
- q''' - volumetric heat generation in fuel (Btu/sec-ft^3)
- q_w''' - volumetric heat generation in wall (Btu/sec-ft^3)
- r - radial location in the rod (ft)
- R_c - outer radius of the cladding (ft)
- R_f - outer radius of the fuel material (ft)

S - transverse gap width (ft)
 Δt - time step (sec)
 T - fluid temperature ($^{\circ}\text{F}$)
 $\hat{T}$ - average fluid temperature around a rod ($^{\circ}\text{F}$)
 t_w - effective wall thickness for heat storage (ft)
 t'_w - effective wall thickness for heat generation (ft)
 T_c - cladding temperature ($^{\circ}\text{F}$)
 T_f - fuel temperature ($^{\circ}\text{F}$)
 T_{fs} - temperature of the fuel surface ($^{\circ}\text{F}$)
 T_w - wall temperature ($^{\circ}\text{F}$)
 u - transverse velocity (ft/sec)
 U - effective wall conductance (Btu/sec-ft²- $^{\circ}\text{F}$)
 v - axial velocity (ft/sec)
 w_T - crossflow due to turbulent exchange (lbm/sec)
 Δx - axial step (ft)
 y_c - cladding thickness (ft)
 Z - factor for effective fluid radial conduction length
 β - coefficient for turbulent mixing
 η_a - axial power factor
 η_r - radial power factor
 η_t - transient power factor
 θ - problem orientation, angle from verticle (degrees)
 ρ - fluid density (lbm/ft³)
 ρ_c - cladding density (lbm/ft³)
 ρ_f - fuel density (lbm/ft³)
 ρ_w - effective wall density (lbm/ft³)
 ϕ - rod-to-channel heat fraction

1.0 INTRODUCTION

The objective of this report is to provide the user of the COBRA-WC (Whole Core) code a basic understanding of the code operation and capabilities. Included in this manual are the equations solved and the assumptions made in their derivations, a general description of the code capabilities, an explanation of the numerical algorithms used to solve the equations, and input instructions for using the code. Also, the auxiliary programs GEOM and SPECSET are described and input instructions for each are given. Input for COBRA-WC sample problems and the corresponding output are given in the appendices.

The COBRA-WC code has been developed from the COBRA-IV-I⁽¹⁾ code to analyze Liquid Metal Fast Breeder Reactor (LMFBR) assembly transients. It was specifically developed to analyze a core flow coastdown to natural circulation cooling. In this transient, single-assembly analysis is not sufficient since heat transfer between adjacent assemblies and interassembly flow redistribution can be significant, particularly in heterogeneous cores. The COBRA-WC core was designed to model many assemblies simultaneously and can account for these interassembly effects.

The basic subchannel nature of the COBRA-IV-I code has been retained in the COBRA-WC code and the equations solved are essentially the same, although the new code is limited to single-phase problems. The COBRA-WC code calculates a solution to the incompressible subchannel conservation equations for mass and momentum and solves energy equations for the coolant, cladding, fuel and other heat-conducting media in the core. The equations are all solved fully implicitly to allow the use of large time steps in long LMFBR transients as well as provide for steady state solutions. While the code was developed to obtain results for the natural circulation transient, its use is not limited to this problem. COBRA-WC has all the single-phase capabilities of the COBRA-IV-I code and can be applied to many of the problems the COBRA-IV-I code has been used for. The subchannel modeling approach used in COBRA-WC makes the code suitable for obtaining detailed flow and temperature distributions for one or several assemblies and less detailed results on a core-wide basis.

Since COBRA-WC was written to solve long transient problems, considerable attention was paid to reducing the computation time whenever possible. Some success has been obtained in this area with the COBRA-WC code solving standard COBRA-IV-I problems in as little as one-quarter of the time required by the COBRA-IV-I code without sacrificing any of the physical modeling or any detail in time and space. Also, the COBRA-WC code is capable of running some transients which could not be run using the COBRA-IV-I code due to numerical instabilities resulting from the explicit (iteratively) coupling between the rod and coolant energy equations.

As the code is released and begins to get wider usage, errors in the code will undoubtedly be discovered. Users are encouraged to provide the developers with a description of the difficulties encountered with COBRA-WC so that these problems may be remedied in future editions of the code. It is hoped that this manual will provide enough information for a person knowledgeable in thermal-hydraulics to apply the code effectively.

2.0 SUMMARY

The COBRA-WC code retains many of the useful features of the COBRA-IV-I code. The most significant features are listed below.

1. The subchannel modeling approach has been retained.
2. The card group input format, though modified to allow for the additional input, is basically the same.
3. The equations solved are the same as those in COBRA-IV-I, and finite difference form similar.
4. The capability to solve large-bundle or many-channel problems using peripheral storage devices has been retained.
5. Wire-wrapped and gridded assemblies are solved in essentially the same manner as in COBRA-IV-I.
6. The orthogonal collocation method is used to model the fuel pins.
7. "Dump" and "Restart" capabilities have not been changed.
8. The auxiliary program GEOM can be used to generate input data for LMFBR assemblies.
9. The auxiliary program SPECSET is used to redimension the COBRA-WC common block variables to allow flexibility in problem size.

There are a few capabilities that were removed from COBRA-WC in the interests of creating a code that could perform LMFBR analysis with the smallest possible computation time.

1. The two phase capability has been removed, restricting the use of the code to fluid conditions prior to boiling.
2. The fully temperature dependent fuel property capability was removed and replaced with a simple but much faster approximation that accounts for the temperature dependence of the fuel properties on a more average basis.
3. Axial conduction in the fuel or coolant is not considered.

4. The line plotting capability in COBRA-IV-I has been removed.

Some features of the COBRA-WC code substantially increase the capabilities over those of COBRA-IV-I.

1. The energy equations for the rod and coolant are solved simultaneously rather than iteratively, eliminating a severe restriction on time step size for certain LMFBR transients.
2. The subroutine XSCHEM in COBRA-IV-I was replaced by a much faster scheme, RECIRC, which can be used to solve problems with flow recirculation.
3. The input has been modified to make it easier for the user to apply the code to multiassembly problems.
4. Interassembly heat transfer nodes are automatically generated at the user's request.
5. Sodium properties correlations are available internally to the code as a default option. Other coolant properties may still be input in tabular form.
6. A variety of user-definable forcing functions has been added to make the code more flexible.
7. A flow redistribution or network model was added to COBRA-WC to account for interassembly flow redistribution that may occur during low flow or natural circulation transients. In conjunction with this network model, the code was given the capability of calculating an implicit transient solution when a time-dependent pressure drop is specified.
8. Variable axial step size has been included to allow users more modeling flexibility and to save computer time and storage.
9. For many problems a direct solution of the momentum equations at each axial level is much faster than using the iterative procedure of COBRA-IV-I. An option exists in COBRA-WC to use the direct-inversion technique.

10. The conducting wall model was modified to optionally couple to a single coolant node rather than to coolant nodes on both sides to model additional transient heat capacity effects. Heat generation within a wall may also be modeled.
11. A variety of other minor modifications were made to reduce storage and computer running times.

In the sections which follow, the COBRA-WC equations and the methods of solution are discussed, the code organization described, input instruction given, and sample problems presented.

3.0 CONSERVATION EQUATIONS

The COBRA-WC code was developed to solve equations for the conservation of mass, momentum, and energy in a rod bundle or portion of an LMFBR core. The equations are essentially the same as those found in the COBRA-IV-I code with a few further simplifying assumptions which will be discussed later.

The equations have been derived by performing suitable balances on finite control volumes. The finite-difference equations found in the code come directly from these balances so no attempt will be made to obtain the partial differential equations from the finite-difference equations although a term-by-term correspondence will be pointed out.

The presence of the rods in an assembly and the coarse noding make it necessary to make some approximations and assumptions for some of the terms in the conservation equations and these assumptions are noted after each equation.

3.1 FLUID CONTROL VOLUMES

The fluid control volume for continuity, energy, and axial momentum is characterized by its cross-sectional area available for flow, the height Δx and the width S of the connection between itself and an adjacent control volume. Figure 1 shows three conceivable shapes for the control volume with 1a being the standard subchannel control volumes. Any series of control volumes connected axially is considered a subchannel. In the equations presented in the next section, the finite-difference terms are written with the corresponding description and partial differential form given in brackets immediately below. The list of symbols and notation at the beginning of this document should be referred to for explanation of the notation used.

FIGURE 1. Possible Control Volume Shapes Using the Generalized Subchannel Noding Approach
a) Standard Subchannel Noding
b) Lumped Subchannel Noding
c) Noding for Fluid Not in a Rod Array

3.2 CONTINUITY EQUATION

$$\bar{A} \frac{\rho - \rho^n}{\Delta t} j = \frac{v_{j-1} A_{j-1} \rho_{j-1}^*}{\Delta x_j} - \frac{v_j A_j \rho_j^*}{\Delta x_j} + \sum_{k \in \psi_i} e_k (u_k S_k \rho_k^*)_j$$

$$\begin{bmatrix} \text{mass storage} \\ A \frac{\partial \rho}{\partial t} \end{bmatrix} = \begin{bmatrix} \text{mass transported axially} \\ - \frac{\partial \rho v A}{\partial x} \end{bmatrix} + \begin{bmatrix} \text{mass transported laterally} \\ - \frac{\partial u A_T \rho}{\partial y} \end{bmatrix} \quad (1)$$

Here and in the following equations the subchannel subscript i has been omitted where the reference is clear. The assumptions made in the derivation of the continuity equation are that the channel area changes linearly with distance over the length of the control volume, the fluid density is uniform throughout the control volume, the axial and lateral velocities give the bulk flow rate through the respective areas, and the lateral connection width is

constant over the length of the control volume. Donor cell differencing is used for the convected quantities as indicated by the asterisk.

3.3 FLUID ENERGY EQUATIONS

$$\bar{A} \frac{\rho h - (\rho h)^n}{\Delta t} \bigg|_j = \frac{v_{j-1} A_{j-1} \rho_{j-1}^* h_{j-1}^*}{\Delta x_j} - \frac{v_j A_j \rho_j^* h_j^*}{\Delta x_j} + \sum_{k \in \psi_i} e_k (u_k S_k \rho_k^* h_k^*) \bigg|_j$$

$$\left[\begin{array}{c} \text{energy} \\ \text{storage} \\ A \frac{\partial \rho i}{\partial t} \end{array} \right] = \left[\begin{array}{c} \text{energy transported} \\ \text{axially} \\ - \frac{\partial \rho v A h}{\partial x} \end{array} \right] + \left[\begin{array}{c} \text{energy transported} \\ \text{laterally} \\ - \frac{\partial \rho u h A_T}{\partial y} \end{array} \right]$$

$$+ \sum_{n \in \lambda_i} \frac{A_{HTR} H_R}{\Delta x_j} (T_c - \hat{T})_n + \sum_{m \in \tau_i} \frac{A_{HTW} H_W}{\Delta x_j} (T_w - T)_m \quad (2)$$

$$+ \left[\text{rod heat flux} \right] + \left[\text{wall heat flux} \right]$$

$$+ \sum_{k \in \psi_i} e_k S_k K_k \frac{T_{II} - T_{JJ}}{l_k Z_k} + \sum_{k \in \psi_i} \frac{e_k w_T}{\Delta x_j} (h_{II} - h_{JJ})$$

$$+ \left[\begin{array}{c} \text{conductive heat} \\ \text{transfer laterally} \end{array} \right] + \left[\begin{array}{c} \text{turbulent energy} \\ \text{exchange} \end{array} \right]$$

In addition to the assumptions made for the continuity equation, it is assumed in the energy equation that the fluid enthalpy is uniform throughout the control volume and that there is no axial heat conduction in the fluid. The use of enthalpy rather than internal energy in the energy storage term requires that a term of the form $(P - P^n)/\Delta t$ be subtracted from the left side of Equation 2. For the problems of interest this term is insignificant and has

been neglected. All other forms of energy which are not explicitly represented in Equation 2 (e.g., potential and kinetic energy) have been neglected.

3.4 AXIAL MOMENTUM EQUATIONS

$$\begin{aligned}
 A \frac{\rho v - (\rho v)^n}{\Delta t} \Big|_j &= \frac{A_{j-1} v_{j-1} v_{j-1}^* \rho_{j-1}^*}{\Delta x_j} - \frac{A_j v_j v_j^* \rho_j^*}{\Delta x_j} + \sum_{k \in \psi_j} e_k (u_k S_k v_k^* \rho_k^*) \Big|_j \\
 \left[\begin{array}{c} \text{axial momentum} \\ \text{storage} \\ A \frac{\partial \rho v}{\partial t} \end{array} \right] &= \left[\begin{array}{c} \text{axial momentum} \\ \text{transported} \\ \text{axially} \\ - \frac{\partial \rho v v A}{\partial x} \end{array} \right] + \left[\begin{array}{c} \text{axial momentum} \\ \text{transported} \\ \text{laterally} \\ - \frac{\partial \rho u v A_T}{\partial y} \end{array} \right] \\
 &+ \bar{A}_j \frac{P_{j-1} - P_j}{\Delta x_j} + \sum_{k \in \psi_j} \frac{e_k w_T}{\Delta x} (v_{II} - v_{JJ}) \\
 &+ \left[\begin{array}{c} \text{pressure} \\ \text{gradient} \\ - \frac{\partial P A}{\partial x} \end{array} \right] + \left[\begin{array}{c} \text{turbulent momentum} \\ \text{exchange} \end{array} \right] \\
 &- \frac{1}{2} \left(\frac{f}{D_h} + \frac{C}{\Delta x_j} \right) \rho_j v_j |v_j| A_j - A \rho g \cos \theta \\
 &- \left[\begin{array}{c} \text{irreversible losses} \\ \text{friction and form} \end{array} \right] - \left[\begin{array}{c} \text{gravitational head} \end{array} \right]
 \end{aligned} \tag{3}$$

In the derivation of the axial momentum equation, it is assumed that all irreversible losses can be obtained by use of suitable friction factors and loss coefficients applied to the bulk velocity. Also, it is assumed that pressure changes linearly along the control volume and the shear stress terms due to flow in the adjacent subchannels can be neglected.

3.5 TRANSVERSE MOMENTUM CONTROL VOLUME

The subchannel approach to modeling rod bundles requires that the transverse momentum control volume be somewhat arbitrarily determined. Figure 2 shows the transverse momentum control volume as it would appear for standard subchannel noding.

FIGURE 2. Transverse Momentum Control Volume for Standard Subchannel Noding

The length S is required code input and should be representative of the actual fluid gap width between adjacent subchannels. The control volume length, ℓ , is determined either by a specified width-to-length ratio or by code input for each transverse connection. Due to the predominately axial nature of the flow in rod bundles, the fluid-thermal solution is relatively insensitive to physically reasonable dimensions of the transverse momentum control volume. It is assumed that inside the control volume the transverse velocity is normal to the transverse gap (g - g in Figure 2). Outside of the control volume the flow is taken to have no transverse component. The length ℓ should be chosen with these assumptions in mind.

3.6 TRANSVERSE MOMENTUM EQUATION

$$S\Delta x_j \frac{\rho^*u - (\rho^*u)^n}{\Delta t}{}_k = S_k v_{j-1} (\rho^*u)^*_{k,j-1} - S_k v_j (\rho^*u)^*_{k,j}$$

$$\begin{bmatrix} \text{lateral} \\ \text{momentum} \\ \text{storage} \\ A_T \frac{\partial \rho u}{\partial t} \end{bmatrix} = \begin{bmatrix} \text{transverse momentum} \\ \text{transported axially} \\ - \frac{\partial \rho u v A}{\partial x} \end{bmatrix} \quad (4)$$

$$+ (P_{II} - P_{JJ})_{j-1} \frac{S_k \Delta x_j}{\ell_k} - C_T |u_k| u_k \frac{\rho S \Delta x_j}{2 \ell_k}$$

$$+ \begin{bmatrix} \text{pressure gradient} \\ - A \frac{\partial P}{\partial y} \end{bmatrix} - \begin{bmatrix} \text{irreversible loss} \end{bmatrix}$$

Further assumptions in the transverse momentum equation are that 1) all the irreversible pressure loss can be accounted for by the form loss coefficient, C_T , 2) there is no momentum contribution from adjacent gaps (i.e., the $\partial \rho u u / \partial y$ and $\partial \rho u w / \partial z$ terms have been neglected), and 3) there are no applied body forces in the transverse direction. It may also be noted from Equation 4 that the length, ℓ , controls the magnitude of the fluid inertia (time and space) relative to the rest of the terms in the transverse momentum equation. As the length is increased, the inertial terms become more important in determining the transverse flow.

3.7 Rod Energy Equations

A one-dimensional heat conduction equation is solved for the fuel temperature distribution. Since orthogonal collocation techniques are used to solve

the diffusion equation, the partial differential equation rather than the finite-difference equation is described here.

$$\rho_f c_f \frac{\partial T_f}{\partial t} = \frac{k_f}{r} \frac{\partial}{\partial r} \left(r \frac{\partial T_f}{\partial r} \right) + q''' \quad (5)$$

For the fuel it is assumed that 1) there is no heat transfer axially, 2) the heat is generated uniformly throughout the fuel at a given axial height, and 3) the fuel properties do not vary with the radial variation in temperature. An option in the code that allows the users to make the fuel properties vary with the axial temperature changes is described later in this section. The axial node lengths correspond to the fluid cell length Δx_j . The rod materials and dimensions within each axial length are assumed constant but may vary from one axial step to the next. Figure 3 shows a cross section of a typical rod. The region marked as fuel may actually be any material. Also, the gap may be eliminated simply by making the gap conductance very large. In this manner the rod model may be used to simulate solid pins such as those in a reflector region.

The code is also capable of modeling an annular fuel section which could be useful in calculating temperature distributions in a bundle with sintered fuel or electrically heated rods. The method of solution and the assumptions are the same as for the solid cylindrical fuel except that the user may specify that the heat generation be uniform throughout the fuel or converted to a heat flux imposed on the inner surface.

The nature of the orthogonal collocation technique for solving the conduction equation makes it difficult to handle problems with temperature-dependent properties. In the COBRA-WC code the temperature-dependent fuel properties are modeled in an approximate manner. The fuel properties are area-weighted averaged at each axial level as

$$\bar{K}_f = \frac{1}{R_f^2} \sum_{i=1}^I K_{f_i} (r_i^2 - r_{i-1}^2) \quad (6)$$

where K_f is computed from the fuel temperature at the radial location $(r_i + r_{i-1})/2$. A similar calculation is carried out for the average specific heat. This method gives reasonable results for most LMFBR transients without increasing the computation time significantly.

FIGURE 3. Cross Section of COBRA-WC Model for a Nuclear Fuel Rod

3.8 CLADDING ENERGY EQUATION

The cladding energy equation is obtained by performing a lumped energy balance on the cladding material at each axial step.

$$y_c \rho_c c_c \frac{T_c - T_c^n}{\Delta t} = - H_R (T_c - \hat{T}) + H_g \frac{R_f}{R_c} (T_{fs} - T_c) \quad (7)$$

$$\left[\begin{array}{c} \text{energy} \\ \text{storage} \\ y_c \rho_c c_c \frac{\partial T_c}{\partial t} \end{array} \right] = - \left[\begin{array}{c} \text{convective heat} \\ \text{transfer to} \\ \text{the fluid} \end{array} \right] + \left[\begin{array}{c} \text{heat transfer} \\ \text{across the gap} \end{array} \right]$$

Here it is assumed that there is no axial heat transfer and the temperature is uniform around the circumference of the cladding. The gap conductance, H_g , is assumed constant and the film coefficient is given by user-specified correlations.

3.9 WALL ENERGY EQUATION

Figure 4 shows a cross section of a typical wall node, which could be used to represent the duct wall and the interduct sodium-filled gap in an LMFBR. The wall energy equation is similar in form to the cladding energy equation since a lumped formulation is again used.

$$\rho_w c_w t_w \frac{T_w^n - T_w}{\Delta t} = U_1 (T_1 - T_w) + U_2 (T_2 - T_w) + q_w'' t_w'$$

$$\left[\begin{array}{c} \text{energy} \\ \text{storage} \\ \rho_w c_w t_w \frac{\partial T_w}{\partial t} \end{array} \right] = \left[\begin{array}{c} \text{heat transfer} \\ \text{from subchannel} \\ \#1 \end{array} \right] + \left[\begin{array}{c} \text{heat} \\ \text{transfer} \\ \text{from} \\ \text{subchannel} \\ \#2 \end{array} \right] + \left[\begin{array}{c} \text{heat} \\ \text{generation} \end{array} \right] \quad (8)$$

In the wall energy equation it is assumed that there is no heat transfer axially. The conductances are obtained as

$$\frac{1}{U_i} = \frac{1}{H_i} + \frac{1}{2K_w} \quad (9)$$

where H_i is the film coefficient and K_w is the effective wall conductance defined in equation (11). The user must supply the effective heat capacitance, $\rho_w c_w t_w$, and the effective wall conductance. When a single wall node is made up of two or more different materials (e.g., in the situation shown in Figure 4), the effective heat capacitance is calculated as the sum of the effective heat capacitance of the various materials.

FIGURE 4. Cross Section of COBRA-WC Model for a Heat-Conducting Wall

$$\rho_w c_w t_w = \sum_{i \in \Omega_w} \rho_i c_i t_i \quad (10)$$

where Ω_w is the set of wall components (2 ducts and the sodium for the case in Figure 4). Similarly, the effective wall conductance is calculated as

$$\frac{1}{K_w} = \sum_{i \in \Omega_w} \frac{t_i}{K_i} \quad (11)$$

3.10 Heat Generation and Transfer Terms

The heat generation is specified in input as a heat density (MBtu/hr-ft³). The actual heat generated in any axial step in a rod is determined by the rod dimensions and three multipliers. The multipliers are the radial power factor, the axial power factor and the transient power factor. The total heat produced in an axial step in a rod is given by

$$q_f = q''' R_f^2 \pi \eta_r \eta_a \eta_t \Delta x_j \quad (12)$$

If the orthogonal collocation model is not used, the dimension used for calculating the material volume for heat generation is the rod radius rather than the fuel radius.

The heat delivered to the fluid in channel i from rod n is given by:

$$q = H_{HTR} \phi_{i,n} q_n'' \quad (13)$$

where ϕ_{in} is the fraction of heat produced by rod n delivered to channel i , and is specified by the user. This ϕ_{in} may be set to values larger than 1.0 to model many rods with a single pin.

For the walls the total heat generated in an axial step is given by

$$q_w = q_w''' t_w' D_w \eta_a \eta_t \Delta x_j \quad (14)$$

where t_w' is an effective thickness for heat generation which need not be consistent with the physical thickness of the wall.

The film coefficient, H_R , used in Equations 2 and 6 is defined as a weighted average of channel film coefficients. A channel film coefficient, H_i , is calculated for each channel based on the local Reynolds and Prandtl numbers and the user-specified correlation. The rod film coefficient is then calculated as:

$$H_{R_N} = \frac{\sum_{i \in Y_n} \phi_{i,n} H_i}{\sum_{i \in Y_n} \phi_{i,n}} \quad (15)$$

The average temperature of the fluid around a rod, $\hat{T}$, is defined analogously as

$$\hat{T}_n = \frac{\sum_{i \in Y_n} \phi_{i,n} T_i}{\sum_{i \in Y_n} \phi_{i,n}} \quad (16)$$

If the rod is connected thermally to only one channel, then $\hat{T}$ is simply the fluid temperature, T .

4.0 SOLUTION TECHNIQUES

The discussion of solution techniques can be conveniently separated into two parts: 1) the solution of all the energy equations, and 2) the solution of the momentum and continuity equations.

4.1 ENERGY SOLUTION

In the COBRA-IV-I code, the rod and fluid energy equations are solved separately, passing a boundary condition back and forth until both sets of equations converged. The rod temperatures are calculated using the fluid temperatures as a boundary condition. A rod heat flux is then calculated and used in the solution for the fluid enthalpy. The high rod power density and low effective heat capacitance of the sodium make this procedure unstable for LMFBTR transients unless very small time steps are used. To overcome this problem in the COBRA-WC code all the energy equations (fuel, clad, wall and fluid) are solved simultaneously at each level, eliminating the explicit calculation of a rod heat flux.⁽²⁾

Orthogonal collocation⁽³⁾ is applied to the spatial term in the fuel conduction equation while the transient term is calculated by finite difference. By letting $r' = r/R$ the fuel conduction equation can be rewritten as:

$$\rho_f c_f \frac{T_f - T_f^n}{\Delta t} = \frac{K_f}{R_f^2 r'} \frac{\partial}{\partial r'} \left(r' \frac{\partial T_f}{\partial r'} \right) + q''' \quad (17)$$

Since a uniform peripheral boundary condition and uniform heat generation is assumed for each rod, the temperature profile must be symmetric. It is assumed that

$$T_f(r') = d_1 + d_2 r'^2 + \dots + d_N r'^{2N-2} \quad (18)$$

where N is the collocation order plus one. With the unknowns (d_i) the fuel temperature can be matched at N radial positions (i.e. the conduction equation is satisfied at these N points). The radial positions or collocation points are chosen as the roots of a set of orthogonal polynomials. Using this technique, the problem can be reduced to solving for the temperatures at the collocation points directly rather than the expansion coefficients, d_i .

Given the collocation points r'_j ($j = 1, 2, \dots, N-1$ the interior collocation points, plus $j=N$, the fuel surface) the temperature at each point can be written as

$$T_f(r'_j) = \sum_{i=1}^N d_i r_j'^{2i-2} \quad (19)$$

or

$$\{T_f\} = [Q] \{d\} \quad (20)$$

where $Q_{ji} = r_j'^{2i-2}$

taking the first and second derivatives of T_f from Equation 19 we have

$$\left. \frac{\partial T_f}{\partial r'} \right|_{r'_j} = \sum_{i=1}^N d_i (2i - 2) r_j'^{2i-3} \quad (21)$$

and

$$\left. \frac{1}{r'} \frac{\partial}{\partial r'} (r' T_f) \right|_{r'_j} = \sum_{i=1}^N d_i (2i-2)^2 r_j'^{2i-4} \quad (22)$$

$$\text{or } \left. \frac{\partial \{T_f\}}{\partial r'} \right|_{r'_j} = [C] [Q]^{-1} \{T_f\} \quad (23)$$

$$\text{and } \frac{1}{r'} \frac{\partial}{\partial r'} \left(r' \frac{\partial \{T_f\}}{\partial r'} \right) = [D] [Q]^{-1} \{T_f\} \quad (24)$$

where

$$C_{ji} = (2i-2) r_j^{2i-3}$$

$$D_{ji} = (2i-2)^2 r_j^{2i-4}$$

and $[Q]^{-1} \{T_f\}$ was substituted for $\{d\}$.

Substitution of Equation 24 into Equation 17 and forward differencing the temporal derivative gives

$$\rho_f c_f \frac{\{T_f\}^n - \{T_f\}^{n-1}}{\Delta t} = \frac{K_f}{R_f^2} [B] \{T_f\} + q'' \quad (25)$$

$$\text{where } [B] = [D] [Q]^{-1}$$

It is assumed here that the inverse of $[Q]$ exists, as it does for the second- and third-order collocation schemes used in the COBRA-WC code. The boundary condition necessary for the calculation of the fuel temperature is given by

$$-\frac{K_f}{R_f} \frac{\partial T}{\partial r'} \bigg|_{r'_N} = H_g (T_N - T_{N+1}) \quad (26)$$

where T_{N+1} is the lumped cladding temperature, T_C .

Using Equation 23 in Equation 26,

$$\frac{K_f}{R_f} \sum_{i=1}^N A_{Ni} T_i = H_g (T_N - T_{N+1}) \quad (27)$$

where

$$[A] = [C] [Q]^{-1}$$

The cladding temperature is given by Equation 7 which, written in terms of the collocation temperatures, is

$$\frac{\rho_c c_c}{\Delta t} (T_{N+1} - T_{N+1}^n) = \frac{H_g}{y_c} \frac{r_N'}{r_{N+1}'} (T_N - T_{N+1}) - \frac{H_R}{y_c} (T_{N+1} - \hat{T}) \quad (28)$$

where $\hat{T}$ is an average temperature of the fluid surrounding the rod.

Equations 25, 27, and 28 are combined to yield a matrix equation of the form

$$[M] \begin{Bmatrix} T_1 \\ \vdots \\ T_{N+1} \end{Bmatrix} = \{S(\hat{T})\} \quad (29)$$

which gives the fuel and cladding temperatures as a linear function of the averaged fluid temperature, $\hat{T}$, the only other unknown at this point. Equation 29 is then reduced by Gauss elimination to give

$$M' T_{N+1} = S'(\hat{T}) \quad (30)$$

It may be noted that if the geometry and fuel and gap properties for a given rod remain constant, then the matrix $[M]$ is constant except for the film coefficient, H . Consequently, most of the calculations required for M' need be done only once. The source term $S'(T_F)$ involves the power densities q''' and the old time temperatures, T_j^n , and so must be updated as these quantities change. It is important to realize that $S'(\hat{T})$ is still linear with respect to $\hat{T}$ and that $\hat{T}$ is a linear combination of the fluid temperatures T by

Equation 16. Equation 30 can therefore be easily combined with the fluid energy equation to solve for the fluid temperatures. Substitution of Equation 16 into Equation 30 gives

$$T_{N+1} = \frac{S' (T_i, i \in \gamma_n)}{M'} \quad (31)$$

which is linear in T_i .

Equation 31 is used to eliminate the cladding temperature in the fluid energy equation.

The wall temperature for wall m at some axial level can also be expressed as a linear combination of the adjacent subchannel fluid temperatures.

Rearrangement of Equation 8, the wall energy equation, gives

$$T_w = \frac{\frac{T_w^n \rho_w c_w t_w}{\Delta t} + U_1 T_1 + U_2 T_2 + q_w'' t_w'}{\frac{c_w t_w \rho_w}{\Delta t} + U_1 + U_2} \quad (32)$$

or

$$T_w = R (T_i, i \in \xi_m) \quad (33)$$

Substituting Equations 31 and 33 into the fluid energy Equation 2 for channel i at axial level j gives

$$\begin{aligned}
\bar{A} \frac{\rho h - (\rho h)^n}{\Delta t} \bigg|_j &= \frac{v_{j-1} A_{j-1} \rho_{j-1}^* h_{j-1}^*}{\Delta k_j} - \frac{v_j A_j \rho_j^* h_j^*}{\Delta x_j} \\
&+ \sum_{k \in \psi_j} e_k (u_k S_k \rho_k^* h_k^*) \bigg|_j + \sum_{n \in \lambda_j} \frac{A_{HTR_n} H_{R_n}}{\Delta x_j} \frac{S'(T_i, i \epsilon \gamma_n)}{M'} - \hat{T} \\
&+ \sum_{k \in \psi_j} e_k S_k \frac{K_k (T_{II} - T_{JJ})}{\rho_k Z_k} + \sum_{k \in \psi_j} \frac{e_k w_T}{\Delta x_j} (h_{II} - h_{JJ}) \\
&+ \sum_{m \in \tau_j} \frac{A_{HTW_m} H_{W_i}}{\Delta x_j} (R(T_i, i \epsilon \xi_i) - T)
\end{aligned} \tag{34}$$

To solve for the fluid enthalpies, it is necessary to convert the fluid temperatures to enthalpies by the following approximation

$$T = T_0 + \frac{h - h_0}{c} \tag{35}$$

where the reference temperature and enthalpy are chosen arbitrarily as the previous iteration values for T and h , and c is the fluid specific heat. Substituting Equation 35 into Equation 34 and assuming that all variables other than the fluid enthalpies at the j level are the last iterate values gives an equation which is linear in the enthalpies at level j . The equations of this form for each subchannel at level j are combined to form the matrix equation

$$[L] \{h\}_j = \{S_h\} \tag{36}$$

For large problems the matrix $[L]$ is sparse (i.e., few nonzero elements), and therefore only the nonzero elements are stored. The matrix equation is solved by successive over relaxation (SOR) (relaxation factor = 1.2). The number of

iterations is generally independent of the number of subchannels, and convergence is usually achieved in fewer than 10 iterations since the matrix is strongly diagonally dominant.

When Equation 36 is converged at one level, the enthalpies are used in the equation of state to obtain fluid densities, and the solution proceeds at the next axial level.

Once values for the fluid enthalpies have been obtained, the wall, cladding and fuel temperatures can be backed out. The equivalent fluid temperatures are found using the equation of state and these are substituted into Equation 32 to obtain the wall temperatures. Similarly, the cladding temperatures are calculated using Equation 31 and the fuel temperatures are calculated using the upper triangular matrix equation corresponding to Equation 29. It may be noted that it is not necessary to back out the nonfluid temperatures until a converged solution to all equations has been obtained and we are ready to proceed to the next time step.

4.2 MOMENTUM AND CONTINUITY SOLUTION

Two techniques are available in the COBRA-WC code to solve the momentum and continuity equations. The first is very similar to the scheme found in COBRA-IV-I except that pressure rather than crossflow has been chosen as the variable to be solved for. Also, a direct inversion scheme has been added to the momentum solution to decrease running time. The second method is somewhat like the explicit scheme in COBRA-IV-I in that a Poisson equation in pressure is solved, but several modifications have been made which greatly reduce the running time and allow for solutions which are implicit in time. This implicit solution strategy is similar to that in the SIMPLE⁽⁴⁾ and SABRE⁽⁵⁾ codes. The first method works well for most LMFBR operating conditions but results in numerical instabilities when there are large axial velocity gradients in the transverse direction tending toward a localized flow reversal within an assembly. This situation arises when the flow rate in an LMFBR bundle decreases to a small percentage of nominal and a radial temperature skew exists in the assembly (e.g., natural circulation transients). The second solution method was developed to solve the conservation equations in these situations. The

two methods solve nearly identical equations, so shifting from one solution scheme to the other in the course of a transient causes no difficulties. The first scheme will be referred to as the PSOLVE scheme and the second as the RECIRC scheme.

4.2.1 PSOLVE Scheme

In the PSOLVE scheme the axial and transverse momentum equations are combined with the continuity equation in much the same way as in COBRA-IV-I. Since this scheme is used only for problems when the flow direction is positive throughout the subchannels, this assumption is made in the following derivation. Under this assumption the axial momentum equation (Equation (3)) becomes:

$$\begin{aligned} \frac{m_j - m_j^n}{\Delta t} = & - \frac{m_j^2 / A_{j\rho j} - m_{j-1}^2 / A_{j-1\rho j-1}}{\Delta x_j} - \bar{A}_j \frac{p_j - p_{j-1}}{\Delta x_j} \\ & + \sum_{k \in \psi_i} e_k (u_k S_k v_k^{*\rho k})_j + \sum_{k \in \psi_i} e_k \frac{w_T}{\Delta x_j} (v_{II} - v_{JJ}) \\ & - \frac{1}{2} \left(\frac{f}{D_h} + \frac{c}{\Delta x_j} \right) \frac{m_j^2}{A_{j\rho j}} - \rho_j g \bar{A} \cos \theta \end{aligned} \quad (37)$$

where the $Av\rho^*$ have been combined into a single variable, M , for the mass flow rate.

A rearrangement of terms yields:

$$\begin{aligned}
\bar{A}_j \frac{P_j - P_{j-1}}{\Delta x_j} = & - \left(m_j - m_{j-1} \right) \left\{ \frac{1}{\Delta t} + \frac{2\bar{m}_j}{A_j \rho_j} \left[\frac{1}{\Delta x_j} + \frac{1}{2} \left(\frac{f}{D_h} + \frac{C}{\Delta x_j} \right) \right] \right\} \\
& + \frac{m_{j-1}^2}{A_j \rho_j} \left[\frac{A_j \rho_j}{A_{j-1} \rho_{j-1} \Delta x_j} - \frac{1}{\Delta x_j} - \frac{1}{2} \left(\frac{f}{D_h} + \frac{C}{\Delta x_j} \right) \right] \\
& + \frac{m_j^n - m_{j-1}}{\Delta t} + \sum_{k \in \psi_i} (e_k S_k u_k \rho_k^* v_k^* j) \\
& + \sum_{k \in \psi_i} e_k \frac{w_T}{\Delta x_j} (v_{II} - v_{JJ}) - \rho_j g \bar{A}_j \cos \theta
\end{aligned} \tag{38}$$

The continuity relationship (Equation 1) is used to eliminate the first factor on the right side, giving an expression for the axial pressure gradient in terms of the transverse velocities.

$$\begin{aligned}
\frac{P_j - P_{j-1}}{\Delta x_j} = & \frac{m_{j-1}^2}{\bar{A}_j A_j \rho_j \Delta x_j} \left[\frac{A_j \rho_j}{A_{j-1} \rho_{j-1}} - 1 - \frac{1}{2} \left(\frac{f \Delta x_j}{D_h} + C \right) \right] \\
& + \frac{m_j^n - m_{j-1}}{\Delta t \bar{A}_j} - \rho_j g \cos \theta + \frac{1}{\bar{A}_j} \sum_{k \in \psi_i} e_k \frac{w_T}{\Delta x_j} (v_{II} - v_{JJ}) \\
& + \frac{\rho_j - \rho_j^n}{\Delta t} \frac{\Delta x_j}{\Delta t} + \frac{\bar{m}_j}{A_j \rho_j} \left(2 + \frac{f \Delta x_j}{D_h} + C \right) \\
& - \sum_{k \in \psi_i} e_k \left[\frac{\Delta x_j}{\bar{A}_j \Delta t} + \frac{\bar{m}_j}{A_j \bar{A}_j \rho_j} \left(2 + \frac{f \Delta x_j}{D_h} + C \right) - \frac{v_k^*}{\bar{A}_j} \right] \rho_k^* u_k S_k
\end{aligned} \tag{39}$$

The transverse momentum equation (Equation 4) can be rewritten as

$$(\rho^*u)_k = \frac{(\rho^*u)_k^n + \frac{\Delta t}{\Delta x_j} (v_{j-1} (\rho^*u)_{j-1}) + \frac{\Delta t}{\ell} \left[(P_{II} - P_{JJ})_j - \Delta x_j \left(\frac{dP}{dx}_{II} - \frac{dP}{dx}_{JJ} \right) \right]}{1 + v_j \frac{\Delta t}{\Delta x_j} + C_T u_k \frac{\Delta t}{2}} \quad (40)$$

where

$$\frac{dP}{dx}_{II} = \frac{P_{IIj} - P_{IIj-1}}{\Delta x_j} \quad (41)$$

For each of the transverse connections to a subchannel an equation of the form of Equation 40 is substituted into Equation 39 for the ρ^*u_k term on the right side. The resulting set of equations for one axial level is then assembled into a matrix equation.

$$[AAA] \left\{ \frac{dP}{dx} \right\} = \left\{ S_M \right\} \quad (42)$$

As in the energy equation, Equation 42 is sparse since $AAA_{ij} = 0$ only if $i = j$ or subchannel i is connected to subchannel j . Furthermore, at any axial level, the equations which generated Equation 42 are only coupled on an assembly basis. That is, if the problem involves more than one assembly, an equation of the form of Equation 42 will be constructed and solved for each individual assembly. Two methods are available in the COBRA-WC code for solving Equation 42. The first method is the same as that found in the COBRA-IV-I code which uses SOR on the nonzero terms of the AAA matrix. The zero terms are not stored. The second method solves Equation 39 by Gaussian elimination. This method uses more storage since many of the zero terms must be stored. However, by judiciously choosing the numbering scheme for the subchannels, the nonzero

terms can be contained within a small band surrounding the diagonal. Only elements within this band need be stored and operated on to obtain the solution vector. When core storage requirements allow the use of this direct solution scheme, CPU time savings of 2 to 3 times (depending on the problem) can be realized. The first method is retained since for some very large problems the subchannels cannot be numbered in a manner to make the band-width (and therefore the core storage) small enough for the use of the direct solution. The numbering of subchannels and the resulting bandwidth will be discussed in the section on nodding.

Once Equation 42 has been solved for the subchannel pressure gradients at a particular level they can be substituted into Equation 40 to obtain the transverse mass fluxes. The other terms required in Equation 40 are taken to be the previous iteration value. These transverse fluxes are then substituted into the continuity equation (Equation 1) and the axial flow rate, m_j , is obtained. The transverse pressure gradient is then updated using the following expression.

$$\left(P_{II} - P_{JJ} \right)_{j-1} = \left(P_{II} - P_{JJ} \right)_j - \Delta x_j \left(\frac{dP}{dx}_{II} - \frac{dP}{dx}_{JJ} \right) \quad (43)$$

which will be used in Equation 40 on the next sweep through the axial levels.

For problems where there is a possibility of a recirculation zone forming within a bundle or flow region, the RECIRC solution scheme, described in the following section, may be applied.

4.2.2 RECIRC Scheme

The numerical model for solving recirculating flows in the COBRA-WC code uses the same basic technique as the explicit scheme in COBRA-IV-I, which was based on the ICE⁽⁶⁾ methodology, i.e., the solution of a Poisson equation in pressure with subsequent solution of a linearized momentum equation for velocities. The fundamental finite-difference equations are essentially the same as those described in the last section for the PSOLVE scheme except for

the use of an average, rather than donor-cell, density. The major differences between this scheme and the explicit scheme in COBRA-IV-I are in the development of the Poisson equation based on continuity rather than the energy equation, the techniques used to obtain a solution to the Poisson equation in a small amount of computer time and the implicit/explicit operation to minimize overall problem run time.

The momentum and continuity equations are solved by linearizing the momentum equations to get velocity as a linear function of pressure.

$$v = F_v(v, \Delta x, \Delta t, A, u, f, \dots) (P_j - P_{j-1}) + C_v \quad (44)$$

and

$$u = F_u(u, P, \Delta x, \Delta t, \dots) (P_{II} - P_{JJ}) + C_u \quad (45)$$

where F_u , F_v , C_u , and C_v are evaluated using the latest values for each of the variables and are then held constant for the solution of the pressure. The residual error in the continuity equation for each cell is then computed as

$$E_c = \bar{A}_j \Delta x_j \frac{\rho - \rho^n}{\Delta t} - v_{j-1} A_{j-1} \bar{\rho}_{j-1} + v_j A_j \bar{\rho}_j - \sum_{k \in \psi_j} e_k (u_k \bar{\rho}_k \Delta x_j S_k) \quad (46)$$

and the derivatives of E_c with respect to the cell pressure and the surrounding cell pressures are then formed in terms of F_u and F_v and the velocity coefficients in Equation 46. For each cell δP 's are needed such that

$$\sum \delta P \frac{\partial E_c}{\partial P} = -E_c \text{ where the sum is over all cells.}$$

The entire matrix equation to be solved for n cells is then

$$\begin{bmatrix}
 \frac{\partial E_1}{\partial P_1} & \frac{\partial E_1}{\partial P_2} & \cdots & \frac{\partial E_1}{\partial P_n} \\
 \frac{\partial E_2}{\partial P_1} & \frac{\partial E_2}{\partial P_2} & \cdots & \frac{\partial E_2}{\partial P_n} \\
 \vdots & \vdots & \ddots & \vdots \\
 \frac{\partial E_n}{\partial P_1} & \frac{\partial E_n}{\partial P_2} & \cdots & \frac{\partial E_n}{\partial P_n}
 \end{bmatrix}
 \begin{Bmatrix}
 \delta P_1 \\
 \delta P_2 \\
 \vdots \\
 \delta P_n
 \end{Bmatrix}
 =
 -
 \begin{Bmatrix}
 E_{c1} \\
 E_{c2} \\
 \vdots \\
 E_{cn}
 \end{Bmatrix}
 \quad (47)$$

As before, most of the terms in the above matrix will be zero since $\partial E_i / \partial P_j \neq 0$ only if $i = j$ or cell j is connected to cell i with a flow path.

The solution of the above matrix equation takes up a large portion of the overall computation time for the solution of all the conservation equations. Therefore, the particular solution method chosen is very important. Usually the problems solved using the COBRA codes require many cells and since the cell arrangement does not lead to a simple matrix form, the matrix equation is solved iteratively. In the explicit version of COBRA-IV-I, the entire matrix is solved by Gauss Siedel iteration. Convergence using this method can be extremely slow, especially for a cell configuration with a large aspect ratio.

The convergence rate for Equation 47 can be greatly increased by solving portions of the matrix equation by direct inversion. In the COBRA-WC method, a banded matrix is formed for the solution of all δP 's on one axial plane. The δP 's on the levels above or below the level of current solution are taken to be fixed at their previous iteration value. This matrix is solved by direct inversion to obtain the new δP 's for that level, and the process continues at the next axial level. The computational mesh is repeatedly swept through,

level by level, solving for the δP 's until no significant change in any of the δP 's takes place. All problems for which the RECIRC scheme is to be used should be noding in such a way as to minimize the bandwidth as described in Section 6.

This process is similar to solving a one-dimensional problem by Gauss Siedel iteration. But the solution of a one-dimensional problem by Gauss Siedel can be very time consuming, especially when it is considered that a one-dimensional problem can be solved very quickly by inverting the tridiagonal matrix. To take advantage of this, a one-dimensional approximation of the problem is solved between the level-by-level sweeps. This is done without disturbing the shape of pressure profiles at each level. To form the one-dimensional tridiagonal matrix equation the net continuity error is calculated as

$$\bar{E}_{C_j} = \sum_{i \in \text{level } j} E_{C_i} \quad (48)$$

A tridiagonal matrix is then formed:

$$[G]\{\delta \bar{P}\} = \bar{E}_c \quad (49)$$

$$\text{where } G_{ij} = \begin{cases} \frac{\partial \bar{E}_{C_i}}{\partial \bar{P}_j} & \text{if } i-1 \leq j \leq i+1 \\ 0.0 & \text{if } j < i-1 \text{ or } j > i+1 \end{cases}$$

to solve for an average $\delta \bar{P}$ at each level, which can be used to adjust the magnitude of each pressure on that level. The velocities are then updated using the new pressures and Equations 44 and 45 and new continuity errors are calculated by Equation 46.

When the continuity error for each cell becomes sufficiently small, the iteration procedure is stopped. At this point the continuity and linearized momentum equations have been solved. The energy equations for all cells are solved simultaneously using the method previously described. The new fluid densities are obtained from the equation of state.

If the scheme is running in the explicit mode, this is the end of the calculations for a given time step. In the implicit mode the functional relationship between pressure and velocity (Equations 44 and 45) are recomputed, and the continuity and energy equations are solved as before. Convergence is assumed when the change in velocity as computed from Equations 44 and 45 is insignificant.

4.3 BOUNDARY CONDITIONS AND OTHER EQUATIONS

To close the system of equations described in the two previous sections, some system boundary conditions and constitutive relationships are required. The fluid enthalpy or temperature is required at the subchannel inlet. The user may specify an inlet temperature distribution by inputting the inlet temperature for each subchannel. For flow reversals the code calculates the fluid temperature at the top of the subchannels based on the mixed mean outlet temperature if the net bundle flow rate is positive. If the net bundle flow rate becomes negative the user must supply a temperature for the incoming fluid at the top of the assembly.

The code also requires an inlet flow rate or a pressure drop. When using the inlet flow rate option, the user may request uniform inlet mass flux for all subchannels or he may specify flow rates for each assembly. Further, he may specify an inlet flow distribution for any or all assemblies. The user also may choose to allow the code to calculate an inlet flow distribution given a total assembly flow rate. Under this option the code iterates on the individual subchannel flow rates within an assembly until the pressure drop across the first computational cell is the same for all the subchannels. In calculating this pressure drop, which includes only friction, form loss, and gravitational head, it is assumed that there is no transverse flow at the first

level of computational cells. When running a transient under this option, only the steady-state initialization solution will use the equal-pressure drop option. Inlet flows during the transient are determined by multiplying the calculated steady-state inlet flows by the appropriate time-dependent forcing function.

The time-dependent pressure drop boundary condition may be used with or without the network model described below. When used without the network model, a different time-dependent pressure drop may be specified for each assembly. The inlet flow in each subchannel is adjusted so that the calculated pressure drop matches the specified boundary condition.

4.3.1 Network Model

For many modeling situations it may be desirable to allow the code to calculate the flow distribution between assemblies based on the orificing and assembly arrangement. The network model has been developed for the COBRA-WC code to model the pressure losses above and below the core region. When the network model is used, a single pressure drop is specified as a function of time, and the subchannel flow rates are adjusted so that the pressure drop through each possible flow path matches the specified pressure drop. Figure 5 is a schematic description of the network model for a three-assembly problem with a bypass channel. In this particular example, assemblies 1 and 2 may be inner-core assemblies connected to a common high-pressure plenum. Assembly 3 may be an outer core assembly connected to a low-pressure plenum. The bypass channel may represent the thermal liner region. The conservation equations described in the previous section are solved only for the noded length as noted in Figure 5. This noded length normally represents the rod bundle where flow resistance is given by friction factors and loss coefficients. The gravitational head is also accounted for in this region. Along the rest of the flow paths a reduced momentum equation is solved, which takes into account only the flow resistance due to friction and form and the static loss. No inertia terms are included. The energy equation is not solved outside the noded region, and it is assumed that the transport time through the network model is zero.

FIGURE 5. Schematic Description of the Network Model for Pressure Drop Through Reactor Vessel

In the example described by Figure 5, the resistances marked R_{Ain} and R_{Aout} would be the flow resistances associated with the assembly inlet orifices and the outlet hardware (handling socket, etc.), respectively. These loss coefficients can be made dependent on Reynolds number. A gravitational pressure drop can also be modeled by supplying head lengths at the inlet and outlet noted as H_A in Figure 5. The assembly inlet gravitational head loss is calculated using the inlet temperature for density calculations. The outlet gravitational head loss is arrived at using the mixed mean assembly outlet temperature.

The group dynamic loss coefficients, R_{Gin} and R_{Gout} , may represent the flow resistance from a common plenum to the high- and low-pressure plenums or to the bypass entrance region. The group dynamic loss coefficients are assumed to be independent of Reynolds number. Here too, gravitational losses may be modeled by supplying the head lengths. Finally, R_T may represent the dynamic loss coefficient for flow from the inlet nozzle to the common plenum.

For most problems the actual loss coefficients for each of these resistances will not be known, but the flow and corresponding pressure drop across each resistance should be available. The effective loss coefficients are then defined as:

$$R = \frac{\Delta P \delta g_c}{F^2} \quad (50)$$

where ΔP has units lbf/ft^2 , and F is in lbm/sec , giving R the units of 1/ft-lbm . For R_A , which may be dependent on Reynolds number, it is necessary to supply a wetted perimeter so the Reynolds number may be calculated from the flow rate. The wetted perimeter need not have any physical significance but should be chosen so that the correct loss is obtained for a given flow rate when using the specified resistance versus Reynolds number curve.

4.3.2 Radial Thermal Boundary Condition

The thermal boundary condition in the radial direction is zero heat flux at the outermost faces of an assembly or group of assemblies. Constant temperature boundary conditions can be simulated fairly easily by surrounding the region of interest by one or more subchannels having a large flow rate at a specified inlet temperature and modeling connecting walls for heat transfer between these outside channels and the adjacent inner channels.

4.3.3 Friction Factors and Film Coefficients

At least one friction factor of the form

$$F = A \text{Re}^a + B \text{Re}^b + C \quad (51)$$

is required as code input. Additional friction factor correlations may be input with specified subchannel type numbers determining the subchannels where

each correlation is to be used. Two friction factor correlations may be read in for each subchannel type; one to model the turbulent friction factor and the other for the laminar region. The largest of the two friction factors at a given Reynolds number is used in the axial momentum equation.

A heated-wall correction factor to the viscosity is available.⁽⁷⁾ This factor accounts for the smaller drag forces along a heated wall due to the wall viscosity being smaller than the bulk subchannel viscosity. The correction factor is applied as a multiplier on the friction factor, which is calculated using the viscosity at the bulk temperature. The multiplier is computed as

$$M = 1 + \frac{P_h}{P_w} \left[\left(\frac{\mu_{wall}}{\mu_{bulk}} \right)^{.6} - 1 \right] \quad (52)$$

where μ_{wall} is evaluated at the wall temperature calculated from

$$T_{wall} = T_{bulk} + \frac{q'}{P_h H} \quad (53)$$

This correction is based on the assumption that the total perimeter consists of two regions - one uniformly heated (P_h) at q' and the other unheated ($P_w - P_h$). The H is the channel heat transfer coefficient.

Two film coefficient correlations may be input for each channel type where the largest of the two based on local Reynolds and Prandtl numbers is used for computing the heat flux. If no film coefficient correlations are input, the code uses the default correlation of Lyon and Martinelli⁽⁸⁾ for tube bundles in liquid metal. Film coefficient correlations are of the form

$$H = (A Re^a Pr^b + B) K/D \quad (54)$$

where the user supplies the constants A, a, B, and b for calculating the Nusselt number.

Loss coefficients to represent grid spacers or flow blockages may be included as part of the input. The functional form of loss coefficients is:

$$C = \frac{2 \Delta P g_c}{\rho_v^2} \quad (55)$$

These loss coefficients are assumed to be independent of Reynolds number.

4.3.4 Mixing Correlations

The turbulent mixing correlations, which are the same as those found in COBRA-IV, give the user a choice of four different forms:^(9,10,11)

$$1) w_T = \beta S_k G' \quad (56)$$

$$2) w_T = a \text{Re}^b S_k G' \quad (57)$$

$$3) w_T = a \text{Re}^b D' G' \quad (58)$$

$$4) w_T = a \text{Re}^b \frac{S_k}{z_k} D' G' \quad (59)$$

where

$$\text{Re} = \frac{G' D'}{\mu}$$

$$D' = 4 (A_{II} + A_{JJ}) / (Pw_{II} + Pw_{JJ})$$

$$G' = (m_{II} + m_{JJ}) / (A_{II} + A_{JJ})$$

The user may specify different correlations or different coefficients for each assembly type.

The wire-wrap model in the COBRA-WC code is essentially the same as that used in COBRA-IIIC.⁽¹²⁾ In this model the wire-wrap inventory in each channel is determined, and the axial position where each wrap passes through a transverse gap is calculated based on the wire-wrap pitch and starting location. When it has been determined that a wrap passes through a gap at some axial location, the transverse flow in that gap is set to a fraction of the axial flow and is not adjusted further in that iterative sweep. The transverse flow diverted through the gap is given as

$$W_j = v_j (\tan \beta) \rho S \Delta x_j \delta \quad (60)$$

where β is the angle the wire wrap makes with the rod and δ is a userspecified wire-wrap parameter. When δ is set to 1.0 it follows from Equation 60 that the direction of flow in the gap is parallel to the wire wrap. As wire wraps move in and out of channels, the subchannel areas, wetted perimeters, and hydraulic diameters are adjusted accordingly.

When using lumped-channel nodding schemes it may not be feasible to use the standard wire-wrap model. For these cases a peripheral swirl model is similar to that used in the ENERGY⁽¹³⁾ series of codes available. For the swirl model the user must specify only a direction and a parameter which gives the peripheral transverse velocity as a fraction of the assembly average axial velocity.

4.3.5 Equation of State

Although the code was written for LMFBR applications, equation of state information may be input for any single-phase fluid. If no equation of state information is input, the fluid is assumed to be sodium, and the fluid properties are obtained from the ANL-7323 sodium property curve fits.⁽¹⁴⁾ For problems using a coolant other than sodium it is necessary to input a series of cards, each of which specifies a pressure and a corresponding temperature, enthalpy, thermal conductivity, specific heat, specific volume, and viscosity. Linear interpolation is used to obtain properties at fluid temperatures between those input values. The fluid is assumed to be incompressible but is allowed to expand thermally.

5.0 OVERALL CODE DESCRIPTION

This section shows how all the parts described in the previous section are combined to obtain a solution from a set of input cards. The actual input will be described card by card in Section 7.

The main program and executive routine in the COBRA-WC code is called COBRA. COBRA transfers control to various subroutines to read input, solve the conservation equation and print out results. COBRA also handles most of the boundary condition specification. A flow chart indicating the function of program COBRA is given in Figure 6. COBRA reads the first input card to determine if the run is to be a restart (i.e., pick up the results from an old solution and continue calculations possibly with minor input changes), or a new case in which all the calculational variables are initially zeroed. An input card image listing is then generated for user debug. If new input is to be read, COBRA calls the input routines, which are described in Section 5.1. Once the input has been read and the problem geometry and operating conditions established, COBRA begins the transient time loop with one pass through the loop for each time step. The first pass through this loop is used for obtaining a steady-state solution for the problem, which then serves as an initial condition for the transient. This steady-state solution is accomplished simply by setting the time step to a large number ($\Delta t = 10^6$) and continuing on as though it were any other time step. Setting the time step to a large number effectively eliminates any contribution of the storage terms in the conservation equations.

Within the transient time loop in COBRA the boundary conditions corresponding to the transient time elapsed are then set. This includes setting the inlet temperature and the pressure drop or inlet flow for each subchannel. The appropriate routines for solving the conservation equations are then called. These routines were described to some extent in Section 4.2, but Section 5.2 further describes them in terms of their interaction with other parts of the code. When control is returned back to program COBRA a solution to the conservation equations has been obtained for that time step. A routine is then called to print the desired results and the calculations continue with the next time step.

FIGURE 6. Flow Chart for COBRA

5.1 INPUT SUBROUTINES

The input routines have been split into three parts; SETUP, SETIN and SETOUT. Subroutine SETUP, which is the routine called by program COBRA, does not read any input but acts as the input executive routine. SETUP first calls subroutine SETIN, which actually reads all of the data cards. The card-group input format is similar to that of COBRA-IV-I. Each group is headed by a group card that provides information to subroutine SETIN for transferring control to a part of the subroutine which processes the rest of the information in that group. When all groups have been processed control is returned to SETUP where some further calculations are done to establish all the parameters necessary to start the run. Subroutine SETOUT is then called to print out all the information generated by SETIN and SETUP. This printout provides the user an easy means for checking to see that the code is running the problem that he intended to run. Following this, control is returned to SETUP and then back to COBRA to begin the time loop.

5.2 SOLUTION OF THE CONSERVATION EQUATIONS

At each time step, control is passed to subroutine SCHEME or to RECIRC depending on the user-controlled option. Subroutine SCHEME is called if the PSOLVE solution technique is requested, and RECIRC executes the RECIRC solution scheme described in Section 4.2. As before, these two paths are discussed separately.

Figure 7 lists the program flow when subroutine SCHEME is called. A call to subroutine PREFIX is necessary to calculate the constant matrix elements used in the energy equation solution scheme and to establish the indexing arrays for the rod and subchannel connections. The first pass through all of the axial levels is then started with calls to REHEAT and ENERGY, which calculate the variable matrix elements for the energy solution and solve the energy equations for the first level of computational cells. A call to PROP gives the fluid densities, subchannel film coefficients, and friction factors, and a call to FORCE gives the wire wrap or grid spacer forced diversion transverse flow. Since at any level the momentum equations as solved in subroutine PSOLVE are coupled only within an assembly, there is one call to the

FIGURE 7. Flow Chart Subroutine SCHEME

solution routine for each assembly. At the end of the assembly loop the newly calculated transverse flows and densities are used to calculate the axial flow. The transverse pressure gradients are then updated, and the calculation continues at the next axial level. When calculations for all axial levels have been completed, there are calls to subroutines PBOUND and NETWORK if a pressure boundary condition is used. In these subroutines, the inlet axial flows are adjusted, based on the calculated subchannel pressure drop to satisfy the boundary condition.

Whether or not a pressure boundary condition is used, the convergence of the axial flow rate is checked at this point. If the percent change in any of the axial flows is greater than a user-specified convergence criteria, then all the levels are swept through again. When convergence has been obtained, the rod temperatures are backed out from the fluid temperatures with a call to HOTROD. Control is then returned to program COBRA for the next time step.

The solution order in RECIRC is similar to that of SCHEME but different enough to warrant a separate description here. Figure 8 gives a flow chart for subroutine RECIRC. The first part of the subroutine is very similar to the SCHEME technique except that RECIRC calculates temporary values of the flow rates using the current pressure distribution instead of solving the momentum equations for pressure. An inner iteration assembly-by-assembly loop is then started to solve the momentum and continuity equation simultaneously. This part of the subroutine was described earlier in Section 4.2.2. When convergence has been achieved in the inner loop, a check is made to determine if the code is running in the time implicit or explicit mode. If it is in the explicit mode, the control is returned to program COBRA for the next time step calculations. In the implicit mode, a further check on convergence in the outer loop is made. If convergence has not been attained, then there is another sweep through the outer loop as previously described. A check is made at the end of the outer loop to determine whether the solution scheme would be more efficient in the implicit or explicit mode. This is determined by the number of outer iterations the problem has been taking in the implicit mode, the user-specified implicit time step, and the maximum allowable explicit time

FIGURE 8. Flow Chart for Subroutine RECIRC

step. Since one sweep through the outer loop takes somewhat less time than one explicit time step, the mode is switched from implicit to explicit if

$$\Delta t_{\text{exp}} > 1.5 \Delta t_{\text{imp}} / \text{number of outer iterations}$$

The explicit time step is determined by the Courant limit

$$\Delta t_{\text{exp}} = 0.9 * \underset{\text{all cells}}{\text{MIN}} (\Delta x_j / v_j)$$

A steady-state solution is obtained in this scheme by setting the time step to a large value and running in the implicit mode.

5.3 DATA STORAGE

The potentially large problems to be run on the COBRA-WC code require capability to store much of the data outside of the core memory. The maximum problem size, as determined by the number of coolant cells and rod nodes, that may be run without use of peripheral storage is governed by the core size of the particular computer installation. However, a 217-pin wire-wrapped fuel assembly using standard subchannel noding will most likely require peripheral storage on any non-virtual memory machine currently in use.

The allocation and use of the peripheral storage in COBRA-WC is very much like that in COBRA-IV-I. Since the calculations necessary to solve the conservation equations at any axial level require information for that level and the levels above and below it, only sufficient room for that information is made available in core if the peripheral storage option is requested. As the solution algorithm moves from one level to the next, information from the J-1 level is written onto disk file space and data from the J+1 level is read into core. These data transfers are taken care of by the subroutines ROLLIT, IMAGE and COPY. To facilitate the transfer of the data to and from the disk, a system of variable equivalencing is used, similar to the system used in COBRA-IV-I.

All of the variables that need to be transferred to and from a peripheral storage device are equivalenced to one large array named SAVEAL. Three additional arrays, SAVEA1, SAVEA2 and SAVEA3 are also equivalenced to SAVEAL in such a way that SAVEA1 contains all the J-1 level information, SAVEA2 contains the J level information, and the J+1 level information is equivalenced to SAVEA3. Figure 9 shows how the arrays would be equivalenced if there were only three variables, F, H and P, which were stored externally. In this example, the arrays F, H and P are all two-dimensional arrays (number of channels x 3). For any channel i, only three axial levels are stored in core; e.g., F_{i1} , F_{i2} , and F_{i3} are the axial flow rates at J-1, J, and J+1, respectively. The particular arrangement of having the three variables, F, H, and P, together in the single array is accomplished by dimensioning each of the three variables as 3N x 3 and then overlaying the 3 arrays by equivalencing the first element to the proper position in SAVEAL. For this example the following statements would produce the variable arrangement in Figure 9.

```
Dimension F(3N,3), H(3N,3), P(3N,3), SAVEAL(9N), SAVEA1(3N), SAVEA2(3N),
        SAVEA3(3N),
```

```
Equivalence  (SAVEA1(1), SAVEAL(1)), (SAVEA2(1), SAVEAL(3N+1)),
              (SAVEA3(1), SAVEAL(6N+1)), (F(1,1), SAVEAL(1)),
              (H(1,1), SAVEAL(N+1)), (P(1,1), SAVEAL(2N+1))
```

Use of this storage scheme allows all the variables at one axial level to be transferred from or to external storage by a single read or write with SAVEA1, SAVEA2 or SAVEA3 as the variable list for transfer. The user does not have to be directly concerned about the actual dimensioning and equivalencing since the auxiliary program SPECSET (described in Section 8) handles this function. The general description of the data storage technique has been presented here to give the interested user a more complete understanding of how the code works.

FIGURE 9. Array Equivalency to Facilitate Data Management for the Roll Option

5.3.1 DUMP and RESTART

The same data storage scheme described above is also very useful for storing or "dumping" all the information at the end of a computation for use at a later time as a "restart." The dump and restart capability can be used in two ways. In running the code for a steady-state solution, the calculation may terminate before convergence if more than a user-specified maximum computation time has been used or if convergence has not been achieved in a specified number of iterations. If the user takes the necessary steps to permanently store the "dumped" information, he may restart the solution and continue iterating toward a converged solution at a later time. At the time of restart the user may also change some of the problem input, in which case the dumped solution may be used as a first guess for the solution to the new problem. Secondly, the dump and restart system is useful in making long (in terms of computer time) transient runs. In this case, the user specifies a number of time steps or transient seconds to be run before dumping the solution. The user may then continue the transient run with or without making changes to the input by using the restart option.

At the time a run is completed, a call to subroutine DUMPIT writes out all of the necessary information stored in core and on external devices to a new file identified as TAPE 8. When a restart run is made at a later time subroutine RESTART is called to read the dump file, set the value of all variables stored in core, and put the necessary information on the external devices.

6.0 NODING, INPUT PARAMETERS, AND NODING CONVENTIONS

The subchannel noding approach makes the COBRA-WC code very flexible in terms of the geometries which can be modeled. In general, as the flexibility and generality of a code increases, the amount of input required also increases. There are many parameters and dimensions that the user must supply to use the COBRA-WC code, and it is important that the user understand how each of these input values is to be used to obtain results. The purpose of this section is to provide some direction for the user in preparing the input for a problem and to describe some of the modeling conventions used in the code.

6.1 NODING LMFBR FUEL AND BLANKET ASSEMBLIES

There has been considerable experience gained in using the COBRA-IV-I code for modeling LMFBR assemblies. Since the basis of the COBRA-WC code is the same, it is desirable to take advantage of this experience whenever possible. The COBRA-WC code may be used in the same manner as the COBRA-IV-I code for standard subchannel (Figure 10) analysis; the same set of input parameters which have produced reliable results using COBRA-IV-I should be adequate for the COBRA-WC code. However, it is anticipated that much of the use of the COBRA-WC code will be directed toward multiassembly transient analysis requiring that coarser noding schemes be used for many of the assemblies. Without providing the results of a complete noding study here, some suggestions can be made concerning the node arrangement and the required input parameters. It is suggested that any coarse noding be done in such a way as to preserve the original subchannel boundaries (i.e., the coarse node boundaries should be coincident with and not cross the standard subchannel boundaries). Figure 11 shows a 37-channel model of a 217-pin bundle. If this type of coarse noding is used, the assumptions made for the transverse connections in standard subchannel analysis are still applicable. In previous sections it was mentioned that care should be taken when using the direct inversion matrix solver with PSOLVE or when using the RECIRC scheme. The amount of core storage required to set up and solve the matrix equation depends on the maximum bandwidth for any assembly. The bandwidth for an assembly is one plus twice the maximum

FIGURE 10. Standard Subchannel Noding for a 19-Pin Bundle

difference of channel numbers connected by a transverse gap. An illustration of this numbering technique is given in Section 9.

For coarse noding it is suggested that the transverse momentum control volume length be $N \cdot \ell'$ where ℓ' is the length which would be used for standard subchannel analysis and N is the number of rows of rods between channel centroids. This will give approximately the correct area for momentum transport. The transverse gap width should be the sum of the individual rod-to-rod gaps that make up a connection between lumped subchannels.

The length for calculating conductive heat transfer between adjacent channels is given by

$$\ell_c = 1/GK$$

where the input GK is an assembly-dependent conduction factor. Doubling the value of GK effectively doubles the radial heat transfer due to conduction. Note that $1/GK = ZK$ used in Equation 2.

The optimal value of GK is very problem dependent, and much more work is required to be able to predetermine the conduction factor. For problems where there is no information on the conduction factor, GK should be chosen to make ℓ_c approximately equal to the subchannel centroid-to-centroid distance.

Turbulence modeling in LMFBR bundles has not yet been well defined. Usually, when using the COBRA wire wrap model in standard subchannel analysis, has simple mixing correlation of the form given in equation (56) is used. β is given a value of 0.01 to 0.02. When using lumped noding schemes without the wire-wrap model it is desirable to enhance the turbulent mixing by using a value of β of up to 0.1. The turbulent momentum factor generally has a very small effect on velocity and temperature distribution, but a value of 1.0 may be used if desired. The turbulent momentum factor is used as a multiplier on the turbulent momentum exchange term in the axial momentum equation (Equation 3).

When using lumped noding schemes for the flow channels, it is also desirable to reduce the detail in the modeling of the pins. It is suggested that one pin be modeled for each flow channel. The radial power factor of the single pin can be determined by taking a weighted average of the radial power factors of the associated pins. The weighting factor should be the fraction of each rod surface exposed to the lumped channel. The proper amount of heat is delivered to the channel by making the channel power factor equal to the number of pins the lumped pin represents. Study of the input instructions and sample problems should clarify this procedure. Figure 11 shows one possible lumped noding scheme for a 61-pin bundle.

Some of the COBRA-WC input is in the form of tables for various profiles (axial power generation profile, transient flow factors, etc.). In setting up a problem it is important that the user knows how each of these profiles is to be applied. Generally, simple linear interpolation is used to determine the appropriate factor from a profile table. For the transient profiles the total elapsed time is calculated as the sum of all previous time steps plus the

current time step. This elapsed time is then used to determine factors for the inlet flow and temperature, power, and pressure drop by interpolation between the nearest two tabular values to the elapsed time. For the axial power profile the axial distance used for interpolation is the distance to the center of the cell from the inlet (the bottom of the first computational cell). The Reynolds-number-dependent loss coefficients are calculated by interpolating from the Reynolds-number-versus-loss-coefficient-factor table at the local Reynolds number.

A table may also be input to change the material or dimensions of a rod axially. In this table the endpoint of each material is specified in terms of the distance from the inlet. The axial cells in the rods correspond to the axial cells for the coolant. Each axial rod cell is assumed to be entirely within one material zone. A cell is assumed to be in a particular zone if the top of the cell falls within the zone or is coincident with upper boundary of the zone. Figure 12 shows a rod divided into 7 axial cells and three material zones. The material assumed for each cell is noted.

FIGURE 11. Lumped Subchannel Noding for a 61-Pin Blanket Assembly

FIGURE 12. Axial Fuel Pin Model Showing the Material Typed Assumed for Each Computational Cell

6.2 MODELING OTHER FLOW PATHS

In modeling multiassembly problems it is anticipated that the user will want to model some flow paths which are not pin bundles (e.g., reflectors or bypass flow paths). Experience on the use of the code in this area is limited but as long as the basic assumptions used in the code are not violated and care is taken to ensure that the input is reasonable, then useful results can

be obtained. Since the variety of applications in this area is so large, no attempt will be made to indicate how the input should be chosen for particular problems. It should be noted that the code is not generally applicable to free field calculations since the fluid shear terms are not included in the momentum equations.

6.3 AXIAL NODES AND TIME STEP

The variable axial node length option allows the user some flexibility in selecting a noding scheme for a particular problem. There is no stability limit on the number or length of each node, but the axial node arrangement should be chosen to provide the best results for the lowest computation costs. For this it is important to remember that using the peripheral storage option places a rather severe job cost penalty (depending on the computer facility cost algorithm) on large jobs and can be worse for small jobs. The option should be avoided if at all possible by keeping the number of nodes to a minimum.

There should always be enough axial nodes to adequately resolve the axial power profile. The only other limit on the number of nodes is imposed when the wire-wrap model is used. With this option there must be at least six nodes per axial wire-wrap lead length since a wire is not allowed to pass through more than one transverse gap at each axial level.

Time steps should be chosen in much the same way as the axial steps, i.e., they must be sufficiently small to resolve changes in the boundary conditions and to follow the changes in the transient solution. Each problem must be looked at carefully to determine what transient effects are important and how small the time steps must be so as not to miss them. It is often advisable to run a simple single-channel problem with all the essential features several times with various time steps to determine the largest allowable time step in each region of the transient.

6.4 CONVERGENCE CRITERIA

As previously described, convergence is checked in the code in several ways. The error in the energy equation is computed as $(h - \bar{h})/h$ where $\bar{h}$ is the previous outer iteration enthalpy. The input variable HERROR controls this convergence and has a default value 0.001, which is adequate for most applications. There is another check on the convergence of the energy solution in the Gauss-Siedel iterative scheme. The error is computed similar to that for the outer loop, but the convergence criteria has been internally set in the code to 1.0×10^{-6} .

Convergence for momentum and continuity is checked in different ways depending on whether the PSOLVE scheme or the RECIRC scheme is used. In PSOLVE the rate of change of both crossflow and axial flow are checked as:

$$\text{Max}_{k,j} \left| \frac{W_{k,j} - \bar{W}_{k,j}}{W_{k,j}} \right| \quad \text{and} \quad \text{Max}_{i,j} \left| \frac{F_{i,j} - \bar{F}_{i,j}}{F_{i,j}} \right|$$

where $\bar{W}$ and $\bar{F}$ are the last iterate values for the crossflow and axial flow rate. Default values of 0.1 and 0.01 are available for the transverse (WERRY) and axial flow (FERROR) convergence criteria, respectively. Generally, it is not necessary to converge on the transverse flows as tightly as on the axial flows since the magnitude of the transverse flow is small and changes in the crossflow have a small effect on the axial flow and temperature distribution. When using the Gauss-Siedel solution scheme for the momentum equations, the internal convergence criteria, WERRY, may be set or allowed to default to a value of 0.001 which is generally sufficient.

In the RECIRC scheme convergence is checked as the ratio of the error in the continuity equation to the maximum of the flows at the cell boundaries. FERROR is used as the criteria for convergence in the outer loop, and WERRY is used as the criteria in the inner pressure loop.

6.5 DAMPERS AND ACCELERATORS

A damper or accelerator is applied at several points in the code to maintain stability and to increase convergence rates. Generally, the damper (or accelerator) is applied as

$$\phi = \alpha \phi + (1-\alpha) \bar{\phi} \quad (61)$$

where ϕ is the quantity being damped, α is the damper and $\bar{\phi}$ is the last iterate value. The three dampers used in the COBRA-WC code are DAMPING, ACCELY and ACCELF. DAMPING is used to damp the transverse pressure gradient term used in the transverse momentum equation. A default value of 0.8 is supplied and is usually sufficient. ACCELY is the accelerator for the SOR solution scheme for the momentum equations in PSOLVE. It defaults to 1.6 which, from experience, has given good results for a wide variety of problems. The axial flow damper, ACCELF, defaults to 0.7 and cannot be increased too much except for problems which require very little iteration for convergence.

There are three ramps available in the code to help convergence at the start of a new problem. These ramps allow some of the boundary conditions to be brought into full effect over a number of iterations. The three ramps are identified as: NARAMP, the number of iterations over which channel area changes are introduced; NRAMP, the number of iterations over which the wire-wrap and loss coefficient effects are introduced in the noded region (network losses are not ramped in) and NRAMPH, the number of iterations over which the power is introduced. Each of the ramps is operable only for steady-state solutions and must be reset by card input if they are desired for a restart case.

7.0 COBRA-WC INPUT

7.1 GENERAL DESCRIPTION

COBRA-WC was developed by modifying and extending COBRA-IV-I to model multiassembly LMFBR transient problems. The geometry modeling flexibility has been increased while limiting the code's capability to solve single-phase problems.

In designing the input for COBRA-WC, two objectives were identified: 1) maintain the modeling flexibility of previous versions of COBRA, and 2) keep the required input to a minimum. To meet the first objective, the general form of the COBRA input was retained, i.e., describing the geometry by subchannels. This means that, in addition to the multiassembly capabilities, COBRA-WC has all the single-assembly LMFBR modeling capabilities of COBRA-IV-I, except for axial conduction. To meet the second objective it was decided to allow the user to specify types of assemblies with associated rod configuration types. A particular assembly type is described by input in much the same manner as a single assembly would be described using COBRA-IV-I; i.e., by specifying subchannel dimensions and transverse connections. Once a particular assembly type has been described, the user can identify other assemblies of the same type. The code will then generate the geometry information for other assemblies of the same type. A similar procedure is used for describing rod configurations. An option allows the user to change the rod radial power factors for a given rod configuration type so that assemblies of one type may have varied power profiles. The rod configuration types must correspond to the assembly types; i.e., a type one assembly must have a type one rod configuration, etc.

To simplify the input, the code has been set up to use two sets of subchannel identifiers, the local and global identifiers. The local subchannel identifiers refer to a subchannel by its assembly number and subchannel number within that assembly. All code input and output refer to these numbers. Internally the code uses a global subchannel identifier which is a single subchannel number. This was done to allow use of a large part of the COBRA-IV-I coding as it applied to single assembly analysis.

The procedure for setting up a multiassembly problem should become clearer after studying the input instructions along with the sample problem input.

As in previous versions of COBRA, the input is arranged in card groups with group header cards indicating the problem size and the requested options. As much as possible, the input was separated into the various groups based on some common purpose; e.g., the fluid computational grid is set up using Card Group 4 input and the rod data is supplied in Card Group 8. A brief summary of input in each card group is given below to help the user locate those groups for which input is required for a specific problem.

7.2 CARD GROUP SUMMARY

<u>Card Group</u>	<u>Input</u>
<u>Preliminary Card(s)</u>	<ul style="list-style-type: none"> - maximum computation time limit - restart option - restart parameters - case number and title
<u>Group 1</u> Fluid Properties	<ul style="list-style-type: none"> - fluid property table (not required if the fluid is sodium)
<u>Group 2</u> Friction Factors and Film Coefficients	<ul style="list-style-type: none"> - correlations for film coefficients and friction factors for turbulent and laminar flow
<u>Group 3</u> Axial Heat Flux Profile	<ul style="list-style-type: none"> - any number of tables of heat generation multiplier versus normalized axial distance

Card Group	Input
<u>Group 4</u> Subchannel and Assembly Information	<ul style="list-style-type: none"> - interassembly heat transfer parameters and connections - forcing function identifier for each assembly - network model information (assembly) - subchannel dimensions and connections - thermal connection data
<u>Group 5</u> Area Variation	<ul style="list-style-type: none"> - tables giving normalized area versus normalized axial distance
<u>Group 6</u> Gap Variation	<ul style="list-style-type: none"> - tables giving normalized gap width versus normalized axial distance
<u>Group 7</u> Wire Wraps and Loss Coefficients	<ul style="list-style-type: none"> - wire wrap parameters - spacer grid parameters - network model information (assembly groups) - loss coefficient versus Reynold's number tables - blocked channel information
<u>Group 8</u> Rod Information	<ul style="list-style-type: none"> - rod dimensions - radial power factors - rod material properties - temperature dependent material properties - rod material distribution (axially)

Card Group	Input
<u>Group 9</u>	
Calculation	- roll option
Parameters	- momentum equation solution option
	- subchannel length
	- transient time
	- convergence criteria
	- crossflow resistance
	- number of axial nodes
	- number of time steps
	- time step versus transient time table
	- variable axial node lengths
<u>Group 10</u>	
Mixing Parameters	- turbulent mixing correlation
	- conduction geometry factor
	- swirl model parameters
<u>Group 11</u>	
Boundary	- inlet temperature distribution
Conditions	- inlet flow distribution
	- pressure drop
	- assembly power levels
	- transient forcing functions
<u>Group 12</u>	
Output Parameters	- options to print all or any part of the calculated results.

The following section describes the input options for using the COBRA-WC code. In setting up an input deck, the user should initially decide from which orientation (looking upstream or looking downstream) the problem is to be viewed and maintain all input consistent with that viewpoint. This is particularly important in describing the radial power profile in Card Group 8 and the wire wrap model in Card Group 7.

7.3 INPUT INSTRUCTIONS FOR COBRA-WC

The input instructions are divided into two sections. The first section describes the preliminary cards required for every run. The second lists all of the group input cards, some or all of which may not be required for restart runs. The first card for each group controls the user options for that group.

PRELIMINARY CARDS

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
COBRA.1	<u>MAXT, IECHO</u>	Format (2I5) Must be the first data card of the input deck.
	MAXT	= the computer time limit (sec ₁₀) allowed for problem calculations. Computer CP time limit must be greater than MAXT to allow for printing of results if MAXT is exceeded. Negative MAXT indicates a "Restart" problem from a previously stored solution.
	IECHO	= option to have input card images printed. IECHO = 0: images will be printed, IECHO = 1: no printout. IECHO = 0: default.
RESTR.T.1 ^(a)	<u>NJUMP, NA,</u> <u>IT, NTT, ITT</u>	Format (4I5, F5.0) Optional input: MAXT negative Restart options, where:

(a) For further information on the restart options, see the description of subroutine RESTR.T in Appendix A.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
RESTRT.1 (contd)	NJUMP	<p>= restart flag. NJUMP = 0: continue calculations on a previous steady-state or transient solution; do not read in any additional data.</p> <p>NJUMP = 1: new problem calculation with a previous solution as the first computational guess or continue calculations on a previous solution reading additional data from subroutine setup. The code expects restart information to be on a file with logical life name, TAPE8. Restart information is dumped to TAPE8 after a run is completed.</p> <p>NJUMP = 2: read dump tape, print input and results then STOP. NJUMP = 3: same as NJUMP = 0, but all the input data is printed.</p>
	NA	= number of additional iterations. The old value of NTRIES (SETUP 9.3) is increased by NA in a steady-state problem or is set to NA in a transient. NTRIES may be reset directly in Card Group 9 if NJUMP = 1.
	IT	= 1: flag to begin a transient solution at time zero from a previous steady-state solution. Transient data must be read in (NJUMP=1) from setup. For other restart cases, the value of IT is ignored.
	NTT	= number of additional transient time steps allowed. NTT is used to increase the value of NDT (SETUP.9.3) in order to continue or start a transient.
	TTT	= total additional transient time (sec). The time step size is TTT/NTT unless a time step size forcing function has been or will be (NJUMP=1) supplied in Card Group 9.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.0	<u>KASE, J1, TEXT</u>	Format (2I5,17A4) Case control card, where:
	KASE	= problem case number. K > 0: begin case with core initialized to zero. K < 0: use previous case solution as first guess. K = 0: STOP.
	J1	= print option for input data. J1 = 0: print only new input data. J1 = 1: print all input data. J1 = 2: print only operating conditions. J1 = 10: print all input data, then stop.
	TEXT	= output text for problem identification; maximum: 68 characters.

GROUP INPUT CARDS

Group 1 - Fluid Property Table

If this group data is not input, the fluid properties will be taken from ANL-7327 sodium property curve fits. The system pressure, PLIQ is used only for calculating a saturation temperature. Calculations will be terminated if any temperature rises above the saturation temperature.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.1	<u>1,N1</u>	Format (15I5) = NPROP, number of property cards to be read
SETUP.1.1	<u>PLIQ(I), TEMIQ(I), HLIQ(I), CONLIQ(I), CPLIQ(I), VLIQ(I), VISLIQ(I)</u>	Format (8E10.5), (I=1, N1) Read in N1 fluid property cards, where

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.1.1	PLIQ	= pressure (psia)
(contd)	TEMLIQ	= temperature ($^{\circ}\text{F}$)
	HLIQ	= enthalpy (Btu/lbm)
	CONLIQ	= thermal conductivity (Btu/hr-ft- $^{\circ}\text{F}$)
	CPLIQ	= specific heat (Btu/lbm- $^{\circ}\text{F}$)
	VLIQ	= specific volume (ft ³ /lbm)
	VISLIQ	= viscosity (lbm/ft-hr)

Group 2 - Friction Factors and Heat Transfer Coefficients

Any number of friction factor and film coefficient correlations may be input. Input in Card Group 4 determines which correlation will be applied to each channel.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.2	<u>2,N1,N2,N3</u>	Format (15I5)
	N1	= NFRICT, number of friction factor correlation sets to be read in. Defaults to 1.
	N2	= NHEAT, number of heat transfer coefficient correlation sets to be read in. If NHEAT < 1, defaults to the Lyon-Martinelli correlation.
	N3	= NVISCW, wall viscosity correlation option. N3 = 0: no heated wall correction to the friction factor. N4 = 1: include heated wall correction to the friction factor.
SETUP.2.1	<u>AA(I), BB(I),</u> <u>CC(I), DD(I),</u> <u>EE(I), AAL(I),</u> <u>BBL(I), CCL(I),</u>	Format (8F5.3) (I = 1, N1)
	AA, BB, CC, DD, EE	= constants in the correlation of the form: $f_T = AA (R_e)^{BB} + CC (R_e)^{DD} + EE$
	AAL, BBL, CCL	= optional constants for laminar friction factor correlation of the form: $f_L = AAL (R_e)^{BBL} + CCL$ When the laminar friction factor correlation is specified the code takes the friction factor to be the maximum of f_T and f_L .

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.2.2	<u>AH1(I), AH2(I),</u> <u>AH3(I), AH4(I),</u> <u>AHL1(I), AHL2(I),</u> <u>AHL3(I), AHL4(I),</u>	Format (8F5.3), (I = 1, N2) Optional input: N2 > 0. AH1, AH2, AH3, AH4 = constants for the single-phase heat transfer correlation of the form: $H_T = (K/D) (AH1(I)R_e^{AH2(I)}P_r^{AH3(I)} + AH4(I))$ AHL1, AHL2, AHL3,AHL4 = constants for the optional laminar single-phase heat transfer correlation of the form: $H_L = (K/D) (AH1(I)R_e^{AHL2(I)}P_r^{AHL3(I)} + AHL4(I))$ When the laminar heat transfer correlation is used, the code takes H to be the maximum of H_T and H_L . When N2 = 0, code defaults the turbulent film coefficient: AH1 = 0.025; AH2 = 0.8; AH3 = 0.8; AH4 = 7.0.

Group 3 - Axial Power Profiles

Any number of profiles may be read in. The particular profile to be used for each assembly is determined from Card Group 4 input.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.3	<u>3,N1,N2</u>	Format (15I5)
	N1	= NHFT, number of power profiles to be read in
	N2	= NAX, number of entries in each power profile table
SETUP.3.1	<u>Y(I)</u>	Format (12F5.3), (I = 1, N2)
	Y	= relative position (X/L) at which power factor is given, where L is the total bundle length. must include 0.0 and 1.0 as end points.
SETUP.3.2	<u>AXIAL(I,L)</u>	Format (12F5.3), (I = 1, N2)
	AXIAL	= relative power density at (X/L). Repeat for the N1 profiles; i.e., L = 1, N1.

Group 4 - Channel Layout and Dimensions

In the Card Group 4 input instructions are several references regarding the order in which certain parameters must be input. The code sets up a reference frame based on the first assembly input. The side identified as side 1 on the first assembly must be side 1 on all assemblies. The other sides must be all numbered in a clockwise or all in a counter-clockwise fashion. This restriction is necessary to set up the interassembly heat transfer nodes. Also, the manner in which the face channel numbers are input must be done consistently, either all clockwise or all counter-clockwise. Since it does not matter whether the input is counter-clockwise or clockwise, it makes no difference whether the user's core picture is looking from the top or bottom, as long as his numbering is consistent.

When two assemblies with similar noding are adjacent there will be one heat transfer (IAHT) node generated for each fluid cell along the assembly face. When adjacent assemblies have different noding schemes, the number of IAHT nodes generated is determined by the assembly with the greater number of fluid cells on a face. To obtain satisfactory results in this situation, the number of fluid cells along a face in the more finely noded assembly should be an integer multiple of the number of fluid cells on a face in the coarsely noded assembly.

In all cases, it is assumed that the IAHT nodes between two assemblies are all of equal length. Examination of the sample problem input should help to clear up the Card Group 4 input instructions.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.4	<u>4,N1,N2,N3,N4</u>	Format (I5I5)
	N1	= NASSEM, number of assemblies. Default is 1.
	N2	= IAHT; set to 1 if code-generated inter-assembly heat transfer nodes between neighboring assemblies are desired. IAHT = 2: same as 1, but in addition wall nodes on the uncoupled sides of all the assemblies are generated to model their heat capacity effects. This same additional nodding can be performed for specific assemblies by using IAHT = 1 and using SETUP.4.5.
	N3	= NWK, number of additional wall thermal connections not generated by IAHT = 1 or IAHT = 2 option.
	N4	= NETWK; set to 1 if the pressure drop network model is to be used.
SETUP.4.1	<u>RHODF, WIDTDF, RWALLDF, WTHDF</u>	Format (4E10.5)
		Optional input: IAHT = 1
	RHODF	= default wall heat capacity parameter (Btu/Ft ² -°F) for 1/2 of IAHT connection
	WIDTDF	= side length of duct (in.)
	RWALLDF	= default conductive resistance for the IAHT connection; includes 1/2 the gap and one duct wall (ft ² -sec-°F/Btu)
	WTHDF	= default value for the wall decay heat parameter (in.)

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.4.2	<u>NASS, ITPA,</u> <u>NCHANA, INTAPE,</u> <u>IEDGE,</u> <u>WALLC(1,NASS),</u> <u>WALLC(2,NASS),</u> <u>WALLS(NASS),</u> <u>TMNCVL(NASS),</u>	Format (5I5,4E5.0)
	NASS	= assembly number
	ITPA	= assembly type number
	NCHANA	= number of channels in an assembly of type ITPA
	INTAPE	= tape number from which the input for assembly NASS should be read. Cards will be read if INTAPE = 0. Use INTAPE = 10 if input is generated by program GEOM.
	IEDGE	= 1 indicates that the side channel numbers are to be input in Setup.4.2 (necessary if swirl model is to be used for assemblies of type ITPA). Otherwise, IEDGE=0.
	WALLC(1,NASS)	= value for the wall heat capacity parameter for assembly NASS; 1/2 the IAHT connection only ($\text{Btu/ft}^2\text{-}^\circ\text{F}$). Defaults to RHODF.
	WALLC(2,NASS)	= value of the conductive resistance (includes 1/2 of the gap and the assembly NASS duct wall) ($\text{ft}^2\text{-sec-}^\circ\text{F/Btu}$). Defaults to RWALLDF.
	WALLS	= wall heat generation parameter for the assembly NASS duct wall and the interassembly 1/2 gap (inches). Defaults to WTHDF.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.4.2 (contd)	TMNCVL(NASS)	= Nominal transverse momentum control volume length (in) used for calculating crossflow resistance for lumped subchannel analysis. Should be set to the transverse momentum control volume length which would be used for standard subchannel analysis.
SETUP.4.3	<u>NAFLX(NASS),</u> <u>NFLMC(NASS),</u> <u>NHFVT(NASS),</u> <u>NPFVT(NASS),</u> MDFLT	Format (5I5)
	NAFLX	= identification number of axial heat flux profile (Card Group 3) to be used in assembly NASS. Defaults to 1.
	NFLMC	= identification number of heat transfer coefficient correlation (Card Group 2) used in assembly NASS. Defaults to 1.
	NHFVT	= identification number of heat flux versus time profile (Card Group 11) for use in assembly NASS. Defaults to 0, i.e., uses steady-state value throughout the transient.
	NPFVT	= identification number of pressure drop or flow versus time profile (Card Group 11) for use in assembly NASS. Defaults to 0; i.e., uses steady-state value for all time.
	MDFLT	= default value for the subchannel friction factor correlation specified as N in SETUP.4.7. Defaults to 1.
SETUP.4.4	<u>NETGRP(NASS),</u> <u>NINFF(NASS),</u> <u>NOUTFF(NASS),</u> <u>RAIN(NASS),</u> <u>PWIN(NASS),</u>	Format (3I5,6F10.0)

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.4.4 (contd)	<u>HAIN(NASS),</u> <u>RAOUT(NASS),</u> <u>PWOUT(NASS),</u> <u>HAOUT(NASS)</u>	Optional input: NETWK = 1
	NETGRP	= assembly grouping number to be used with NASS. Loss coefficients for group NETGRP must be specified in Card Group 7. Defaults to NETGRP = 1.
	NINFF	= identification number for loss coefficient forcing function (Card Group 7) versus Reynolds number to be used with assembly inlet loss, RAIN. Defaults to 0; no forcing function.
	NOUTFF	= identification number for loss coefficient forcing function (Card Group 7) versus Reynolds number to be used with assembly outlet loss RAOUT. Defaults to 0, no forcing function.
	RAIN	= inlet loss parameter (1/ft-lbm) to be applied at NASS inlet. $P_{LOSS} = RAIN \cdot m^2 / g_c$.
	PWIN	= wetted perimeter (inches) associated with inlet loss RAIN; used only in Reynolds number calculation when NINFF > 0. Defaults to 1.0.
	HAIN	= gravitational head length (inches) associated with the assembly inlet loss.
	RAOUT	= outlet loss parameter (1/ft-lbm) to be applied at NASS outlet. $P_{LOSS} = RAOUT \cdot m^2 / g_c$.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.4.4 (contd)	PWOUT	= wetted perimeter (inches) associated with outlet loss RAOUT; used only in Reynolds number calculation when NOUTFF > 0. Defaults to 1.0
	HAOUT	= gravitational head length (inches) associated with the assembly outlet loss.
SETUP.4.5	<u>ISIDE(NASS,I)</u>	Format (16I5), (I = 1, 6) Optional input: IAHT > 0
	ISIDE	= adjacent assembly number for assembly NASS on side I. Sides must be consistently ordered for all assemblies and progress around the assembly. If ISIDE(NASS,I) = 0 then there will be no interassembly heat transfer on that side. If ISIDE (NASS,I) = NASS, wall nodes on side I will be set up which connect only to assembly NASS.
SETUP.4.6*	<u>IFACE(ITYPE, I,J)</u>	Format (13I5/), ((J = 1, 13), I = 1, 6) Optional input IAHT > 0 or IEDGE = 1
	IFACE(ITYPE, I,J)	number of channels on side I for an assembly of type ITYPE (when J = 1). Number of channels on face I for assemblies of type ITYPE (when J ≥ 2). Numbers must progress around the assembly, and the pattern must be consistent for all assemblies.
SETUP.4.7*	<u>N, I, AC(I),</u> <u>PW(I), PH(I),</u> <u>LC(I,L),</u> <u>GAPS(I,L),</u> <u>DIST(I,L)</u>	Format (I1,I4,3E5.2, 4(15,2E5.2)), ((L = 1, 4) I = 1, NCHANA)

Read NCHANA cards of Channel Geometry, where:

*indicates that those cards must be read in only the first time a new assembly type number, ITYPE, appears on SETUP.4.2.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.4.7 (contd)	N	= friction factor correlation type. If blank or zero, type MDFLT (SETUP.4.3) is assigned. If $N > 0$, type N is assigned. The subchannel type indicates the appropriate friction factor correlation to be used (Card Group 2).
	I	= subchannel identification number.
	AC	= nominal subchannel area (in.^2).
	PW	= nominal subchannel wetted perimeter (in.).
	PH	= nominal subchannel heated perimeter (in.).
	LC	= adjacent subchannel identification number, for up to 4 subchannels adjacent to subchannel I. Each connection should be identified only once.
	GAPS	= nominal GAP width (in.) between subchannel I and the adjacent subchannel specified by LC.
	DIST	= transverse momentum control volume length (in.) between the adjacent subchannels specified by LC. Optional input, DIST will be calculated from GAPS and SL (group 9) parameter if set to 0.

Repeat SETUP.4.2-4.7 until all assemblies have been read in.

SETUP.4.8	<u>J1, IKW(KW),</u> <u>RWALL(1,KW),</u> <u>J2, JKW(KW),</u> <u>RWALL(2,KW),</u> <u>RHOLCP(KW),</u> <u>WIDTH(KW),</u> <u>WLTHCK(KW)</u>	Format (2(I2,I3,E5.2),3E5.2), (KW = 1, N3) Optional input: $N3 > 0$ can be used in conjunction with $IAHT > 0$.
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<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.4.8 (contd)		Thermal connection data for subchannels with thermal wall connections not generated using the IAHT options.
	J1, J2	= assembly numbers associated with local subchannel IKW and JKW
	IKW,JKW	= local subchannel numbers adjacent to wall. JKW and J2 may be set to zero to signify a wall with only one connection for modeling wall transient heat capacity effects.
	RWALL(1,KW), RWALL(2,KW)	= effective resistance of the wall associated with the IKW and JKW subchannels, respectively ($\text{ft}^2\text{-sec-}^\circ\text{F/Btu}$). If JKW = 0, RWALL(2,KW) need not be specified.
	RHOLCP	= wall heat capacity parameter ($\text{Btu/ft}^2\text{-}^\circ\text{F}$)
	WIDTH	= width of wall (in.). Heat conduction area = WIDTH x ΔX .
	WLTHCK	= wall decay heat parameter (in.)

Group 5 - Area Variation

Card Group 5 represents input axial profiles for subchannel area variation factors. This is an optional group.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.5	<u>5,N1,N2,N3</u>	Format (15I5)
	N1	= NAFAC, number of subchannels for which area variation tables are to be read
	N2	= NAXL, number of axial locations for subchannel area variation
	N3	= NARAMP, the number of iterations for gradual insertion of area variations. If blank or zero, NARAMP = 1. For a "restart" case, NARAMP must be reread if required.
SETUP.5.1	<u>AXL(I),</u>	Format (12F5.3), (I = 1, N2) Table of axial locations, where:
	AXL	= axial location (X/L) where subchannel area variations will be specified. Read in N2 values which apply to all subchannels specified in SETUP.5.2.
SETUP.5.2	<u>NASS, I,</u> <u>(AFAC(L,J))</u>	Format (2I5/(12F5.3), ((L = 1, N2), J = 1, N1) For N1 subchannels read area variation factors at N2 axial locations corresponding to (AXL), where:
	NASS	= assembly number
	I	= identification number of a subchannel for which area variations are being specified. Read NASS and I, then skip to the next card and read a complete set of factors (AFAC) corresponding to the AXL locations. Repeat until factors for N1 subchannels are read.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
	AFACT	= relative subchannel area (A_i/A_{nominal}) at each axial level (AXL)

Group 6 - Gap Size Variations

Card Group 6 represents input axial profiles for gap size variation. Card Group 6 is an optional group.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.6	<u>6,N1,N2</u>	Format (15I5)
	N1	= NGAPS, number of gaps for which gap variation tables are to be read
	N2	= NGXL, number of axial locations for gap variation
SETUP.6.1	<u>GAPXL(L)</u>	Format (12F5.3), (L = 1, N2) Table of axial locations, where:
	GAPXL	= axial locations (X/L) where gap variations will be specified. Read N2 values which apply to all gaps (K) specified in SETUP.6.2.
SETUP.6.2	<u>NASS, K,</u> <u>GFACT(L,LL)</u>	Format (2I5/(12F5.3)), (L = 1, N2), LL = 1, N1) For N1 gaps, read gap variations at N2 axial locations (GAPXL)
	NASS	= assembly number
	K	= gap identification number of gap to be varied. Read NASS and K, then skip to the next card and read N2 gap variation factors. Repeat until factors for N1 gaps are read.
	GFACT	= gap variation factors for gap K. Read N2 values for each K corresponding to each GAPXL location. $GFACT = (GAP_i / GAP_{nominal})$.

Group 7 - Wire Wraps and Loss Coefficients

Currently the wire wrap model can only be used for assembly #1. Loss coefficients and wire wraps may be used in the same assembly

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.7	<u>7,N1,N2,N3,</u> <u>N4,N5,N6,N7,</u> <u>N8,N9</u>	Format (15I5)
	N1	= J6. N1 = 1 specifies wire wrap input only. N1 = 2 specifies grid spacer input only. N1 = 3 specifies both wire wrap input and grid spacer loss coefficient input.
	N2	= number of gaps for which wire wrap crossing data is supplied
	N3	= NOLC, number of loss coefficients to be input in SETUP.7.4
	N4	= NRAMP, number of iterations over which the loss terms and/or wire wrap effects are to be ramped into the solution. For a "restart", NRAMP must be reread if required.
	N5	= logical unit from which card sets SETUP.7.2 and SETUP.7.3 are to be read. N5 = 0: read from input deck. N5 > 0: read from logical unit N5. N5 = 9 if using GEOM. output.
	N6	= NLCFF, number of loss coefficient forcing functions versus Re profiles to be input in (SETUP 7.7) for use with the network model or the loss coefficients (SETUP.7.4). Defaults to 0.
	N7	= NLCFP, number of points in loss coefficient forcing function versus Re profiles (SETUP.7.6 - 7.7). When N6 > 0, N7 is set to a minimum value of 2.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.7 (contd)	N8	= NOGRP, number of assembly groups for the network model. NOGRP must be > 0 when NETWK = 1 (Card Group 4).
	N9	= NBLOCK, number of axial locations where axial flow blockages occur; can be used only with scheme RECIRC.
SETUP.7.1	<u>PITCH, DIA, THICK</u>	Format (3E10.5) Optional input: J6 = 1 or 3 Wire wrap specifications, where:
	PITCH	= wire wrap pitch (in.)
	DIA	= rod or cladding outer diameter (in.)
	THICK	= wire wrap diameter (in.)
SETUP.7.2	<u>K, DUR(K), XCROSS(K,L),</u>	Format (I5, 2E5.2), (L = 1, 2) Optional input: J6 = 1 or 3 Wrap crossing data, where:
	K	= gap number
	DUR	= parameter determining the amount of forced crossflow due to wire wrap. Recommended value DUR = 1.0.
	XCROSS	= wire wrap crossing angle. XCROSS is calculated by dividing the angle between the gap and wire (at the bundle inlet) by 360. The value is positive if the wrap is moving from a smaller to a higher number subchannel and negative if otherwise. If the wire wrap is on a gap boundary at the bundle inlet, XCROSS = ± 1.0 , not zero.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.7.3	<u>NWRAPS(I)</u>	<p>Format (10I5) (I = 1, Number of channels in Assembly #1)</p> <p>Optional input: J6 = 1 or 3</p> <p>Wrap inventory where:</p> <p>NWRAPS(I) = number of wires initially in subchannel I. Read an integer value of the number of wires present at the bundle inlet. For wires located on the gap boundary, the wrap is assumed to be in the subchannel into which it is proceeding. Read 10 values per data card until the inventory for all subchannels is read.</p>
SETUP.7.4	<u>NB, ILC(I),</u> <u>LCFF(I),</u> <u>FACTOR(I),</u> <u>CD(I), KLC(I),</u> <u>FXFLOW(I)</u>	<p>Format (3I5, 2E10.4, I5, E10.4), (I=1,N3)</p> <p>Optional input: J6 = 2 or 3 AND N3 > 0</p> <p>NB = assembly number in which loss coefficient is to be applied</p> <p>ILC = local channel number in which loss coefficient is to be applied; changed to global channel number in SETIN</p> <p>LCFF = the loss coefficient forcing function profile which is to be applied to this loss coefficient; refers to SETUP.7.5 input. Default = 0; no forcing function.</p> <p>FACTOR = the relative height in channel ILC at which the loss coefficient is to be applied (X/L)</p> <p>CD = loss coefficient</p>

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.7.4 (contd)	KLC	= local gap number at which forced diversion crossflow fraction FXFLOW is to be specified. Blank indicates no forced crossflow.
	FXFLOW	= fraction of axial flow in neighboring channel to be diverted across gap KLC at the axial node corresponding to FACTOR. Positive flow across the gap is defined in the direction of increasing adjacent channel number. Optional input, KLC > 0.
SETUP.7.5	<u>RTIN, RGIN(L),</u> <u>HGIN(L),</u> <u>RGOUT(L),</u> <u>HGOUT(L)</u>	Format (F10.5/(4F10.5)), (L = 1, N8) Optional input: NETWK = 1
	RTIN	= loss parameter (1/ft-lbm) to be applied to the total flow rate (sum of all assembly flow rates); Reynolds number independent
	RGIN	= loss parameter (1/ft-lbm) to be applied at assembly grouping L inlet; Reynolds number independent
	HGIN	= gravitational head length (in.) associated with the group inlet pressure loss
	RGOUT	= loss parameter (1/ft-lbm) to be applied at assembly grouping L outlet; Reynolds number independent
	HGOUT	= gravitational head length (in.) associated with the group outlet pressure loss
SETUP.7.6	<u>RECL(I)</u>	Format (12E5.0), (I = 1, N7) Optional input: (NETWK = 1 or J6 > 1) AND N6 > 0
	RECL	= Reynolds number at which points in the N6 loss coefficient forcing functions are given

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.7.7	<u>FFLC(I,L)</u>	Format (12E5.0), (I = 1, N7) Optional input: N6 > 0
	FFLC	= loss coefficient forcing function profile corresponding to RECL. Read in N6 profiles.
SETUP.7.8	<u>NBLOKA, NBLOKC,</u> <u>IBLOKA(I),</u> <u>IBLOKC(I)</u>	Format (2I5/(16(I2,I3))), I=1,NBLOKC) Repeat NBLOCK times
	NBLOKA	= axial level where the blockage is located
	NBLOKC	= number of channels blocked at axial level NBLOKA
	IBLOKA	= assembly number with blocked channel
	IBLOKC	= blocked channel number

Group 8 - Rod Layout and Fuel Properties

Card Group 8 defines radial rod power factor, rod-channel connections, and material properties. Sample problems should be helpful in setting up the Card Group 8 input data.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.8	<u>8,N1,N2,</u> <u>N3,N4,N5</u>	Format (15I5)
	N1	= number of assemblies for which rod data is to be read
	N2	= NC, order of approximation used in fuel model. N2 = 0: no fuel model. N2 = 2: 2nd order collocation solution. N2 = 3: 3rd order collocation. N2 > 3 or N2 = 1 is not acceptable.
	N3	= NFUEL, the number of fuel materials for which thermal properties are to be specified; not applicable if N2 = 0. If blank, NFUEL = 1 is assigned.
	N4	= NQAX, additional fuel model options: NQAX = 0: no additional options. NQAX = 1: fuel properties are temperature dependent axially. Operational only for NC = 2.
	N5	= NRODTP, option for axially varying fuel material. N5 = 0: each fuel rod is constructed of a single material and no axially varying data are read. N5 > 0: must read fuel zone information (SETUP.8.6) for each rod type N.
SETUP.8.1	<u>NOA, ITPA,</u> <u>NORODS, INTAPE,</u> <u>IPFR</u>	Format (5I5)
	NOA	= assembly number

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.8.1 (contd)	ITYPA	= rod configuration type number
	NORODS	= number of rods in configuration type ITYPE
	INTAPE	= tape number which from input should be read, INTAPE = 0: input will be on cards. Use INTAPE = 11 if using input generated by pro- gram GEOM.
	IPFR	= option to change radial power factors for a rod configuration type. If IPFR = 0, no changes will be made. IPFR > 0 indicates the number of cards to be read SETUP.8.3
SETUP.8.2*	<u>N, I, DR(I),</u> <u>RADIAL, LR(I, L),</u> <u>PHI(I,L)</u>	Format (I2,I3,2E5.2,6(I5, E5.2)), (L = 1, 6) Read in NORODS cards of rod input data, where: N = the fuel shape and fuel material options. The value of N determines the material prop- erty configuration of Rod I. Default N = 1. <u>For N5 = 0</u> (axially uniform fuel) N corre- sponds to one of N3 materials (SETUP.8.2) of which Rod I is made. <u>For N5 > 0</u> (axially varying fuel zones) N corresponds to one of N5 material configurations specifying the fuel material versus axial height (SETUP.8.6). If any rod is specified to have axially varying fuel zones (N5 > 0), all rods (including axially uniform rods) must have an axial configuration specified (SETUP.8.6).

*Indicates card(s) must be read in only the first time a new rod configuration number, ITYPE, appears on SETUP.8.1.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.8.2 (contd)	I	= rod identification number for assembly type ITYPA
	DR	= outer rod diameter (in.). If there is clad- ding around rod, DR is the cladding outer diameter.
	RADIAL	= radial power factor for rod I as a fraction of the average rod power (Group 11)
	LR	= identification numbers of subchannels sur- rounding rod I. Read in up to 6 subchannels.
	PHI	= fraction of the total rod power input to adjacent subchannel
SETUP.8.3	<u>IRN(L), IDF(L),</u> <u>RPF(L)</u>	Format (2I5, F5.0) (L=1,IPFR) Optional input: IPFR > 0 for assembly number NOA.
	IRN	= rod ID number (must be read in order)
	IDF	= same definition as N in SETUP.8.2
	RPF	= radial power factor for rod IRN
	Repeat SETUP.8.1 - 8.3 for up to NASSWR times	
SETUP.8.4	<u>KFUEL(I),</u> <u>CFUEL(I),</u> <u>RFUEL(I),</u> <u>DFUEL(I),</u> <u>KCLAD(I),</u> <u>CCLAD(I),</u> <u>RCLAD(I),</u> <u>TCLAD(I),</u> <u>HGAP(I),</u> <u>DROD(I),</u> <u>GEOMF(I),</u> <u>DFUELI(I)</u>	Format (10E5.2,I5,E5.2)), (I = 1, N3)

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.8.4 (contd)		Optional Input: N3 > 0 and NC > 0 Material properties. Read N3 cards corresponding to N3 materials for which thermal properties are specified. Each fuel rod consists of one or more of these materials. For N5 = 0, the fuel type N (SETUP.8.2) corresponds to the material type I.
	KFUEL	= thermal conductivity of the fuel (Btu/hr-ft ⁰ F)
	CFUEL	= specific heat of fuel (Btu/lb- ⁰ F)
	RFUEL	= fuel density (lb/ft ³)
	DFUEL	= fuel diameter (in.)
	KCLAD	= thermal conductivity of cladding (Btu/hr-ft- ⁰ F)
	CCLAD	= specific heat of cladding (Btu/lb- ⁰ F)
	RCLAD	= density of cladding (lb/ft ³)
	TCLAD	= cladding thickness (in.)
	HGAP	= Fuel-Clad Gap conductance coefficient (Btu/hr-ft ² - ⁰ F)
	DROD	= outer diameter of the fuel rod, including the cladding (in.)
	GEOMF	= fuel rod geometry indicator = 0: solid cylindrical fuel rod with internal heat generation = 1: annular cylindrical fuel rod with internal heat generation

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.8.4 (contd)	GEOMF (contd)	= 2: annular cylindrical fuel rod with a heat flux boundary condition on the inner fuel surface
	DFUELI	= inner diameter of the fuel for an annular fuel rod (in.). (Read in only if GEOMF > 0).
SETUP.8.5	<u>NTNODE, NFNODE,</u> <u>TVARY(I),</u> <u>VARYK(I),</u> <u>VARCP(I)</u>	Format (2I5/(12E5.3)), (I = 1, NTDNDE) Optional input: NC = 2 and NQAX = 1 Temperature dependent fuel property table; for material type 1 only.
	NTNODE	= number of entries in the property table
	NFNODE	= number of points used for integrating radial temperature profile to obtain fuel properties
	TVARY	= temperature(⁰ F)
	VARYK	= thermal conductivity (Btu/hr-ft- ⁰ F)
	VARYCP	= specific heat (Btu/lb- ⁰ F)
SETUP.8.6	<u>NZONE(I),</u> <u>ZEND(I,K),</u> <u>IZTYP(I,K)</u>	Format (I5/(6(E5.2,I5))), ((K = 1, NZONE(I)), I = 1, N5) Optional input: N5 > 0 Option to specify axially varying fuel materials. Must read in a fuel zone configuration table for each rod type (SETUP.8.2).
	NZONE	= number of axial zones to be read for a table of fuel material versus axial distance for fuel type I

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.8.5	ZEND	= relative axial location (X/L) of the end of a fuel zone. If fuel type I is axially uniform, $ZEND(I,1) = 1.0$.
	IZTYPE	= Type of material in fuel zone ending at ZEND. Each IZTYP corresponds to a material specified in SETUP.8.4. Only material type 1 can have temperature-dependent thermal properties.

Group 9 - Computational Variables

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.9	<u>9,N1,N2,N3,</u> <u>N4,N5,N6</u>	Format (15I5)
	N1	= NSKIPX, output print option. N1 = 0 or 1: print all axial levels. N1 > 1: print every N1 axial levels.
	N2	= NSKIPT, output print option. N2 = 0 or 1: print all time steps. N2 > 1: print every N2 time steps. N2 < 0: print every TRANT (SETUP.9.6) transient seconds.
	N3	= ISHEME = 1: iterative solution scheme for momentum equations (SCHEME) = 2: direct solution scheme for momentum equations (SCHEME) = 3: recirculation solution scheme for momen- tum equations (RECIRC)
	N4	= IROLL, problem roll option. N4 = 0: no roll option; all variables reside in core at all times. N4 = 1: only 3 axial levels of information (J - 1, J, and J + 1) are stored in core at one time. Use only when problem size demands external storage.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.9 (contd)	N5	= ITSTEP, maximum time step table. N5 = 0: a constant time step of TTIME/NDT (SETUP.9.1, 9.3) will be used. For N5 > 0, read in N5 pairs of (time versus maximum time step) information for variable maximum time steps (SETUP.9.4).
	N6	= NAZONE, number of axial zones for variable axial step size. A different axial step size may be specified for each zone (SETUP.9.5). If NAZONE = 0 the axial step size will default to Z/NDX (SETUP.9.1, 9.3).
SETUP.9.1	<u>Z, TTIME, WERRX,</u> <u>WERRY, FERROR,</u> <u>HERROR, DAMPNG,</u> <u>ACCELY, ACCELF</u>	Format (16E5.0)
	Z	= total axial length (in.)
	TTIME	= total transient time (sec)
	WERRX	= external crossflow convergence limit. This is defined for implicit pressure solution as the maximum allowable error in iterative crossflows at any axial level. If any error is greater than WERRX, the solution proceeds through another iterative sweep over the entire bundle. Default is 1.E-2.
	WERRY	= internal pressure convergence limit. N3 = 1 convergence limit for the iterative Gauss Seidel solution scheme at axial level J. N3 = 3: inner loop limit for recirculation solution scheme. Default is 1.E-3.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.9.1 (contd)	FERROR	= the external axial flow convergence limit, defined for the implicit axial momentum equation as the maximum allowable error for iterative axial flows. If error is greater than FERROR, another iterative sweep of the entire bundle is made. Default is 1.E-3.
	HERROR	= convergence limit for fluid enthalpy. Default is 0.001.
	DAMPNG	= damping factor for iterative transverse pressure drop term in the crossflow momentum equation. Default is 1.0.
	ACCELY	= accelerator for the iterative Gauss Siedel solution for the momentum equations. Default is 1.6.
	ACCELF	= damping factor for iterative axial flow. Default is 0.7.
		Note: All dampers and accelerators are applied as $X^n = \alpha X^n + (1-\alpha)X^{n-1}$ where X is the variable damped (accelerated), α is the damping factor, and n is the iteration level.
SETUP.9.2	<u>KIJ, SL,</u> <u>FTM, THETA</u>	Format (16E5.0)
	KIJ	= gap flow resistance between adjacent channels. Default = 0.5
	SL	= transverse momentum geometry factor. Width-to-length ratio of the transverse momentum control volume. Used only if DIST is not specified in card group 4 (SETUP 4.7). Default = 0.5.
	FTM	= turbulent momentum parameter. Default is 0.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.9.2 (contd)	THETA	= bundle orientation in degrees away from the vertical. Default = 0.0.
SETUP.9.3	<u>NDX, NDT,</u> <u>NTRIES, ITRY</u>	Format (5I5)
	NDX	= number of axial nodes
	NDT	= total number of time steps allowed. For implicit transients, the time step size is (TTIME/NDT) unless a time/step table (N5 > 0) is read in.
	NTRIES	= maximum number of external iterations allowed regardless of WERRX and FERROR. Default is 20.
	ITRY	= maximum number of internal iterations allowed regardless of WERRY. Default is 20 or 2 times the number of gaps, whichever is larger.
SETUP.9.4	<u>YT(I), FT(I)</u>	Format (12E5.0), (I = 1, N5) Optional input: N5 > 1 Read in N5 pairs of values for a table of time steps size versus time, where:
	YT	= time (sec) for maximum time step. Table must include time = 0.
	FT	= maximum time step (sec) allowed at this time.
SETUP.9.5	<u>NSTEPS(I), VDX(I)</u>	Format (8(I5,E5.0)), (I = 1, N6) Optional input: N6 > 0 Variable axial step size information
	NSTEPS(I)	= number of computational cells in Zone I
	VDX(I)	= axial step size (inches) in Zone I

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.9.6	<u>TRANT</u>	Format (F5.3) Optional input: N2 < 0
	TRANT	= option to print transient results based on a TRANT time interval (sec)

Group 10 - Turbulent Mixing Correlation and Fluid Conduction

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.10	<u>10,N1,N2,N3</u>	Format (15I5)
	N1	<p>= NSCBC, single-phase turbulent mixing option. Several forms of the equation for turbulent crossflow W' are possible:</p> <ol style="list-style-type: none"> 1) $W'_K = ABETA * (S_K G)$ 2) $W'_K = ABETA * Re ** BBETA * (S_K G)$ 3) $W'_K = ABETA * Re ** BBETA * (DG)$ 4) $W'_K = ABETA * Re ** BBETA * (S_K / \ell_k) (DG)$ <p>where the constants ABETA and BBETA (SETUP.10.1) are applied to the equation selected by N1. R_e is the local Reynolds number based on axial velocity; G is the axial mass flux; S_K is the gap width; D is the average (across the gap) hydraulic diameter; and ℓ_k is the transverse momentum control volume length.</p> <p>N1 = 1: use equation 1. N1 = 2: use equation 2. N1 = 3: use equation 3. N1 = 4: use equation 4.</p>
	N2	= Number of assembly types in which a swirl flow mixing model will be used
	N3	= 1 if fluid conduction in the radial direction is to be considered

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.10.1	<u>(NATYPE,</u> <u>ABETA(NATYPE),</u> <u>BBETA(NATYPE),</u> <u>GK(NATYPE)</u>	Format (I5,3E5.0), (I = 1, MAXTYP) Optional input: N1 > 0 or N3 = 1 Read one card for each assembly type (MAXTYP = total number of assembly types) NATYPE = assembly type number ABETA, BBETA = constant coefficients for the turbulent mixing correlation selected (see N1). BBETA = 0, if N1 = 1. GK = Geometry factor for radial conduction. If N3 = 0 or GK = 0.0, conduction in the fluid will not be included in the calculation.
SETUP.10.2	<u>NATYPE, IDIR,</u> <u>CONSTI</u>	Format (2I5,E5.0) Optional input: N2 > 0 Read N2 cards. NATYPE = assembly type number IDIR = swirl direction indicator. Zero indicates counterclockwise (from top of bundle looking upstream); 1 indicates clockwise. CONSTI = swirl velocity as a fraction of the average bundle velocity

Group - 11 Operating Conditions and Transient Forcing Functions

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.11	<u>11,N1,N2,N3,N4,</u> <u>N5,N6,N7,N8,N9,</u> <u>N10,N11,N12,N13</u>	Format (15I5)
	N1	= IH, option for specified inlet enthalpy or temperature. N1 = 0: HIN (SETUP.11.1) is the inlet enthalpy. N1 = 1: HIN is the inlet temperature. N1 = 2: read in an inlet enthalpy for each subchannel. N1 = 3: read in an inlet temperature for each subchannel (SETUP.11.1).
	N2	= IG, option to specify inlet mass flux. N2 = 0: GIN (SETUP.11.1) is the inlet mass flux for each subchannel. N2 = 1: GIN is the average core mass flux, but the subchannel flow is split to give equal DP/DX across the first axial node within each assembly. N2 = 2: GIN is the average core mass flux, but assembly flow is split by flow fractions supplied in SETUP.11.3 and uses uniform mass flux within each assembly. N2 = 3: sub-channel flow is split within each assembly by flow fractions supplied in SETUP.11.4. N2 = 4: both options N2 = 2 and N2 = 3 are taken. All flow fractions are on GIN.
	N3	= transient forcing function for system pressure. Read in NP pairs of values for a table of system pressure factors versus time.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.11 (contd)	N4	= transient forcing function for inlet enthalpy or temperature. Read in NH pairs of values for a table of inlet enthalpy or temperature factors versus time.
	N5	= NG, transient forcing function for inlet mass flux or pressure drop. N5 = number of entries in each table.
	N6	= NGPRFL, number of transient forcing functions for inlet mass flux or pressure drop profiles to be read in.
	N7	= K10, an option for pressure drop boundary condition transients. If K10 = 1, the tabular values for the inlet mass flux (N5) are a fraction of the steady-state pressure drop. If K10 = 2, the tabular values are the desired pressure drop (psia).
	N8	= NHX, transient forcing function for exit enthalpy. Read in NHX pairs of values for a table of exit enthalpy factor versus time.
	N9	= transient forcing function for average power density. N9 = number of entries in each table.
	N10	= NQPRFL, number of power density transient forcing function profiles to be read in.
	N11	= NRPF, option to specify individual subchannel or assembly power densities. N11 = 0: PDN (SETUP.11.1) is the power density for each assembly. N11 = 1: read in relative power factors for each assembly (SETUP.11.12). N11 = 2: read in power density for each assembly (SETUP.11.12).

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.11 (contd)	N12	= NDPA, option to specify different pressure drop boundary conditions for each assembly (if set to 1). This option available only when NETWK = 0 (Group 7). Defaults to 0.
	N13	= NRAMPH, the number of iterations over which the power is to be ramped in. Defaults to 1.
SETUP.11.1	<u>PEXIT, HIN, GIN, PDN, HOUT, DPS</u>	Format (6F10.0) Operating conditions, where:
	PEXIT	= system pressure (psia)
	HIN	= inlet enthalpy (Btu/lbm) or temperature ($^{\circ}$ F) depending on N1
	GIN	= inlet mass flux (Mlbm/hr-ft ²) to be distributed by the N2 option
	PDN	= nominal power density (Mbtu/hr-ft ³) (based on fuel diameter when fuel model is used)
	HOUT	= exit enthalpy (Btu/lbm). If HOUT is specified, and the flow reverses, the "new" exit enthalpy will be HOUT. Otherwise, for HOUT blank, the "new" exit enthalpy will be the calculated core average exit enthalpy.
	DPS	= an option to specify a pressure drop rather than a flow boundary condition in the steady-state implicit solution scheme. The code iterates on the total inlet flow rate until the calculated pressure drop is close to DPS (psia). When NETWK = 1, DPS is the pressure drop across the whole problem and individual assembly boundary conditions are

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.11.1 (contd)	DPS	found based on user input loss coefficients (Card Groups 4 and 7). When NETWK = 0, DPS is the pressure drop for each subchannel, unless N12 = 1 and SETUP.11.13 is read in.
SETUP.11.2	<u>HINLET(I)</u>	Format (12E5.0), (I = 1, NCHANL) Optional input: N1 = 2 or 3 Inlet enthalpy or temperature, where: HINLET = inlet enthalpy (N1 = 2) or inlet temperature (N1 = 3) of each individual subchannel; read one value for each subchannel.
SETUP.11.3	<u>GINLET(I)</u>	Format (12E5.0), (I = 1, NASSEM) Optional input: N2 = 2 or 4 Assembly inlet flow rate multiplier, where: GINLET = assembly inlet flow factor (GIN(I)/GIN) for each individual assembly.
SETUP.11.4	<u>NASSIN, IA,</u> <u>GINC(IA,IC)</u>	Format (I5/((I5/(12E5.0))), ((IC = 1, NCHANA(IA)), I = 1, NASSIN) Optional input: N2 = 3 Subchannel inlet flow rate fraction, where: NASSIN = number of assemblies for which individual subchannel flow fractions are supplied IA = assembly number GINC(IA,IC) = fraction of core mass flux for subchannel IC
SETUP.11.5	<u>YP(I), FT(I)</u>	Format (12E5.0), (I = 1, N3) Optional input: N3 > 1 Pressure transient table, where: YP = transient time (sec) when factor is applied FT = fraction of steady-state system pressure at transient time (YP)

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.11.6	<u>YH(I), FH(I)</u>	Format (12E5.0), (I = 1, N4) Optional input: N4 > 1 Enthalpy or temperature transient table. YH = the transient time (sec) when factor is applied FH = the fraction of inlet enthalpy (N1 = 0 or 2) or the fraction of inlet temperature (N1 = 1 or 3) at the transient time (YH)
SETUP.11.7	<u>YG(I)</u>	Format (12E5.0), (I = 1, N5) Optional input: N5 > 1 Inlet flow or pressure drop boundary condition transient table. YG = the transient time (sec) when factor is applied
SETUP.11.8	<u>FG(I,J)</u>	Format (12E5.0), ((I = 1, N5), J = 1, N6) Optional input: N5 > 1 FG = the fraction of steady-state inlet flow at the transient time (YG) if inlet flow boundary condition is specified K10 = 0 (Group 11). For pressure drop boundary conditions (K10 = 1 or 2), FG is either the fraction of the steady-state pressure drop (K10 = 1) or FG is the pressure drop in psi (K10 = 2) at the transient time (YG). Input N6 profiles.
SETUP.11.9	<u>YQ(I)</u>	Format (12E5.0), (I = 1, N9) Optional input: N9 > 1 Power density transient table. YQ = the transient time (sec) when factor is applied

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.11.10	<u>FQ(I,J)</u>	Format (12E5.0), ((I = 1, N9), J = 1, N10)) Optional input: N9 > 1 FQ = the fraction of steady-state heat flux at the transient time (YQ). Input N10 profiles.
SETUP.11.11	<u>YHX(I), FHX(I)</u>	Format (12E5.0), (I = 1, NHX) Optional input: N8 > 1 Exit enthalpy transient table. YHX = the transient time (sec) when factor is applied. FHX = the fraction of steady state exit enthalpy (HOUT) at the transient time (YHX) to be used if the flow reverses.
SETUP.11.12	<u>PDNA(NASS)</u>	Format (16E5.0), (NASS = 1, NASSEM) Optional input: N11 > 0 Assembly power densities. PDNA = the relative assembly power (N11 = 1) or the absolute assembly power density (N11 = 2) (Mbtu/hr-ft ³)
SETUP.11.13	<u>DPA(I)</u>	Format (12E5.0), (I = 1, NASSEM) Optional input: NDPA = 1 DPA = pressure drop boundary condition specified for each assembly, replacing DPS in SETUP.11.1. Used only when NETWK = 0.

Group 12 - Output Options for Calculations

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.12	<u>12,N1,N2,N3,N4,</u> <u>N5,N6,N7</u>	Format (15I5)
	N1	= NOUT, print option. Each of the five digit locations specify a separate print option where a one means print all the data from that option and a zero indicates no printout is desired. The options controlled by the digits in the first four locations are subchannels, rods, crossflows, and wall data, respectively. A one in the fifth digit is the same as N1 = 11110. These print options may be overridden by options N2 through N7.
	N2	= NPCHAN, an option for specific subchannel data printout. N2 = 0: data for all subchannels printed if called for by N1. N2 > 0: read N2 subchannel identification numbers of subchannels to be printed.
	N3	= NPROD, an option for specific fuel rod heat flux and/or temperature printout. N3 = 0: data for all rods are printed if called for by N1. N3 > 0: read in N3 rod identification numbers of rods to be printed.
	N4	= NPNODE, an option for interior fuel node temperature printout for all rods specified by N3. Option only applies if interior rod temperatures are calculated using the fuel model (GROUP 8). N4 = 0: print rod centerline, rod surface and cladding surface temperature. N4 = 3 to 7: N4 equally spaced interior rod temperatures are printed along with the cladding surface temperature.

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.12 (contd)	N5	= NPGAP, an option for specific gap crossflow printout. N5 = 0: data for all gaps printed if called for by N1. N5 > 0: read gap numbers of gaps to be printed.
	N6	= an option to have the assembly average and/or channel exit values printed. N6 = 0: no additional printout. N6 = 1: subchannel exit values printed. N6 = 2: assembly averaged values printed. N6 = 3: include both N6 = 1 and N6 = 2 options.
	N7	= NPWALL, an option for specific wall temperature printout. N7 = 0: print all wall temperatures if called for by N1. N7 > 0: read N7 thermal connection numbers to be printed.
SETUP.12.1	<u>PRINTA(I),</u> <u>PRINTC(I)</u>	Format (16(I2,I3)), (I = 1, N2) Optional input: N2 > 0
	PRINTA, PRINTC	= read assembly and subchannel identification numbers of N2 subchannels for which data is to be printed
SETUP.12.2	<u>PRINTA(I),</u> <u>PRINTR(I)</u>	Format (16(I2,I3)), (I = 1, N3) Optional input: N3 > 0
	PRINTA, PRINTR	= read assembly and rod numbers of N3 rods for which heat flux and temperatures are to be printed

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
SETUP.12.3	<u>PRINTA(I),</u> <u>PRINTG(I)</u>	Format (16(I2,I3)), (I = 1, N5) Optional input: N5 > 0 PRINTA, PRINTG = read assembly and GAP numbers of N5 gaps for which crossflows are to be printed
SETUP.12.4	<u>PRINTW(I)</u>	Format (12I5), (I=1, N7) Optional input: N7 > 0 PRINTW = read N7 thermal connection numbers for which wall temperatures are to be printed

8.0 PROGRAM SPECSET

Auxiliary program SPECSET is used to redimension COBRA in order to minimize the computer core storage requirements. In this way, COBRA utilizes only that portion of core storage necessary to solve a particular problem. The SPECSET routine has three main functions:

1. to automatically set up a consistent set of dimensions for COBRA compatible with the user-specified problem size
2. to calculate the relative storage location of the variables equivalenced to the vector SAVEAL
3. to allocate storage in large core memory (LCM) on CDC-7600 machines, if desired.

The first function is accomplished by performing a character-by-character search through a complete set of COBRA specification statements for dummy dimension parameters. Each statement is written to an output file with the dummy parameters replaced by integer values calculated or specified from the user-supplied input defining the problem size.

The second function is required because the storage scheme in COBRA uses equivalencing to overlap array storage as described in Section 5. Program SPECSET calculates the appropriate equivalencing starting locations based on the problem size information supplied by the user.

The third function is accomplished by simply removing a C from column 1 on all level 2 statements if storage in LCM is desired. If not, the level 2 statements are considered to be comments.

8.1 SPECSET INPUT

The input to SPECSET is in two sections. The first section contains dummy card images of all COBRA COMDECKS (as shown in Appendix D, Table D-1). This data set must be available for input from logical unit 2 (TAPE 2).

The data in the second section consists of a set of parameters which define the problem size and code options required. With the exception of the first data card, the order in which the data are specified is immaterial.

The first card must contain the characters LCM in the first three columns if large core memory on a CDC-7600 is to be utilized for variable storage. If large core memory is not desired or the code is to be run on some other system, the first card should be blank. The remaining cards specify the value of the dimensioning parameters using the form

Columns 1 and 2	3	4 through 6
"parameter"	=	"xxx"

where "parameter" consists of a two-letter code and "xxx" is its required numerical value, which must be right justified to column 6. Default values will be supplied for any parameter not specified. The parameters may be input in any order. The available parameters, with their default values in parentheses, are listed below.

- IE - Width of energy and momentum coefficient matrix (21)
- IH - Maximum number of second-order connections to any channel (through the rod) (6)
- IR - Maximum number of rods interacting with a channel (6)
- IT - Maximum number of assembly types (7)
- IU - Maximum number of assemblies (7)
- IV - Maximum number of channels on an assembly face plus one (4)
- IW - Maximum number of loss coefficient forcing function profiles (3)
- IX - Maximum number of flow separated regions within a single assembly (1); this must be specified when using the RECIRC scheme.
- MA - Maximum number of subchannels that can have area variations (1)
- MC - Maximum number of subchannels (95)

ME - MX if no storage on peripherals (34)

ME - 3 for storage on peripherals (this implies that axial values will be rolled in COBRA)

MG - Maximum number of subchannel gap connections (160)

MI - Maximum number of connections to a channel (thermal + flow) (7)

MJ - Maximum number of assembly groupings in network model (1)

MK - Maximum number of loss coefficients (1)

ML - Maximum number of axial locations for gap and area variation (1)

MM - Maximum number of points in any one of the following profiles: Loss coefficient versus Reynolds number, flow or pressure drop versus time, heat flux versus time, system pressure versus time, inlet and exit enthalpies versus time (29)

MN - Number of fuel collocation points plus three (5)

MO - Maximum number of gaps coupled to any one gap (via a channel) plus one (7 for square arrays, 5 for triangular) (11)

MP - Maximum number of cards in property table, axial heat flux table or forcing function versus time tables (31)

MR - Maximum number of fuel rods (80)

MS - Maximum number of gaps that can have gap spacing variations (1)

MT - Maximum number of fuel types (10)

MV - Maximum number of axial heat flux profiles (2)

MW - Maximum number of wall connections (60)

MX - Maximum number of axial nodes plus one (34)

MY - Maximum number of axial fuel type divisions (4)

MZ - Maximum number of axial locations for grid spacers (1)

Appendix D gives a list and explanation of the control cards which could be used to change the dimensions (SPEC) in a COBRA file. If the user intends to run a series of problems of similar size the COBRA file need only be redimensioned once and permanently filed. Any problem of smaller dimensions will also run on the file though it may not be economical if the problem is long running and considerably smaller than the problem the code was originally redimensioned for.

9.0 PROGRAM GEOM

Program GEOM automatically calculates and makes card images of COBRA input data for input Card Groups 4, 7, and 8 for hexagonal rod bundles. It can be used to generate:

- subchannel areas, wetted perimeters, heated perimeters and the subchannel connection logic required in Group 4
- the relative wirewrap crossing information for the wire wrap model in Group 7
- the initial wire wrap inventory for Group 7
- the fuel rod diameter, radial power factor and rod-to-channel connection data for Group 8
- an option to calculate geometries that either include or omit the corner subchannels.

There is optional input that allows the user to change the standard GEOM numbering scheme for the subchannels or to consolidate subchannels and rods for coarser noding schemes. The option to change the standard numbering scheme can be useful when it is desired to run the problem with the direct solution of momentum equations since the width of the coefficient matrix is determined by the largest difference in channel identification numbers for any two adjacent channels. The standard subchannel and rod numbering scheme is demonstrated in Figure 13. Figure 14 gives the optimal subchannel numbering scheme for the standard subchannel noding of a 37-pin bundle when using the direct inversion routine for the momentum solution.

Two general input forms are available to the user. Under the first option, the user specifies the subchannel area, wetted perimeter, and heated perimeter for typical internal, side and corner subchannels. Under the second option, the code calculates the areas and perimeters from the overall bundle geometry descriptors. A description of the GEOM input follows.

FIGURE 13. Samples of GEOM Rod and Channel Numbering Scheme

FIGURE 14. Optimal GEOM Numbering Scheme for Standard Subchannel Noding of a 37-Pin Bundle

9.1 GEOM INPUT

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
GEOM.1	<u>JCONTU, HEADER</u>	Format (I5,18A4)
	JCONTU	= 1: standard GEOM run = -1: read in optional input to renumber subchannels (GEOM.2) = 2: read in optional input to lump subchannels and rods (GEOM.13)
	HEADER	= job or problem title up to 72 characters.
GEOM.2	<u>ICHANS, IOLD(I), INEW(I)</u>	Format (I5/16I5), (I=1, ICHANS)
		Optional input: JCONTU = -1
	ICHANS	= number of channels for which GEOM is to generate data
	IOLD	= standard channel number
	INEW	= new channel number
GEOM.3	<u>IFORM</u>	Format (I1)
	IFORM	= 1: use option 1 for GEOM input cards (GEOM.4, 5, 6, 7) = 2: use option 2 for GEOM input cards (GEOM.8)
GEOM.4	<u>AI,WPI,HPI</u>	Format (3F5.3)
		Optional input: IFORM = 1
	AI	= area (in. ²) of an interior channel
	WPI	= wetted perimeter (in.) of an interior channel
	HPI	= heated perimeter (in.) of an interior channel
GEOM.5	<u>AS, WPS, HPS</u>	Format (3F5.3)
		Optional input: IFORM = 1

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
	AS,WPS,HPS	= same as GEOM.4 but the information is for a side channel
GEOM.6	<u>AC,WPC,HPC</u>	Format (3F5.3) Optional input: IFORM = 1
	AC,WPC,HPC	= same as GEOM.4 but for a corner channel
GEOM.7	<u>GII, CII, GIS,</u> <u>CIS, GSS, CSS,</u> <u>GCS, CCS</u>	Format (8F5.3) Optional input: IFORM = 1
	GII, CII	= gap width (in.) and transverse momentum control volume length (in.) for interior-to-interior connections
	GIS, CIS	= same for interior-to-side connections
	GSS, CSS	= same for side-to-side connections
	GCS, CCS	= same for corner-to-side connections
GEOM.8	<u>PITCH, RDIAM,</u> <u>PDR, FFD, RPF</u>	Format (5F5.3) Optional input: IFORM = 2 Only two of first three parameters are required.
	PITCH	= rod pitch (in.)
	RDIAM	= rod diameter (in.)
	PDR	= ratio of rod pitch to rod diameter
	FFD	= flat-to-flat I.D. duct dimension (in.)
	RPF	= rod packing factor. RPF = 1: assembly tolerances uniformly distributed (interior and side gaps have same width). RPF = 0: assembly tolerances are applied only to the side channels and gaps. RPF can be anything between 0.0 and 1.0.
	WDIAM	= wire wrap diameter (in.)

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
GEOM.9	<u>IOUT(1), IOUT(2),</u> <u>IOUT(3), NPUN,</u> <u>IRODP, NZONE</u>	Format (6I1)
	IOUT(1)	= 1: area and gap connection data for COBRA group 4 will be generated. Set to zero if this data is not desired.
	IOUT(2)	= 1: COBRA group 7 wire wrap data generated
	IOUT(3)	= 1: rod to channel connection data for group 8 generated
	NPUN	= 1: output is punched
	IRODP	0: individual rod powers for group 8 are to be read from logical unit IRODP using format specified by NZONE. Card reader is logical unit 5.
	NZONE	= 1: input radial power factors by zones rather than rod by rod. NZONE equals the number of zones. All rods within one zone will be assigned the same radial power factor. NZONE = 0: input radial power factors rod by rod.
GEOM.10	<u>NRODS, RD,</u> <u>RP, IFF, IDIR,</u> <u>WWSA, DUR, ICOR</u>	Format (I5,2F5.3,3I5,F5.3,I5)
	NRODS	= number of rods in the bundle
	RD	= nominal rod diameter
	RP	= nominal rod power factor

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
GEOM.10 (contd)	IFF	= subchannel friction typing parameter. IFF = 0: all subchannels are type 1. IFF = 1: interior subchannels are type 1, side are type 2, and corner are type 3. IFF = 2: the subchannels are typed via optional input card GEOM 12.
	IDIR	= wire wrap direction indicator. IDIR = 0 indicates counterclockwise wrapping (Figure 15) and IDIR = 1 for clockwise. Note that IDIR = 0 looking from the downstream end of the bundle wraps the wire in the same direction as IDIR = 1 from the upstream end. User view orientation is unimportant as long as all input is consistent with that view.
	WWSA	= wire wrap starting angle to the nearest degree (integer value). Measure counter clockwise as shown in Figure 15.
	DUR	= wire wrap crossflows forcing parameter for Card Group 7.
	ICOR	= corner subchannel switch. ICOR = 0: , corner subchannels omitted. ICOR = 1: corner subchannels will be included in the Group 4 output.
GEOM.11	<u>NTYPS, (IMIN(I),</u> <u>IMAX(I))</u>	Format (12I5), (I = 1, NTYPS) Optional input: IFF = 3 Format (GEOM.10)
	NTYPS	= number of subchannel types

a) Wire wrap starting angle = 0°
counterclockwise rotation

b) Wire wrap starting angle = 90°
counterclockwise rotation*

c) Wire wrap starting angle = 90°
clockwise rotation*

d) Wire wrap starting angle
convention

*NOTE: When a wrap is initially on a gap the initial wrap inventory is determined by moving the wrap completely into the channel toward which it is moving. Compare b and c above.

FIGURE 15. Definition of Wrap Starting Angle
and Rotation Direction

<u>Card Label</u>	<u>Variables</u>	<u>Format and Explanation</u>
GEOM.11 (contd)	IMIN,IMAX	= minimum and maximum subchannel numbers for each type; assumes the subchannels are numbered in the standard pattern
GEOM.12	<u>RPFF(N)</u>	Format (12F5.3), (N = 1, NRODS) Optional input: IRODP > 0 and NZONE = 0 (GEOM.9)
	RPFF	= individual rod power factor
GEOM.13	<u>ISIZE(I),</u> <u>ZFACTR(I),</u> <u>IZONE(I,L,)</u>	Format (I5,F5.3/(14I5)), ((L=1, ISIZE(I)), I = 1, NZONE)
		Optional input: IRODP > 0 and NZONE > 0 (GEOM.9)
	ISIZE(I)	= number of rods in Zone I
	ZFACTR(I)	= radial power factor for rods in Zone I
	IZONE(I,L)	= rod numbers in Zone I (any order)
GEOM.14	<u>ICH1, ICH2, NEWC</u>	Format (3I5) Optional input: JCONTU = 2 Format (GEOM.1)
	ICH1,ICH2,NEWC	= channels ICH1 through ICH2 inclusively will be lumped into channel NEWC. Read as many cards as necessary. A particular value for NEWC may be read more than once. A blank card indicates the end of input for GEOM.14.

Multiassembly problems may be set up using GEOM by simply reading another header card (GEOM.1) and proceeding as for the initial bundle. A blank card terminates the GEOM run.

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APPENDIX A
SUBROUTINE DESCRIPTION

APPENDIX A

SUBROUTINE DESCRIPTION

Subroutine AREA (J, JX)

This subroutine calculates subchannel area, gap and hydraulic diameter variations by using a tabular list of area and gap variations as a function of axial distance as input. Linear interpolation is used to select values from these tables. When wire wrap mixing is included, AREA corrects the subchannel flow area and hydraulic diameter according to the wire wrap inventory. J and JX are the calculational level and the axial node, respectively. For nonrolled problems, J = JX. For rolled problems J = 2. Subroutine AREA is called by subroutines RECIRC and SCHEME.

Subroutine CLEAR

Subroutine CLEAR is used to selectively zero COMMON prior to execution. The size of any COMMON area to be zeroed is computed using the CDC system routine LOCF. If the code is to be used on a system other than CDC this routine may have to be changed to remove the calls to the LOCF routine. Subroutine CLEAR is called by the main program, COBRA.

Program COBRA

The main program performs variable initialization either by setting the variable to zero or by calling the RESTRT routine which initializes variables to the values saved from a previous run. It also controls input and output via the subroutines SETUP and RESULT. The user specified solution option for the conservation equations is initiated either with a call to SCHEME (for the PSOLVE steady state and implicit transient method described in Section 4.2.1) or a call to RECIRC (for the RECIRC steady state and implicit/explicit transient method described in Section 4.2.2). The transient boundary conditions and

forcing functions are set in COBRA at the beginning of each timestep. A more detailed description of COBRA is provided in Section 5 of this document.

Subroutine COLOC (IA, ISYM, KK, RMIN, RMAX)

Subroutine COLOC sets up the fuel model orthogonal collocation coefficient matrices A , B , and Q^{-1} as defined in Section 4.1. Although the routine was set up for both cylindrical ($IA=2$) fuel geometries with an annular or solid ($ISYM = 1$ or $ISYM = 2$) configuration and planar fuel geometry ($IA=1$), only the cylindrical fuel options are currently available in COBRA-WC. Subroutine COLOC is called by subroutine SETIN.

Entry COPY (KEYS, LU, RECORD)

COPY is used to write data from variable array RECORD in computer memory to record KEYS of peripheral storage file LU. RECORD can correspond, through equivalencing, to the set of field variables at one of the three calculational levels in core, $J-1$, J , or $J+1$. Thus COPY, in conjunction with subroutine IMAGE can swap a recently calculated set of variables at calculational level $J-1$ that are in core with a set of previous iterate values at level $J+2$ from peripheral storage as the calculation level proceeds up the axial mesh.

Entry COPY is an entry point in subroutine IMAGE and is called by most of the major subroutines.

Subroutine CURVE (FX, X, F, Y, N, J, ISAVE)

This subroutine performs linear interpolation of tabulated data. The variables in the argument list are defined as:

FX = quantity to be found

X = independent variable

F = input array of values of the dependent variable

Y = input array of values of the independent variable

N = number of F values in table

J = error signal

ISAVE = Table search switch. For ISAVE = 1, a complete table search on the independent variable is done. For ISAVE = 2, the location in the table which brackets the independent variable is known from a previous call to curve, and the table search is not performed.

Subroutine CURVE is called by all the major subroutines in COBRA-WC.

Subroutine DIFFER (IPART, J, JX)

Subroutine DIFFER is divided into 4 parts as indicated by the variable IPART.

Part 1 is called by subroutines SCHEME and RECIRC for each axial level at the beginning of the outer iteration loop. The fluid lateral conduction terms for the energy equation are determined based on previous iterate enthalpies. If the wall heat transport model is used, the overall wall-to-coolant heat transfer coefficient UWALL is determined.

Part 2 calculates the diversion crossflow resistance, Cij, and is called by subroutine PSOLVE.

Part 3 calculates the irreversable pressure loss coefficient, DPK(I), due to friction and drag for the axial momentum equation. The other components of the pressure gradient are computed, with the exception of the diversion crossflow terms, and are designated as DPDX(I). Part 3 is called by subroutine SCHEME.

Part 4 calculates the irreversible pressure loss coefficient, DPK(I), due to friction and drag for the RECIRC formulation of the axial momentum equation. Part 4 is called by MOMENT.

Subroutine DUMPIT

This subroutine is used to store all labeled and blank COMMON on logical unit 8. This routine allows the user to save the current computed values, look at the results and, then, if desired, continue the solution.

Subroutine DUMPIT is called by the main program, COBRA.

Subroutine ECHO (IPR, ICR, IFL)

Subroutine ECHO reads the COBRA-WC input from logical unit ICR and prints alphanumeric card images to logical unit IFL and the printer IPR. These printed card images can be used by the user to debug the input data deck. At the end of ECHO, logical unit IFL is rewound and is used as the input file for subroutine SETIN. Subroutine ECHO is called as an option by subroutine COBRA.

Subroutine ELAP (MTIME)

ELAP determines the CPU time used thus far in the calculation. This is compared with the maximum time allowed, MAXT, to determine if the calculation should be terminated.

Subroutine ELAP is called by subroutines COBRA, RECIRC and SCHEME.

Subroutine ENERGY (J, JP1, JM1, JX)

Subroutine ENERGY sets up and solves the combined rod, wall, and coolant energy equations (see Section 4.1) at axial level J and axial node JX, using the method of successive overrelaxation to determine the coolant enthalpy distribution. The energy equation coefficient matrix is designated HAH and the source vector as DHDX. After the coolant temperatures are found, the wall temperatures, if any, are backed out using Equation 30. Subroutine ENERGY is called by subroutines RECIRC and SCHEME.

Subroutine EXPROP (J)

Subroutine EXPROP determines the average enthalpy, density and viscosity at the bundle exit. These properties are used for inlet conditions in the event of flow reversal. Subroutine EXPROP is called by subroutine ENERGY.

Subroutine FORCE (J, JX)

Subroutine FORCE is provided to specify forced diversion crossflow at selected gaps and at selected axial positions. If a forced crossflow is specified, the variable FDIV = 1.0; otherwise, FDIV = 0. Subroutine FORCE

includes two options for forced crossflow mixing. One option is the wire wrap mixing model for which FORCE computes a forced crossflow when a wire crosses a gap. The other option is for a specified flow fraction diverted from one subchannel to an adjacent subchannel by grid spacers.

Subroutine FORCE is called by subroutines SCHEME and RECIRC.

Subroutine HOTROD (J)

HOTROD calculates the final fuel rod temperature field after the energy and fluid solutions have converged for a given timestep. This is accomplished first by finding the clad temperature using Equation 24 and the surrounding fluid temperatures, and then back-substituting into the reduced temperature Equations 22 and 23. Subroutine HOTROD is called by subroutines RECIRC and SCHEME.

Subroutine IMAGE (KEYS, LU, RECORD)

IMAGE is used to write data from record KEYS of peripheral storage file LU to variable array RECORD in computer memory. RECORD can correspond, through equivalencing, to the set of field variables at one of the three calculational levels in core; J-1, J, or J+1. Thus IMAGE, when used in conjunction with Entry COPY, can swap a recently calculated set of variables at calculational level J-1 that are in core with a set of previous iterate values at level J+2 from peripheral storage as the calculation level proceeds up the axial mesh. Subroutine IMAGE is called by most the major subroutines.

Subroutine INVR (A, N)

INVR finds the inverse of $N \times N$ matrix $[A]$. Subroutine INVR is called by subroutine COLOC to find the inverse of the collocation coefficient $[Q]$ defined in Equation 18.

Subroutine LIMITS (NUM, MIN, MAX, GROUP, CARD, ERROR)

This routine is designed for use within subroutine SETIN to enhance the editing of input data. Its function is to guarantee that the number of values

read into an array are within the dimensioned limits of the code. If not, the parameter, NUM, is changed only for the convenience of editing; however, the case will be terminated after the input is edited. In addition, a limit of twenty-five accumulated errors are allowed, after which the editing will cease.

NUM = input parameter to be checked
MIN = minimum allowable value for NUM
MAX = maximum allowable value for NUM
GROUP = card group identifier for editing diagnostics
CARD = input card counter; for labeling which card may be in error
ERROR = alphanumeric flag for editing. If ERROR = "yes", the code will terminate following the editing of input data.

Subroutine LOAD (X, Y, Z, MIN, MAX, LIMIT, STEP, IMAGE, CARD, LU)

LOAD is used to replace redundant logic within subroutine SETIN. It is designed to allow the loading of input data only after the group card parameters have been verified.

X = first variable to be loaded (Step = 1).
Y = second variable to be loaded (Step = 2).
Z = third variable to be loaded (Step = 3).
STEP = the number of variables to be loaded sequentially. (1 STEP 3)
MIN = the maximum allowable sets of (X,Y,Z) which can be loaded.
MAX = the number of sets of (X,Y,Z) the user attempts to load.
If (MAX MIN), then a dummy read is used to account for remaining cards.
This allows subsequent input to be edited.
LIMIT = the maximum number of data values per card which can be loaded via the formatted IMAGE
IMAGE = the variable FORMAT to be used for loading input data
CARD = input card counter for labeling which card may be in error
LU = input device used for reading input data.

Subroutine LOADL (X, Y, Z, MIN, MAX, LIMIT, STEP, IMAGE, CARD, LU)

LOADL Is identical in function to subroutine LOAD, except that (X,Y,Z) are variables which may be allocated to Level 2 (large core memory) on a CDC-7600 system. This routine is used regardless of the system on which COBRA is being run and the necessary storage allocations are provided by Program SPECSET. Subroutine LOADL is called by Subroutine SETIN.

Subroutine MIX (J)

MIX calculates the turbulent mixing parameters W_T , which is designated by WP(K). The various forms of user input correlations that are available are described in Section 4.3 and the input instructions. Subroutine MIX is called by subroutines RECIRC and SCHEME.

Subroutine MOMENT (JX, J, JMI, JPI, IPART)

MOMENT calculates the axial and lateral subchannel flowrates for a given pressure field at computational Level J from the linearized momentum Equations 37 and 38. The partial derivatives W/P and F/P are also calculated for use by RECIRC in the solution of the continuity and linearized momentum equations. Subroutine MOMENT is called by subroutine RECIRC.

Subroutine NETWORK (ITER)

When the pressure boundary condition network model is specified, subroutine NETWORK calculates the contribution by network orifice and head losses to the total specified problem pressure boundary condition. These losses are based on the latest assembly flowrates.

Subroutine NETWORK is called by subroutines PBOUND and RESULT.

Subroutine ONED (IPART)

ONED forms a one dimensional approximation to the multi-dimensional continuity and momentum solution (see Section 4.2.2) at a given level and solves it using direct inversion. Subroutine ONED Is called by RECIRC.

Subroutine PBOUND (JUMPS, NT, ACCF)

PBOUND is called by subroutine SCHEME when a pressure boundary condition is specified. PBOUND is used to modify the inlet flowrate until all subchannel pressure drops are equal to their individually specified pressure drops. This pressure drop is the user input pressure boundary condition minus the network orifice and head losses, determined in NETWORK, if any. Each new flow guess is determined by an extrapolation/interpolation procedure based on damped, old iterate value flowrates and pressure drops. The parameter JUMPS is a convergence flag which when set to 2 by PBOUND, indicates that the code has converged upon a specified pressure drop. NT is the iteration count and ACCF is the flow acceleration factor.

Subroutine PREFIX

PREFIX is used to compute the constant fuel rod collocation coefficients for the matrix $[M]$ shown in Equation 27. These coefficients are used to implicitly link the fuel and coolant energy equations. The subroutine is divided into sections for the different combinations of collocation order and fuel rod type. PREFIX is called by RECIRC and SCHEME.

Subroutine PROP (IPART, J, JX, JMI, JPI)

PROP consists of two parts. The first part uses the code sodium property correlations or optional Group 1 property table to build the physical property arrays stored in variable DATA. Part 2 calculates fluid properties, the friction factor, and the film coefficient for a given set of fluid conditions. Subroutine PROP is called by subroutines COBRA, RECIRC, SCHEME, SETIN and SPLIT.

Subroutine PSOLVE (J, JX)

PSOLVE sets up and solves the combined momentum and continuity Equations 37 described in Section 4.2.1 by successive-over-relaxation at the calculational Level J. If the direct Gaussian elimination solution is desired, subroutine SOLVER is called. Subroutine PSOLVE is called by subroutine SCHEME.

Subroutine RECIRC (JUMP, ISTART, JUMPS)

RECIRC is the managing subroutine for the RECIRC solution scheme for recirculating flows. It calls the subroutines which solve the energy momentum and state equations while solving the continuity equation internally. JUMP is the flow convergence flag; ISTART is the starting iteration number; and JUMPS is the indicator for convergence on pressure drop boundary condition problems.

Subroutine REHEAT (J, JX)

REHEAT computes the heat flux dependent terms in the rod energy equation matrix $[M]$ shown in Equation 27. These terms are used to implicitly link the fuel and coolant energy equations. The subroutine is divided into sections for the different combinations of collocation order and fuel type. Subroutine REHEAT is called by subroutines RECIRC and SCHEME.

Subroutine REHEATV (N, NT, L, KL, J, JX, IPART, LN, LQ)

REHEATV modifies some of the terms computed in REHEAT when the variable fuel rod property option is specified. This option is currently available only for second order collocation for a solid fuel type. REHEATV is called by subroutine REHEAT.

Subroutine RESTRT (NTSTRT, ISTART)

This routine initializes variables to the values that were saved by subroutine DUMPIT from a previous solution. The first function of RESTRT is to retrieve the previously saved solution and initialize COMMON to the stored values. Next, a RESTRT data card is read defining the type of restart desired. In addition to the restart data read, certain values from the previous solution dictate how the solution may be restarted. The flow chart in Figure A.1 illustrates the RESTRT options available in the code. RESTRT is called by subroutine COBRA.

FIGURE A.1. Subroutine RESTRT Available Code Options

Subroutine RESULT (NT)

All printing of the results is done by this subroutine. NT is the current time increment number.

Subroutine RESULT is called by subroutine COBRA.

Subroutine ROLLIT (J, JX, SAVEA1, SAVEA2, SAVEA3, NWR, NDXP1, LUO, LUI)

This subroutine is used in conjunction with the roll option to input and output temporary storage values of the axial dependent variables. J is the current calculation level, and JX is the physical axial level. The variables SAVEA1, SAVEA2, and SAVEA3 are vectors of length NWR, which are equivalenced to the axial dependent variables at the axial levels J-1, J, and J+1, respectively. NDXP1 and LUI are the number of axial nodes plus one, and the logical unit, respectively. ROLLIT calls subroutines IMAGE and COPY to accomplish the actual data transfer. ROLLIT is called by subroutines SCHEME and RECIRC.

Subroutine SCHEME (NTRIES, JUMP, ISTART, MAXT, NJUMP, JUMPS)

SCHEME is similar to RECIRC in that it is the managing subroutine for the PSOLVE solution scheme. SCHEME calls subroutines to solve the energy, momentum and state equations and solves the continuity equation. NTRIES is the maximum number of sweeps through the axial levels allowed; JUMP is the flow convergence flag; ISTART is the first iteration number; MAXT is the maximum allowable computation time; NJUMP is the restart flag; and JUMPS is the convergence indicator for pressure drop boundary condition problems.

Subroutine SETIN (IGPERR, ERROR)

SETIN is used to input the COBRA-WC data, perform error checks and initialize variables. Subroutine SETIN₆₆ is called by subroutine SETUP.

Subroutine SETOUT

SETOUT prints out the input read in SETIN. Subroutine SETOUT is called by subroutine SETUP.

Subroutine SETUP

SETUP is the driver routine for the data input phase. It also performs some variable manipulation and initialization. Subroutine SETUP is called by the main program, COBRA.

Subroutine SOLVER

SOLVER performs a direct Gaussian elimination solution for banded matrices and is used in the WC solution of the momentum and continuity equations. Subroutine SOLVER is called by subroutines PSOLVE and RECIRC.

Subroutine SPLIT (GIN)

SPLIT corrects the input flow by an extrapolation/interpolation iteration procedure until an equal pressure drop across the first node is found. The procedure assumes that no diversion crossflow occurs within the first node. Total bundle inlet flow is conserved. Subroutine SPLIT is called by subroutine SETIN.

Subroutine SWIRL (J)

SWIRL imposes a circumferential swirl flow on the peripheral subchannels in an assembly type, if the swirl option is specified. Subroutine SWIRL is called by subroutines RECIRC and SCHEME.

Subroutine VPROP (J)

VPROP calculates the volume average thermal conductivity and heat capacity for a fuel rod when using the variable fuel property option. Subroutine VPROP is called by subroutine HOTROD.

APPENDIX B
VARIABLES USED IN CODE

APPENDIX B

A list of the variables used in the code and a brief description is given to help the interested user in understanding the code. The subroutine or card group where the variable is principally used is identified and the COMDECK where the variable is stored is listed. The subscripts on the variables correspond to the dimension given by program SPECSET. Many of the variables are equivalenced to each other so care must be taken not to indiscriminately reset the variables in the code.

<u>Variables</u>		<u>Principle Definition</u>	<u>Comdeck</u>
A(M1,ME)	Subchannel flow area (ft ²)	AREA	SPEC 3
AA(IW)	Coefficient for turbulent friction factor correlation	Group 2	SPEC 9
AAD(IE,MC)	Coefficient matrix for the solution of banded matrices	SOLVER	SPEC 2
AAL(IW)	Coefficient for laminar friction factor correlation	Group 2	SPEC 9
AASAV(16,MT)	Orthogonal collocation matrix $\frac{1}{2}A_{\frac{1}{2}}$	COLOC	SPEC 12
ABAR(MC)	Subchannel exit density (lbm/ft ³)	EXPROP	SPEC 19
AC(MC)	Subchannel nominal flow area (in. ²)	Group 4	SPEC 1
ACCELF	External acceleration factor for axial flow	Group 9	SPEC 2
ACCELFH	Internal acceleration factor for combined energy equation	SETIN	SPEC 2
ACCELY	Internal acceleration factor for pressure solution	Group 9	SPEC 2
AFACT(ML,MA)	Relative subchannel area variation	Group 5	SPEC 7
AHL1(IW)-AHL4(IW)	Coefficients for laminar heat transfer coefficient equation	Group 2	SPEC 10
AH1(IW)-AH4(IW)	Coefficients for turbulent heat transfer coefficient equation	Group 2	SPEC 10
ALLF	Total problem flowrate (lbm/s)	NETWORK	SPEC 6
AMIX(IT)	Coefficient for turbulent mixing correlation	Group 2	SPEC 32
AN(MC)	Subchannel nominal flow area (ft ²)	SETIN	SPEC 2
APP(M1,ME)	Average of the area at the current node, J, and at the previous node, J-1 (ft ²)	AREA	SPEC 14
ATOTAL	Summation of subchannel flow areas (ft ²)	SETIN	SPEC 2
AVGCP(M1,ME)	Fuel average specific heat (Btu/lbm-°F)	VPROP	SPEC 5
AVGK(M1,ME)	Fuel average conductivity (Btu/sec-ft-°F)	VPROP	SPEC 5
AXIAL(MP,MV)	Relative axial power distributions	Group 3	SPEC 2
AXL(ML)	Relative axial location of channel area variations	Group 5	SPEC 7
B(MG)	Coefficient for calculating crossflow	PSOLVE	SPEC 14
BB(IW)	Coefficient for turbulent friction factor correlation	Group 2	
BBL(IW)	Coefficient for laminar friction factor correlation	Group 2	SPEC 9
BBSAV(16,MT)	Orthogonal collocation matrix $\{B\}$	COLOC	SPEC 19
BMIX(IT)	Coefficient for turbulent mixing correlation	Group 10	SPEC 32
CARD	Input data card counter	SETIN	
CC(IW)	Coefficient for turbulent friction factor correlation	Group 2	SPEC 9
CCL(IW)	Coefficient for laminar friction factor correlation	Group 2	SPEC 9
CCLAD(MT)	Specific heat of the cladding material (Btu/lbm-°F)	Group 8	SPEC 12
CD(MK)	Channel loss coefficient	Group 7	SPEC 6

Variables		Principle Definition	Comdeck
CFUEL(MT)	Specific heat of fuel material (Btu/lbm- ⁰ F)	Group 8	SPEC 12
CIJ(MG)	Crossflow resistance	DIFFER	SPEC 14
CIN1(MT)-CIN12(MT)	Terms in the fuel rod energy equation coefficient matrix	PREFIX, REHEAT	SPEC 33
CIN1V(MT)-CIN6V(MT)	Variable property modification of CIN1-CIN6	REHEATV	SPEC 34
CIP(MC)	Inverse fluid specific heat, $1/c_p$ (lbm- ⁰ F/Btu)	DIFFER	SPEC 2
CON(MC)	Fluid thermal conductivity (Btu/hr-ft- ⁰ F)	PROP	SPEC 1
CONK(MG)	Fluid lateral conduction term	DIFFER	SPEC 8
CONLIQ(MP)	Property table fluid thermal conductivity entry (Btu/hr-ft- ⁰ F)	Group 1	SPEC 9
CONS(MX)	Source vector for calculating average δP 's	ONED	SPEC 2
CONST(IB)	Source vector for calculating axial flows	MOMENT	SPEC 2
CP(MC)	Fluid specific heat (Btu/lbm- ⁰ F)	PROP	SPEC 2
CPLIQ(MP)	Property table fluid specific heat entry (Btu/lbm- ⁰ F)	Group 1	SPEC 9
CR(MT)	DFUEL/DRDOD	PREFIX	SPEC 34
C1(MT)-C13(MT)	Terms in the fuel rod energy equation coefficient matrix	PREFIX, REHEAT	SPEC 33
D(MR)	Rod diameter, DR/12 (ft)	SETIN	SPEC 12
DAMPNG	Damping factor on the transverse pressure drop, SP	Group 9	SPEC 2
DATE	Today's date	DOY	SPEC 19
DATIN(N2)	Peripheral storage vector for input data	SETIN	SPEC 1
DC(MC)	Subchannel hydraulic diameter, 4AC/PW (in.)	SETIN	SPEC 1
DD(IW)	Coefficient for turbulent friction factor correlation	Group 2	SPEC 9
DDUCT(IU,IX)	Array which gives the flow separated regions within one assembly	SETIN	SPEC 2
DFDP(M1,ME)	$\partial F/\partial P$, derivative of axial flow with respect to pressure	MOMENT	SPEC 14
DFDPD(MX)	Diagonal terms in tridigonal matrix for solution of δP	ONED	SPEC 2
DFDPO(MX)	Off-diagonal terms in tridigonal matrix for solution of δP	ONED	SPEC 2
DFDPR(IL,IM)	Same as DFDP, used with the roll option	RECIRC	SPEC 2
DFDX(MC)	dF/dX , derivative of axial flow with respect to distance	SCHEME	SPEC 8
DFUEL	Diameter of the fuel pellet, (ft)	Group 8	SPEC 12
DFUELI	Inner diameter of the fuel for an annular fuel rod, (ft)	Group 8	SPEC 32
DHDX(MC)	dH/dX , derivative of fluid enthalpy with respect to distance	ENERGY	SPEC 8
DHYD(M1,ME)	Local subchannel hydraulic diameter (ft)	SETIN	SPEC 3
DHYDN(MC)	Nominal hydraulic diameter (ft)	SETIN	SPEC 2
DIA	Diameter of rod including clad, wire wrap model (ft)	Group 7	SPEC 6

<u>Variables</u>		<u>Principle Definition</u>	<u>Comdeck</u>
DIMMER(MT)	$4 \cdot \text{DROD} / \text{DFUEL}^2$	PREFIX	SPEC 34
DIST(MC,4)	Transverse momentum control volume length, ℓ , (in.)	Group 4	SPEC 1
DIS1-DIS21	Terms in the fuel rod energy equation coefficient matrix	PREFIX, REHEAT	SPEC 33
DPA(IU)	Static pressure drop (lbf/ft^2) or assembly pressure drop	NETWORK	SPEC 6
DPBAR(IU)	Bundle average total pressure drop (lbf/ft^2)	PBOUND	SPEC 2
DPDX(MC)	Axial pressure gradient (lbf/ft^3)	PSOLVE, SCHEME	SPEC 8
DPK(MC)	Losses due to frictional and loss coefficient	DIFFER	SPEC 1
DPOLD(MC,2)	Old iterate value for subchannel total pressure drop (lbf/ft^2)	PBOUND	SPEC 2
DPPRI(IU)	Old iterate value for bundle pressure drop (lbf/in.^2)	NETWORK	SPEC 6
DPS	Desired total pressure drop (lbf/in.^2)	Group 11	SPEC 2
DPT(IU)	Desired bundle total pressure drop (lbf/ft^2)	PBOUND, NETWORK	SPEC 6
DPWP(MC)	Turbulent momentum exchange	DIFFER	SPEC 14
DR(MR)	Rod diameter including cladding, (in.)	Group 4	SPEC 1
DROD (MT)	Rod diameter including cladding for a particular material type, (in.)	Group 8	SPEC 34
DS1-DS21	Terms in the fuel rod energy equation coefficient matrix	REHEAT, PREFIX	SPEC 33
DT	Nominal time step (sec)	Group 9	SPEC 2
DTGC	$\text{DT} \cdot \text{GC}$	COBRA	SPEC 2
DTII(MG)	Temporary storage of channel IK(K) crossflow coefficients in momentum equation solution	PSOLVE	SPEC 2
DTIMP	Implicit time step	COBRA	SPEC 2
DTJJ(MG)	Same as DTII for JK(K)	PSOLVE	SPEC 2
DTMAXE	Maximum allowable explicit time step	RECIRC	SPEC 2
DUR(MG)	Multiplier on effective fraction of wire wrap pitch for forcing crossflow	Group 7	SPEC 6
DWDP(M1,ME)	Change in crossflow with respect to pressure change	MOMENT	SPEC 14
DWDPR(IN,IM)	Same as DWDP, used with the roll option	RECIRC	SPEC 2
DX(MX)	Axial node length for node J (ft)	Group 9	SPEC 2
EE(IW)	Coefficient for turbulent friction factor correlation	Group 2	SPEC 9
ELEV	Gravity, COS(THETA)	SETIN	SPEC 2
END1-END19	Common block end points for determining common length		SPEC 2

<u>Variables</u>		<u>Principle Definition</u>	<u>Comdeck</u>
ERROR	Input data error flag	SETIN	
ETIME	Elapsed transient time (sec)	COBRA	SPEC 19
F(M1,ME)	Subchannel local mass flow (lbm/sec)	SCHEME, RECIRC	SPEC 3
FACTOR(MK)	Relative height at which loss coefficient is to be applied	Group 7	SPEC 6
FDIV(MG)	Flag for forced crossflow; FDIV=1.0, crossflow is forced	FORCE	SPEC 6
FERROR	Flow convergence criteria	Group 9	SPEC 2
FFLC(MM,IW)	Loss coefficient forcing function profile	Group 7	SPEC 6
FFOLD(MC,2)	Old iterate value for subchannel inlet flowrate (lbm/sec)	PBOUND	SPEC 2
FG(MM,IW)	Forcing function for steady state flow or pressure drop at transient time, YG	Group 11	SPEC 19
FH(MM)	Forcing function for inlet enthalpy or temperature at transient time, YH	Group 11	SPEC 19
FHX(MM)	Forcing function for steady state exit enthalpy at transient time, YHX	Group 11	SPEC 19
FINLET	Subchannel inlet flow (lbm/sec)	SETIN	SPEC 2
FLO(IU)	Total assembly flow (lbm/sec)	NETWORK	SPEC 6
FLOG(MJ)	Total group flow (lbm/sec)	NETWORK	SPEC 6
FLOW(MC)	Sum of J and J-1 axial level flow (lbm/sec)	DIFFER	SPEC 2
FOLD(M1,ME)	Mass flow from the previous time step (lbm/sec)	COBRA	SPEC 2
FP(MM)	Forcing function for steady state system pressure at transient time, YP	Group 11	SPEC 19
FPRI(IU)	Old iterate assembly pressure drop (lbf/ft ²)	NETWORK	SPEC 6
FQ(MM,IW)	Forcing function for steady state heat flux at transient time, YQ	Group 11	SPEC 19
FR(IL,IM)	Same as F, used with the roll option	RECIRC	SPEC 2
FSP(MC)	Friction factor	PROP	SPEC 2
FT(MP)	Maximum time step size at transient time, YT	Group 9	SPEC 19
FTEMP(MC)	Old iterate value of axial flow (lbm/sec)	MOMENT	SPEC 14
FTM	Turbulent momentum parameter	Group 9	SPEC 11
FXFLOW(MK)	User specified forced crossflow fraction	Group 7	SPEC 6
GAP(M1,ME)	Local gap spacing between adjacent channels (ft)	SETIN	SPEC 4
GAPN(MG)	Nominal gap spacing, GAPS/12 (ft)	SETIN	SPEC 7
GAPS(MC,4)	Nominal gap spacing between adjacent channels (in.)	Group 4	SPEC 2
GAPXL(ML)	Relative axial locations of gap width variation	Group 6	SPEC 1

Variables		Principle Definition	Comdeck
GASSEM(IT)	Swirl velocity as a fraction of average bundle velocity	Group 10	SPEC 32
GC	$32.2 \text{ lbm-ft/lbf-sec}^2$	COBRA	SPEC 2
GEOMF(MT)	Fuel rod geometry indicator	Group 8	SPEC 32
GFACT(ML,MS)	Relative gap width variation	Group 6	SPEC 7
GIN	Bundle inlet mass flux (lbm/hr-ft^2)	Group 11	SPEC 19
GK(IT)	Geometry factor for conduction	Group 10	SPEC 11
H(MI,ME)	Local subchannel enthalpy (Btu/lbm)	ENERGY	SPEC 2
HAH(IE,MC)	Combined energy equation coefficient matrix	ENERGY	SPEC 2
HAIN(IU)	Static head length associated with assembly inlet loss (in.)	Group 4	SPEC 6
HAOUT(IU)	Static head length associated with assembly outlet loss (in.)	Group 4	SPEC 6
HEATER(MR)	Coefficient for rod temperature calculations	REHEAT	SPEC 34
HERROR	Energy equation allowable external convergence error	Group 9	SPEC 2
HEXIT(MC)	Enthalpy at the bundle exit (Btu/lbm)	COBRA	SPEC 19
HFILM(MC)	Heat transfer coefficient ($\text{Btu/hr-ft}^2\text{-}^\circ\text{F}$)	PROP	SPEC 2
HGAP(MT)	Gap conductance coefficient between fuel and cladding ($\text{Btu/hr-ft}^2\text{-}^\circ\text{F}$)	Group 8	SPEC 12
HGHPI(MT)	$HGAP/(1+HGAP*TCLAD/KCLAD)$	PREFIX	SPEC 34
HGCRT(MT)	$HGAP*CR/TCLAD$	PREFIX	SPEC 34
HGIN(MJ)	Static head length associated with group inlet loss (in.)	Group 7	SPEC 6
HGOUT(MJ)	Static head length associated with group outlet loss (in.)	Group 7	SPEC 6
HGRK(MT)	$HGAP*DFUEL/(2*KFUEL)$	PREFIX	SPEC 34
HIN	Inlet enthalpy (Btu/lbm) or temperature ($^\circ\text{F}$)	Group 11	SPEC 19
HINLET(MC)	Subchannel inlet enthalpy (Btu/lbm) or temperature ($^\circ\text{F}$)	Group 11	SPEC 2
HLIQ(MP)	Property table fluid enthalpy entry (Btu/lbm)	Group 1	SPEC 9
HOLD(MI,ME)	Local enthalpy at previous timestep (Btu/lbm)	COBRA	SPEC 2
HOUT	Problem exit enthalpy (Btu/lbm)	Group 11	SPEC 19
HPERIM(MC)	Heated perimeter, $PH/12(\text{ft})$	SETIN	SPEC 2
HSCM(IB)	Vector used for solution of the energy equation	ENERGY	SPEC 2
HSURF(MI,ME)	Average rod surface heat transfer coefficient ($\text{Btu/hr-ft}^2\text{-}^\circ\text{F}$)	PROP	SPEC 5
IAHT	Flag for interassembly heat transfer option = 0, no interassembly heat transfer = 1, interassembly heat transfer	Group 4	
IBWL	Left matrix band width	SOLVER	SPEC 2
IBWR	Right matrix band width	SOLVER	SPEC 2
IDAREA(MC)	Identification number for a subchannel that has area variations	SETIN	SPEC 7

<u>Variables</u>		<u>Principle Definition</u>	<u>Comdeck</u>
IDFUEL(MR)	Rod type for property designation	Group 8	SPEC 12
IDGAP(MG)	Identification number for a gap that has gap variation	SETIN	SPEC 7
IDIRECT	Flag for direct Gaussian elimination of momentum equations	SETIN	SPEC 2
IDTGC	$1/(DT*GC)$	COBRA	SPEC 2
IDTYP(MT)	Flag for fuel shape and collocation order	SETIN	SPEC 12
IE	SPECSET parameter - width of HAH matrix		SPEC 19
IERROR	Error flag, if >1 print error messages	COBRA	SPEC 2
IEXP	Flag to set implicit or explicit mode in RECIRC	COBRA, RECIRC	SPEC 2
IFACE(IT,6,IV)	The channel numbers on each face of each adjacent assembly	Group 4	SPEC 2
IFDIV(MG)	Temporary storage for printing wire wrap forced crossflow data	SCHEME, RECIRC	SPEC 6
IFTYP(MI,ME)	Fuel type identifier	SETIN	SPEC 5
IG	Option for specifying inlet mass flux (see input-N2)	Group 11	SPEC 19
IH	Option for specifying inlet enthalpy (see input-N1)	Group 11	SPEC 19
IHALT	Maximum number of inner energy equation iterations at each level	SETIN	SPEC 2
IHIGH	= IE	PREFIX	SPEC 2
IK(MG)	Identifies subchannels adjacent to a gap when paired with JK	SETIN	SPEC 2
IKW(MW)	Identifies subchannels adjacent to a wall when paired with JKW	SETIN	SPEC 2
ILC(MK)	Subchannel number in which loss coefficient, FACTOR, is applied	Group 7	SPEC 6
ILOC(N8)	Singly dimensioned ILOCS	SETIN	SPEC 14
ILOCS(N1,MC)	Array to identify gaps and walls connected to subchannel I	SETIN	SPEC 2
ILOW	= MI+1	PREFIX	SPEC 2
ILOWP1	= ILOW+1	PREFIX	SPEC 2
IM(MS)	Identifies subchannels on opposite sides of a gap with gap variations	SETIN	SPEC 19
IMP(10)	Dummy variable used in printout of crossflow information	RESULT	SPEC 19
IPOINT(IU,7)	For each assembly, identifies assembly type, first and last channel number, first and last gap number and the first and last rod number	SETIN	SPEC 2
IPRNTA	Flag specifying the assembly average exit value printout option	SETIN	SPEC 2
IPRNTE	Flag specifying the subchannel exit value printout option	SETIN	SPEC 2
IR	SPECSET parameter - maximum number of rods interacting with a channel		SPEC 19
IROLL	Data storage option; if 1, the ROLL option is used (N4)	Group 9	SPEC 2

<u>Variables</u>		<u>Principle Definition</u>	<u>Comdeck</u>
ISAVIT(MC)	Stores the number of iterations for which a value has been used in the pressure boundary condition scheme	PBOUND	SPEC 6
IScheme	Solution option to be used. (see input manual) (N3)	Group 9	SPEC 2
ISIDE(IU,6)	Specifies the assembly number adjacent to each face	Group 4	SPEC 2
ISTAR(MG)	Number of the donor channel for crossflow through gap K.	DIFFER	SPEC 6
ISWIRL(IT)	Mixing model option 0 = pure mixing model, 1 = swirl flow model, 2 = wire wrap model	SETIN	SPEC 32
IT	SPECSET parameter - maximum number of assembly types		SPEC 19
ITERAT	Loop counter for the external iteration loop	SCHEME, RECIRC	SPEC 2
ITRY	Maximum number of external iterations	Group 9	SPEC 2
ITRYM	Minimum number of internal iterations for PSOLVE	SCHEME	SPEC 2
ITSAVE	Number of iterations per implicit time step the code is taking	RECIRC	SPEC 2
ITSTEP	Number of elements in variable maximum timestep table (N5)	Group 9	SPEC 19
ITYPIN(IT,3)	For each assembly type, identifies first assembly number of that type, number of channels, and number of gaps	SETIN	SPEC 2
IU	SPECSET parameter - maximum number of assemblies		SPEC 19
IV	SPECSET parameter - maximum number of channels on an assembly face + 4		SPEC 19
IW	SPECSET parameter - maximum number of loss coefficient forcing function profiles		SPEC 19
IWIDE	Matrix band width	SOLVER	SPEC 2
IX	SPECSET parameter - maximum number of flow separated regions within a single assembly		SPEC 19
IZTYP(MT,MY)	Identification number of the fuel type in each fuel zone	Group 8	SPEC 12
I2	Logical unit for input, defaulted to 5	COBRA	SPEC 2
I3	Logical unit for printout, defaulted to 6	COBRA	SPEC 2
I8	Logical unit for restart dump input and output, defaulted to 8	COBRA	SPEC 19
JK(MG)	See IK	SETIN	SPEC 2
JKW(MW)	See IKW	SETIN	SPEC 2
JLC(MK)	Axial node number at which loss coefficient, FACTOR, is applied	SETUP	SPEC 6
JM(MS)	see IM		SPEC 19

<u>Variables</u>		<u>Principle Definition</u>	<u>Comdeck</u>
JMP(10)	See IMP	RESULT	SPEC 19
J1	Directs printout of input data	Case Control Card	SPEC 2
J5	Flags radial thermal conduction option (N3)	Group 10	SPEC 11
J6	Flags wire wrap and loss coefficient options (N1)	Group 7	SPEC 6
KCLAD(MT)	Thermal conductivity of cladding material (Btu/hr-ft- ⁰ F)	Group 8	SPEC 12
KFUEL(MT)	Thermal conductivity of fuel material (Btu/hr-ft- ⁰ F)	Group 8	SPEC 12
KIJ	Crossflow resistance coefficient	Group 9	SPEC 2
KLC(MK)	Gap number at which specified diversion crossflow, FXFLOW, is applied	Group 7	SPEC 6
K10	Option for pressure drop boundary condition transients (N7)	Group 11	SPEC 19
LAMNF(IW)	Flags when laminar friction factors are input	SETIN	SPEC 9
LAMNH(IW)	Flags when laminar heat transfer coefficients are input	SETIN	SPEC 10
LC(MC,4)	Adjacent subchannel, LC(I,J), is the Jth subchannel adjacent to subchannel I	Group 4	SPEC 1
LCASS(IU)	Indicates if loss coefficients are applied to a particular assembly	FORCE	SPEC 6
LCFF(MK)	Loss coefficient forcing function number applied to a given loss coefficient	Group 7	SPEC 6
LENGTH(MG)	Transverse momentum control volume length, λ , (ft)	SETIN	SPEC 2
LR(MR,6)	Identification number of subchannel facing rod N	Group 8	SPEC 12
LRI(IR,MC)	Identification number of rod facing Channel I	PREFIX	SPEC 34
LUI	READ/WRITE device for ROLL option	COBRA	SPEC 2
MA	SPECSET parameter - maximum number of subchannels with area variation		SPEC 19
MAXT	Maximum computer execution time allowable before dump		SPEC 19
MAXTYP	Total number of assembly types	SETIN	SPEC 2
MC	SPECSET parameter - maximum number of subchannels		SPEC 19
ME	SPECSET parameter - MX if no peripheral storage, 3 if roll option is used		SPEC 19
MFLAG(MC)	Interpolation/extrapolation scheme indicator for equal flowsplit option	SPLIT	SPEC 2
MG	SPECSET parameter - maximum number of subchannel gap connections		SPEC 19
MI	SPECSET parameter - maximum number of thermal and flow connections to a channel		SPEC 19
MJ	SPECSET parameter - maximum number of assembly groupings		SPEC 19
MK	SPECSET parameter - maximum number of loss coefficients		SPEC 19

<u>Variables</u>		<u>Principle Definition</u>	<u>Comdeck</u>
ML	SPECSET parameter - maximum number of axial locations for gap and area variations		SPEC 19
MLEN	Length of I/O records when using the roll option with RECIRC	COBRA	SPEC 2
MM	SPECSET parameter - maximum number of points in the temporal profiles		SPEC 19
MN	SPECSET parameter - number of fuel collocation points plus three		SPEC 19
MO	SPECSET parameter - maximum number of gaps coupled to any one gap (via a channel)		SPEC 19
MP	SPECSET parameter - maximum number of entries in property table, and forcing function vs. time table		SPEC 19
MR	SPECSET parameter - maximum number of fuel rods		SPEC 19
MS	SPECSET parameter - maximum number of gaps with gap variations		SPEC 19
MT	SPECSET parameter - maximum number of fuel types		SPEC 19
MV	SPECSET parameter - maximum number of heat flux profiles		SPEC 19
MW	SPECSET parameter - maximum number of wall connections		SPEC 19
MX	SPECSET parameter - maximum number of axial nodes plus 1		SPEC 19
MY	SPECSET parameter - maximum number of fuel type divisions		SPEC 19
MZ	SPECSET parameter - maximum number of axial locations for grid spacers		SPEC 19
M1	SPECSET parameter - computed width of SAVEA1, SAVEA2 and SAVEA3 arrays		SPEC 19
NAAA	Maximum width of AAA matrix	COBRA	SPEC 2
NAAAP1	NAAA + 1	COBRA	SPEC 2
NAAH	Maximum number of connections to a channel plus one	COBRA	SPEC 2
NAAHP1	NAAH + 1	COBRA	SPEC 2
NACH(MC)	Assembly number that channel I is a part of	SETIN	SPEC 2
NAFACT	Total number of subchannel area variations (N1)	Group 5	SPEC 7
NAFLX	Axial heat flux profile associated with assembly NASS	Group 4	SPEC 2
NARAMP	Number of iterations for inserting area variations (N3)	Group 5	SPEC 7
NASSEM	Total number of assemblies		SPEC 2
NAX	Number of entries in each axial heat flux table (N2)	Group 3	SPEC 2
NAXL	Number of axial positions for subchannel area variations (N2)	Group 5	SPEC 7
NAZONE	Number of axial zones for variable axial step size (N6)	Group 9	
NC	Order of the fuel collocation model (N1)	Group 8	SPEC 12

<u>Variables</u>		<u>Principle Definition</u>	<u>Comdeck</u>
NCH(MA)	Global channel number for which area variation is specified	SETIN	SPEC 7
NCHANA	Number of channels in assembly type ITYP A	Group 4	SPEC 2
NCHAN	Total number of channels	SETIN	SPEC 2
NCHAN1	First channel number in assembly NASS	SETIN	SPEC 2
NCHAN2	Last channel number in assembly NASS	SETIN	SPEC 2
NCOUNT(MR)	Number of channels connected to rod N	PREFIX	SPEC 31
NCTYPE(MC)	Channel type designator; 1 = interior channel, 2 = edge channel	SETIN	SPEC 32
NDT	Number of timesteps for transient	Group 9	SPEC 19
NDTP1	NDT + 1	SETIN	SPEC 19
NDX	Number of axial nodes	Group 9	SPEC 2
NDXP1	NDX + 1		SPEC 2
NETGRP(IU)	Assembly grouping number to be used with assembly NASS during network option	Group 4	SPEC 6
NETWK	Pressure boundary condition network model option (N4)	Group 4	SPEC 6
NFLAG(MC)	Interpolation/extrapolation scheme indicator for network inlet flow guess	PBOUND	SPEC 2
NFLGC	Print flag for crossflow results	Group 12	SPEC 19
NFLGR	Print flag for rod temperature results	Group 12	SPEC 19
NFLGS	Print flag for subchannel results	Group 12	SPEC 19
NFLGW	Print flag for wall temperature results	Group 12	SPEC 19
NFLMC(IU)	Heat transfer coefficient correlation number to be used with NASS	Group 4	SPEC 10
NFNODE	Number of points for averaging temperature dependent fuel properties	SETIN	SPEC 9
NFRICT	Total number of friction factor correlation sets (N1)	Group 2	SPEC 9
NFUEL T	Number of integrating points used in variable fuel property option	Group 8	SPEC 12
NG	Number of entries in inlet mass flux or pressure drop transient forcing function table (N5)	Group 11	SPEC 19
NGAP(MS)	Gap number for which gap width variation occurs	Group 6	SPEC 7
NGAPS	Total number of gaps for which gap variations occur (N1)	Group 6	SPEC 7
NGAP1	First gap number in assembly NASS	SETIN	SPEC 2
NGAP2	Last gap number in assembly NASS	SETIN	SPEC 2
NGPRFL	Total number of transient forcing function profiles for inlet mass flux or pressure drop (N6)	Group 11	SPEC 19
NGXL	Maximum number of positions for gap variations (N2)	Group 6	SPEC 7
NH	Number of entries in the inlet enthalpy vs. time forcing function table (N4)	Group 11	SPEC 19

<u>Variables</u>		<u>Principle Definition</u>	<u>Comdeck</u>
NHEAT	Total number of heat transfer correlation sets (N2)	Group 2	SPEC 10
NHFT	Total number of axial heat flux forcing function tables (N1)	Group 3	SPEC 2
NHFVT(IU)	Heat flux vs. time profile associated with assembly NASS	Group 4	SPEC 12
NHIGH(MC)	Number of higher order thermal connections to subchannel I	PREFIX	SPEC 31
NHX	Number of elements in exit enthalpy transient table (N8)	Group 11	SPEC 19
NINFF(IU)	Loss coefficient forcing function number associated with assembly inlet loss, RAIN	Group 4	SPEC 6
NJUMP	Restart option flag; = 1 problem is restarted	RESTRT	SPEC 19
NK	Total number of gap connections	SETIN	SPEC 2
NLCFF	Total number of loss coefficient forcing function profiles (N6)	Group 7	SPEC 6
NLCFP	Number of entries in loss coefficient forcing function profiles (N7)	Group 7	SPEC 6
NLOW(MC)	Number of lower order thermal connections to Channel I	PREFIX	SPEC 31
NOGRP	Number of assembly groupings for network model (N8)	Group 7	SPEC 6
NOLC	Number of subchannel loss coefficients, CD (N3)	Group 7	SPEC 6
NOUT	Output options for subchannel, rod, crossflow, and wall results or any combination (N1)	Group 12	SPEC 19
NOUTFF(IU)	Loss coefficient forcing function number associated with assembly outlet loss, RAOUT	Group 4	SPEC 6
NP	Number of elements in pressure transient tables (N3)	Group 11	SPEC 19
NPCHAN	Output option, number of channels to be printed (N2)	Group 12	SPEC 19
NPFVT(IU)	Pressure drop or flow vs. time profile number associated with assembly NASS	Group 4	SPEC 19
NPGAP	Output option, number of gaps to be printed (N5)	Group 12	SPEC 19
NPNODE	Output option, radial nodes for which fuel temperatures will be printed (N4)	Group 12	SPEC 19
NPOINT	= IE	PREFIX	SPEC 2
NPROD	Output option, number of rods to be printed (N3)	Group 12	SPEC 19
NPROP	Number of entries in property table (N1)	Group 1	SPEC 9
NPWALL	Output option, number of walls to be printed (N7)	Group 12	SPEC 19
NQ	Number of entries in the average heat flux transient table (N9)	Group 11	SPEC 19
NQAX	Axially temperature dependent fuel property option (N4)	Group 8	SPEC 12
NQPRFL	Total number of heat flux transient forcing function profiles (N10)	Group 11	SPEC 19
NRAMP	Number of iterations to insert the effect of wires or loss coefficients (N4)	Group 7	SPEC 6

<u>Variables</u>		<u>Principle Definition</u>	<u>Comdeck</u>
NRC	= NR	PREFIX	SPEC 2
NROD	Total number of rods	SETIN	SPEC 2
NRODTP	Option for axially varying fuel material (N5)	Group 8	SPEC 12
NROW	Number of rows in matrix to be solved	SOLVER	SPEC 2
NRPF	Option to specify individual assembly power densities	Group 11	SPEC 2
NSCBC	Subcooled mixing option (N1)	Group 10	SPEC 11
NSKIPT	Output option, print every NSKIPT timesteps (N2)	Group 9	SPEC 19
NSKIPX	Output option, print every NSKIPX axial nodes (N1)	Group 9	SPEC 19
NSWIRL	Number of assembly types in which swirl flow mixing model is used (N2)	Group 10	SPEC 2
NTNODE	Number of entries in the temperature dependent fuel property table	Group 8	SPEC 9
NTRIES	Maximum number of external iterations	Group 9	SPEC 19
NTYPE(MC)	Friction factor correlation number associated with Channel I	SETIN	SPEC 9
NVISCW	Option for wall viscosity correction to the friction factor (N3)	Group 2	SPEC 9
NWK	Number of wall connections	SETIN	SPEC 2
NWR	Maximum number of connections to a channel (thermal + flow)	COBRA	SPEC 2
NWRAP(MC)	Number of wire wraps in each channel	AREA	SPEC 2
NWRAPS(MC)	Initial wire wrap inventory for each channel	Group 7	SPEC 2
NZONE(MT)	Number of fuel zones	Group 8	SPEC 12
OUTPUT(12)	Array used to print output	RESULT	SPEC 19
P(M1,ME)	Relative pressure at axial location J in subchannel I (lbf/ft ²)	SCHEME, RECIRC	SPEC 3
PDN	Nominal power density (MBtu/hr-ft ³)	Group 11	SPEC 2
PDNA(IU)	Relative assembly power or absolute assembly power density (MBtu/hr-ft ³)	Group 11	SPEC 2
PDROP	Old time total pressure drop (lbf/ft ²)	COBRA	SPEC 6
PERIM(MC)	Wetted perimeter, PW/12(ft)	SETIN	SPEC 2
PEXIT	System operating pressure, (psia)	Group 11	SPEC 2
PH(MC)	Subchannel heated perimeter, (in.)	Group 4	SPEC 1
PHEAD	Total static pressure drop across network model (lbf/ft ²)	NETWORK	SPEC 6
PHI(MR,6)	Fraction of the heated perimeter of rod N facing subchannel I	Group 8	SPEC 12
PHITOT(MR)	1/PHTOT (1/ft)	PREFIX	SPEC 34
PHTOT	Total heated perimeter (ft)	SETIN	SPEC 19
PI	Constant = 3.14159	COBRA	SPEC 2
PITCH	Wire wrap lead length (ft)	Group 7	SPEC 6

<u>Variables</u>		<u>Principle Definition</u>	<u>Comdeck</u>
PLIQ(MP)	Pressure entries in the fluid property table (psia)	Group 1	SPEC 9
POWR(IJ)	Assembly transient power factor	COBRA	SPEC 12
PR(IL,IM)	Same as P used with roll option in RECIRC	RECIRC	SPEC 2
PREF	System pressure (lbf/in ²)	Group 11	SPEC 10
PREFOL	Old time system pressure (lb/in ²)	COBRA	SPEC 9
PRINT(12)	Logical variable; directs output of selected input data groups	SETIN	SPEC 19
PRINIC(MC)	Channel numbers for which information will be printed	Group 12	SPEC 19
PRINTG(MG)	Gap numbers for which information will be printed	Group 12	SPEC 19
PRINTN(10)	Array for radial fuel node printing	SETIN	SPEC 19
PRINTR(MR)	Rod numbers for which information will be printed	Group 12	SPEC 19
PRINTW(MW)	Wall node numbers for which information will be printed	Group 12	SPEC 19
PW(MC)	Subchannel wetted perimeter (in.)	Group 4	SPEC 1
PWIN(IU)	Wetted perimeter associated with the network model assembly inlet loss coefficient (in.)	Group 4	SPEC 6
PWOUT(IU)	Wetted perimeter associated with the network model assembly outlet loss coefficient (in.)	Group 4	SPEC 6
QAX	Interpolated local power factor obtained from axial heat flux table	REHEAT	SPEC 2
QOH	Maximum error in energy solution	ENERGY	SPEC 2
QPRIM(MC)	Source term in energy equation	DIFFER, ENERGY	SPEC 2
QSAV(16,MT)	Orthogonal collocation matrix (Q)	COLOC	SPEC 12
Q1(MR)-Q4(MR)	Fuel rod collocation source terms	REHEAT	SPEC 34
RADIAL(MR)	Radial power factor of rod N	Group 8	SPEC 12
RAIN(IU)	Network model assembly inlet loss parameter (1/ft-lbm)	Group 4	SPEC 6
RAOUT(IU)	Network model assembly outlet loss parameter (1/ft-lbm)	Group 4	SPEC 6
RCCLAD(MT)	Product of cladding density and specific heat (Btu/ft ³ -°F)	PREFIX	SPEC 34
RCFUEL(MT)	Product of fuel density and specific heat (Btu/ft ³ -°F)		SPEC 34
RCLAD(MT)	Density of cladding material (lbm/ft ³)	Group 8	SPEC 12
RECALL	Flag to compute rod temperatures. RECALL = 1.0 if rod temperatures are to be calculated	SCHEME, RECIRC	SPEC 12
RECL(MM)	Reynolds number entries in loss coefficient forcing function tables	Group 7	SPEC 6
REMXA(MT) - REMXK(MT)	Terms in reduced fuel rod energy equation	PREFIX	SPEC 32
RFUEL(MT)	Density of fuel material (lbm/ft ³)	Group 8	SPEC 12

<u>Variables</u>		<u>Principle Definition</u>	<u>Comdeck</u>
RGIN(MJ)	Network model group inlet loss parameter (1/ft-lbm)	Group 7	SPEC 6
RGOUT(MJ)	Network model group outlet loss parameter (1/ft-lbm)	Group 7	SPEC 6
RHO(M1,ME)	Local density (lbm/ft ³)	SCHEME, RECIRC	SPEC 3
RHOBAR(M1,ME)	Average density, $.5*(\rho_j + \rho_{j+1})$	PROP	SPEC 3
RHOLCP(MW)	Wall heat capacity parameter (Btu/ft ² -°F)	Group 4	SPEC 2
RHOOLD(M1,ME)	Density at the previous timestep (lbm/ft ³)	COBRA	SPEC 3
RMUINLT	Inlet viscosity used in network model calculation (lbm/ft-sec)	COBRA	SPEC 6
ROTATE(IT)	Indicates direction of swirl flow	Group 10	SPEC 32
RTIN	Network model total flow loss parameter (1/ft-lbm)	Group 7	SPEC 6
RWALL(2,MW)	Wall thermal resistance (ft ² -sec-°F/Btu)	Group 4	SPEC 2
R2KF(MT)	$DFUEL^2/(4*KFUEL)$	PREFIX	SPEC 34
SAVEAL(M2)	Equivalenced array for peripheral storage of axially dimensioned variables	COBRA	SPEC 2
SAVEA1(M1)	Dummy array that stores variables for the J-1 level during ROLL option	COBRA	SPEC 15
SAVEA2(M1)	Dummy array that stores variables for the J level during ROLL option	COBRA	SPEC 15
SAVEA3(M1)	Dummy array that stores variables for the J+1 level during ROLL option	COBRA	SPEC 15
SAVRES(M5)	Dummy array used for output	RESULT	SPEC 15
SAVRI(IO)	Dummy array used for roll I/O in RECIRC	RECIRC	SPEC 2
SFOLD(MC,2)	Old iterate value of flow in equal pressure drop flow split calculation (lbm/s)	SPLIT	SPEC 2
SIGNAL(18)	Alphanumeric variable that names subroutine in which error has occurred	SETUP	SPEC 19
SL	Transverse momentum parameter, s/l	Group 9	SPEC 2
SP(M1,ME)	Interchannel pressure difference, (lbf/ft ²)	SCHEME, RECIRC	SPEC 4
SPOLD(MC,2)	Old iteration value of node pressure drop in equal pressure drop flow split calculation	SPLIT	SPEC 2
T(MC)	Subchannel coolant temperature (°F)	PROP	SPEC 2
TCLAD(MT)	Cladding thickness, (ft)	Group 8	SPEC 12
TEMLIQ(MP)	Temperature entry in fluid property table (°F)	Group 1	SPEC 9
TERM1(MC)	Utility array		SPEC 14
TERM2(MC)	Utility array		SPEC 2
TEXT(17)	Alphanumeric problem identifier	COBRA	SPEC 19

<u>Variables</u>		<u>Principle Definition</u>	<u>Comdeck</u>
THETA	Subchannel orientation from vertical (degrees)	Group 9	SPEC 2
THICK	Diameter of wire wrap (ft)	Group 7	SPEC 6
TICLAD(MT)	1/TCLAD	PREFIX	SPEC 34
TIME(2)	Clock time	TODS	SPEC 19
TIN	Nominal inlet coolant temperature ($^{\circ}\text{F}$)	SETIN	SPEC 19
TINLET(MC)	Subchannel inlet coolant temperature ($^{\circ}\text{F}$)	SETIN	SPEC 2
TMH(MC)	Correction to coolant temperature for fluid conduction heat transfer ($^{\circ}\text{F}$)	DIFFER	SPEC 2
TPRINT	Total time to next printout of transient results	RESULT	SPEC 2
TRANT	Transient time printout interval, (sec)	Group 9	SPEC 2
TREF	Reference temperature for table lookup	PROP	SPEC 12
TROD(MN,N4,ME)	Rod temperatures at collocation points	HOTROD	SPEC 2
TSAVE(4,MR)	Temporary value of rod temperatures	HOTROD	SPEC 34
TTIME	Total transient time (sec)	Group 9	SPEC 19
TVARY(MP)	Temperature entry in temperature dependent fuel property table ($^{\circ}\text{F}$)	Group 8	SPEC 9
TWALL(M1,ME)	Temperature of the wall ($^{\circ}\text{F}$)	ENERGY	SPEC 4
US(MG)	Average axial velocity at a gap (ft/sec)	PSOLVE	SPEC 2
UWALL(2,MW)	Total wall-to-coolant resistance ($\text{Btu/s-ft}^2\text{-}^{\circ}\text{F}$)	Group 4	SPEC 2
UWCP(2,MW)	UWALL/coolant heat capacity	DIFFER	SPEC 2
V(MC)	Specific volume (ft^3/lbm)	PROP	SPEC 2
VARYCP(MP)	Specific heat entry in temperature dependent fuel property table ($\text{Btu/lbm-}^{\circ}\text{F}$)	Group 8	SPEC 9
VARYK(MP)	Thermal conductivity entry in temperature dependent fuel property table ($\text{Btu/hr-ft-}^{\circ}\text{F}$)	Group 8	SPEC 9
VASSEM(IU)	Average assembly velocity	SCHEME	SPEC 32
VISC(MC)	Coolant viscosity (lbm/sec-ft)	PROP	SPEC 2
VISCW(MC)	Wall viscosity correction to friction factor (lbm/ft-sec)	PROP	SPEC 2
VISLIQ(MP)	Viscosity entry in property table (lbm/ft-sec)	Group 1	SPEC 9
VLIQ(MP)	Specific volume entry in property table (ft^3/lbm)	Group 1	SPEC 9
VP(MC)	Same as V (ft^3/lbm)	PROP	SPEC 2
VPA(MC)	V/A (ft/lbm)	SCHEME	SPEC 2
W(M1,ME)	Crossflow (lbm/ft-sec)	SCHEME, RECIRC	SPEC 4

<u>Variables</u>		<u>Principle Definition</u>	<u>Comdeck</u>
WALLC(2,IU)	Utility Array		SPEC 2
WALLS(IU)	Utility Array		SPEC 2
WBAR(MX)	Average crossflow magnitude	PSOLVE	SPEC 6
WERRX	Convergence criteria	Group 9	SPEC 2
WERRY	Convergence criteria	Group 9	SPEC 2
WIDTH(MW)	Width of wall connection (in.)	Group 4	SPEC 2
WLTHCK(MW)	Wall decay heat parameter (in.)	Group 4	SPEC 2
WOLD(MI,ME)	Crossflow from previous timestep (lbm/ft-sec)	COBRA	SPEC 4
WP(MG)	Turbulent crossflow (lbm/ft-sec)	DIFFER	SPEC 2
WPP(MG)	Total of turbulent and conduction energy transfer	DIFFER	SPEC 14
WR(IN,IM)	Same as W, used with roll option in RECIRC	RECIRC	SPEC 2
WSAVE(MG)	Old iterate value of crossflow (lbm/ft-sec)	PSOLVE	SPEC 2
WSIGN	Gives sign of crossflow for swirl	SETIN	SPEC 32
WTEMP(MG)	Old iterate value of crossflow	MOMENT	SPEC 14
X(MX)	Axial distance from bundle entrance (in.)	SETUP	SPEC 2
XCROSS(MG,2)	Relative angle/360 ⁰ of wire wrap gap crossing	Group 7	SPEC 6
Y(MP)	Relative axial location for axial heat flux table	Group 3	SPEC 2
YG(MM)	Time axis for inlet flow or pressure drop forcing function (sec)	Group 11	SPEC 19
YH(MM)	Time axis for inlet enthalpy forcing function (sec)	Group 11	SPEC 19
YHX(MM)	Time axis for exit enthalpy forcing function (sec)	Group 11	SPEC 19
YP(MM)	Time axis for system pressure forcing function (sec)	Group 11	SPEC 19
YQ(MM)	Time axis for heat flux forcing function (sec)	Group 11	SPEC 19
YT(MP)	Time axis for maximum time step forcing function (sec)	Group 9	SPEC 19
Z	Total axial length (ft)	SETIN	SPEC 2
ZEND(MT,MY)	Relative axial location of the end of a fuel zone	Group 8	SPEC 12
ZZ	Total axial length (in.)	Group 9	SPEC 19

APPENDIX C
COMDECKS

UNLABELED OLDPL

MASTER AUDIT, IDENT CARD TOTAL

UPDATE 1.3-477.

05/09/80 10.12.34.

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC

SPEC8 *COMDECK SPEC8

SPEC8 MA#
 SPEC8 MC#
 SPEC8 ME#
 SPEC8 MG#
 SPEC8 MI#
 SPEC8 MJ#
 SPEC8 MK#
 SPEC8 ML#
 SPEC8 MM#
 SPEC8 MN#
 SPEC8 MO#
 SPEC8 MP#
 SPEC8 MR#
 SPEC8 MS#
 SPEC8 MT#
 SPEC8 MV#
 SPEC8 MW#
 SPEC8 MX#
 SPEC8 MY#
 SPEC8 MZ#
 SPEC8 NI#
 SPEC8 NJ#
 SPEC8 JA#
 SPEC8 JE#
 SPEC8 IR#
 SPEC8 IT#
 SPEC8 IU#
 SPEC8 IV#
 SPEC8 IW#
 SPEC8 IX#
 SPEC8 IY#

SPEC8	1	A
SPEC8	2	A
SPEC8	3	A
SPEC8	4	A
SPEC8	5	A
SPEC8	6	A
SPEC8	7	A
SPEC8	8	A
SPEC8	9	A
SPEC8	10	A
SPEC8	11	A
SPEC8	12	A
SPEC8	13	A
SPEC8	14	A
SPEC8	15	A
SPEC8	16	A
SPEC8	17	A
SPEC8	18	A
SPEC8	19	A
SPEC8	20	A
SPEC8	21	A
SPEC8	22	A
SPEC8	23	A
SPEC8	24	A
SPEC8	25	A
SPEC8	26	A
SPEC8	27	A
SPEC8	28	A
SPEC8	29	A
SPEC8	30	A
SPEC8	31	A
SPEC8	32	A
SPEC8	33	A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC1

SPEC1 *COMDECK SPEC1

SPEC1 DIMENSION AC(MC),PW(MC),PH(MC),DC(MC),OR(MR),
 SPEC1 2 LC(MC,4),GAPS(MC,4),DIST(MC,4),
 SPEC1 3 DATIN(M2)
 SPEC1 EQUIVALENCE (DATIN(1),TERM2(1),AC(1)),(PW(1),DPW(1)),
 SPEC1 1 (PH(1),FLOW(1)),
 SPEC1 2 (DC(1),OPRTH(1)),(DR(1),V(1)),
 SPEC1 3 (LC(1,1),VPA(1)),(GAPS(1,1),CON(1)),
 SPEC1 4 (DIST(1,1),VP(1))
 SPEC1 CLCM LEVEL 2,DATIN,AC,PH,PH,DC,DR,HINLET,FINLET,TJNLET,LC,
 SPEC1 CLCM 1 GAPS,DIST

SPEC1	1	A
SPEC1	2	A
SPEC1	3	A
SPEC1	4	A
SPEC1	5	A
SPEC1	6	A
SPEC1	7	A
SPEC1	8	A
SPEC1	9	A
SPEC1	10	A
SPEC1	11	A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC2

SPEC2 *COMDECK SPEC2

SPEC2 COMMON IX(MG),JK(MC),Y(MX),LENGTH(MG),Y(MP),AXIAL(MP,MV),

SPEC2	1	A
SPEC2	2	A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPECS

SPEC2	2	WJOTH(MW),IKW(MW),JKW(MW),QOH,UWCP(2,MW),HVAL(2,MW),	SPEC2	3	A
SPEC2	2	RWALL(2,MW),RHOLCP(MW),KIJ,Z,THETA,PI,NAX,T2,Y3,IERROD,	SPEC2	4	A
SPEC2	3	JJ,ATOTAL,QAX,ELEV,FERRON,ITERAT,DTGC,GC,AL,POUT,LUI,IRDL,	SPEC2	5	A
SPEC2	4	DT,PEXIT,NWR,WERRX,WERRV,ITRY,ITRYM,ACCELY,ACCEL1,NAAA,	SPEC2	6	A
SPEC2	5	NAAP1,ACCELF,DAMPNG,NAAM,NAAP1,ITDP,DPS,DX(MY),IDTGC,	SPEC2	7	A
SPEC2	7	EXTRA(100),DTI,ACCELM,IMIGH,ILOW,ILOWPI,NPOINT,	SPEC2	8	A
SPEC2	8	NRC,ISOLVE,IALTY,HFRROR,TPRINT,TRANT,NOMOM,NHET,NAFLX(III),	SPEC2	9	A
SPEC2	9	IASS,NSWIRL,ITSAVE,FTM,J5,NACBC,GX(II),NRAMPH	SPEC2	10	A
SPEC2	+	,IScheme,JDIRECT,ISYM,IRWL,IRWR,IC,IWIDE,NROW	SPEC2	11	A
SPEC2	*,END		SPEC2	12	A
SPEC2		COMMON/LOOP/NCHANL,NK,NDXP1,NROD,NTRYX,NDX,NWX	SPEC2	13	A
SPEC2	1	,KEY(IY,3),HLEN	SPEC2	14	A
SPEC2	*,END		SPEC2	15	A
SPEC2		COMMON/LARGE1/SAVEAL(MP),TERM2(MC),DPK(MC),FLOW(MC),QPRIM(MC),	SPEC2	16	A
SPEC2	1	V(MC),VPA(MC),VISC(MC),VISCN(MC),WFILM(MC),	SPEC2	17	A
SPEC2	2	CON(MC),CP(MC),FSP(MC),CIP(MC),VP(MC),T(MC),	SPEC2	18	A
SPEC2	3	TMM(MC),NWRAP(MC),PERIM(MC),HPERIM(MC),TINLET(MC),	SPEC2	19	A
SPEC2	4	FYNLET(MC),HINLET(MC),WPC(MG),DTJ1(MG),DTJ2(MG),US(MG),	SPEC2	20	A
SPEC2	5	WRAVE(MG),WALLS(III),WALLC(2,IU),WLTCHK(MW),PDNA(II),IEXP,	SPEC2	21	A
SPEC2	6	DTMAXE,DTIMP,PDN,NRPF,IPRNTA,IPRNTA,DDUCT(IU,IX)	AFIV21	1	A
SPEC2	*,END		SPEC2	23	A
SPEC2		COMMON/DHED/DFOPD(MX),DFOPD(MX),CONS(MX)	SPEC2	24	A
SPEC2		COMMON/LARGE3/AN(MC),DHYDN(MC),NWRAP3(MC),DPOLD(MC,2),	SPEC2	25	A
SPEC2	1	FFOLD(MC,2),MFLAG(MC)	SPEC2	26	A
SPEC2	*,END		SPEC2	27	A
SPEC2		REAL IDTGC,LENGTH,KIJ	SPEC2	28	A
SPEC2		LOGICAL MFLAG	SPEC2	29	A
SPEC2	CLCM	LEVEL 2,SAVEAL	SPEC2	30	A
SPEC2	CLCM	LEVEL 2,AN	SPEC2	31	A
SPEC2		COMMON,SMALL1/HAH(IE,MC),ILUCS(N1,MC),IPDINT(IU,7),NGAP1,VSCN(MC),	SPEC2	32	A
SPEC2	1	NRAP2,NCHAN1,NCHAN2,NCHANA,NASSEH,NAB3,NACH(MC),MAXTYP,	SPEC2	33	A
SPEC2	2	ITYPIN(IT,3),JCHAN(N6,MC),	SPEC2	34	A
SPEC2	3	IFACE(IT,6,IV),ISIDE(IU,4),	AFIV21	1	A
SPEC2	2	END19	SPEC2	35	A
SPEC2		DIMENSION DPRAR(III),SPOLD(MC,2),SFOLD(MC,2),MFLAG(MC)	SPEC2	36	A
SPEC2		DIMENSION PSCH(MC),IRLOKA(4C),IBLOKC(MC)	SPEC2	37	A
SPEC2		DIMENSION AAD(IE,MC),CONST(I8)	AFIV21	2	A
SPEC2	CLCM	LEVEL 2,MFLAG,CONST	AFIV21	3	A
SPEC2		LOGICAL MFLAG	SPEC2	40	A
SPEC2		EQUIVALENCE (MFLAG(1),TERM2(1)),(DPRAR(1),HAH(1,1)),	SPEC2	41	A
SPEC2	1	(VSCN(1),PSCH(1)),	SPEC2	42	A
SPEC2	2	(SPOLD(1,1),HAH(1,1)),(SFOLD(1,1),HAH(1,1S)),	SPEC2	43	A
SPEC2	3	(AAD(1,1),HAH(1,1)),(CONST(1),TERM2(1)),	SPEC2	44	A
SPEC2	4	(IRLOKA(1),SFOLD(1,1)),(IRLOKC(1),SFOLD(1,2))	AFIV21	4	A
SPEC2		DIMENSION PRFIL(IM),FR(IL,IM),DFOPR(IL,IM),WPC(IM,IM)	SPEC2	47	A
SPEC2	5	DWOPR(IM,IM)	SPEC2	48	A
SPEC2	CLCM	LEVEL 2,PR,FR,DFOPR,WR,DWOPR	SPEC2	49	A
SPEC2		EQUIVALENCE (PR(1,1),SAVEAL(1)),(FR(1,1),SAVEAL(1)),	SPEC2	50	A
SPEC2	5	(DFOPR(1,1),SAVEAL(12)),(WR(1,1),SAVEAL(13)),	SPEC2	51	A
SPEC2	5	(DWOPR(1,1),SAVEAL(14))	SPEC2	52	A
SPEC2		COMMON/SPACE/SAVRI(IN)	SPEC2	53	A
SPEC2	CLCM	LEVEL 2,SAVRI	SPEC2	54	A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC3

SPEC3 *COMDECK SPEC3
 SPEC3 DIMENSION P(M1,ME),H(M1,ME),F(M1,ME),RHO(M1,ME),
 SPEC3 1 HOLD(M1,ME),FOLD(M1,ME),RHOOLD(M1,ME),
 SPEC3 2 A(M1,ME),DHVD(M1,ME),RHOBAR(M1,ME),
 SPEC3 3 DFDP(M1,ME),APP(M1,ME)
 SPEC3 EQUIVALENCE (P(1,1),SAVEAL(HU)),(F(1,1),SAVEAL(NP)),
 SPEC3 1 (RHO(1,1),SAVEAL(NC)),(HOLD(1,1),SAVEAL(NG)),
 SPEC3 2 (A(1,1),SAVEAL(NS)),(DHVD(1,1),SAVEAL(NL)),
 SPEC3 3 (H(1,1),SAVEAL(NA)),(FOLD(1,1),SAVEAL(NX)),
 SPEC3 4 (RHOOLD(1,1),SAVEAL(NN)),(RHOBAR(1,1),SAVEAL(NT)),
 SPEC3 5 (DFDP(1,1),SAVEAL(NR)),(APP(1,1),SAVEAL(ME))
 SPEC3 CLCM LEVEL 2, P,H,F,RHO,HOLD,FOLD,RHOOLD,A,DHVD,RHOBAR,DFDP,APP

SPEC3 1 A
 SPEC3 2 A
 SPEC3 3 A
 SPEC3 4 A
 SPEC3 5 A
 SPEC3 6 A
 SPEC3 7 A
 SPEC3 8 A
 SPEC3 9 A
 SPEC3 10 A
 SPEC3 11 A
 SPEC3 12 A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC4

SPEC4 *COMDECK SPEC4
 SPEC4 DIMENSION W(M1,ME),WOLD(M1,ME),SP(M1,ME),
 SPEC4 2 GAP(M1,ME),TWALL(M1,ME)
 SPEC4 EQUIVALENCE (W(1,1),SAVEAL(I)),(WOLD(1,1),SAVEAL(M3)),
 SPEC4 1 (GAP(1,1),SAVEAL(M4)),(SP(1,1),SAVEAL(M5)),
 SPEC4 2 (TWALL(1,1),SAVEAL(MY))
 SPEC4 CLCM LEVEL 2, W,WOLD,GAP,SP,TWALL

SPEC4 1 A
 SPEC4 2 A
 SPEC4 3 A
 SPEC4 4 A
 SPEC4 5 A
 SPEC4 6 A
 SPEC4 7 A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC5

SPEC5 *COMDECK SPEC5
 SPEC5 DIMENSION IFITYP(M1,ME),FLUX(M1,ME),TRDD(MN,M4,ME),
 SPEC5 1 HURF(M1,ME),AVGCP(M1,ME),AVGK(M1,ME)
 SPEC5 EQUIVALENCE (IFITYP(1,1),SAVEAL(M9)),(FLUX(1,1),SAVEAL(MB)),
 SPEC5 1 (HURF(1,1),SAVEAL(MD)),(TRDD(1,1,1),SAVEAL(MF)),
 SPEC5 2 (AVGK(1,1),SAVEAL(N9)),(AVGCP(1,1),SAVEAL(NB))
 SPEC5 CLCM LEVEL 2, FLUX,TRDD,HURF,IFITYP,AVGCP,AVGK

SPEC5 1 A
 SPEC5 2 A
 SPEC5 3 A
 SPEC5 4 A
 SPEC5 5 A
 SPEC5 6 A
 SPEC5 7 A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC6

SPEC6 *COMDECK SPEC6
 SPEC6 COMMON/RGRIN/RECL (HM),FFLC(MH,IW),JLC(MK),ILC(MK),KLC(MK),
 SPEC6 1 FXFLNH(MK),LCASS(IU),CD(MK),LCFF(MK),NOLC,NLFF,NLCF,J6,
 SPEC6 2 NRAMP,THICK,DJA,FDIV(M3),DUR(MG),PITCH,WBAR(MY),
 SPEC6 3 XCRSS(MB,2),NARAMP,IFDIV(MG),FACTOR(MK),IFB(MC),NRLOCK
 SPEC6 4 ,FLN(IU),FLOG(MJ),JCON(IU),PWIN(IU),PWOUT(IU),RAIN(IU),
 SPEC6 5 ,PAGUT(IU),RGIN(MJ),RGOUT(MJ),NETGRP(IU),NINFF(IU),
 SPEC6 6 ,NOUTFF(IU),NPA(IU),DPT(IU),RMUINLT,NDRP,PDROP,PHEAD,
 SPEC6 7 ,NETWK,FRPT(IU),DPPRI(IU),ISAVIT(MC),LBLOK(MK,2),ISLOKT
 SPEC6 8 ,RTIN,HGIN(MJ),HROUT(MJ),HAIN(IU),HADUT(IU),ALF
 SPEC6 9 ,GHEAD(MC)
 SPEC6 *END*
 SPEC6 LOGICAL LCASS,JCON
 SPEC6 DIMENSION ISTAR(MG)
 SPEC6 EQUIVALENCE(ISTAR(1),IFDIV(1))
 SPEC6 COMMON/ICONT/ ICOUNT

SPEC6 1 A
 SPEC6 2 A
 SPEC6 3 A
 SPEC6 4 A
 SPEC6 5 A
 SPEC6 6 A
 SPEC6 7 A
 SPEC6 8 A
 SPEC6 9 A
 SPEC6 10 A
 SPEC6 11 A
 SPEC6 12 A
 SPEC6 13 A
 SPEC6 14 A
 SPEC6 15 A
 SPEC6 16 A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC7

SPEC7 *COMDECK SPEC7
 SPEC7 COMMON /RAREA/ AFACT(ML,MA),GFACT(ML,MS),AXL(ML),GAPYL(ML),
 SPEC7 1 NARAMP,NAFACT,NAXL,NGXL,NGAPS,NCH(MA),NGAP(MS)
 SPEC7 *END4
 SPEC7 COMMON/LARGE4/ IDAREA(MC),IDGAP(MG),GAPN(MG)
 SPEC7 *END7
 SPEC7 CLCM LEVEL 2, IDAREA

SPEC7	1	A
SPEC7	2	A
SPEC7	3	A
SPEC7	4	A
SPEC7	5	A
SPEC7	6	A
SPEC7	7	A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC8

SPEC8 *COMDECK SPEC8
 SPEC8 DIMENSION DPOX(MC),DHOX(MC),DFOX(MC),CONK(MG)
 SPEC8 EQUIVALENCE (DHOX(1),CP(1)),(DFOX(1),RSP(1)),(DPOX(1),CON(1)),
 SPEC8 1 (CONK(1),HAM(1,1))
 SPEC8 CLCM LEVEL 2, DPOX,DHOX,DFOX

SPEC8	1	A
SPEC8	2	A
SPEC8	3	A
SPEC8	4	A
SPEC8	5	A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC9

SPEC9 *COMDECK SPEC9
 SPEC9 COMMON/PROP1/PLIQ(MP),TEMLIQ(MP),HLIQ(MP),CONLIQ(MP),
 SPEC9 1 CPLIQ(MP),VTSLIQ(MP),VLIJ(MP),AA(IW),AB(IW),CC(TW),DD(IW),
 SPEC9 2 EE(IW),AAL(IW),BRL(IW),CCL(IW),LAMNH(IW),TVARY(MP),
 SPEC9 3 VARYK(MP),VARYCP(MP),NTNODE,NFNODE,PREFOL,NPROD,NVISCH,
 SPEC9 4 NPTICT,NTYPE(MC)
 SPEC9 *END4
 SPEC9 LOGICAL LAMNH
 SPEC9 DIMENSION TT(MD),HMF(MP),VVF(MP)
 SPEC9 EQUIVALENCE(TT,TFMLIQ),(HMF,HLIQ),(VVF,VLIQ)

SPEC9	1	A
SPEC9	2	A
SPEC9	3	A
SPEC9	4	A
SPEC9	5	A
SPEC9	6	A
SPEC9	7	A
SPEC9	8	A
ACTV21	5	A
ACTV21	6	A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC10

SPEC10 *COMDECK SPEC10
 SPEC10 COMMON/PROP2/PREF,LAMNH(IW),NHEAT,NFLMC(IU),AHL(IW),AH2(IW),
 SPEC10 1 AHL(IW),AHL4(IW),AHL1(IW),AHL2(IW),AHL3(IW),AHL4(IW)
 SPEC10 *END4
 SPEC10 LOGICAL LAMNH

SPEC10	1	A
SPEC10	2	A
SPEC10	3	A
SPEC10	4	A
SPEC10	5	A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC12

SPEC12 *COMDECK SPEC12
 SPEC12 COMMON /FUEL/ KFUEL(MT),KCLAD(MT),RFUEL(MT),RCLAD(MT),CFUEL(MT),
 SPEC12 1 CCLAD(MT),TCLAD(MT),HGAP(MT),LR(MR,6),DFUEL(MT),
 SPEC12 2 PHIMR(6),RADTAL(MR),D(MR),POWR(IJ),
 SPEC12 3 TREF,ZEND(MT,MY),IDFUEL(MG),NHEVT(IU),
 SPEC12 4 INTYP(MT),N7UNE(MT),IZTYP(MT,MY),AASAV(16,MT),
 SPEC12 5 BRSAV(16,MT),DQSAV(16,MT),NGAX,NC,NRODTP,
 SPEC12 6 NFUEL,KQC,RFCALL
 SPEC12 *END11
 SPEC12 REAL KFUEL,KCLAD
 SPEC12 CLCM LEVEL 2, KFUEL

SPEC12	1	A
SPEC12	2	A
SPEC12	3	A
SPEC12	4	A
SPEC12	5	A
SPEC12	6	A
SPEC12	7	A
SPEC12	8	A
SPEC12	9	A
SPEC12	10	A
SPEC12	11	A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC14

SPEC14	*COMDECK SPEC14	SPEC14	1	A
SPEC14	DIMENSION TERM1(MC),R(MG),CIJ(MG),DPWP(MC),ILOCC(MB),	SPEC14	2	A
SPEC14	1WPP(MG),WTEMP(MG),FTEMP(MC),DWDOP(M1,ME)	SPEC14	3	A
SPEC14	EQUIVALENCE (TERM1(1),VISCH(1)),(B(1),WP(1),CIJ(1),WPP(1)),	SPEC14	4	A
SPEC14	2 (ILOCC(1),ILOCC(1,1)),(DPWP(1),FSP(1)),	SPEC14	5	A
SPEC14	3 (DWDOP(1,1),WTEMP(1),SP(1,1)),(FTEMP(1),TERM1(1))	SPEC14	6	A
SPEC14	CLCM LEVEL 2,UB,TERM1,B,CIJ,DPWP,WPP,WTEMP,FTEMP,DWDOP	SPEC14	7	A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC15

SPEC15	*COMDECK SPEC15	SPEC15	1	A
SPEC15	DIMENSION SAVEA1(M1),SAVEA2(M1),SAVEA3(M1).	SPEC15	2	A
SPEC15	1 SAVRES(N5)	SPEC15	3	A
SPEC15	EQUIVALENCE (SAVEA1(1),SAVEA1(1)),(SAVEA2(1),SAVEA1(NK)),	SPEC15	4	A
SPEC15	1 (SAVEA3(1),SAVEA1(NW)),(SAVRES(1),SAVEA2(1))	SPEC15	5	A
SPEC15	CLCM LEVEL 2,SAVEA1,SAVEA2,SAVEA3	SPEC15	6	A
SPEC15	CLCM LEVEL 2,SAVRES	SPEC15	7	A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC19

SPEC19	*COMDECK SPEC19	SPEC19	1	A
SPEC19	COMMON/INMATN/ OUTPUT(12),PRINT(12),TEXT(17),DATE(2),TIME(2).	SPEC19	2	A
SPEC19	1 TOUMY(10),PHYOT,ETIME,YP(MM),FP(MM),YG(MM),FG(MM,IX),	SPEC19	3	A
SPEC19	2 YH(MM),FH(MM),YQ(MM),FQ(MM,IX),YT(MP),FHX(MM),VHX(MM),	SPEC19	4	A
SPEC19	3FT(MP),HOUT,NHX,NOUT,NPCHAN,NP3AP,NPNDDE,NPRON,	SPEC19	5	A
SPEC19	4 PRYNTN(10),NSK1PT,NSK1PX,MN,MR,MC,MG,MP,MX,MW,MY,ME,	SPEC19	6	A
SPEC19	5MZ,MK,MS,MA,M1,MT,ML,NP,MV,IV,IU,IT,NG,NQ,NH,IN,YG,	SPEC19	7	A
SPEC19	6 MJ,MY,MD,IA,IX,IR,IE,IM(MS),JM(MS),MAXT,NJUMP,	SPEC19	8	A
SPEC19	7IMP(10),JMP(10),JB,X10,NOT,NOTP1,KASE,NTRIES,ITSTEP,HIN,	SPEC19	9	A
SPEC19	8TIN,GIN,ZZ,NRPFL,NQPRFL,NPVT(IU)	SPEC19	10	A
SPEC19	*END13,97GNAL(18),H1,HP,H3,H4,H5,H6,H7,H8	SPEC19	11	A
SPEC19	COMMON/LARGE2/PRINTC(MC),PRINTG(MG),PRINTR(MR),HXYIT(MC),	SPEC19	12	A
SPEC19	1 AAR(MC),NFLGR,NFLGC,NFLGR,NFLGW,NPALL,PRINTW(MW),NASSI(10),	SPEC19	13	A
SPEC19	2 NASSJ(10),END14	SPEC19	14	A
SPEC19	INTEGER PRINTC,PRINTG,PRINTN,PRINTR,PRINTW	SPEC19	15	A
SPEC19	LOGICAL PRINT	SPEC19	16	A
SPEC19	CLCM LEVEL 2,PRINTC	SPEC19	17	A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC20

SPEC20	*COMDECK SPEC20	SPEC20	1	A
SPEC20	DIMENSION SAVEA1(M1),SAVEA2(M1),SAVEA3(M1)	SPEC20	2	A
SPEC20	CLCM LEVEL 2,SAVEA1,SAVEA2,SAVEA3	SPEC20	3	A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC22

SPEC22	*COMDECK SPEC22	SPEC22	1	A
SPEC22	DIMENSION F(MP),V(MP)	SPEC22	2	A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC23

SPEC23	*COMDECK SPEC23	SPEC23	1	A
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UNLABELED OLDPL

MASTER AMOIT, IDENT CARD TOTAL

UPDATE 1.3-477.

05/09/80 19.12.30.

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC23

SPEC23 CLCM LEVEL 2, SPC23, ISPC23, SPC24, ISPC24, SPC61, ISPC61
 SPEC23 CLCM LEVEL 2, SPC72, ISPC72, SPC12, ISPC12, SPC20, ISPC20
 SPEC23 CLCM LEVEL 2, SPC32, ISPC32, SPC33, ISPC33
 SPEC23 CLCM LEVEL 2, SPC34, ISPC34

SPEC23 2 A
 SPEC23 3 A
 SPEC23 4 A
 SPEC23 5 A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC24

SPEC24 *COMDECK SPEC24
 SPEC24 CLCM LEVEL 2, X, Y, Z

SPEC24 1 A
 SPEC24 2 A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC25

SPEC25 *COMDECK SPEC25
 SPEC25 CLCM LEVEL 2, VARS

SPEC25 1 A
 SPEC25 2 A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC26

SPEC26 *COMDECK SPEC26
 SPEC26 CLCM LEVEL 2, ISTORE, STORE, STORES, LOGICL

SPEC26 1 A
 SPEC26 2 A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC27

SPEC27 *COMDECK SPEC27
 SPEC27 CLCM LEVEL 2, A, B

SPEC27 1 A
 SPEC27 2 A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC30

SPEC30 *COMDECK SPEC30
 SPEC30 DIMENSION RECORD(1)
 SPEC30 CLCM LEVEL 2, RECORD

SPEC30 1 A
 SPEC30 2 A
 SPEC30 3 A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC31

SPEC31 *COMDECK SPEC31
 SPEC31 COMMON/INDEX/INDEX(HIGH(MC), LOW(MC), NCOUNT(MR),
 SPEC31 2 END15

SPEC31 1 A
 SPEC31 2 A
 SPEC31 3 A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC32

SPEC32 *COMDECK SPEC32
 SPEC32 COMMON/INDEX/INDEX(MT), DFUEL(MT), REMIXA(MT), REMIXB(MT),
 SPEC32 1 REMIXC(MT), REMIXD(MT), REMIXE(MT), REMIXF(MT),
 SPEC32 2 REMIXG(MT), REMIXH(MT), REMIXI(MT), REMIXJ(MT),
 SPEC32 3 REMIXK(MT), C12(MT), CIN12(MT), C13(MT),
 SPEC32 4 NSIGN(MC), NCTYPE(MC), VASSEM(IU), GASSEM(IT),
 SPEC32 5 AMIX(IT), RMIX(IT), ISWIRL(IT), ROTATE(IT),
 SPEC32 8 END16
 SPEC32 CLCM LEVEL 2, INDEX

SPEC32 1 A
 SPEC32 2 A
 SPEC32 3 A
 SPEC32 4 A
 SPEC32 5 A
 SPEC32 6 A
 SPEC32 7 A
 SPEC32 8 A
 SPEC32 9 A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC33

SPEC33 *COMDECK SPEC33

SPEC33 1 A

UNLABELED OLDPL

MASTER AUDIT, IDENT CARD TOTAL

UPDATE 1.3-477.

09/09/80 19.12.34.

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC33

SPEC33 COMMON/REDUCE/DS1(MT),DS6(MT),DS7(MT),DS11(MT),
 SPEC33 1 DS13(MT),DS19(MT),DS21(MT),DS1(MT),DS6(MT),
 SPEC33 2 DIR7(MT),DS11(MT),DS13(MT),DIR19(MT),
 SPEC33 3 DIR21(MT),REMIX1(MT),REMIX2(MT),REMIX3(MT),
 SPEC33 4 REMIX4(MT),REMIX5(MT),REMIX6(MT),REMIX7(MT),
 SPEC33 5 REMIX8(MT),C1(MT),C2(MT),C3(MT),C4(MT),C5(MT),
 SPEC33 6 C6(MT),C7(MT),C8(MT),C9(MT),C10(MT),C11(MT),
 SPEC33 7 CIN1(MT),CIN2(MT),CIN3(MT),CIN4(MT),CIN5(MT),
 SPEC33 8 CIN6(MT),CIN7(MT),CIN8(MT),CIN9(MT),CIN10(MT),
 SPEC33 9 CIN11(MT),
 SPEC33 * END17
 SPEC33 CLCM LEVEL 2,DS1

SPEC33	2	A
SPEC33	3	A
SPEC33	4	A
SPEC33	5	A
SPEC33	6	A
SPEC33	7	A
SPEC33	8	A
SPEC33	9	A
SPEC33	10	A
SPEC33	11	A
SPEC33	12	A
SPEC33	13	A

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SPEC34

SPEC34 *COMDECK SPEC34
 SPEC34 COMMON/REPEAT/DRDD(MT),REFUEL(MT),RECLAD(MT),TICLAD(MT),
 SPEC34 1 DIMMER(MT),REFUEL(MT),RECLAD(MT),R2KF(MT),HGAP1(MT),
 SPEC34 2 HGRK(MT),CR(MT),HGCRT(MT),HEATER(MR),Q1(MR),
 SPEC34 3 Q2(MR),Q3(MR),Q4(MR),RING(MR),RANG(MR),RUNG(MR),
 SPEC34 4 HUNG(MR),PHITOT(MR),CIN1V(MR),CIN4V(MR),
 SPEC34 5 CSV(MR),CIN6V(MR),C7V(MR),TSAVE(4,MR)
 SPEC34 *END18
 SPEC34 CLCM LEVEL 2, DRDD
 SPEC34 DIMENSION LRI(1R,MC)
 SPEC34 EQUIVALENCE (HAH(1,1),LRI(1,1))
 SPEC34 LAST

SPEC34	1	A
SPEC34	2	A
SPEC34	3	A
SPEC34	4	A
SPEC34	5	A
SPEC34	6	A
SPEC34	7	A
SPEC34	8	A
SPEC34	9	A
SPEC34	10	A
SPEC34	11	A
SPEC34	12	A

APPENDIX D
CONTROL STATEMENTS FOR REDIMENSIONING A COBRA-WC FILE

APPENDIX D

CONTROL STATEMENTS FOR REDIMENSIONING A COBRA-WC FILE

Instructions for redimensioning a COBRA-WC file on a CDC 7600 computer under the SCOPE operating system are given in this appendix. It is assumed in the control statements listed below that the user has catalogued under ID=COBRA permanent files for updatable versions of COBRA-WC, COMDECKWC, and SPECSETWC. The control statements below will probably require some modification for each computer installation, but all the general sequence of steps described by the comments should be followed. The operation of program SPECSET is described in Section 8 of the main report.

	<u>Comments</u>
ATTACH,NEWS,UCOMDECKWC,ID=COBRA	Updatable version of COMDECKWC
UPDATE(P=NEWS,S=TAPE2,F,N.L=12347)	Creates the source file on logical unit 2 of the specdecks with variable subscripts
RETURN,NEWS.	
RETURN,NEWPL.	
REWIND(TAPE2)	
COPYSBF(TAPE2,OUTPUT)	List comdecks
REWIND(TAPE2)	
ATTACH(SPFIX,USPECSETWC,ID=COBRA)	Updatable version of SPECSETWC
UPDATE(P=SPFIX,F,N)	Creates compilable version of SPECSETWC. Changes to program SPECSETWC can be made at this point.
RETURN,NEWPL.	
FTN,I,L=0,B=SPEC.	Creates binary version of SPECSETWC

RETURN,COMPILE

SPEC.

Runs program SPECSETWC - requires input from unit 2 and spec parameters as shown below - writes specdecks to file NEWPU

REWIND(NEWPU)

COPYSBF(NEWPU,OUTPUT)

Lists specdecks with constant subscripts

REWIND(NEWPU)

ATTACH(DUM1,UCOBRAWC,ID=COBRA)

Updatable version of COBRAWC

UPDATE(P=DUM1,N=NUM1,C=0,L=1,F,E)

First COBRA update - removes old specdecks from file

UPDATE(P=NUM1,N=NUM2,C=0,L=1234,F,E)

Second COBRA update - removes old specdeck idents from file - changes to COBRAWC can be made at this point

RETURN(NUM1,DUM1)

REQUEST(NEWPL,*PF)

UPDATE(P=NUM2,F,E,N,L=1)

Third COBRA update - inserts new specdecks (on file NEWPU) - creates new updatable version of COBRAWC

CATALOG,NEWPL,ID=COBRA,RP=999

Permanently stores updatable version of COBRAWC under file name FNU

RETURN(NUM2,NEWPU,NEWPL)

REQUEST(NEWB,*PF)

RFL(160000)

FTN,I,L=0,PL=99999,B=NEWB.

CATALOG,NEWB,FNB,ID=COBRA,RP=999.

Permanently stores binary version of COBRAWC under file name FNB

REDUCE.

EOF

*/COMDECK UPDATES

Updates to COMDECKWC, if any

EOF

*/SPECSET UPDATES

Updates to SPECSETWC, if any

EOF

LCM

SPECSET parameter input

MJ= 1

MA= 1

MS= 1

MK= 1

ML= 1

MP= 31

MZ= 1

MI= 7

MM= 29

MR= 80

MW= 60

IE= 21

IV= 4

MC= 95

MN= 5

MX= 34

ME= 34

IR= 6

IW= 3

MO= 11

MT= 10

MY= 7

IT= 7

MG=160

MV= 2

IA= 75

IX= 20

LCM on first card indicates that
LEVEL 2 storage is to be used.

EOF

*PD SPECS, SPEC34

Updates command to remove old
specdecks

EOF

*/COBRA UPDATES

Updates to COBRAWC, if any

EOF

*AF NEWPU,YANK\$\$\$

Updates command to add new spec-
decks

EOF

APPENDIX E
SAMPLE PROBLEMS

APPENDIX E - SAMPLE PROBLEMS

XX08 SAMPLE PROBLEM

Several natural circulation experiments have been conducted in the Experimental Breeder Reactor-II (EBR-II) as part of the XX08 instrumented assembly effort. XX08 test 7A was one of these experiments and will be used to illustrate the use of the COBRA-WC code. In this test, the reactor was operated at a reduced power (28.19 percent of nominal) and flow rate (33.0 percent of nominal) until the fission product inventory attained a near equilibrium state. The primary and auxiliary pumps were then manually tripped and shortly thereafter (3.4 seconds) the reactor automatically scrammed because of a low flow trip. The secondary system pumps were then manually shut down to simulate total loss of on-site and off-site plant power. Eventually the flow coasted down to the point where there was only natural circulation through the loop driven by the decay heat in the core and the cooling from the secondary system.

The XX08 assembly was instrumented with flow meters at the assembly inlet and outlet, eighteen coolant thermocouples in and above the fuel region, and six fuel centerline thermocouples 0.322 m above the core bottom (total core length was 0.343 m). Temperatures and flow on the XX08 assembly were recorded during the 5-minute transient, after which the primary pumps were turned on to provide 100 percent of normal operating flow.

The COBRA-WC code was used to simulate the experiment during the natural circulation transient in order to include the interassembly heat transfer among the XX08 and surrounding assemblies. Significantly lower power-to-flow ratios in three adjacent assemblies made interassembly heat transfer a potentially important consideration. The steady-state thermal and hydraulic characteristics of the seven assemblies and other initial conditions are listed in Tables E.1 and E.2.

TABLE E.1. EBR-II Assembly Steady-State Pretest Power and Flow Characteristics

Subassembly	Assembly Model Number	Power (kW)	Flow (lb/hr)	P (psi)
XX08	1	110.1	5804	3.4
X263B	2	5.5	1536	3.3
X280A	3	105.4	7136	3.3
Mark-II,A	4	159.5	8059	3.4
Mark-II,B	5	168.6	8059	3.4
X321	6	53.4	2260	3.3
X316	7	109.2	4574	3.3

TABLE E.2. Operating Conditions Used in Simulation of EBR-II Natural Circulation Experiment^(a)

Inlet Temperature (^o F)	664.0
Pressure (psia)	20.0
Inlet mass flux (10^6 lbm/hr-ft ²) ^(a)	1.667
Power density (10^6 Btu/hr-ft ³) ^(b)	1.0
Turbulent mixing factor,	0.020
Radial Conduction Geometry factor, GK (XX08)	3.0
Radial Conduction Geometry factor, GK(adj.ass.)	2.0
Traverse Momentum Geometry factor, (S/L)	0.5

(a) Based on XX08.

(b) Actual power densities are provided for individual assemblies; this is a dummy number.

The XX08 assembly shown in Figure E.1 is a double-ducted, 61-pin assembly. It was modeled by 55 channels: 37 channels in the rod bundle and 18 channels in the flow annulus between ducts. The power generated by the 61-rods was modeled by 37 pins, one for each channel. The radial power used for each model pin represents an average of the radial power of each of the fuel rods falling within a model channel weighted by its fractional contribution. Figure E.2 shows the model channels with respect to the 61-pin rod bundle. The total power generated at any time (including time zero) will be the product of the steady-state nominal power, radial power factor (Figure E.1) axial power factor (Table E.3) and the transient power (Table E.4). The three transient power factors for each time are for different assemblies in the seven-assembly cluster model. The profile number used for each assembly is identified in the input. Table E.5 gives the flow multipliers for the transient. Other XX08 assembly characteristics are given in Table E.6.

The surrounding assemblies comprise two driver fuel assemblies (MK-II) and four experimental assemblies, one of which is structural (X263) and the other three fueled (X280A, X321, X316). The location of each adjacent assembly with respect to the XX08 assembly is shown in Figure E.3 with details of each individual assembly model given as Figures E.4 through E.8. The structural assembly (Figure E.4) was modeled with only six channels and pins because it had a relatively flat radial profile. The fuel experiments (Figures E.5 and E.8) and the driver fuel assembly (Figure E.6) were modeled by thirteen channels and pins. The X321 fuel experiment (Figure E.7) has half tubes on each duct face which have coolant flowing inside.

The XX08 test 7A natural circulation transient has been analyzed with the COBRA-WC code using the model described above. The printout includes the input listing, steady-state results, and transient results through ten seconds. The actual analysis covered 120 seconds but it is hoped this will be sufficient to meet the objectives of this sample problem.

TO CORE CENTER

FIGURE E.1. XX08 Assembly and Radial Power Profile

FIGURE E.2. COBRA-WC Model of XX08 Assembly
(Channels are numbered to minimize
bandwidth for direct solution scheme.)

TABLE E.3. Axial Power Distribution

<u>X (in.)</u>	<u>X/L</u>	<u>Axial Power Factor</u>
0	0	0.017
0.5	0.020	0.020
0.501	0.021	1.641
1	0.042	1.650
2	0.083	1.706
3	0.125	1.784
4	0.167	1.853
5	0.208	1.909
6	0.250	1.931
7	0.292	1.939
8	0.333	1.920
9	0.375	1.877
10	0.417	1.810
11	0.458	1.713
12	0.500	1.610
13	0.542	1.508
14	0.583	1.414
14.01	0.584	0.020
16	0.667	0.010
18	0.750	0.006
20	0.833	0.004
24.0	1.000	0.001

TABLE E.4. Transient Power Factors

<u>Time (sec)</u>	<u>1</u>	<u>2</u>	<u>3</u>
0.00	0.285	0.285	0.285
2.00	0.285	0.285	0.285
4.00	0.088	0.131	0.100
6.00	0.046	0.094	0.061
8.00	0.040	0.086	0.055
10.00	0.035	0.080	0.050
12.00	0.031	0.076	0.045
14.00	0.026	0.071	0.039
16.00	0.024	0.068	0.037
18.00	0.023	0.066	0.036
20.00	0.021	0.065	0.034
30.00	0.017	0.059	0.030
40.00	0.015	0.056	0.027
50.00	0.014	0.054	0.025
60.00	0.012	0.052	0.023
80.00	0.011	0.049	0.021
100.00	0.010	0.047	0.020
150.00	0.009	0.044	0.018
200.00	0.008	0.040	0.016
250.00	0.007	0.037	0.015
300.00	0.007	0.035	0.014

TABLE E.5. Transient Flow Factors

<u>Time (sec)</u>	<u>1</u>
0.00	0.321
1.00	0.320
2.50	0.295
5.00	0.220
7.50	0.180
10.00	0.158
12.50	0.132
15.00	0.118
17.50	0.100
20.00	0.090
22.50	0.079
25.00	0.065
27.50	0.055
30.00	0.045
32.50	0.040
35.00	0.035
37.50	0.027
40.00	0.025
45.00	0.027
50.00	0.030
60.00	0.032
70.00	0.032
90.00	0.028
125.00	0.028

TABLE E.6. XX08 Subassembly Characteristics

<u>Subassembly Parameters</u>	<u>Dimension</u>
Hex can, flat-to-flat I.D.	1.83 in.
Hex can wall	0.04 in.
Thimble gap (between hex walls)	0.15 in.
Element diameter, O.D.	0.174 in.
Wire wrap diameter	0.049 in.
Wire wrap pitch	6.0 in.
Sodium bond thickness	0.010 in.
Clad thickness	0.012 in.
Number of elements	61
Wire wrap zero reference angle (start of fuel, Z = 0.5 in.)	105°
<u>Steady State Pretest Conditions</u> ^(a)	<u>Value</u>
Total bundle flow, lb/hr	5.804 x 10 ³
Total thimble flow, lb/hr	0.6052 x 10 ³
Average element heat flux (over 24 in. of length) Btu/hr-ft ²	0.67615 x 10 ⁵
Inlet temperature, °F	664
Inner Hex can average heat flux (over 24 in. of length), Btu/hr-ft ^{2(b)}	1.69 x 10 ³
Total subassembly power, kW	110.1
Total S/A pressure drop (inlet and outlet orifices included), psi	3.7

(a) Auxiliary pump has been turned off.

(b) It was assumed that this heat flux was equally divided over both inner (bundle side) and outer (thimble side) hex can faces.

XX08 MULTIASSEMBLY MODEL

FIGURE E.3. Model of XX08 and Adjacent Assemblies

FIGURE E.4. X263 Structural Test Assembly and Model Noding

FIGURE E.5. X280B Experimental Fuel Assembly and Model Noding

FIGURE E.6. MK-II Driver Fuel Assembly and Model Noding

FIGURE E.7. X321 Fuel Assembly and Model Noding

FIGURE E.8. X316 Experimental Fuel Assembly and Model Noding

 THIS IS THE COBRA-WHOLE CORE CODE FOR MULTIASSEMBLY LMFRR ANALYSIS
 WRITTEN AT PACIFIC NORTHWEST LABORATORY DURING 1977-1980
 DOE CONTRACT AG102044 AND CRRRP CONTRACT D1813-407A1

CREATION DATE FOR THIS CYCLE = 2-1-80

COBRA DIMENSION PARAMETERS

MA# 1	MC# 140	ME# 20	MG# 330
MI# 7	MJ# 1	MX# 2	ML# 1
MM# 30	MN# 5	MO# 11	MP# 30
MR# 140	MS# 1	MT# 10	MY# 4
MW# 60	MY# 20	MY# 5	MZ# 1
NI# 0460	NJ# 12	NI# 9	IA# 140
JE# 30	IR# 3	IT# 6	IU# 7
JV# 8	IW# 6	IH# 9	IX# 20

***** THE FOLLOWING IS AN IMAGE LISTING OF THE CORRA-WC INPUT CARDS *****
GEOM GENERATED INPUT IS NOT INCLUDED

	1	2	3	4	5	6	7	8
1234567890123456789012345678901234567890123456789012345678901234567890								
2	1							
3	2	1	0	0	0	0	0	0
4	0.316-n.25	0	0	64.0	-1.0	0	0	0
5	3	2	22	0	0	0	0	0
6	0	.020	.021	.042	.083	.125	.167	.208
7	.417	.458	.500	.542	.583	.625	.667	.708
8	.017	.020	.240	.240	.706	.741	.831	.909
9	1.810	1.713	1.610	1.508	1.410	1.300	1.200	1.100
10	0.835	0.920	0.931	1.501	1.551	1.491	1.591	1.651
11	1.622	1.555	1.421	1.273	1.092	1.000	1.293	1.690
12	4	7	1	18	0	0	0	0
13		.245	1.322		4.78			
14	1	1	55	0	0	.224		
15	1	1	1	1	1			
16	2	3	4	5	5	7		
17	3	40	44	48				
18	3	52	54	50				
19	3	46	42	39				
20	3	43	47	51				
21	3	55	53	49				
22	3	45	41	38				
23	0	1.0223	1.6160	3.189	4.0494	3.983	2.0540	2.2801
24	0	2.0223	1.6160	3.189	4.0494	3.983	3.0540	2.2801
25	0	3.0382	1.9934	5.466	7.0988	1.680	6.0494	2.2801
26	0	4.0564	1.6401	1.640	9.0494	3.709	8.0494	3.709
27	0	5.0382	1.9934	5.466	10.0988	1.680	11.0540	2.2801
28	0	6.0223	1.6160	3.189	13.0494	3.983	12.0540	2.2801
29	0	7.0282	1.8199	1.8199	8.0494	4.281	13.0494	4.281
30	0	8.0564	1.6401	1.640	15.0494	3.709	9.0494	3.709
31	0	9.0564	1.6401	1.640	15.0494	3.709	16.0494	3.709
32	0	10.0282	1.8199	1.8199	17.0494	4.281	0	0
33	0	11.0223	1.6160	3.189	17.0494	3.983	18.0540	2.2801
34	0	12.0223	1.6160	3.189	13.0494	3.983	19.0540	2.2801
35	0	13.0564	1.6401	1.640	14.0494	3.709	20.0494	4.281
36	0	14.0564	1.6401	1.640	15.0494	3.709	22.0494	3.709
37	0	15.0564	1.6401	1.640	16.0494	3.709	23.0494	3.709
38	0	16.0564	1.6401	1.640	23.0494	3.709	17.0494	3.709
39	0	17.0564	1.6401	1.640	18.0494	3.983	25.0494	4.281
40	0	18.0223	1.6160	3.189	26.0540	2.2801	0	0
41	0	19.0382	1.9934	5.466	20.0988	1.680	27.0540	2.2801
42	0	20.0282	1.8199	1.8199	21.0494	4.281	0	0
43	0	21.0564	1.6401	1.640	22.0494	3.709	29.0494	3.983
44	0	22.0564	1.6401	1.640	23.0494	3.709	30.0494	4.281
45	0	23.0564	1.6401	1.640	24.0494	3.709	31.0494	3.709
46	0	24.0564	1.6401	1.640	25.0494	4.281	33.0494	3.983
47	0	25.0282	1.8199	1.8199	26.0988	1.680	0	0
48	0	26.0382	1.9934	5.466	33.0540	2.2801	0	0
49	0	27.0223	1.6160	3.189	28.0540	2.2801	0	0
50								

	0	1	2	3	4	5	6	7	8
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
52	0	30.05641.6401.640		31.0494.4281	36.0494.3983	32.0494.3983		0	
53	0	31.0292.8199.8199		37.0988.1680	0	0		0	
54	0	32.0223.6160.3189		33.0540.2065	37.0540.2801	0		0	
55	0	33.0223.6160.3189		0	0	0		0	
56	0	34.0382.9934.5466		35.0540.2401	0	0		0	
57	0	35.0223.6160.3189		36.0540.2065	0	0		0	
58	0	36.0223.6160.3189		37.0540.2401	0	0		0	
59	0	37.0382.9934.5466		0	0	0		0	
60		38.0521.6946							
61		39.0521.6946							
62		40.0521.6946							
63		41.0672.8960							
64		42.0672.8960							
65		43.0521.6946							
66		44.0672.8960							
67		45.0521.6946							
68		46.0521.6946							
69		47.0672.8960							
70		48.0521.6946							
71		49.0521.6946							
72		50.0521.6946							
73		51.0521.6946							
74		52.0521.6946							
75		53.0672.8960							
76		54.0672.8960							
77		55.0521.6946							
78		2	2	6	0	0	.778		
79		2	1	2	1	1			
80		0	0	3	1	7	0		
81		1	4						
82		1	3						
83		1	2						
84		1	1						
85		1	6						
86		1	5						
87		1.112	4.2262.9		2.005	.9	6.005	.9	
88		2.112	4.2262.9		3.005	.9			
89		3.112	4.2262.9		4.005	.9			
90		4.112	4.2262.9		5.005	.9			
91		5.112	4.2262.9		6.005	.9			
92		6.112	4.2262.9						
93		7	3	13					
94		1	1	1	1				
95		0	0	0	4	1	2		
96		1	8						
97		1	9						
98		1	10						
99		1	11						
100		1	12						
101		1	13						
102		1.30307.3802.922							
103		2.15153.6951.461		1.151	.610	3.151	.650		
104		3.15153.6951.461		1.151	.610	4.151	.650		
105		4.15153.6951.461		1.151	.610	5.151	.650		
	0	1	2	3	4	5	6	7	8
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890

	0	1	2	3	4	5	6	7	8
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
26A	1	7	.1741.017	7	10.5				
26B	1	8	.1741.044	82.667					
27A	1	9	.174 .978	92.667					
271	1	10	.174 .966	102.667					
272	1	11	.174 .954	112.667					
273	1	12	.1741.024	122.667					
274	1	13	.1741.034	132.667					
275		5	4	13	0	13			
276		1		1.0					
277		2		1.022					
278		3		.997					
279		4		.988					
280		5		.978					
281		6		1.004					
282		7		1.013					
283		8		1.044					
284		9		.994					
285		10		.975					
286		11		.956					
287		12		1.007					
288		13		1.026					
289		6	5	12					
290	4	1	.5061.020	1	1.0				
291	4	2	.506 .990	2	1.0				
292	4	3	.506 .990	3	1.0				
293	4	4	.506 .981	4	1.0				
294	4	5	.5061.001	5	1.0				
295	4	6	.5061.011	6	1.0				
296	4	7	.5061.040	71.167					
297	4	8	.506 .997	81.167					
298	4	9	.506 .979	91.167					
299	4	10	.506 .961	101.167					
300	4	11	.5061.002	111.167					
301	4	12	.5061.021	121.167					
302		7	6	13					
303	5	1	.2901.0	1	12.				
304	5	2	.2901.013	22.167					
305	5	3	.290 .998	32.167					
306	5	4	.290 .993	42.167					
307	5	5	.290 .989	52.167					
308	5	6	.2901.002	62.167					
309	5	7	.2901.008	72.167					
310	5	8	.2901.025	8	1.0				
311	5	9	.290 .995	9	1.0				
312	5	10	.290 .986	10	1.0				
313	5	11	.290 .977	11	1.0				
314	5	12	.2901.004	12	1.0				
315	5	13	.2901.015	13	1.0				
316		13.00.140481.00.174	13.00.140481.00.0129999.0.174						
317		12.90.0445972.00.130	13.00.140481.00.0129999.0.174						
318		13.00.140481.0.805	13.00.140481.00.0129999.8054						
319		13.00.140481.0.3100	13.00.140481.00.0129999.3100						
320		12.90.0445972.0.2600	13.00.140481.00.0209999.0.3100						
321		13.00.140481.0.506	13.00.140481.00.0129999.506						
	0	1	2	3	4	5	6	7	8
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890

INPUT FOR CASE 1 ERR=11 XX0A ASSEMBLY CORPA=MC SAMPLE CYCLEM

DATE 05/06/80 0 TIME 21.34.53. 2

SUMMARY OF INPUT OPTIONS

GROUP	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14	N15
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	2	22	0	0	0	0	0	0	0	0	0	0	0	0	0
4	7	1	18	0	0	0	0	0	0	0	0	0	0	0	0
5	7	2	9	0	5	0	0	0	0	0	0	0	0	0	0
6	0	-1	3	0	6	0	0	0	0	0	0	0	0	0	0
10	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
11	1	4	0	0	24	1	0	0	21	3	2	0	0	0	0
1211010	0	1	0	0	0	0	10	0	0	0	0	0	0	0	0

FRICTION FACTOR CORRELATIONS

TYPE 1 FMAX OF (.31A*RE**(-.250) + -.000*RE**(-0.000) + -.0000) OR (.44*000*RE**(-1.000) + -.0.000)

HEAT TRANSFER CORRELATIONS

TYPE 1 H = K/D(.025*RE**(.800)*PR**(.800) + 7.000)

HEAT FLUX DISTRIBUTION

X/L RELATIVE FLUX PROFILES

	1	2
0.000	.017	.835
.020	.020	.992
.021	1.240	.993
.042	1.240	1.150
.083	1.706	1.354
.125	1.784	1.499
.167	1.853	1.590
.208	1.909	1.653
.250	1.931	1.681
.292	1.939	1.698
.333	1.920	1.690
.375	1.877	1.673
.417	1.810	1.622
.458	1.713	1.555
.500	1.610	1.426
.542	1.508	1.273
.583	1.414	.992
.584	.020	.992
.667	.010	.909
.750	.006	.793
.833	.004	.189
1.000	.001	.068

AXIAL HEAT FLUX PROFILE NUMBER 1
HEAT FLUX VS. TIME PROFILE NUMBER 1

HEAT TRANSFER CORRELATION NUMBER 1
INLET FLOW VS. TIME PROFILE NUMBER 1

LOCAL	GLOBAL	FRICTN	AREA	WETTED
CH NO	CH NO	FACTOR	(SQ-IN)	PERIM.
		TYPE		(IN)

HEATE
PERIM
(IN)

HYDRAULIC
DIAMETER
(IN)

(ADJACENT CHANNEL NO.; SPACING, MDW. C. V. LENGTH)

1	1	1	.022300	.616000	.318900	.144905	(4, .049, .398)	(2, .054, .280)	(4, .054, .280)	(0, -.000, -.000)
2	2	1	.022300	.616000	.318900	.144905	(4, .049, .398)	(5, .054, .280)	(0, -.000, -.000)	
3	3	1	.038200	.993400	.546600	.153815	(7, .099, .168)	(6, .054, .280)	(0, -.000, -.000)	
4	4	1	.056400	1.640000	1.640000	.137561	(9, .049, .571)	(8, .049, .571)	(7, .049, .428)	
5	5	1	.038200	.993400	.546600	.153815	(10, .099, .168)	(11, .054, .280)	(0, -.000, -.000)	
6	6	1	.022300	.616000	.318900	.144905	(13, .049, .398)	(12, .054, .280)	(0, -.000, -.000)	
7	7	1	.022300	.616000	.318900	.137578	(8, .049, .428)	(13, .049, .571)	(0, -.000, -.000)	
8	8	1	.056400	1.640000	1.640000	.137561	(15, .049, .571)	(9, .049, .571)	(18, .049, .571)	
9	9	1	.056400	1.640000	1.640000	.137561	(15, .049, .571)	(16, .049, .571)	(17, .049, .571)	
10	10	1	.022300	.616000	.318900	.137578	(17, .049, .428)	(0, .000, .000)	(0, -.000, -.000)	
11	11	1	.022300	.616000	.318900	.144905	(17, .049, .398)	(18, .054, .280)	(0, -.000, -.000)	
12	12	1	.022300	.616000	.318900	.144905	(13, .049, .398)	(19, .054, .280)	(0, -.000, -.000)	
13	13	1	.056400	1.640000	1.640000	.137561	(14, .049, .571)	(20, .049, .571)	(0, -.000, -.000)	
14	14	1	.056400	1.640000	1.640000	.137561	(15, .049, .571)	(22, .049, .571)	(20, .049, .571)	
15	15	1	.056400	1.640000	1.640000	.137561	(16, .049, .571)	(23, .049, .571)	(0, -.000, -.000)	
16	16	1	.056400	1.640000	1.640000	.137561	(23, .049, .571)	(17, .049, .571)	(24, .049, .571)	
17	17	1	.056400	1.640000	1.640000	.137561	(18, .049, .398)	(25, .049, .571)	(0, -.000, -.000)	
18	18	1	.022300	.616000	.318900	.144905	(26, .054, .280)	(0, .000, .000)	(0, -.000, -.000)	
19	19	1	.038200	.993400	.546600	.153815	(20, .099, .168)	(27, .054, .280)	(0, -.000, -.000)	
20	20	1	.022300	.616000	.318900	.137578	(21, .049, .428)	(0, .000, .000)	(0, -.000, -.000)	
21	21	1	.056400	1.640000	1.640000	.137561	(22, .049, .571)	(29, .049, .571)	(27, .049, .571)	
22	22	1	.056400	1.640000	1.640000	.137561	(23, .049, .571)	(30, .049, .571)	(0, -.000, -.000)	
23	23	1	.056400	1.640000	1.640000	.137561	(24, .049, .571)	(31, .049, .571)	(0, -.000, -.000)	
24	24	1	.056400	1.640000	1.640000	.137561	(25, .049, .571)	(33, .049, .571)	(31, .049, .571)	
25	25	1	.022300	.616000	.318900	.153815	(26, .099, .168)	(0, .000, .000)	(0, -.000, -.000)	
26	26	1	.038200	.993400	.546600	.153815	(33, .054, .280)	(0, .000, .000)	(0, -.000, -.000)	
27	27	1	.022300	.616000	.318900	.144905	(34, .054, .280)	(0, .000, .000)	(0, -.000, -.000)	
28	28	1	.022300	.616000	.318900	.144905	(34, .054, .280)	(0, .000, .000)	(0, -.000, -.000)	
29	29	1	.022300	.616000	.318900	.137578	(30, .049, .428)	(34, .049, .571)	(0, -.000, -.000)	
30	30	1	.056400	1.640000	1.640000	.137561	(31, .049, .428)	(36, .049, .571)	(0, -.000, -.000)	
31	31	1	.022300	.616000	.318900	.137578	(37, .099, .168)	(0, .000, .000)	(0, -.000, -.000)	
32	32	1	.022300	.616000	.318900	.144905	(33, .054, .280)	(37, .054, .280)	(0, -.000, -.000)	
33	33	1	.022300	.616000	.318900	.144905	(0, -.000, -.000)	(0, .000, .000)	(0, -.000, -.000)	
34	34	1	.038200	.993400	.546600	.153815</				

INTRAASSEMBLY THERMAL CONNECTION DATA FOR ASSEMBLY NUMBER						
CONNECTION NO.	WALL AVERAGE HEAT CAPACITY (B/FT ² -F)	WIDTH OF CONNECTION (FT)	CHANNEL NO.	CONDUCTIVE CHANNEL RESISTANCE (FT ² -S-F/R)	CONDUCTIVE CHANNEL RESISTANCE (FT ² -S-F/R)	DETAILED HEAT PARAMETER (FT)

CONNECTION NO.	WALL AVERAGE HEAT CAPACITY (B/FT ² -F)	WIDTH OF CONNECTION (FT)	CHANNEL NO.	CONDUCTIVE CHANNEL RESISTANCE (FT ² -S-F/R)	CHANNEL NO.	CONDUCTIVE RESISTANCE (FT ² -S-F/R)	DETAILED HEAT PARAMETER (FT)
25	.224	.025	2	.4620	40	.4620	0.000000
26	.224	.037	5	.4620	44	.4620	0.000000
27	.224	.025	11	.4620	49	.4620	0.000000
28	.224	.025	18	.4620	52	.4620	0.000000
29	.224	.037	26	.4620	54	.4620	0.000000
30	.224	.025	33	.4620	50	.4620	0.000000
31	.224	.025	32	.4620	46	.4620	0.000000
32	.224	.037	37	.4620	42	.4620	0.000000
33	.224	.025	36	.4620	49	.4620	0.000000
34	.224	.025	35	.4620	43	.4620	0.000000
35	.224	.037	34	.4620	47	.4620	0.000000
36	.224	.025	28	.4620	51	.4620	0.000000
37	.224	.025	27	.4620	55	.4620	0.000000
38	.224	.037	19	.4620	53	.4620	0.000000
39	.224	.025	12	.4620	49	.4620	0.000000
40	.224	.025	6	.4620	55	.4620	0.000000
41	.224	.037	3	.4620	41	.4620	0.000000
42	.224	.025	1	.4620	48	.4620	0.000000

ROD INPUT DATA FOR ASSEMBLY NUMBER 1
LOCAL GLOBAL TYPE DIAM RADIAL POWER
ROD NO. ROD NO. NO. (IN) FACTOR

LOCAL ROD NO.	GLOBAL ROD NO.	TYPE NO.	DJAN (IN)	RADIAL POWER FACTOR	FRACTION OF POWER TO ADJACENT CHANNELS (ADJ. CHANNEL NO.)											
1	1	1	.1740	1.0000	.5833 (1)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
2	2	1	.1740	1.0900	.5833 (2)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
3	3	1	.1740	.8100	1.0000 (3)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
4	4	1	.1740	1.0000	3.0010 (4)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
5	5	1	.1740	1.0000	1.0000 (5)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
6	6	1	.1740	.0100	.5833 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
7	7	1	.1740	.9522	1.5000 (7)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
8	8	1	.1740	1.0580	3.0010 (8)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
9	9	1	.1740	1.0610	3.0010 (9)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
10	10	1	.1740	1.0780	1.5000 (10)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
11	11	1	.1740	1.0640	.5833 (11)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
12	12	1	.1740	.8515	.5833 (12)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
13	13	1	.1740	.8178	3.0010 (13)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
14	14	1	.1740	1.0400	3.0010 (14)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
15	15	1	.1740	1.0420	3.0010 (15)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
16	16	1	.1740	1.0410	3.0010 (16)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
17	17	1	.1740	1.0590	3.0010 (17)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
18	18	1	.1740	1.0560	.5833 (18)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
19	19	1	.1740	1.0300	1.0000 (19)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
20	20	1	.1740	1.0340	1.5000 (20)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
21	21	1	.1740	1.0210	3.0010 (21)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
22	22	1	.1740	1.0280	3.0010 (22)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
23	23	1	.1740	1.0280	3.0010 (23)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
24	24	1	.1740	1.0210	3.0010 (24)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
25	25	1	.1740	1.0390	1.5000 (25)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
26	26	1	.1740	1.0380	1.0000 (26)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
27	27	1	.1740	1.0140	.5833 (27)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
28	28	1	.1740	1.0100	.5833 (28)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
29	29	1	.1740	.8811	1.5000 (29)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
30	30	1	.1740	1.0130	3.0010 (30)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
31	31	1	.1740	1.0140	1.5000 (31)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
32	32	1	.1740	1.0160	.5833 (32)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
33	33	1	.1740	1.0200	.5833 (33)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
34	34	1	.1740	.5100	1.0000 (34)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
35	35	1	.1740	1.0100	.5833 (35)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
36	36	1	.1740	1.0100	.5833 (36)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	
37	37	1	.1740	1.0100	1.0000 (37)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)	

E.23

ASSEMBLY NUMBER 2 INPUT DESCRIPTION

AXIAL HEAT FLUX PROFILE NUMBER 2
HEAT FLUX VS. TIME PROFILE NUMBER 2

HEAT TRANSFER CORRELATION NUMBER 1
INLET FLOW VS. TIME PROFILE NUMBER 1

SURCHANNEL INPUT DATA FOR ASSEMBLY NUMBER 2

LOCAL CH NO	GLOBAL CH NO	FRICTN FACTOR	AREA (SQ-IN)	WETTED PERIM. (IN)	HEATED PERIM. (IN)	HYDRAULIC DIAMETER (IN)	(ADJACENT CHANNEL NO., SPACING, MOM. C. V. LENGTH)			
1	56	1	.112000	4.226000	2.900000	.106010	(2, .005, .900)	(6, .005, .900)	(0, -.000, -.000)	(0, -.000, -.000)
2	57	1	.112000	4.226000	2.900000	.106010	(3, .005, .900)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
3	58	1	.112000	4.226000	2.900000	.106010	(4, .005, .900)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
4	59	1	.112000	4.226000	2.900000	.106010	(5, .005, .900)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
5	60	1	.112000	4.226000	2.900000	.106010	(6, .005, .900)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
6	61	1	.112000	4.226000	2.900000	.106010	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)

ROD INPUT DATA FOR ASSEMBLY NUMBER 2

LOCAL ROD NO.	GLOBAL ROD NO.	TYPE NO.	DIAM (IN)	RADIAL POWER FACTOR	FRACTION OF POWER TO ADJACENT CHANNELS (ADJ. CHANNEL NO.)									
1	3A	2	.0050	.9230	1.1670	(1)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
2	3B	2	.0050	.9580	1.1670	(2)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
3	40	2	.0050	.9920	1.1670	(3)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
4	41	2	.0050	1.0680	1.1670	(4)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
5	42	2	.0050	1.0420	1.1670	(5)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
6	43	2	.0050	1.0170	1.1670	(6)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)

ASSEMBLY NUMBER 3 INPUT DESCRIPTION

AXIAL HEAT FLUX PROFILE NUMBER 1
HEAT FLUX VS. TIME PROFILE NUMBER 1

HEAT TRANSFER CORRELATION NUMBER 1
INLET FLOW VS. TIME PROFILE NUMBER 1

SURCHANNEL INPUT DATA FOR ASSEMBLY NUMBER 3

LOCAL CH NO	GLOBAL CH NO	FRICTN FACTOR	AREA (SQ-IN)	WETTED PERIM. (IN)	HEATED PERIM. (IN)	HYDRAULIC DIAMETER (IN)	(ADJACENT CHANNEL NO., SPACING, MOM. C. V. LENGTH)			
1	62	1	.151500	7.349000	2.922000	.164025	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
2	63	1	.151500	7.349000	1.461000	.164005	(1, .151, .610)	(3, .151, .610)	(0, -.000, -.000)	(0, -.000, -.000)
3	64	1	.151500	7.349000	1.461000	.164005	(1, .151, .610)	(4, .151, .610)	(0, -.000, -.000)	(0, -.000, -.000)
4	65	1	.151500	7.349000	1.461000	.164005	(1, .151, .610)	(5, .151, .610)	(0, -.000, -.000)	(0, -.000, -.000)
5	66	1	.151500	7.349000	1.461000	.164005	(1, .151, .610)	(6, .151, .610)	(0, -.000, -.000)	(0, -.000, -.000)
6	67	1	.151500	7.349000	1.461000	.164005	(1, .151, .610)	(7, .151, .610)	(0, -.000, -.000)	(0, -.000, -.000)
7	68	1	.151500	7.349000	1.461000	.164005	(1, .151, .610)	(2, .151, .610)	(0, -.000, -.000)	(0, -.000, -.000)
8	69	1	.117800	2.874000	1.623000	.163953	(2, .151, .380)	(9, .076, .990)	(0, -.000, -.000)	(0, -.000, -.000)
9	70	1	.117800	2.874000	1.623000	.163953	(3, .151, .380)	(10, .076, .990)	(0, -.000, -.000)	(0, -.000, -.000)
10	71	1	.117800	2.874000	1.623000	.163953	(4, .151, .380)	(11, .076, .990)	(0, -.000, -.000)	(0, -.000, -.000)
11	72	1	.117800	2.874000	1.623000	.163953	(5, .151, .380)	(12, .076, .990)	(0, -.000, -.000)	(0, -.000, -.000)
12	73	1	.117800	2.874000	1.623000	.163953	(6, .151, .380)	(13, .076, .990)	(0, -.000, -.000)	(0, -.000, -.000)
13	74	1	.117800	2.874000	1.623000	.163953	(7, .151, .380)	(8, .076, .990)	(0, -.000, -.000)	(0, -.000, -.000)

ROD INPUT DATA FOR ASSEMBLY NUMBER 3

LOCAL ROD NO.	GLOBAL ROD NO.	TYPE NO.	DIAM (IN)	RADIAL POWER FACTOR
1	44	3	.3100	1.0000
2	45	3	.3100	1.0170
3	46	3	.3100	.9910
4	47	3	.3100	.9880
5	48	3	.3100	.9860
6	49	3	.3100	1.0070
7	50	3	.3100	1.0120
8	51	3	.3100	1.0340
9	52	3	.3100	.9910
10	53	3	.3100	.9760
11	54	3	.3100	.9710
12	55	3	.3100	1.0140
13	56	3	.3100	1.0240

FRACTION OF POWER TO ADJACENT CHANNELS (ADJ. CHANNEL NO.)

3.0000 (1)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
1.5000 (2)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
1.5000 (3)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
1.5000 (4)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
1.5000 (5)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
1.5000 (6)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
1.5000 (7)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
1.1670 (8)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
1.1670 (9)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
1.1670 (10)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
1.1670 (11)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
1.1670 (12)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
1.1670 (13)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)

ASSEMBLY NUMBER 4 INPUT DESCRIPTION

AXIAL HEAT FLUX PROFILE NUMBER 1
HEAT FLUX VS. TIME PROFILE NUMBER 1

HEAT TRANSFER CORRELATION NUMBER 1
INLET FLOW VS. TIME PROFILE NUMBER 1

SUBCHANNEL INPUT DATA FOR ASSEMBLY NUMBER 4

LOCAL CH NO	GLOBAL CH NO	FRICTN TYPE	AREA (SQ-IN)	WETTED PERIM. (IN)
1	75	1	.211800	4.407000
2	76	1	.185300	7.356000
3	77	1	.185300	7.356000
4	78	1	.185300	7.356000
5	79	1	.185300	7.356000
6	80	1	.185300	7.356000
7	81	1	.185300	7.356000
8	82	1	.095100	3.144000
9	83	1	.095100	3.144000
10	84	1	.095100	3.144000
11	85	1	.095100	3.144000
12	86	1	.095100	3.144000
13	87	1	.095100	3.144000

HEATED
PERIM.
(IN)

HYDRAULIC
DIAMETER
(IN)

(ADJACENT CHANNEL NO., SPACING, NOM. C. V. LENGTH)

6.560000	.100773 (0)	0.0500, .7700 (3)	0.0500, .7700 (0)	0.0500, .7700 (0)	0.0500, .7700 (0)
5.740000	.100761 (1)	0.0500, .7700 (3)	0.0500, .7700 (0)	0.0500, .7700 (0)	0.0500, .7700 (0)
5.740000	.100761 (1)	0.0500, .7700 (3)	0.0500, .7700 (0)	0.0500, .7700 (0)	0.0500, .7700 (0)
5.740000	.100761 (1)	0.0500, .7700 (3)	0.0500, .7700 (0)	0.0500, .7700 (0)	0.0500, .7700 (0)
5.740000	.100761 (1)	0.0500, .7700 (3)	0.0500, .7700 (0)	0.0500, .7700 (0)	0.0500, .7700 (0)
5.740000	.100761 (1)	0.0500, .7700 (3)	0.0500, .7700 (0)	0.0500, .7700 (0)	0.0500, .7700 (0)
5.740000	.100761 (1)	0.0500, .7700 (3)	0.0500, .7700 (0)	0.0500, .7700 (0)	0.0500, .7700 (0)
1.458000	.120992 (2)	0.0500, .2900 (10)	0.0250, .1000 (0)	0.0500, .2900 (0)	0.0500, .2900 (0)
1.458000	.120992 (3)	0.0500, .2900 (10)	0.0250, .1000 (0)	0.0500, .2900 (0)	0.0500, .2900 (0)
1.458000	.120992 (4)	0.0500, .2900 (11)	0.0250, .1000 (0)	0.0500, .2900 (0)	0.0500, .2900 (0)
1.458000	.120992 (5)	0.0500, .2900 (12)	0.0250, .1000 (0)	0.0500, .2900 (0)	0.0500, .2900 (0)
1.458000	.120992 (6)	0.0500, .2900 (13)	0.0250, .1000 (0)	0.0500, .2900 (0)	0.0500, .2900 (0)
1.458000	.120992 (7)	0.0500, .2900 (8)	0.0250, .1000 (0)	0.0500, .2900 (0)	0.0500, .2900 (0)

ROD INPUT DATA FOR ASSEMBLY NUMBER 4

LOCAL ROD NO.	GLOBAL ROD NO.	TYPE NO.	DIAM (IN)	RADIAL POWER FACTOR
1	57	1	.1740	1.0000
2	58	1	.1740	1.0220
3	59	1	.1740	.9890
4	60	1	.1740	.9830
5	61	1	.1740	.9770
6	62	1	.1740	1.0120
7	63	1	.1740	1.0170
8	64	1	.1740	1.0440
9	65	1	.1740	.9780
10	66	1	.1740	.9660
11	67	1	.1740	.9530
12	68	1	.1740	1.0240
13	69	1	.1740	1.0340

FRACTION OF POWER TO ADJACENT CHANNELS (ADJ. CHANNEL NO.)

12.0000 (1)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
10.5000 (2)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
10.5000 (3)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
10.5000 (4)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
10.5000 (5)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
10.5000 (6)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
10.5000 (7)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
2.6670 (8)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
2.6670 (9)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
2.6670 (10)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
2.6670 (11)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
2.6670 (12)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)
2.6670 (13)	-0.0000 (0)	-0.0000 (6)	-0.0000 (0)	-0.0000 (0)	-0.0000 (0)

ASSEMBLY NUMBER 5 INPUT DESCRIPTION

AXIAL HEAT FLUX PROFILE NUMBER 1
HEAT FLUX VS. TIME PROFILE NUMBER 1

HEAT TRANSFER CORRELATION NUMBER 1
INLET FLOW VS. TIME PROFILE NUMBER 1

SUBCHANNEL INPUT DATA FOR ASSEMBLY NUMBER 5

LOCAL CH NO	GLOBAL CH NO	FRICTN FACTOR	AREA (SQ-IN)	WETTED PERIM. (IN)	HEATED PERIM. (IN)	HYDRAULIC DIAMETER (IN)	(ADJACENT CHANNEL NO., SPACING, MM, C. V. LENGTH)			
CH NO	CH NO	TYPE								
1	88	1	.211400	8.407000	8.560000	.106773	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
2	89	1	.185300	7.356000	5.740000	.106761	(1, .050, .770)	(3, .050, .770)	(0, -.000, -.000)	(0, -.000, -.000)
3	90	1	.185300	7.356000	5.740000	.106761	(1, .050, .770)	(4, .050, .770)	(0, -.000, -.000)	(0, -.000, -.000)
4	91	1	.185300	7.356000	5.740000	.106761	(1, .050, .770)	(5, .050, .770)	(0, -.000, -.000)	(0, -.000, -.000)
5	92	1	.185300	7.356000	5.740000	.106761	(1, .050, .770)	(6, .050, .770)	(0, -.000, -.000)	(0, -.000, -.000)
6	93	1	.185300	7.356000	5.740000	.106761	(1, .050, .770)	(7, .050, .770)	(0, -.000, -.000)	(0, -.000, -.000)
7	94	1	.185300	7.356000	5.740000	.106761	(1, .050, .770)	(8, .050, .770)	(0, -.000, -.000)	(0, -.000, -.000)
8	95	1	.095100	3.144000	1.458000	.120992	(2, .050, .290)	(9, .025, .100)	(0, -.000, -.000)	(0, -.000, -.000)
9	96	1	.095100	3.144000	1.458000	.120992	(3, .050, .290)	(10, .025, .100)	(0, -.000, -.000)	(0, -.000, -.000)
10	97	1	.095100	3.144000	1.458000	.120992	(4, .050, .290)	(11, .025, .100)	(0, -.000, -.000)	(0, -.000, -.000)
11	98	1	.095100	3.144000	1.458000	.120992	(5, .050, .290)	(12, .025, .100)	(0, -.000, -.000)	(0, -.000, -.000)
12	99	1	.095100	3.144000	1.458000	.120992	(6, .050, .290)	(13, .025, .100)	(0, -.000, -.000)	(0, -.000, -.000)
13	100	1	.095100	3.144000	1.458000	.120992	(7, .050, .290)	(8, .025, .100)	(0, -.000, -.000)	(0, -.000, -.000)

ROD INPUT DATA FOR ASSEMBLY NUMBER 5

LOCAL ROD NO.	GLOBAL ROD NO.	TYPE	DIAM (IN)	RADIAL POWER FACTOR	FRACTION OF POWER TO ADJACENT CHANNELS (ADJ. CHANNEL NO.)									
1	70	1	.1740	1.0000	12.0000	(1)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
2	71	1	.1740	1.0220	10.5000	(2)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
3	72	1	.1740	.9970	10.5000	(3)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
4	73	1	.1740	.9980	10.5000	(4)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
5	74	1	.1740	.9780	10.5000	(5)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
6	75	1	.1740	1.0040	10.5000	(6)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
7	76	1	.1740	1.0130	10.5000	(7)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
8	77	1	.1740	1.0440	2.6670	(8)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
9	78	1	.1740	.9930	2.6670	(9)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
10	79	1	.1740	.9750	2.6670	(10)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
11	80	1	.1740	.9560	2.6670	(11)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
12	81	1	.1740	1.0070	2.6670	(12)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)
13	82	1	.1740	1.0260	2.6670	(13)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)	-0.0000	(0)

ASSEMBLY NUMBER 6 INPUT DESCRIPTION

AXIAL HEAT FLUX PROFILE NUMBER 1
HEAT FLUX VS. TIME PROFILE NUMBER 1

HEAT TRANSFER CORRELATION NUMBER 1
INLET FLOW VS. TIME PROFILE NUMBER 1

SUBCHANNEL INPUT DATA FOR ASSEMBLY NUMBER 6

LOCAL CH NO	GLOBAL CH NO	FRICTN FACTOR	AREA (SQ-IN)	WETTED PERIM. (IN)	HEATED PERIM. (IN)	HYDRAULIC DIAMETER (IN)	(ADJACENT CHANNEL NO., SPACING, MM, C. V. LENGTH)			
CH NO	CH NO	TYPE								
1	101	1	.062900	1.693000	1.590000	.148612	(2, .047, .094)	(6, .047, .094)	(7, .047, .094)	(8, .047, .094)
2	102	1	.062900	1.693000	1.590000	.148612	(3, .047, .094)	(7, .047, .094)	(8, .047, .094)	(9, .047, .094)
3	103	1	.062900	1.693000	1.590000	.148612	(4, .047, .094)	(8, .047, .094)	(9, .047, .094)	(10, .047, .094)
4	104	1	.062900	1.693000	1.590000	.148612	(5, .047, .094)	(9, .047, .094)	(10, .047, .094)	(11, .047, .094)
5	105	1	.062900	1.693000	1.590000	.148612	(6, .047, .094)	(10, .047, .094)	(11, .047, .094)	(12, .047, .094)
6	106	1	.062900	1.693000	1.590000	.148612	(7, .047, .094)	(11, .047, .094)	(12, .047, .094)	(0, -.000, -.000)
7	107	1	.193000	4.794000	1.855000	.161035	(8, .047, .094)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
8	108	1	.193000	4.794000	1.855000	.161035	(9, .047, .094)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
9	109	1	.193000	4.794000	1.855000	.161035	(10, .047, .094)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
10	110	1	.193000	4.794000	1.855000	.161035	(11, .047, .094)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
11	111	1	.193000	4.794000	1.855000	.161035	(12, .047, .094)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
12	112	1	.193000	4.794000	1.855000	.161035	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)

ROD INPUT DATA FOR ASSEMBLY NUMBER 6

LOCAL ROD NO.	GLOBAL ROD NO.	TYPE NO.	DIAM (IN)	RADIAL POWER FACTOR
1	83	4	.5060	1.0200
2	84	4	.5060	.9990
3	85	4	.5060	.9900
4	86	4	.5060	.9810
5	87	4	.5060	1.0010
6	88	4	.5060	1.0110
7	89	4	.5060	1.0400
8	90	4	.5060	.9970
9	91	4	.5060	.9790
10	92	4	.5060	.9610
11	93	4	.5060	1.0020
12	94	4	.5060	1.0210

FRACTION OF POWER TO ADJACENT CHANNELS (ADJ. CHANNEL NO.)

LOCAL ROD NO.	GLOBAL ROD NO.	TYPE NO.	DIAM (IN)	RADIAL POWER FACTOR	ADJ. CHANNEL NO.	FRACTION OF POWER
1	83	4	.5060	1.0200	1	1.0000 (1) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
2	84	4	.5060	.9990	2	1.0000 (2) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
3	85	4	.5060	.9900	3	1.0000 (3) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
4	86	4	.5060	.9810	4	1.0000 (4) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
5	87	4	.5060	1.0010	5	1.0000 (5) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
6	88	4	.5060	1.0110	6	1.0000 (6) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
7	89	4	.5060	1.0400	7	1.1670 (7) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
8	90	4	.5060	.9970	8	1.1670 (8) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
9	91	4	.5060	.9790	9	1.1670 (9) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
10	92	4	.5060	.9610	10	1.1670 (10) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
11	93	4	.5060	1.0020	11	1.1670 (11) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
12	94	4	.5060	1.0210	12	1.1670 (12) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)

ASSEMBLY NUMBER 7 INPUT DESCRIPTION

AXIAL HEAT FLUX PROFILE NUMBER 1
HEAT FLUX VS. TIME PROFILE NUMBER 1

HEAT TRANSFER CORRELATION NUMBER 1
INLET FLOW VS. TIME PROFILE NUMBER 1

SUBCHANNEL INPUT DATA FOR ASSEMBLY NUMBER 7

LOCAL CH NO	GLOBAL CH NO	FRICTN TYPE	AREA (SQ-IN)	WETTED PERIM. (IN)
1	113	1	.432100	13.040000
2	114	1	.109400	2.937000
3	115	1	.109400	2.937000
4	116	1	.109400	2.937000
5	117	1	.109400	2.937000
6	118	1	.109400	2.937000
7	119	1	.109400	2.937000
8	120	1	.159300	3.530000
9	121	1	.159300	3.530000
10	122	1	.159300	3.530000
11	123	1	.159300	3.530000
12	124	1	.159300	3.530000
13	125	1	.159300	3.530000

HEATED PERIM. (IN) HYDRAULIC DIAMETER (IN) (ADJACENT CHANNEL NO.; SPACING, NOM. C. V. LENGTH)

LOCAL CH NO	GLOBAL CH NO	FRICTN TYPE	AREA (SQ-IN)	WETTED PERIM. (IN)	HEATED PERIM. (IN)	HYDRAULIC DIAMETER (IN)	ADJACENT CHANNEL NO.	SPACING	NOM. C. V.	LENGTH
1	113	1	.432100	13.040000	10.930000	.132546	0	-.0000	-.0000	0
2	114	1	.109400	2.937000	1.974000	.148996	1	.057	.790	3
3	115	1	.109400	2.937000	1.974000	.148996	1	.057	.790	4
4	116	1	.109400	2.937000	1.974000	.148996	1	.057	.790	5
5	117	1	.109400	2.937000	1.974000	.148996	1	.057	.790	6
6	118	1	.109400	2.937000	1.974000	.148996	1	.057	.790	7
7	119	1	.109400	2.937000	1.974000	.148996	1	.057	.790	8
8	120	1	.159300	3.530000	.911000	.180510	2	.057	.260	9
9	121	1	.159300	3.530000	.911000	.180510	3	.057	.260	10
10	122	1	.159300	3.530000	.911000	.180510	4	.057	.260	11
11	123	1	.159300	3.530000	.911000	.180510	5	.057	.260	12
12	124	1	.159300	3.530000	.911000	.180510	6	.057	.260	13
13	125	1	.159300	3.530000	.911000	.180510	7	.057	.260	8

ROD INPUT DATA FOR ASSEMBLY NUMBER 7

LOCAL ROD NO.	GLOBAL ROD NO.	TYPE NO.	DIAM (IN)	RADIAL POWER FACTOR
1	95	5	.2900	1.0000
2	96	5	.2900	1.0130
3	97	5	.2900	.9980
4	98	5	.2900	.9930
5	99	5	.2900	.9890
6	100	5	.2900	1.0020
7	101	5	.2900	1.0080
8	102	5	.2900	1.0250
9	103	5	.2900	.9850
10	104	5	.2900	.9860
11	105	5	.2900	.9770
12	106	5	.2900	1.0040
13	107	5	.2900	1.0150

FRACTION OF POWER TO ADJACENT CHANNELS (ADJ. CHANNEL NO.)

LOCAL ROD NO.	GLOBAL ROD NO.	TYPE NO.	DIAM (IN)	RADIAL POWER FACTOR	ADJ. CHANNEL NO.	FRACTION OF POWER
1	95	5	.2900	1.0000	12	12.0000 (1) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
2	96	5	.2900	1.0130	2	2.1670 (2) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
3	97	5	.2900	.9980	3	2.1670 (3) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
4	98	5	.2900	.9930	4	2.1670 (4) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
5	99	5	.2900	.9890	5	2.1670 (5) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
6	100	5	.2900	1.0020	6	2.1670 (6) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
7	101	5	.2900	1.0080	7	2.1670 (7) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
8	102	5	.2900	1.0250	8	1.0000 (8) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
9	103	5	.2900	.9850	9	1.0000 (9) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
10	104	5	.2900	.9860	10	1.0000 (10) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
11	105	5	.2900	.9770	11	1.0000 (11) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
12	106	5	.2900	1.0040	12	1.0000 (12) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)
13	107	5	.2900	1.0150	13	1.0000 (13) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0) -0.0000 (0)

THERMAL PROPERTIES OF FUEL MATERIAL

2 ORDER OF COLLOCATION

TYPE NO.	COND. (B/HR-FT-F)	FUEL PROPERTIES		DIA. (IN.)	COND. (B/HR-FT-F)	CLAD PROPERTIES		THICK. (IN.)	CAP COND. (B/HR-FT2-F)	COL	GEOM	SYM	JDTYP
		SP. HEAT (B/LB-F)	DENSITY (LB/FT3)			SP. HEAT (B/LB-F)	DENSITY (LB/FT3)						
1	13.00	.1400	441.0	.1740	13.00	.1400	441.0	.0120	9999.00	1	1	1	1
2	12.90	.0445	972.0	.1700	13.00	.1400	441.0	.0120	9999.00	2	1	1	2
3	13.00	.1400	441.0	.4050	13.00	.1400	441.0	.0120	9999.00	3	1	1	3
4	13.00	.1400	441.0	.3100	13.00	.1400	441.0	.0120	9999.00	4	1	1	4
5	12.90	.0445	972.0	.2600	13.00	.1400	441.0	.0200	9999.00	5	1	1	5
6	13.00	.1400	441.0	.5060	13.00	.1400	441.0	.0120	9999.00	6	1	1	6
7	12.90	.0445	972.0	.4730	13.00	.1400	441.0	.0150	9999.00	7	1	1	7
8	13.00	.1400	441.0	.2900	13.00	.1400	441.0	.0120	9999.00	8	1	1	8
9	12.90	.0445	972.0	.2600	13.00	.1400	441.0	.0120	9999.00	9	1	1	9

AXIAL FUEL TYPE LAYOUT

ROD NO.	FUEL ZONE DESCRIPTION
TYPE ZONES	FUEL TYPE - (X/L RANGE)
1	1 = (0.00 - .02) 2 = (.02 - .60) 1 = (.60 - 1.00)
2	1 = (0.00 - 1.00)
3	4 = (0.00 - .02) 5 = (.02 - .60) 4 = (.60 - 1.00)
4	6 = (0.00 - .02) 7 = (.02 - .60) 6 = (.60 - 1.00)
5	8 = (0.00 - .02) 9 = (.02 - .60) 8 = (.60 - 1.00)

INTERASSEMBLY THERMAL CONNECTION DATA

CONNECTION NO.	WALL AVERAGE HEAT CAPACITY (B/FT2-F)	WIDTH OF CONNECTION (FT)	ASSEMBLY NO.	CHANNEL NO.	CONDUCTIVE RESISTANCE (FT2-S-F/B)	ASSEMBLY NO.	CHANNEL NO.	CONDUCTIVE RESISTANCE (FT2-S-F/B)	DECAY HEAT PARAMETER (FT)
1	1.002	.037	1	48	4.7800	2	1	4.7800	0.000000
2	.444	.037	1	44	4.7800	2	1	4.7800	0.000000
3	1.002	.037	1	40	4.7800	2	1	4.7800	0.000000
4	.469	.037	1	50	4.7800	3	12	4.7800	0.000000
5	.444	.037	1	54	4.7800	3	12	4.7800	0.000000
6	1.002	.037	1	52	4.7800	3	12	4.7800	0.000000
7	.444	.037	1	39	4.7800	4	13	4.7800	0.000000
8	.444	.037	1	42	4.7800	4	13	4.7800	0.000000
9	1.002	.037	1	46	4.7800	4	13	4.7800	0.000000
10	.444	.037	1	51	4.7800	5	8	4.7800	0.000000
11	.444	.037	1	47	4.7800	5	8	4.7800	0.000000
12	1.002	.037	1	43	4.7800	5	8	4.7800	0.000000
13	.570	.037	1	49	4.7800	6	8	4.7800	0.000000
14	.444	.037	1	53	4.7800	6	8	4.7800	0.000000
15	1.002	.037	1	55	4.7800	6	8	4.7800	0.000000
16	.469	.037	1	38	4.7800	7	10	4.7800	0.000000
17	.444	.037	1	41	4.7800	7	10	4.7800	0.000000
18	1.002	.037	1	45	4.7800	7	10	4.7800	0.000000
19	1.023	.110	2	2	4.7800	3	13	4.7800	0.000000
20	1.023	.110	2	6	4.7800	7	9	4.7800	0.000000
21	.469	.110	3	11	4.7800	4	8	4.7800	0.000000
22	.444	.110	4	12	4.7800	5	9	4.7800	0.000000
23	.570	.110	5	13	4.7800	6	9	4.7800	0.000000
24	.591	.110	5	7	4.7800	7	11	4.7800	0.000000

CALCULATION PARAMETERS
 LATERAL RESISTANCE FACTOR .5000
 S/L PARAMETER .5000
 TURBULENT MOMENTUM FACTOR -0.0000
 CHANNEL ORIENTATION (DEGREES) -0.0000
 CHANNEL LENGTH (INCHES) 24.0000
 NUMBER OF AXIAL NODES 12
 TOTAL TRANSIENT TIME (SECONDS) 4.0000
 NUMBER OF TIME STEPS 125
 NOMINAL TIME STEP (SECONDS) .0320
 ROLL OPTION (0 = NO ROLL) 0

DATA FOR IMPLICIT SOLUTION
 EXTERNAL ITERATION LIMIT 20
 INTERNAL ITERATION LIMIT 20
 CONVERGENCE FACTORS
 EXTERNAL (DW/W) .10000
 INTERNAL (DP/P) .00001
 FLOW (DP/F) .00100
 ENERGY (DH/H) .00100
 ACCELERATION FACTORS
 CROSS FLOW SOLUTION .90000
 LATERAL DELTA=P .80000
 FLOW .70000

AXIAL NODING

NODE NO.	INTEGRAL HEIGHT (IN.)	NODAL LENGTH (IN.)	NODE NO.	INTEGRAL HEIGHT (IN.)	NODAL LENGTH (IN.)	NODE NO.	INTEGRAL HEIGHT (IN.)	NODAL LENGTH (IN.)
1	0.0- 2.0	2.000	2	2.0- 4.0	2.000	3	4.0- 6.0	2.000
4	6.0- 8.0	2.000	5	8.0- 10.0	2.000	6	10.0- 12.0	2.000
7	12.0- 14.0	2.000	8	14.0- 16.0	2.000	9	16.0- 18.0	2.000
10	18.0- 20.0	2.000	11	20.0- 22.0	2.000	12	22.0- 24.0	2.000

TIME STEP VARIATION TABLE
 TIME STEP SIZE
 (SEC) (SEC)
 0.00000 .10000
 10.99000 .10000
 15.00000 .50000
 24.99000 .50000
 25.00000 2.00000
 120.00000 2.00000

MIXING PARAMETERS
 ASSEMBLY MIXING MIXING COEFFICIENTS
 TYPE NO. CORRELATION ABETA BBETA
 1 1 .020 -0.000
 2 1 .020 -0.000
 3 1 .020 -0.000
 4 1 .020 -0.000
 5 1 .020 -0.000
 6 1 .020 -0.000

FORCED MIXING CONDUCTION MIXING
 MODEL DIRECTION PARAMETER GEOMETRY FACTOR
 NONE 0.000 200
 NONE 0.000 200
 NONE 0.000 200
 NONE 0.000 200
 NONE 0.000 200
 NONE 0.000 200

OPERATING CONDITIONS

SYSTEM PRESSURE ■ 20.0 PSIA
 INLET ENTHALPY ■ 354.8 BTU/LRM
 INLET TEMPERATURE ■ 664.000 DEGREES F
 NOMINAL MASS FLUX ■ 1.667 MILLION LRM/FT²-HR
 NOMINAL POWER DENSITY ■ 1.0000 MILLION BTU/HR-FT²
 UNIFORM INLET TEMPERATURE

ASSEMBLY MASS FLUX FRACTIONS (ASSEMBLY = FLUX FRACTION)

(1 = 1.000E+00) (2 = 6.152E-01) (3 = 1.001E+00) (4 = 1.145E+00) (5 = 1.145E+00) (6 = 3.963E-01)
 (7 = 6.025E-01)

INDIVIDUAL SUBCHANNEL FLOWS SPECIFIED (CHANNEL=FLOW)

(1 = 7.170E-02) (2 = 7.170E-02) (3 = 1.224E-01) (4 = 1.813E-01) (5 = 1.224E-01) (6 = 7.170E-02)
 (7 = 9.067E-02) (8 = 1.813E-01) (9 = 1.813E-01) (10 = 9.067E-02) (11 = 7.170E-02) (12 = 7.170E-02)
 (13 = 1.813E-01) (14 = 1.813E-01) (15 = 1.813E-01) (16 = 1.813E-01) (17 = 1.813E-01) (18 = 7.170E-02)
 (19 = 1.224E-01) (20 = 9.067E-02) (21 = 1.813E-01) (22 = 1.813E-01) (23 = 1.813E-01) (24 = 1.813E-01)
 (25 = 9.067E-02) (26 = 1.224E-01) (27 = 7.170E-02) (28 = 7.170E-02) (29 = 9.067E-02) (30 = 1.813E-01)
 (31 = 9.067E-02) (32 = 7.170E-02) (33 = 7.170E-02) (34 = 1.224E-01) (35 = 7.170E-02) (36 = 7.170E-02)
 (37 = 1.224E-01) (38 = 2.647E-02) (39 = 2.647E-02) (40 = 2.647E-02) (41 = 3.414E-02) (42 = 3.414E-02)
 (43 = 2.647E-02) (44 = 3.414E-02) (45 = 2.647E-02) (46 = 2.647E-02) (47 = 3.414E-02) (48 = 2.647E-02)
 (49 = 2.647E-02) (50 = 2.647E-02) (51 = 2.647E-02) (52 = 2.647E-02) (53 = 3.414E-02) (54 = 3.414E-02)
 (55 = 2.647E-02) (56 = 2.215E-01) (57 = 2.215E-01) (58 = 2.215E-01) (59 = 2.215E-01) (60 = 2.215E-01)
 (61 = 2.215E-01) (62 = 9.752E-01) (63 = 4.876E-01) (64 = 4.876E-01) (65 = 4.876E-01) (66 = 4.876E-01)
 (67 = 4.876E-01) (68 = 4.876E-01) (69 = 3.791E-01) (70 = 3.791E-01) (71 = 3.791E-01) (72 = 3.791E-01)
 (73 = 3.791E-01) (74 = 3.791E-01) (75 = 7.797E-01) (76 = 6.822E-01) (77 = 6.822E-01) (78 = 6.822E-01)
 (79 = 6.822E-01) (80 = 6.822E-01) (81 = 6.822E-01) (82 = 3.501E-01) (83 = 3.501E-01) (84 = 3.501E-01)
 (85 = 3.501E-01) (86 = 3.501E-01) (87 = 3.501E-01) (88 = 7.797E-01) (89 = 6.822E-01) (90 = 6.822E-01)
 (91 = 6.822E-01) (92 = 6.822E-01) (93 = 6.822E-01) (94 = 6.822E-01) (95 = 3.501E-01) (96 = 3.501E-01)
 (97 = 3.501E-01) (98 = 3.501E-01) (99 = 3.501E-01) (100 = 3.501E-01) (101 = 8.015E-02) (102 = 8.015E-02)
 (103 = 8.015E-02) (104 = 8.015E-02) (105 = 8.015E-02) (106 = 8.015E-02) (107 = 2.459E-01) (108 = 2.459E-01)
 (109 = 2.459E-01) (110 = 2.459E-01) (111 = 2.459E-01) (112 = 2.459E-01) (113 = 2.459E-01) (114 = 2.119E-01)
 (115 = 2.119E-01) (116 = 2.119E-01) (117 = 2.119E-01) (118 = 2.119E-01) (119 = 2.119E-01) (120 = 3.086E-01)
 (121 = 3.086E-01) (122 = 3.086E-01) (123 = 3.086E-01) (124 = 3.086E-01) (125 = 3.086E-01)

ASSEMBLY POWER DENSITIES (ASSEMBLY = POWER DENSITY)

(1 , 1.173E+02) (2 , 1.332E+00) (3 , 9.014E+01) (4 , 1.139E+02)
 (5 , 1.204E+02) (6 , 2.017E+01) (7 , 5.724E+01)

FORCING FUNCTIONS FOR INLET FLOW
 TIME RELATIVE INLET FLOW MULTIPLIERS
 (SEC)

	1
0.00	.321
1.00	.320
2.50	.295
5.00	.220
7.50	.180
10.00	.154
12.50	.132
15.00	.114
17.50	.100
20.00	.090
22.50	.079
25.00	.065
27.50	.055
30.00	.045
32.50	.040
35.00	.035
37.50	.027
40.00	.025
45.00	.027
50.00	.030
60.00	.032
70.00	.032
90.00	.028
125.00	.028

FORCING FUNCTIONS FOR HEAT FLUX
 TIME RELATIVE HEAT FLUX MULTIPLIERS
 (SEC)

	1	2	3
0.00	.285	.285	.285
2.00	.285	.285	.285
4.00	.088	.131	.100
6.00	.046	.094	.061
8.00	.040	.086	.055
10.00	.035	.080	.050
12.00	.031	.076	.045
14.00	.026	.071	.039
16.00	.024	.068	.037
18.00	.023	.066	.036
20.00	.021	.065	.034
30.00	.017	.059	.030
40.00	.015	.056	.027
50.00	.014	.054	.025
60.00	.012	.052	.023
80.00	.011	.049	.021
100.00	.010	.047	.020
150.00	.009	.044	.014
200.00	.008	.040	.016
250.00	.007	.037	.015
300.00	.007	.035	.014

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 0.0000 DT = ***** IMPLICIT DT = 0.0000 EXPLICIT DT = .0030 MODF = 0

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	40	*****	.0648	113	10
2	30	5.7978	.0078	108	6
3	34	4.2666	.0040	95	13
4	33	1.2848	.0022	45	2
5	29	.2365	.0014	45	2
6	27	.0636	.0011	45	2
7	24	.0185	.0008	45	2
8	23	.0057	.0006	41	13
9	20	.0040	.0004	105	13
10	18	.0026	.0003	105	13
11	17	.0016	.0002	105	13
12	14	.0011	.0001	5	12
13	14	.0009	.0001	5	13

CORRA WHOLE CORE CODE RESULTS
 CASE 1 FOR-TT XCOR ASSEMBLY CORRA=WC SAMPLE PROBLEM

DATE 04/09/80 0 TIME 21.36.04.2

E.32

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS PRESSURE = 20.0 Psia
 CHANNEL 3
 ASSEMBLY 1

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIV. QUALITY	VOLID FRACTION	FLOW (LB/SEC)	MASS FLOW (M/R/HR-FT2)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.9781	354.80	668.00	54.18	0.000	0.000	.0394	5350	2.7432	.03820
2.0	.8947	358.41	675.71	54.08	0.000	0.000	.0401	5441	2.7940	.03820
4.0	.8117	363.69	692.89	53.94	0.000	0.000	.0409	5501	2.8328	.03820
6.0	.7291	369.55	711.99	53.78	0.000	0.000	.0408	5534	2.8590	.03820
8.0	.6469	375.77	732.29	53.61	0.000	0.000	.0409	5552	2.8767	.03820
10.0	.5651	382.10	753.01	53.44	0.000	0.000	.0409	5557	2.8882	.03820
12.0	.4839	388.25	773.17	53.27	0.000	0.000	.0409	5551	2.8944	.03820
14.0	.4032	394.06	792.29	53.12	0.000	0.000	.0408	5538	2.8962	.03820
16.0	.3226	399.91	798.33	53.07	0.000	0.000	.0407	5520	2.8944	.03820
18.0	.2419	407.46	808.07	53.02	0.000	0.000	.0407	5526	2.8952	.03820
20.0	.1613	409.23	809.24	52.98	0.000	0.000	.0407	5524	2.8974	.03820
22.0	.0807	400.66	813.94	52.94	0.000	0.000	.0407	5528	2.9000	.03820
24.0	0.0000	401.93	818.14	52.90	0.000	0.000	.0408	5534	2.9058	.03820

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS

PRESSURE = 20.0 PSIA

CHANNEL 15
ASSEMBLY 1

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (M/R/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.9781	354.80	664.00	54.18	0.000	0.000	.0542	5350	2.7432	.05640
2.0	.8947	364.29	694.85	53.92	0.000	0.000	.0579	5320	2.7403	.05640
4.0	.8117	377.99	739.54	53.55	0.000	0.000	.0577	5300	2.7489	.05640
6.0	.7291	392.64	787.58	53.16	0.000	0.000	.0576	5291	2.7449	.05640
8.0	.6469	407.46	836.34	52.75	0.000	0.000	.0576	5290	2.7859	.05640
10.0	.5651	421.67	883.23	52.36	0.000	0.000	.0576	5294	2.8096	.05640
12.0	.4839	434.46	925.64	52.01	0.000	0.000	.0577	5307	2.8345	.05640
14.0	.4032	445.51	962.23	51.70	0.000	0.000	.0579	5322	2.8595	.05640
16.0	.3225	444.97	980.51	51.72	0.000	0.000	.0580	5336	2.8657	.05640
18.0	.2419	444.23	958.05	51.74	0.000	0.000	.0582	5345	2.8696	.05640
20.0	.1613	443.37	955.19	51.76	0.000	0.000	.0582	5351	2.8717	.05640
22.0	.0807	442.42	952.05	51.79	0.000	0.000	.0583	5355	2.8721	.05640
24.0	0.0000	441.41	948.70	51.82	0.000	0.000	.0583	5355	2.8709	.05640

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS

PRESSURE = 20.0 PSIA

CHANNEL 41
ASSEMBLY 1

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (M/R/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.7458	354.80	664.00	54.18	0.000	0.000	.0110	0845	.4330	.06720
2.0	.6828	356.99	671.10	54.12	0.000	0.000	.0110	0845	.4339	.06720
4.0	.6200	361.05	684.29	54.01	0.000	0.000	.0110	0845	.4348	.06720
6.0	.5573	366.18	700.99	53.87	0.000	0.000	.0110	0845	.4359	.06720
8.0	.4948	371.93	719.73	53.72	0.000	0.000	.0110	0845	.4371	.06720
10.0	.4325	377.99	739.54	53.55	0.000	0.000	.0110	0845	.4385	.06720
12.0	.3704	384.05	759.47	53.39	0.000	0.000	.0110	0845	.4398	.06720
14.0	.3085	389.91	778.61	53.23	0.000	0.000	.0110	0845	.4411	.06720
16.0	.2467	393.27	789.66	53.14	0.000	0.000	.0110	0845	.4419	.06720
18.0	.1849	395.61	797.33	53.08	0.000	0.000	.0110	0845	.4428	.06720
20.0	.1232	397.45	803.39	53.03	0.000	0.000	.0110	0845	.4429	.06720
22.0	.0616	399.02	808.53	52.98	0.000	0.000	.0110	0845	.4432	.06720
24.0	0.0000	400.40	813.10	52.94	0.000	0.000	.0110	0845	.4435	.06720

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS

PRESSURE = 20.0 PSIA

CHANNEL 1
ASSEMBLY 2

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (M/R/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.9008	354.80	664.00	54.18	0.000	0.000	.0711	3292	1.6876	.11200
2.0	.8256	355.10	664.97	54.17	0.000	0.000	.0711	3292	1.6880	.11200
4.0	.7503	355.74	667.05	54.15	0.000	0.000	.0711	3292	1.6887	.11200
6.0	.6751	356.76	670.36	54.13	0.000	0.000	.0711	3293	1.6890	.11200
8.0	.5999	358.17	674.92	54.09	0.000	0.000	.0712	3294	1.6917	.11200
10.0	.5248	359.93	680.65	54.04	0.000	0.000	.0712	3296	1.6940	.11200
12.0	.4497	362.01	687.43	53.98	0.000	0.000	.0713	3298	1.6970	.11200
14.0	.3746	364.34	695.02	53.92	0.000	0.000	.0713	3301	1.7006	.11200
16.0	.2996	366.67	702.59	53.86	0.000	0.000	.0714	3305	1.7047	.11200
18.0	.2247	368.91	709.91	53.80	0.000	0.000	.0715	3310	1.7092	.11200
20.0	.1497	371.07	716.94	53.74	0.000	0.000	.0716	3316	1.7141	.11200
22.0	.0748	373.13	723.66	53.69	0.000	0.000	.0718	3323	1.7191	.11200
24.0	0.0000	375.09	730.07	53.63	0.000	0.000	.0719	3329	1.7243	.11200

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 12
ASSEMBLY 3

PRESSURE = 20.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (LB/HR-FT2)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.0426	354.80	664.00	54.18	0.000	0.000	.1217	.5354	2.7460	.11780
2.0	.0627	359.97	660.79	54.04	0.000	0.000	.1217	.5354	2.7530	.11780
4.0	.0730	367.34	704.79	53.84	0.000	0.000	.1217	.5354	2.7630	.11780
6.0	.0737	375.17	730.35	53.63	0.000	0.000	.1217	.5354	2.7730	.11780
8.0	.0246	383.09	756.24	53.42	0.000	0.000	.1217	.5354	2.7847	.11780
10.0	.0459	390.73	781.31	53.21	0.000	0.000	.1217	.5354	2.7953	.11780
12.0	.0675	397.68	804.13	53.02	0.000	0.000	.1217	.5354	2.8050	.11780
14.0	.0895	403.79	824.23	52.85	0.000	0.000	.1214	.5353	2.8134	.11780
16.0	.1115	403.73	824.04	52.85	0.000	0.000	.1214	.5353	2.8129	.11780
18.0	.1337	403.72	824.02	52.85	0.000	0.000	.1214	.5353	2.8124	.11780
20.0	.1558	403.75	824.14	52.85	0.000	0.000	.1214	.5351	2.8124	.11780
22.0	.0779	403.42	824.36	52.85	0.000	0.000	.1214	.5351	2.8124	.11780
24.0	0.0000	403.41	824.65	52.85	0.000	0.000	.1214	.5351	2.8124	.11780

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 13
ASSEMBLY 4

PRESSURE = 20.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (LB/HR-FT2)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	1.1735	354.80	664.00	54.18	0.000	0.000	.1124	.5126	3.1410	.09510
2.0	1.0738	359.14	678.04	54.06	0.000	0.000	.1137	.5304	3.2410	.09510
4.0	.9741	365.29	698.11	53.90	0.000	0.000	.1141	.5435	3.3168	.09510
6.0	.8749	371.85	719.50	53.72	0.000	0.000	.1195	.5515	3.3686	.09510
8.0	.7762	378.54	741.35	53.54	0.000	0.000	.1204	.5541	3.4041	.09510
10.0	.6780	385.09	762.80	53.36	0.000	0.000	.1204	.5544	3.4245	.09510
12.0	.5804	391.20	782.84	53.20	0.000	0.000	.1210	.5594	3.4445	.09510
14.0	.4836	396.75	801.10	53.04	0.000	0.000	.1210	.5595	3.4534	.09510
16.0	.3868	397.74	804.33	53.02	0.000	0.000	.1210	.5593	3.4544	.09510
18.0	.2901	398.71	807.55	52.99	0.000	0.000	.1209	.5593	3.4560	.09510
20.0	.1934	399.49	810.74	52.96	0.000	0.000	.1209	.5593	3.4572	.09510
22.0	.0967	400.64	813.82	52.94	0.000	0.000	.1210	.5594	3.4600	.09510
24.0	0.0000	401.58	816.97	52.91	0.000	0.000	.1210	.5594	3.4629	.09510

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 8
ASSEMBLY 5

PRESSURE = 20.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (LB/HR-FT2)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	1.1724	354.80	664.00	54.18	0.000	0.000	.1124	.5126	3.1410	.09510
2.0	1.0727	359.40	678.93	54.05	0.000	0.000	.1157	.5304	3.2414	.09510
4.0	.9730	365.89	700.04	53.88	0.000	0.000	.1181	.5436	3.3179	.09510
6.0	.8737	372.77	722.49	53.69	0.000	0.000	.1195	.5515	3.3701	.09510
8.0	.7751	379.73	745.25	53.51	0.000	0.000	.1204	.5561	3.4059	.09510
10.0	.6770	386.51	767.44	53.32	0.000	0.000	.1204	.5585	3.4304	.09510
12.0	.5796	392.78	788.05	53.15	0.000	0.000	.1210	.5590	3.4462	.09510
14.0	.4828	398.45	806.67	53.00	0.000	0.000	.1209	.5592	3.4551	.09510
16.0	.3862	399.24	809.23	52.98	0.000	0.000	.1209	.5589	3.4544	.09510
18.0	.2897	400.06	811.99	52.95	0.000	0.000	.1208	.5587	3.4552	.09510
20.0	.1931	400.90	814.74	52.93	0.000	0.000	.1208	.5586	3.4562	.09510
22.0	.0966	401.75	817.53	52.91	0.000	0.000	.1208	.5586	3.4577	.09510
24.0	0.0000	402.60	820.34	52.88	0.000	0.000	.1208	.5587	3.4600	.09510

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 8
ASSEMBLY 6

PRESSURE = 20.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (M/LB-HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.7733	354.40	644.00	54.18	0.000	0.000	.0789	2120	1.0871	.19300
2.0	.7073	350.41	643.50	54.02	0.000	0.000	.0791	2124	1.0924	.19300
4.0	.6416	349.49	711.79	53.78	0.000	0.000	.0788	2117	1.0932	.19300
6.0	.5763	378.92	742.59	53.53	0.000	0.000	.0782	2101	1.0905	.19300
8.0	.5114	388.45	774.47	53.26	0.000	0.000	.0775	2082	1.0860	.19300
10.0	.4469	398.22	805.93	53.00	0.000	0.000	.0768	2062	1.0805	.19300
12.0	.3827	407.12	835.22	52.74	0.000	0.000	.0760	2041	1.0745	.19300
14.0	.3189	415.11	861.58	52.54	0.000	0.000	.0752	2020	1.0681	.19300
16.0	.2551	415.75	863.70	52.52	0.000	0.000	.0747	2008	1.0618	.19300
18.0	.1914	416.35	865.68	52.51	0.000	0.000	.0745	2001	1.0585	.19300
20.0	.1276	416.91	867.58	52.49	0.000	0.000	.0744	1998	1.0575	.19300
22.0	.0638	417.46	869.35	52.48	0.000	0.000	.0744	1999	1.0583	.19300
24.0	0.0000	417.97	871.04	52.46	0.000	0.000	.0745	2002	1.0602	.19300

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 10
ASSEMBLY 7

PRESSURE = 20.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (M/LB-HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.5174	354.40	644.00	54.18	0.000	0.000	.0991	3220	1.4828	.15930
2.0	.4476	358.42	675.73	54.08	0.000	0.000	.1011	3291	1.4906	.15930
4.0	.3781	363.60	692.59	53.94	0.000	0.000	.1024	3330	1.7164	.15930
6.0	.3090	369.09	710.47	53.79	0.000	0.000	.1028	3347	1.7282	.15930
8.0	.2403	374.68	728.74	53.64	0.000	0.000	.1025	3337	1.7281	.15930
10.0	.1721	380.30	747.12	53.49	0.000	0.000	.1018	3312	1.7201	.15930
12.0	.1043	385.68	764.75	53.34	0.000	0.000	.1007	3278	1.7068	.15930
14.0	.0369	390.72	781.26	53.21	0.000	0.000	.0995	3238	1.6805	.15930
16.0	.2695	391.81	784.85	53.18	0.000	0.000	.0984	3209	1.6762	.15930
18.0	.2022	392.94	788.57	53.15	0.000	0.000	.0980	3190	1.6673	.15930
20.0	.1348	394.10	792.37	53.12	0.000	0.000	.0977	3179	1.6624	.15930
22.0	.0674	395.26	796.18	53.08	0.000	0.000	.0975	3174	1.6610	.15930
24.0	0.0000	396.41	799.97	53.05	0.000	0.000	.0975	3174	1.6616	.15930

W/D-WALL TEMPERATURE SUMMARY TIME = 0.0000 SECONDS
(ASSEMBLY NO. = CHANNEL NO.)

AXIAL LEVEL (INCHES)	(1- 44) (2- 1)	(1- 54) (3- 12)	(1- 42) (4- 13)	(1- 47) (5- 8)	(1- 53) (6- 8)	(1- 41) (7- 10)	(1- 5) (1- 44)	(1- 24) (1- 54)	(1- 37) (1- 42)	(1- 7) (1- 41)
2.0	668.47	677.01	675.44	674.37	678.18	673.44	675.06	676.23	675.85	673.44
4.0	676.82	697.50	693.52	690.30	700.99	688.49	694.50	695.79	694.61	689.45
6.0	687.58	720.95	714.33	709.03	727.01	705.79	715.42	718.42	716.40	707.49
8.0	699.93	745.79	736.51	728.92	754.79	724.10	735.01	741.09	739.90	726.70
10.0	713.22	770.71	758.97	749.29	782.87	747.17	760.55	768.27	763.94	747.41
12.0	728.82	794.37	780.59	769.15	809.75	763.10	782.10	792.77	787.31	767.44
14.0	740.26	818.06	800.75	788.00	834.60	779.95	802.00	815.41	809.28	786.18
16.0	748.91	822.03	808.23	795.70	841.77	787.22	808.00	820.42	817.65	794.07
18.0	755.51	825.82	813.61	801.99	846.70	792.90	812.16	831.06	823.88	801.47
20.0	761.10	828.61	818.00	807.47	850.57	797.81	815.13	836.10	828.89	806.45
22.0	766.10	830.84	821.83	812.40	853.88	802.29	817.92	840.20	833.09	811.44
24.0	770.68	832.69	825.28	816.90	856.80	804.45	820.12	843.46	836.70	815.00

CALCULATED ROD TEMPERATURES AT TIME = 0.0000 SECONDS
 ROD NO. 15
 ASSEMBLY 1 (FUEL TYPE 1 - CYLINDER)

ROD O.D. = .174 (IN.) ZONE-(FUEL DIA.(IN.)) = 1-(.174) 2-(.130) 3-(.174)

AXIAL ZONE (IN.)	HEAT FLUX (MRTU/HR-FT ²)	TYPE	SURF (R/H-FT ²)	FLUID	CLAS	FUEL TEMPERATURES(F.) (RELATIVE RADTUS(R/RO))	
						T(1) (1.000)	T(2) (0.000)
0.0 - 2.0	.0874	2	27331.2	694.8	694.0	718.7	743.2
2.0 - 4.0	.1257	2	27374.1	739.6	744.2	773.9	809.3
4.0 - 6.0	.1346	2	26493.5	787.6	792.6	824.5	842.3
6.0 - 8.0	.1367	2	26415.0	834.3	841.5	873.9	912.3
8.0 - 10.0	.1323	2	25942.3	883.3	884.4	919.7	956.9
10.0 - 12.0	.1207	2	25561.5	925.6	930.4	959.9	992.9
12.0 - 14.0	.1064	2	25220.4	962.3	966.5	991.7	1021.6
14.0 - 16.0	.0019	1	25240.9	960.5	960.6	960.9	961.4
16.0 - 18.0	.0010	1	25266.8	958.1	958.1	959.3	958.6
18.0 - 20.0	.0006	1	25295.6	955.2	955.2	955.3	955.5
20.0 - 22.0	.0004	1	25326.2	952.0	952.1	952.1	952.3
22.0 - 24.0	.0002	1	25357.8	948.7	948.7	948.7	948.8

ITERATIONS = 14

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = .1000 DT = .1000 IMPLICIT DT = .1000 EXPLICIT DT = .0831 MODE = 0

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	11	.0005	.0001	5	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = .1831 DT = .0831 IMPLICIT DT = .1000 EXPLICIT DT = .0831 MODE = 1

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	11	.0006	.0001	13	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = .2831 DT = .1000 IMPLICIT DT = .1000 EXPLICIT DT = .0831 MODE = 0

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	11	.0009	.0001	48	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = .3662 DT = .0831 IMPLICIT DT = .1000 EXPLICIT DT = .0832 MODE = 1

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	10	.0007	.0001	44	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = .4662 DT = .1000 IMPLICIT DT = .1000 EXPLICIT DT = .0832 MORE = 0

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	11	.0003	.0001	113	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = .5494 DT = .0832 IMPLICIT DT = .1000 EXPLICIT DT = .0832 MORE = 1

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	10	.0005	.0001	48	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = .6494 DT = .1000 IMPLICIT DT = .1000 EXPLICIT DT = .0832 MORE = 0

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	7	.0003	.0001	45	2

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = .7324 DT = .0832 IMPLICIT DT = .1000 EXPLICIT DT = .0833 MORE = 1

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	10	.0005	.0001	48	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = .8324 DT = .1000 IMPLICIT DT = .1000 EXPLICIT DT = .0833 MORE = 0

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	7	.0003	.0001	45	2

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = .9159 DT = .0833 IMPLICIT DT = .1000 EXPLICIT DT = .0833 MORE = 1

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	10	.0005	.0001	48	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 1.0159 DT = .1000 IMPLICIT DT = .1000 EXPLICIT DT = .0834 MORE = 0

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	11	.0009	.0001	71	2

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 1.0993 DT = .0834 IMPLICIT DT = .1000 EXPLICIT DT = .0837 MODE = 1

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0052	.0001	71	2

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 1.1993 DT = .1000 IMPLICIT DT = .1000 EXPLICIT DT = .0841 MODE = 0

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	14	.0051	.0001	45	2
2	13	.0037	.0001	74	13
3	12	.0011	.0000	71	3
4	7	.0004	.0000	99	7

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 1.2834 DT = .0841 IMPLICIT DT = .1000 EXPLICIT DT = .0844 MODE = 1

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0073	.0002	71	2

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 1.3678 DT = .0844 IMPLICIT DT = .1000 EXPLICIT DT = .0847 MODE = 1

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0063	.0002	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 1.4525 DT = .0847 IMPLICIT DT = .1000 EXPLICIT DT = .0851 MODE = 1

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0063	.0003	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 1.5376 DT = .0851 IMPLICIT DT = .1000 EXPLICIT DT = .0854 MODE = 1

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0065	.0003	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 1.6230 DT = .0854 IMPLICIT DT = .1000 EXPLICIT DT = .0857 MODE = 1

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0066	.0004	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 1.7087 DT = .0857 IMPLICIT DT = .1000 EXPLICIT DT = .0860 MODE = 1

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0067	.0004	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 1.7947 DT = .0860 IMPLICIT DT = .1000 EXPLICIT DT = .0863 MODE = 1

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0068	.0005	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 1.8810 DT = .0863 IMPLICIT DT = .1000 EXPLICIT DT = .0866 MODE = 1

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0070	.0005	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 1.9677 DT = .0866 IMPLICIT DT = .1000 EXPLICIT DT = .0870 MODE = 1

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0071	.0005	121	13

COBRA WHOLE CORE CODE RESULTS
 CASE 1 FAR-TI XFOR ASSEMBLY COBRA-WC SAMPLE PROBLEM

DATE 04/09/80 0 TIME 21.40.56.2

CALCULATED FLUID CONDITIONS AT TIME = 1.9677 SECONDS
CHANNEL 3
ASSEMBLY 1

PRESSURE = 20.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (HR/HP-FTS)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.9489	354.80	664.00	54.18	0.000	0.000	.0378	5065	2.5969	.03820
2.0	.8675	358.55	676.14	54.08	0.000	0.000	.0380	5152	2.6462	.03820
4.0	.7870	363.98	693.84	53.93	0.000	0.000	.0384	5208	2.6822	.03820
6.0	.7069	369.97	713.35	53.77	0.000	0.000	.0388	5240	2.7070	.03820
8.0	.6272	378.27	733.95	53.60	0.000	0.000	.0397	5255	2.7238	.03820
10.0	.5480	382.66	750.85	53.43	0.000	0.000	.0398	5259	2.7341	.03820
12.0	.4692	388.83	775.09	53.26	0.000	0.000	.0397	5253	2.7398	.03820
14.0	.3910	394.63	794.13	53.10	0.000	0.000	.0398	5240	2.7409	.03820
16.0	.3128	396.28	799.55	53.06	0.000	0.000	.0398	5232	2.7392	.03820
18.0	.2347	397.89	804.84	53.01	0.000	0.000	.0398	5230	2.7406	.03820
20.0	.1565	399.39	809.75	52.97	0.000	0.000	.0398	5232	2.7437	.03820
22.0	.0782	400.75	810.25	52.93	0.000	0.000	.0398	5237	2.7463	.03820
24.0	0.0000	402.00	818.35	52.90	0.000	0.000	.0397	5245	2.7542	.03820

CALCULATED FLUID CONDITIONS AT TIME = 1.9677 SECONDS
CHANNEL 15
ASSEMBLY 1

PRESSURE = 20.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (HR/HP-FTS)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.9490	354.80	664.00	54.18	0.000	0.000	.0551	5065	2.5969	.05640
2.0	.8675	364.68	696.11	53.91	0.000	0.000	.0548	5038	2.5948	.05640
4.0	.7870	378.82	742.27	53.53	0.000	0.000	.0546	5018	2.6036	.05640
6.0	.7069	393.82	791.44	53.12	0.000	0.000	.0545	5010	2.6198	.05640
8.0	.6272	408.87	841.00	52.71	0.000	0.000	.0548	5011	2.6408	.05640
10.0	.5480	423.22	888.41	52.32	0.000	0.000	.0548	5018	2.6643	.05640
12.0	.4692	436.04	930.89	51.97	0.000	0.000	.0547	5030	2.6888	.05640
14.0	.3910	447.03	967.34	51.66	0.000	0.000	.0549	5046	2.7133	.05640
16.0	.3129	445.87	963.49	51.69	0.000	0.000	.0550	5050	2.7188	.05640
18.0	.2347	444.75	959.77	51.72	0.000	0.000	.0551	5068	2.7210	.05640
20.0	.1565	443.66	956.17	51.75	0.000	0.000	.0552	5074	2.7233	.05640
22.0	.0782	442.59	952.60	51.78	0.000	0.000	.0552	5077	2.7231	.05640
24.0	0.0000	441.50	949.00	51.81	0.000	0.000	.0552	5078	2.7215	.05640

CALCULATED FLUID CONDITIONS AT TIME = 1.9677 SECONDS
CHANNEL 41
ASSEMBLY 1

PRESSURE = 20.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (HR/HP-FTS)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.7407	354.80	664.00	54.18	0.000	0.000	.0104	0800	.4103	.06720
2.0	.6818	357.08	671.39	54.12	0.000	0.000	.0104	0800	.4108	.06720
4.0	.6191	361.25	684.94	54.01	0.000	0.000	.0104	0800	.4117	.06720
6.0	.5565	366.48	701.97	53.86	0.000	0.000	.0104	0800	.4128	.06720
8.0	.4941	372.29	720.94	53.71	0.000	0.000	.0104	0801	.4140	.06720
10.0	.4319	378.39	740.88	53.54	0.000	0.000	.0104	0801	.4154	.06720
12.0	.3699	384.48	760.73	53.38	0.000	0.000	.0104	0801	.4167	.06720
14.0	.3080	390.33	779.99	53.22	0.000	0.000	.0104	0801	.4180	.06720
16.0	.2463	393.57	790.65	53.13	0.000	0.000	.0104	0801	.4187	.06720
18.0	.1847	395.81	797.99	53.07	0.000	0.000	.0104	0801	.4193	.06720
20.0	.1231	397.59	803.84	53.02	0.000	0.000	.0104	0801	.4197	.06720
22.0	.0615	399.12	808.87	52.98	0.000	0.000	.0104	0801	.4200	.06720
24.0	0.0000	400.47	813.33	52.94	0.000	0.000	.0104	0801	.4203	.06720

CALCULATED FLUID CONDITIONS AT TIME = 1.9677 SECONDS
CHANNEL 1
ASSEMBLY 2

PRESSURE = 20.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (HR/HP-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.8840	354.80	664.00	54.18	0.000	0.000	.0673	3114	1.5976	.11200
2.0	.8099	355.11	665.01	54.17	0.000	0.000	.0673	3114	1.5980	.11200
4.0	.7361	355.77	667.13	54.15	0.000	0.000	.0673	3117	1.5987	.11200
6.0	.6623	356.81	670.53	54.12	0.000	0.000	.0674	3117	1.5999	.11200
8.0	.5885	358.24	675.16	54.09	0.000	0.000	.0674	3119	1.6017	.11200
10.0	.5148	360.03	680.99	54.04	0.000	0.000	.0674	3120	1.6040	.11200
12.0	.4411	362.14	687.83	53.98	0.000	0.000	.0675	3123	1.6070	.11200
14.0	.3675	364.49	695.49	53.92	0.000	0.000	.0675	3126	1.6107	.11200
16.0	.2939	366.82	703.08	53.86	0.000	0.000	.0674	3131	1.6148	.11200
18.0	.2204	369.06	710.40	53.79	0.000	0.000	.0674	3134	1.6194	.11200
20.0	.1469	371.21	717.41	53.74	0.000	0.000	.0679	3142	1.6242	.11200
22.0	.0734	373.27	724.12	53.68	0.000	0.000	.0680	3149	1.6293	.11200
24.0	0.0000	375.22	730.50	53.63	0.000	0.000	.0682	3154	1.6344	.11200

CALCULATED FLUID CONDITIONS AT TIME = 1.9677 SECONDS
CHANNEL 12
ASSEMBLY 3

PRESSURE = 20.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (HR/HP-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.9170	354.80	664.00	54.18	0.000	0.000	.1152	5070	2.5994	.11780
2.0	.8397	360.19	681.50	54.03	0.000	0.000	.1152	5070	2.6064	.11780
4.0	.7612	367.82	706.35	53.83	0.000	0.000	.1152	5070	2.6163	.11780
6.0	.6841	375.87	732.62	53.61	0.000	0.000	.1152	5070	2.6268	.11780
8.0	.6072	383.95	759.06	53.39	0.000	0.000	.1152	5069	2.6374	.11780
10.0	.5307	391.69	784.47	53.18	0.000	0.000	.1152	5069	2.6474	.11780
12.0	.4543	398.69	807.46	52.99	0.000	0.000	.1152	5069	2.6569	.11780
14.0	.3778	404.79	827.57	52.82	0.000	0.000	.1152	5069	2.6650	.11780
16.0	.3030	404.45	826.43	52.83	0.000	0.000	.1151	5067	2.6642	.11780
18.0	.2273	404.24	825.73	52.84	0.000	0.000	.1151	5067	2.6636	.11780
20.0	.1515	404.13	825.36	52.84	0.000	0.000	.1151	5067	2.6634	.11780
22.0	.0758	404.09	825.24	52.84	0.000	0.000	.1151	5067	2.6634	.11780
24.0	0.0000	404.10	825.28	52.84	0.000	0.000	.1151	5067	2.6634	.11780

CALCULATED FLUID CONDITIONS AT TIME = 1.9677 SECONDS
CHANNEL 13
ASSEMBLY 4

PRESSURE = 20.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (HR/HP-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	1.1253	354.80	664.00	54.18	0.000	0.000	.1064	5799	2.9734	.09510
2.0	1.0289	359.32	678.69	54.06	0.000	0.000	.1096	5973	3.0691	.09510
4.0	.9334	365.70	699.44	53.89	0.000	0.000	.1118	6095	3.1419	.09510
6.0	.8383	372.45	721.44	53.70	0.000	0.000	.1132	6171	3.1917	.09510
8.0	.7437	379.27	743.74	53.52	0.000	0.000	.1146	6215	3.2238	.09510
10.0	.6497	385.92	765.54	53.34	0.000	0.000	.1145	6239	3.2492	.09510
12.0	.5563	392.08	785.75	53.17	0.000	0.000	.1144	6249	3.2644	.09510
14.0	.4635	397.65	804.04	53.02	0.000	0.000	.1144	6248	3.2734	.09510
16.0	.3708	398.38	806.45	53.00	0.000	0.000	.1146	6247	3.2741	.09510
18.0	.2781	399.18	809.08	52.98	0.000	0.000	.1146	6247	3.2757	.09510
20.0	.1854	400.02	811.84	52.95	0.000	0.000	.1146	6249	3.2781	.09510
22.0	.0927	400.89	814.72	52.93	0.000	0.000	.1147	6252	3.2811	.09510
24.0	0.0000	401.77	817.60	52.91	0.000	0.000	.1148	6257	3.2849	.09510

CALCULATED FLUID CONDITIONS AT TIME = 1.9677 SECONDS

PRESSURE = 20.0 PSIA

CHANNEL 8
ASSEMBLY 5

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (MILB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	1.1241	354.80	660.00	54.18	0.000	0.000	.1060	.5790	2.9734	.09510
2.0	1.0278	359.60	679.57	54.05	0.000	0.000	.1094	.5973	3.0496	.09510
4.0	.9322	364.32	701.44	53.87	0.000	0.000	.1118	.6095	3.1430	.09510
6.0	.8372	371.39	724.52	53.68	0.000	0.000	.1132	.6171	3.1932	.09510
8.0	.7427	380.50	747.79	53.49	0.000	0.000	.1140	.6215	3.2275	.09510
10.0	.6487	387.38	770.31	53.30	0.000	0.000	.1144	.6235	3.2500	.09510
12.0	.5554	393.70	791.06	53.13	0.000	0.000	.1146	.6247	3.2661	.09510
14.0	.4627	399.37	809.70	52.97	0.000	0.000	.1146	.6248	3.2740	.09510
16.0	.3702	399.90	811.44	52.96	0.000	0.000	.1145	.6249	3.2740	.09510
18.0	.2777	400.52	813.50	52.94	0.000	0.000	.1145	.6249	3.2762	.09510
20.0	.1851	401.22	815.81	52.92	0.000	0.000	.1145	.6249	3.2785	.09510
22.0	.0926	401.98	818.30	52.90	0.000	0.000	.1145	.6249	3.2785	.09510
24.0	0.0000	402.77	820.91	52.88	0.000	0.000	.1146	.6247	3.2817	.09510

CALCULATED FLUID CONDITIONS AT TIME = 1.9677 SECONDS

PRESSURE = 20.0 PSIA

CHANNEL 8
ASSEMBLY 6

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (MILB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.7675	354.80	660.00	54.18	0.000	0.000	.0747	.2007	1.0291	.19300
2.0	.7019	360.99	684.10	54.01	0.000	0.000	.0748	.2010	1.0338	.19300
4.0	.6367	369.85	712.98	53.77	0.000	0.000	.0748	.2002	1.0340	.19300
6.0	.5719	379.40	744.16	53.52	0.000	0.000	.0739	.1986	1.0307	.19300
8.0	.5074	389.19	776.26	53.25	0.000	0.000	.0732	.1966	1.0255	.19300
10.0	.4435	398.79	807.81	52.99	0.000	0.000	.0724	.1945	1.0194	.19300
12.0	.3799	407.68	837.06	52.75	0.000	0.000	.0716	.1923	1.0129	.19300
14.0	.3166	415.62	863.30	52.53	0.000	0.000	.0708	.1903	1.0061	.19300
16.0	.2533	415.99	864.52	52.52	0.000	0.000	.0700	.1890	.9998	.19300
18.0	.1899	416.46	866.09	52.50	0.000	0.000	.0701	.1888	.9962	.19300
20.0	.1266	416.96	867.70	52.49	0.000	0.000	.0700	.1881	.9952	.19300
22.0	.0633	417.48	869.42	52.48	0.000	0.000	.0700	.1881	.9950	.19300
24.0	0.0000	417.98	871.09	52.46	0.000	0.000	.0702	.1885	.9970	.19300

CALCULATED FLUID CONDITIONS AT TIME = 1.9677 SECONDS

PRESSURE = 20.0 PSIA

CHANNEL 10
ASSEMBLY 7

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (MILB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.8061	354.80	660.00	54.18	0.000	0.000	.0938	.2052	1.5446	.15930
2.0	.7371	358.54	676.20	54.08	0.000	0.000	.0937	.3115	1.6003	.15930
4.0	.6685	363.90	693.58	53.93	0.000	0.000	.0940	.3154	1.6243	.15930
6.0	.6004	369.51	711.84	53.78	0.000	0.000	.0932	.3164	1.6342	.15930
8.0	.5327	375.21	730.45	53.63	0.000	0.000	.0940	.3152	1.6326	.15930
10.0	.4655	380.89	749.04	53.48	0.000	0.000	.0940	.3125	1.6230	.15930
12.0	.3987	386.31	766.80	53.33	0.000	0.000	.0940	.3089	1.6092	.15930
14.0	.3322	391.34	783.31	53.19	0.000	0.000	.0937	.3040	1.5923	.15930
16.0	.2658	392.24	786.27	53.17	0.000	0.000	.0924	.3020	1.5770	.15930
18.0	.1993	393.24	789.55	53.14	0.000	0.000	.0923	.3002	1.5693	.15930
20.0	.1329	394.30	793.09	53.11	0.000	0.000	.0919	.2992	1.5642	.15930
22.0	.0664	395.41	796.67	53.08	0.000	0.000	.0918	.2988	1.5637	.15930
24.0	0.0000	396.52	800.33	53.05	0.000	0.000	.0918	.2988	1.5647	.15930

MID-WALL TEMPERATURE SUMMARY TIME = 1.9677 SECONDS
(ASSEMBLY NO. = CHANNEL NO.)

AXIAL LEVEL (INCHES)	(1- 44) (2- 1)	(1- 54) (3- 12)	(1- 42) (4- 13)	(1- 47) (5- 8)	(1- 53) (6- 8)	(1- 41) (7- 10)	(1- 5) (1- 44)	(1- 24) (1- 54)	(1- 37) (1- 42)	(1- 3) (1- 41)
2.0	668.53	677.19	675.60	674.52	678.53	673.57	676.79	676.72	676.28	674.00
4.0	676.95	697.89	693.87	690.82	701.31	698.76	695.41	696.73	695.53	689.90
6.0	687.78	721.51	714.83	709.49	727.45	706.16	716.60	710.89	717.72	708.16
8.0	700.17	746.48	737.12	729.49	755.29	724.75	730.54	744.75	741.49	728.00
10.0	713.49	771.48	759.65	749.92	783.42	743.88	762.32	770.10	765.69	748.45
12.0	727.11	795.16	781.30	769.81	810.30	762.63	783.79	794.67	789.12	769.52
14.0	740.55	816.84	801.46	788.66	835.12	780.47	803.62	817.67	811.05	787.64
16.0	749.13	822.57	808.72	796.16	842.07	787.58	808.00	825.85	818.82	795.45
18.0	755.67	826.19	813.95	802.31	846.87	793.13	812.73	831.85	824.63	801.70
20.0	761.22	828.86	818.24	807.70	850.67	797.97	815.64	836.61	829.37	807.66
22.0	766.20	831.01	822.01	812.57	853.95	802.41	818.07	840.52	833.40	811.82
24.0	770.77	832.82	823.42	817.04	856.85	806.54	820.18	843.78	836.90	816.09

CALCULATED ROD TEMPERATURES AT TIME = 1.9677 SECONDS
 ROD NO. 15
 ASSEMBLY 1 (FUEL TYPE 1 - CYLINDER)

ROD O.D. = .174 (IN.) ZONE=(FUEL DIA.(IN.)) = 1-(.174) 2-(.130) 3-(.174)

AXIAL ZONE (IN.)	HEAT FLUX (MTU/HR-FT ²)	TYPE	HURF (R/H-FT ²)	FLUID	CLAD	FUEL TEMPERATURE(F.) (RELATIVE RADTUA(D/PO))	
						T(1) (1.000)	T(2) (0.000)
0.0 - 2.0	.0065	2	27719.6	694.1	699.2	719.8	744.2
2.0 - 4.0	.1238	2	27269.6	742.2	746.7	774.3	811.3
4.0 - 6.0	.1316	2	26779.3	791.3	796.3	827.8	865.1
6.0 - 8.0	.1330	2	26264.7	840.9	846.0	877.9	915.7
8.0 - 10.0	.1282	2	25919.5	888.3	893.3	924.1	960.6
10.0 - 12.0	.1163	2	25483.8	930.8	935.4	963.4	998.7
12.0 - 14.0	.1020	2	25100.5	967.3	971.4	996.0	1025.2
14.0 - 16.0	-.0027	1	25119.9	963.5	963.4	963.1	962.8
16.0 - 18.0	-.0018	1	25177.2	959.8	959.7	959.5	959.3
18.0 - 20.0	-.0010	1	25212.6	956.2	956.1	956.0	955.9
20.0 - 22.0	-.0005	1	25205.9	952.6	952.6	952.5	952.5
22.0 - 24.0	-.0003	1	25227.6	949.0	949.0	949.0	948.9

ITERATIONS = 2

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 2.0546 DT = .0870 IMPLICIT DT = .1000 EXPLICIT DT = .0873 MODE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0072	.0005	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 2.1419 DT = .0873 IMPLICIT DT = .1000 EXPLICIT DT = .0876 MODE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0074	.0003	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 2.2296 DT = .0876 IMPLICIT DT = .1000 EXPLICIT DT = .0880 MODE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0076	.0004	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 2.3175 DT = .0880 IMPLICIT DT = .1000 EXPLICIT DT = .0883 MODE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0078	.0008	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 2.4059 DT = .0883 IMPLICIT DT = .1000 EXPLICIT DT = .0887 MODE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0080	.0011	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 2.4945 DT = .0887 IMPLICIT DT = .1000 EXPLICIT DT = .0890 MODE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0081	.0015	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 2.5836 DT = .0890 IMPLICIT DT = .1000 EXPLICIT DT = .0897 MODE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	13	.0101	.0018	72	2

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 2.6733 DT = .0897 IMPLICIT DT = .1000 EXPLICIT DT = .0904 MODE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	13	.0138	.0021	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 2.7636 DT = .0904 IMPLICIT DT = .1000 EXPLICIT DT = .0911 MODE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	13	.0144	.0024	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
 TIME = 2.8547 DT = .0911 IMPLICIT DT = .1000 EXPLICIT DT = .0918 MODE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	13	.0149	.0027	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE

TIME = 2.9064 DT = .0918 IMPLICIT DT = .1000 EXPLICIT DT = .0925 MODE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	14	.0154	.0030	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE

TIME = 3.0390 DT = .0925 IMPLICIT DT = .1000 EXPLICIT DT = .0932 MODE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	13	.0158	.0033	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE

TIME = 3.1322 DT = .0932 IMPLICIT DT = .1000 EXPLICIT DT = .0940 MODE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	13	.0162	.0036	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE

TIME = 3.2262 DT = .0940 IMPLICIT DT = .1000 EXPLICIT DT = .0947 MODE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	13	.0167	.0039	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE

TIME = 3.3209 DT = .0947 IMPLICIT DT = .1000 EXPLICIT DT = .0955 MODE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	13	.0171	.0041	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE

TIME = 3.4163 DT = .0955 IMPLICIT DT = .1000 EXPLICIT DT = .0962 MODE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	13	.0175	.0044	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
TIME = 3.5126 DT = .0962 IMPLICIT DT = .1000 EXPLICIT DT = .0970 NONE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	13	.0180	.0047	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
TIME = 3.6096 DT = .0970 IMPLICIT DT = .1000 EXPLICIT DT = .0978 NONE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	13	.0185	.0050	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
TIME = 3.7074 DT = .0978 IMPLICIT DT = .1000 EXPLICIT DT = .0986 NONE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	13	.0189	.0053	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
TIME = 3.8060 DT = .0986 IMPLICIT DT = .1000 EXPLICIT DT = .0993 NONE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	13	.0194	.0056	121	13

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
TIME = 3.9054 DT = .0993 IMPLICIT DT = .1000 EXPLICIT DT = .1003 NONE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	13	.0200	.0059	42	8

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE
TIME = 4.0055 DT = .1000 IMPLICIT DT = .1000 EXPLICIT DT = .1012 NONE = i

ITERATION NO.	PRESSURE SWEEPS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	13	.0206	.0062	42	8

COBRA WHOLE CORE CODE RESULTS
CASE 1 EBR-II XNOR ASSEMBLY COBRA-WC SAMPLE PROBLEM

DATE 04/09/80 0 TIME 21.45.10.2

CALCULATED FLUID CONDITIONS AT TIME = 4.0055 SECONDS

PRESSURE = 20.0 PSIA

CHANNEL 3
ASSEMBLY 1

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (M/LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.8821	354.80	664.00	54.18	0.000	0.000	.0307	.4164	2.1351	.03820
2.0	.8062	356.87	670.70	54.12	0.000	0.000	.0312	.4234	2.1747	.03820
4.0	.7315	360.31	681.90	54.03	0.000	0.000	.0314	.4288	2.2026	.03820
6.0	.6570	364.66	696.08	53.91	0.000	0.000	.0318	.4312	2.2214	.03820
8.0	.5829	369.75	712.63	53.79	0.000	0.000	.0318	.4320	2.2335	.03820
10.0	.5091	375.37	730.99	53.63	0.000	0.000	.0318	.4325	2.2401	.03820
12.0	.4357	381.26	750.27	53.47	0.000	0.000	.0319	.4317	2.2426	.03820
14.0	.3627	387.20	769.55	53.31	0.000	0.000	.0317	.4303	2.2421	.03820
16.0	.2900	391.41	783.55	53.19	0.000	0.000	.0314	.4289	2.2399	.03820
18.0	.2174	394.88	794.93	53.10	0.000	0.000	.0315	.4270	2.2384	.03820
20.0	.1449	397.64	804.00	53.02	0.000	0.000	.0315	.4273	2.2386	.03820
22.0	.0724	399.81	811.15	52.96	0.000	0.000	.0315	.4272	2.2405	.03820
24.0	0.0000	401.54	816.86	52.91	0.000	0.000	.0315	.4275	2.2442	.03820

CALCULATED FLUID CONDITIONS AT TIME = 4.0055 SECONDS

PRESSURE = 20.0 PSIA

CHANNEL 15
ASSEMBLY 1

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (M/LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.8821	354.80	664.00	54.18	0.000	0.000	.0453	.4164	2.1351	.05640
2.0	.8062	360.15	681.37	54.04	0.000	0.000	.0450	.4140	2.1282	.05640
4.0	.7315	368.80	709.54	53.80	0.000	0.000	.0449	.4123	2.1287	.05640
6.0	.6570	379.20	743.52	53.52	0.000	0.000	.0448	.4115	2.1355	.05640
8.0	.5829	390.82	781.59	53.21	0.000	0.000	.0448	.4113	2.1474	.05640
10.0	.5091	403.01	821.63	52.88	0.000	0.000	.0448	.4117	2.1630	.05640
12.0	.4357	415.03	861.33	52.55	0.000	0.000	.0449	.4124	2.1810	.05640
14.0	.3627	426.38	898.86	52.24	0.000	0.000	.0449	.4138	2.2004	.05640
16.0	.2900	433.33	921.84	52.04	0.000	0.000	.0452	.4151	2.2158	.05640
18.0	.2174	437.52	935.79	51.93	0.000	0.000	.0453	.4164	2.2275	.05640
20.0	.1449	439.74	943.14	51.86	0.000	0.000	.0454	.4174	2.2353	.05640
22.0	.0724	440.61	948.04	51.84	0.000	0.000	.0455	.4180	2.2397	.05640
24.0	0.0000	440.62	948.05	51.84	0.000	0.000	.0455	.4183	2.2412	.05640

CALCULATED FLUID CONDITIONS AT TIME = 4.0055 SECONDS

PRESSURE = 20.0 PSIA

CHANNEL 41
ASSEMBLY 1

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (M/LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.7433	354.80	664.00	54.18	0.000	0.000	.0085	.0658	.3373	.06720
2.0	.6811	356.46	669.37	54.13	0.000	0.000	.0085	.0658	.3378	.06720
4.0	.6185	359.71	679.93	54.05	0.000	0.000	.0085	.0658	.3380	.06720
6.0	.5559	364.06	694.09	53.93	0.000	0.000	.0085	.0657	.3385	.06720
8.0	.4936	369.20	710.84	53.79	0.000	0.000	.0085	.0657	.3391	.06720
10.0	.4314	374.97	729.36	53.64	0.000	0.000	.0085	.0656	.3397	.06720
12.0	.3694	380.79	748.70	53.48	0.000	0.000	.0085	.0655	.3403	.06720
14.0	.3076	386.71	768.10	53.32	0.000	0.000	.0085	.0654	.3409	.06720
16.0	.2459	391.00	782.18	53.20	0.000	0.000	.0085	.0654	.3413	.06720
18.0	.1843	394.26	792.90	53.11	0.000	0.000	.0085	.0653	.3416	.06720
20.0	.1228	396.80	801.23	53.04	0.000	0.000	.0085	.0653	.3419	.06720
22.0	.0614	398.81	807.85	52.99	0.000	0.000	.0085	.0653	.3421	.06720
24.0	0.0000	400.44	813.24	52.94	0.000	0.000	.0085	.0652	.3423	.06720

CALCULATED FLUID CONDITIONS AT TIME = 4.0055 SECONDS

PRESSURE = 20.0 Psia

CHANNEL 1
ASSEMBLY 2

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (M/LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.8419	354.80	664.00	54.18	0.000	0.000	.0553	.2542	1.3138	.11200
2.0	.7712	355.10	664.96	54.17	0.000	0.000	.0554	.2562	1.3138	.11200
4.0	.7009	355.78	667.17	54.15	0.000	0.000	.0554	.2563	1.3146	.11200
6.0	.6306	356.49	670.79	54.12	0.000	0.000	.0554	.2564	1.3150	.11200
8.0	.5604	358.43	675.77	54.08	0.000	0.000	.0554	.2569	1.3177	.11200
10.0	.4902	360.36	682.04	54.03	0.000	0.000	.0554	.2568	1.3202	.11200
12.0	.4200	362.62	689.40	53.97	0.000	0.000	.0554	.2571	1.3239	.11200
14.0	.3499	365.14	697.60	53.90	0.000	0.000	.0554	.2576	1.3274	.11200
16.0	.2799	367.61	705.67	53.83	0.000	0.000	.0554	.2581	1.3318	.11200
18.0	.2098	369.97	713.34	53.77	0.000	0.000	.0554	.2587	1.3367	.11200
20.0	.1399	372.18	720.56	53.71	0.000	0.000	.0561	.2594	1.3418	.11200
22.0	.0699	374.25	727.33	53.65	0.000	0.000	.0562	.2602	1.3471	.11200
24.0	0.0000	376.21	733.72	53.60	0.000	0.000	.0564	.2610	1.3520	.11200

CALCULATED FLUID CONDITIONS AT TIME = 4.0055 SECONDS

PRESSURE = 20.0 Psia

CHANNEL 12
ASSEMBLY 3

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (M/LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.8600	354.80	664.00	54.18	0.000	0.000	.0947	.4164	2.1372	.11780
2.0	.7844	358.23	675.12	54.09	0.000	0.000	.0947	.4168	2.1406	.11780
4.0	.7139	363.50	692.29	53.95	0.000	0.000	.0947	.4167	2.1450	.11780
6.0	.6416	369.48	712.09	53.78	0.000	0.000	.0947	.4167	2.1510	.11780
8.0	.5695	376.15	733.54	53.61	0.000	0.000	.0947	.4165	2.1583	.11780
10.0	.4977	382.90	755.62	53.42	0.000	0.000	.0944	.4164	2.1652	.11780
12.0	.4261	389.45	777.10	53.24	0.000	0.000	.0944	.4163	2.1717	.11780
14.0	.3549	395.60	797.31	53.08	0.000	0.000	.0944	.4161	2.1777	.11780
16.0	.2838	397.93	804.96	53.01	0.000	0.000	.0944	.4159	2.1794	.11780
18.0	.2128	399.71	810.82	52.96	0.000	0.000	.0944	.4158	2.1805	.11780
20.0	.1418	401.06	815.27	52.93	0.000	0.000	.0944	.4156	2.1812	.11780
22.0	.0709	402.08	818.63	52.90	0.000	0.000	.0944	.4155	2.1816	.11780
24.0	0.0000	402.85	821.16	52.88	0.000	0.000	.0944	.4153	2.1818	.11780

CALCULATED FLUID CONDITIONS AT TIME = 4.0055 SECONDS

PRESSURE = 20.0 Psia

CHANNEL 13
ASSEMBLY 4

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (M/LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	1.0043	354.80	664.00	54.18	0.000	0.000	.0975	.4764	2.4444	.09510
2.0	.9194	357.19	671.75	54.11	0.000	0.000	.0972	.4910	2.4525	.09510
4.0	.8345	360.95	688.98	54.01	0.000	0.000	.0921	.5018	2.5006	.09510
6.0	.7495	365.42	698.53	53.89	0.000	0.000	.0932	.5082	2.6193	.09510
8.0	.6649	370.42	714.81	53.76	0.000	0.000	.0939	.5118	2.6446	.09510
10.0	.5807	375.75	732.22	53.62	0.000	0.000	.0942	.5136	2.6608	.09510
12.0	.4969	381.17	749.97	53.47	0.000	0.000	.0943	.5141	2.6706	.09510
14.0	.4126	386.56	767.62	53.32	0.000	0.000	.0942	.5136	2.6754	.09510
16.0	.3306	390.23	779.65	53.22	0.000	0.000	.0941	.5128	2.6761	.09510
18.0	.2478	393.36	789.95	53.14	0.000	0.000	.0939	.5120	2.6763	.09510
20.0	.1651	396.01	798.64	53.07	0.000	0.000	.0938	.5114	2.6771	.09510
22.0	.0825	398.22	805.91	53.00	0.000	0.000	.0938	.5112	2.6790	.09510
24.0	0.0000	400.04	812.03	52.95	0.000	0.000	.0938	.5113	2.6821	.09510

CALCULATED FLUID CONDITIONS AT TIME = 4.0055 SECONDS
CHANNEL 8
ASSEMBLY 5

PRESSURE = 20.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (M/R/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	1.0053	754.40	664.00	54.18	0.000	0.000	.0875	.4748	2.4444	.09510
2.0	.9188	757.32	672.17	54.11	0.000	0.000	.0902	.4914	2.5227	.09510
4.0	.8335	761.26	684.97	54.01	0.000	0.000	.0921	.5018	2.5810	.09510
6.0	.7486	765.89	700.05	53.88	0.000	0.000	.0932	.5081	2.6197	.09510
8.0	.6640	771.03	716.82	53.74	0.000	0.000	.0939	.5117	2.6448	.09510
10.0	.5798	776.48	734.63	53.60	0.000	0.000	.0948	.5138	2.6607	.09510
12.0	.4961	782.00	752.68	53.45	0.000	0.000	.0942	.5137	2.6698	.09510
14.0	.4129	787.46	770.57	53.30	0.000	0.000	.0941	.5131	2.6730	.09510
16.0	.3300	791.09	782.50	53.20	0.000	0.000	.0939	.5120	2.6735	.09510
18.0	.2473	794.19	792.68	53.11	0.000	0.000	.0938	.5111	2.6727	.09510
20.0	.1648	796.80	801.25	53.04	0.000	0.000	.0936	.5104	2.6726	.09510
22.0	.0824	798.98	808.42	52.98	0.000	0.000	.0934	.5100	2.6738	.09510
24.0	0.0000	800.81	814.48	52.93	0.000	0.000	.0934	.5100	2.6763	.09510

CALCULATED FLUID CONDITIONS AT TIME = 4.0055 SECONDS
CHANNEL 8
ASSEMBLY 6

PRESSURE = 20.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (M/R/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.7554	754.40	664.00	54.18	0.000	0.000	.0614	.1650	.8461	.19300
2.0	.6908	760.13	681.30	54.04	0.000	0.000	.0614	.1651	.8485	.19300
4.0	.6266	768.22	707.65	53.82	0.000	0.000	.0610	.1638	.8457	.19300
6.0	.5628	777.34	737.45	53.57	0.000	0.000	.0603	.1610	.8392	.19300
8.0	.4994	786.97	768.98	53.31	0.000	0.000	.0594	.1585	.8308	.19300
10.0	.4364	796.59	800.54	53.05	0.000	0.000	.0584	.1569	.8214	.19300
12.0	.3737	805.64	830.34	52.80	0.000	0.000	.0575	.1540	.8123	.19300
14.0	.3113	813.83	857.36	52.58	0.000	0.000	.0566	.1520	.8029	.19300
16.0	.2491	815.29	882.20	52.54	0.000	0.000	.0560	.1504	.7952	.19300
18.0	.1868	816.23	895.31	52.51	0.000	0.000	.0557	.1495	.7910	.19300
20.0	.1245	816.91	907.54	52.49	0.000	0.000	.0555	.1492	.7895	.19300
22.0	.0623	817.49	916.46	52.48	0.000	0.000	.0554	.1493	.7902	.19300
24.0	0.0000	818.01	921.15	52.46	0.000	0.000	.0557	.1497	.7924	.19300

CALCULATED FLUID CONDITIONS AT TIME = 4.0055 SECONDS
CHANNEL 10
ASSEMBLY 7

PRESSURE = 20.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (M/R/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.7924	754.40	664.00	54.18	0.000	0.000	.0771	.2508	1.2864	.15930
2.0	.7153	757.23	671.87	54.11	0.000	0.000	.0787	.2562	1.3151	.15930
4.0	.6488	761.02	688.21	54.01	0.000	0.000	.0796	.2591	1.3326	.15930
6.0	.5827	765.37	698.37	53.89	0.000	0.000	.0797	.2592	1.3380	.15930
8.0	.5169	770.23	714.21	53.76	0.000	0.000	.0790	.2570	1.3281	.15930
10.0	.4516	775.44	731.22	53.62	0.000	0.000	.0779	.2534	1.3126	.15930
12.0	.3866	780.75	748.59	53.48	0.000	0.000	.0765	.2489	1.2826	.15930
14.0	.3220	786.00	765.77	53.34	0.000	0.000	.0750	.2440	1.2706	.15930
16.0	.2573	788.79	778.93	53.26	0.000	0.000	.0738	.2400	1.2510	.15930
18.0	.1931	791.15	782.68	53.20	0.000	0.000	.0729	.2373	1.2391	.15930
20.0	.1287	793.16	788.25	53.14	0.000	0.000	.0724	.2356	1.2317	.15930
22.0	.0643	794.89	794.95	53.09	0.000	0.000	.0722	.2348	1.2286	.15930
24.0	0.0000	796.40	799.94	53.05	0.000	0.000	.0721	.2347	1.2287	.15930

HYD-WALL TEMPERATURE SUMMARY TIME = 4.0055 SECONDS
(ASSEMBLY NO. = CHANNEL NO.)

AXIAL LEVEL (INCHES)	(1- 44) (2- 1)	(1- 34) (3- 12)	(1- 42) (4- 13)	(1- 47) (5- 8)	(1- 33) (6- 8)	(1- 41) (7- 10)	(1- 5) (1- 40)	(1- 24) (1- 30)	(1- 37) (1- 42)	(1- 3) (1- 41)
2.0	668.10	675.57	673.67	672.67	677.82	679.42	671.52	672.97	671.70	670.33
4.0	675.94	694.29	689.94	686.70	699.85	684.23	684.84	684.32	685.25	681.56
6.0	686.28	716.30	708.46	703.45	725.49	709.51	700.48	700.56	702.56	696.01
8.0	698.36	740.12	729.22	722.00	753.08	730.43	719.31	725.74	722.68	712.04
10.0	711.57	764.48	750.78	741.49	781.17	759.26	730.38	740.49	744.50	731.58
12.0	725.26	788.04	772.05	761.01	808.20	789.08	759.85	772.67	767.17	751.02
14.0	738.91	810.01	792.36	779.98	833.29	814.27	779.88	796.15	789.51	770.50
16.0	748.34	818.21	802.60	790.33	841.29	825.18	792.45	811.63	804.44	784.11
18.0	758.62	823.69	810.16	798.67	846.75	832.06	802.13	823.56	815.83	794.87
20.0	761.65	827.62	816.10	805.61	850.90	837.75	809.03	831.87	824.42	803.34
22.0	768.88	830.55	820.95	811.52	854.34	842.46	814.01	838.50	830.90	810.05
24.0	771.55	832.41	825.05	816.65	857.29	847.45	817.64	842.84	835.84	815.86

CALCULATED ROD TEMPERATURES AT TIME = 4.0055 SECONDS
ROD NO. 15
ASSEMBLY 1 (FUEL TYPE 1 = CYLINDER)

ROD O.D. = .174 (IN.) ZONE-(FUEL DIA.(IN.)) = 1-(.174) 2-(.130) 3-(.174)

AXIAL ZONE	HEAT FLUX	TYPE	H SURF	FLUID	CLAD	FUEL TEMPERATURE(F.) (RELATIVE RADJUS(R/P/O))
(IN.)	(MBTU/HR-FT ²)		(R/H-P-FT ²)			T(1) T(2) (1.000) (0.000)
0.0 - 2.0	.0369	2	27615.7	681.3	682.6	690.7 700.4
2.0 - 4.0	.0583	2	27328.9	709.3	711.5	723.7 738.6
4.0 - 6.0	.0689	2	26987.9	743.2	743.8	759.8 776.7
6.0 - 8.0	.0762	2	26612.1	781.2	784.1	799.1 817.2
8.0 - 10.0	.0797	2	26222.2	821.2	824.3	839.6 858.1
10.0 - 12.0	.0787	2	25942.2	860.9	863.9	878.7 896.4
12.0 - 14.0	.0748	2	25487.7	898.4	901.3	915.1 931.5
14.0 - 16.0	.0679	1	25273.0	921.5	923.4	929.8 949.5
16.0 - 18.0	.0314	1	25144.9	935.6	936.8	941.0 947.2
18.0 - 20.0	.0197	1	25078.0	943.0	943.8	946.3 950.1
20.0 - 22.0	.0117	1	25052.1	945.9	946.8	947.9 949.1
22.0 - 24.0	.0065	1	25052.3	946.0	946.3	947.1 948.3

ITERATIONS = 2

INPUT TRANSIENT TIME COMPLETED

COMMON DUMPED TO TAPE 8

NRU SAMPLE PROBLEM

One of the primary concerns in commercial light water reactor safety is the hydraulic and material behavior during the heatup, reload, and quench sequence of a loss-of-coolant accident (LOCA). An experiment has been designed at PNL which will be used in the Canadian National Research Universal (NRU) reactor in an attempt to provide data on the LOCA. The COBRA-WC code was used to model the pre-transient phase of this experiment. During this phase, the assembly is operated in a steady, low-power condition using steam as the coolant. It is referred to as the pretransient phase since the zero-flow, LOCA transient is initiated from this phase by closing the steam inlet valve. This problem was chosen as a sample problem because it requires using both water and steam in the same model (but not in the same computational cells) and also indicates the use of the heated wall model.

The design of the NRU test assembly and its interface with the reactor closed loop is illustrated by Figure E.9. The NRU test assembly is composed of the fuel pin bundle, the shroud, and the pressure tube with the two ducts joined to common inlet hardware below the pin bundle. The liner is the inner boundary of the reactor closed loop and is surrounded by a large volume of water maintained at an approximately constant temperature of 100°F. The geometry of the 32-rod bundle is based on a B&W 17 x 17 array. The four corner rods of an otherwise square matrix have been removed.

The COBRA-WC model used to simulate this experiment is shown in Figure E.10. The NRU assembly has been modeled with 41 channels in the pin bundle and four in the shroud-pressure tube annulus. The geometry of these channels and the numbering scheme is also shown in Figure E.10. The shroud and pressure tube were modeled as thermally conducting walls with a heat generation of 0.2 w/gm in each. The liner was not modeled separately, but its thermal resistance was combined with that of the air gap into a film coefficient of 6.0 Btu/hr-ft²-°F. This film coefficient was assigned to the duct-water interface by modeling the surrounding water as a second assembly and specifying the film coefficient. Nearly constant-temperature

NRU EXPERIMENTAL ASSEMBLY

FIGURE E.9. NRU Experimental Assembly

FIGURE E.10. COBRA-WC Model of NRU Assembly

water was maintained by specifying a large mass flow rate of water over the outside duct. The radial pin power profile is given as Figure E.11 and the axial power profile is given as Table E.7. One rod, marked by an "x" in Figure E.11, is used for instrumentation and has zero power.

The analysis of this test required the use of both steam and water with a single phase code. The problem was circumvented by using a property table, (Table E.8), as input with low-temperature (100°F to 125°F) water properties at 1500 psi and 40-psia steam properties at higher temperatures (267.3°F to 1500°F). Since the temperatures of water and steam never overlap, this permitted both phases in the same model. For this problem the check on saturation temperature based on the system pressure is meaningless, and so the pressures do not necessarily correspond with the saturation temperatures in Table E.8. The only requirement is that the temperature at the highest pressure be above any temperature encountered during the calculation. The operating conditions for the simulation are listed in Table E.9.

A listing of the computer output of this sample problem (provided here) shows the input cards, the edited input, and the calculated results.

TABLE E.7. Axial Power Profile

	1
0.000	0.000
0.021	0.032
0.063	0.081
0.104	0.273
0.146	0.458
0.188	0.632
0.229	0.781
0.271	0.933
0.313	1.079
0.354	1.205
0.396	1.309
0.438	1.392
0.479	1.453
0.521	1.492
0.563	1.509
0.604	1.505
0.646	1.479
0.688	1.431
0.729	1.361
0.771	1.269
0.813	1.156
0.854	1.022
0.896	0.868
0.938	0.709
0.979	0.567
1.000	0.000

NRU RADIAL POWER PROFILE

FIGURE E.11. Radial Power Profile for NRU Assembly

TABLE E.8. Fluid Property

<u>PLIQ</u> <u>(PSIA)</u>	<u>TEMLIQ</u> <u>(F)</u>	<u>HLIQ</u> <u>(Btu/lbm)</u>	<u>CONLIQ</u> <u>(Btu/hr-ft-f)</u>	<u>CPLIQ</u> <u>(Btu/lbm-f)</u>	<u>VLIQ</u> <u>(ft³/lbm)</u>	<u>VISIQ</u> <u>(lbm/hr-ft)</u>
10.0000	100.0000	67.9900	0.3634	0.9980	0.0161	1.6460
20.0000	120.0000	87.9700	0.3703	0.9980	0.0162	1.4010
30.0000	267.3000	1169.8000	0.0166	0.5210	10.5000	0.0325
40.0000	300.0000	1186.6000	0.0169	0.5090	11.0400	0.0336
50.0000	400.0000	1236.4000	0.0196	0.4900	12.6200	0.0394
60.0000	500.0000	1285.0000	0.0228	0.4850	14.1700	0.0452
70.0000	600.0000	1333.6000	0.0262	0.4870	15.6900	0.0510
80.0000	700.0000	1382.5000	0.0299	0.4900	17.2000	0.0556
90.0000	800.0000	1432.1000	0.0337	0.5000	18.7000	0.0614
100.0000	900.0000	1482.5000	0.0377	0.5080	20.2000	0.0672
110.0000	1000.0000	1533.7000	0.0419	0.5170	21.7000	0.0730
120.0000	1500.0000	1803.1000	0.0638	0.5600	29.1700	0.0997

TABLE E.9. Simulation Operating Conditions

Coolant	Steam
Flow	3000 H/hr
Pressure	40 psia
Inlet temperature	471 ⁰ F
Water temperature	100 ⁰ F

 THIS IS THE COBRA-WHOLE CORE CODE FOR MULTIASSEMBLY LAMFR ANALYSIS
 WRITTEN AT PACIFIC NORTHWEST LABORATORY DURING 1977-1980
 DOE CONTRACT AG102044 AND CRBR CONTRACT D1813-40741

CREATION DATE FOR THIS CYCLE = 2-1-80

CORPA DIMENSION PARAMETERS

MA#	1	MC#	50	ME#	25	MG#	90
MI#	5	MD#	1	MK#	370	ML#	1
NH#	29	MN#	6	MO#	7	MP#	31
HR#	36	MR#	1	MT#	1	MV#	1
MW#	32	MY#	25	MY#	4	MZ#	10
M1#	1392	NY#	8	N1#	7	JA#	36
YE#	13	IP#	4	IT#	2	IU#	2
IV#	6	IW#	2	IH#	6	IX#	4

***** THE FOLLOWING IS AN IMAGE LISTING OF THE COBRA-WC INPUT CARDS *****
 GEOM GENERATED INPUT IS NOT INCLUDED

	0	1	2	3	4	5	6	7	8	
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	
2	1	NRU SAMPLE PROBLEM								
3	1	13								
4		10.	99.999	67.99	.3634	.998	.0161	1.646		
5		20.	120.	87.97	.3703	.998	.0152	1.401		
6		30.	250.	550.	.015	.500	10.0	.030		
7		40.	267.3	1169.8	.0166	.521	10.50	.0325		
8		50.	300.	1186.6	.0169	.509	11.04	.0336		
9		60.	400.	1236.4	.0196	.490	12.62	.0394		
10		70.	500.	1285.0	.0228	.485	14.17	.0452		
11		80.	600.	1331.6	.0262	.487	15.69	.0510		
12		90.	700.	1382.5	.0299	.490	17.20	.0556		
13		100.	800.	1432.1	.0337	.500	18.70	.0614		
14		110.	900.	1482.5	.0377	.508	20.20	.0672		
15		120.	1000.	1533.7	.0419	.517	21.70	.0730		
16		230.	1500.	1803.1	.0638	.560	29.17	.0997		
17	2	2	2							
18	.185	-.20		64.	-.1.0					
19	.316	-.25		64.	-.1.0					
20	.023	.8	.4	0.						
21	0.	0.	0.55.55							
22	3	1	26							
23	0.	0.0208	0.625	1.042	1.458	1.875	2.292	2.708	3.125	
24	.4792	.5208	.5625	.6042	.6458	.6875	.7292	.7708	.8125	
25	.9792	1.000								
26	0.	0.0323	0.0806	0.2727	0.4580	0.6323	0.7806	0.9330	1.0791	
27	1.4531	.4921	.5091	.5051	.4791	.4311	.3611	.2691	.1561	
28	.56690									
29	4	2	0	20						
30	1	1	45							
31	1	1	0	1						
32	1.	13921.	1911.	191	2.	123	.502	25	.123	
33	2.	13921.	1911.	191	3.	123	.502	27	.123	
34	3.	13921.	1911.	191	23.	123	.409	28	.123	
35	4.	13921.	1911.	191	5.	123	.502	40.	123	
36	5.	13921.	1911.	191	6.	123	.502			
37	6.	13921.	1911.	191	7.	123	.502			
38	7.	13921.	1911.	191	8.	123	.502			
39	8.	13921.	1911.	191	13.	123	.302	30.	123	
40	9.	13921.	1911.	191	10.	123	.502	27.	123	
41	10.	13921.	1911.	191	11.	123	.502	30.	123	
42	11.	13921.	1911.	191	12.	123	.302			
43	12.	13921.	1911.	191	13.	123	.502			
44	13.	13921.	1911.	191	18.	123	.502			
45	14.	13921.	1911.	191	15.	123	.502	24.	123	
46	15.	13921.	1911.	191	16.	123	.302	36.	123	
47	16.	13921.	1911.	191	17.	123	.302			
48	17.	13921.	1911.	191	18.	123	.502			
49	18.	13921.	1911.	191	25.	123	.409			
50	19.	13921.	1911.	191	20.	123	.502	28.	123	
51	20.	13921.	1911.	191	21.	123	.502			
	0	1	2	3	4	5	6	7	8	
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	

FLUID PROPERTY TABLE

PLIQ (PSIA)	TEMP (F)	HLIQ (RTU/LBM)	CONLIQ (RTU/HR-FT-F)	RPLIQ (RTU/LBM-F)	VLIQ (FT ³ /LBM)	VTALIQ (LBM/HR-FT)
10.0000	99.9990	67.9900	.3634	.9980	.0141	1.4440
20.0000	120.0000	87.9700	.3703	.9990	.0142	1.4010
30.0000	250.0000	550.0000	.0150	.5000	10.0000	.0320
40.0000	267.3000	1169.8000	.0146	.5210	10.5000	.0325
50.0000	300.0000	1186.6000	.0169	.5090	11.0400	.0336
60.0000	400.0000	1236.4000	.0196	.4900	12.4200	.0304
70.0000	500.0000	1285.0000	.0228	.4850	14.1700	.0452
80.0000	600.0000	1333.6000	.0262	.4870	15.4900	.0510
90.0000	700.0000	1382.5000	.0299	.4900	17.2000	.0556
100.0000	800.0000	1432.1000	.0337	.5000	18.7000	.0614
110.0000	900.0000	1482.5000	.0377	.5080	20.2000	.0672
120.0000	1000.0000	1533.7000	.0419	.5170	21.7000	.0730
230.0000	1500.0000	1803.1000	.0638	.5600	29.1700	.0927

FRICTION FACTOR CORRELATIONS

TYPE 1 $f_{MAX} = .185 \cdot RE^{-.200} + .0000 \cdot RE^{-(.0000)} + .0000$ OR $(.44 \cdot 1000 \cdot RE^{-.1000} + .0000)$

TYPE 2 $f_{MAX} = .316 \cdot RE^{-.250} + .0000 \cdot RE^{-(.0000)} + .0000$ OR $(.44 \cdot 1000 \cdot RE^{-.1000} + .0000)$

HEAT TRANSFER CORRELATIONS

TYPE 1 $H = K/D (.021 \cdot RE^{.800} \cdot PR^{.400} + 0.000)$

TYPE 2 $H = K/D (.000 \cdot RE^{.800} \cdot PR^{.400} + .0000)$

HEAT FLUX DISTRIBUTION

X/L RELATIVE FLUX PROFILES

0.000	1
.021	0.000
.063	.032
.104	.081
.146	.273
.188	.458
.229	.632
.271	.781
.313	.933
.354	1.079
.396	1.205
.438	1.309
.479	1.392
.521	1.453
.563	1.492
.604	1.509
.646	1.505
.688	1.479
.729	1.431
.771	1.351
.813	1.269
.854	1.156
.896	1.022
.938	.868
.979	.709
1.000	.567
	0.000

ASSEMBLY NUMBER 1 INPUT DESCRIPTION

AXIAL HEAT FLUX PROFILE NUMBER 1

HEAT FLUX VS. TIME PROFILE NUMBER 0

HEAT TRANSFER CORRELATION NUMBER 1

INLET FLOW VS. TIME PROFILE NUMBER 0

SURFACE INPUT DATA FOR ASSEMBLY NUMBER					1	HYDRAULIC	(ADJACENT CHANNEL NO., SPACING, HORIZ. C. V. LENGTH)									
LOCAL	GLOBAL	FRICTN	AREA	WETTED	HEATED	DIAMETER										
CH NO	CH NO	FACTOR	(SQ-IN)	PERIM.	PERIM.	(IN)										
		TYPE		(IN)	(IN)											
1	1	1	.139200	1.191000	1.191000	.467506	(2, .123, .502)	(5, .123, .502)	(22, .123, .426)	(26, .123, .409)						
2	2	1	.139200	1.191000	1.191000	.467506	(3, .123, .502)	(6, .123, .502)	(27, .123, .409)	(0, .000, .000)						
3	3	1	.139200	1.191000	1.191000	.467506	(2, .123, .426)	(7, .123, .502)	(28, .123, .409)	(0, .000, .000)						
4	4	1	.139200	1.191000	1.191000	.467506	(5, .123, .502)	(9, .123, .502)	(40, .123, .409)	(22, .123, .426)						
5	5	1	.139200	1.191000	1.191000	.467506	(4, .123, .502)	(10, .123, .502)	(0, .000, .000)	(0, .000, .000)						
6	6	1	.139200	1.191000	1.191000	.467506	(7, .123, .502)	(11, .123, .502)	(0, .000, .000)	(0, .000, .000)						
7	7	1	.139200	1.191000	1.191000	.467506	(8, .123, .502)	(12, .123, .502)	(0, .000, .000)	(0, .000, .000)						
8	8	1	.139200	1.191000	1.191000	.467506	(13, .123, .502)	(10, .123, .409)	(23, .123, .426)	(0, .000, .000)						
9	9	1	.139200	1.191000	1.191000	.467506	(10, .123, .502)	(14, .123, .502)	(30, .123, .409)	(0, .000, .000)						
10	10	1	.139200	1.191000	1.191000	.467506	(11, .123, .502)	(15, .123, .502)	(0, .000, .000)	(0, .000, .000)						
11	11	1	.139200	1.191000	1.191000	.467506	(12, .123, .502)	(16, .123, .502)	(0, .000, .000)	(0, .000, .000)						
12	12	1	.139200	1.191000	1.191000	.467506	(13, .123, .502)	(17, .123, .502)	(0, .000, .000)	(0, .000, .000)						
13	13	1	.139200	1.191000	1.191000	.467506	(18, .123, .502)	(18, .123, .409)	(0, .000, .000)	(0, .000, .000)						
14	14	1	.139200	1.191000	1.191000	.467506	(15, .123, .502)	(24, .123, .426)	(24, .123, .409)	(0, .000, .000)						
15	15	1	.139200	1.191000	1.191000	.467506	(16, .123, .502)	(19, .123, .502)	(0, .000, .000)	(0, .000, .000)						
16	16	1	.139200	1.191000	1.191000	.467506	(17, .123, .502)	(20, .123, .502)	(0, .000, .000)	(0, .000, .000)						
17	17	1	.139200	1.191000	1.191000	.467506	(18, .123, .502)	(21, .123, .502)	(0, .000, .000)	(0, .000, .000)						
18	18	1	.139200	1.191000	1.191000	.467506	(25, .123, .426)	(22, .123, .409)	(0, .000, .000)	(0, .000, .000)						
19	19	1	.139200	1.191000	1.191000	.467506	(20, .123, .502)	(26, .123, .409)	(24, .123, .426)	(0, .000, .000)						
20	20	1	.139200	1.191000	1.191000	.467506	(21, .123, .502)	(23, .123, .409)	(0, .000, .000)	(0, .000, .000)						
21	21	1	.139200	1.191000	1.191000	.467506	(25, .123, .426)	(24, .123, .409)	(0, .000, .000)	(0, .000, .000)						
22	22	1	.069600	.595400	.595400	.467585	(41, .314, .331)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
23	23	1	.069600	.595400	.595400	.467585	(29, .331, .314)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
24	24	1	.069600	.595400	.595400	.467585	(37, .331, .314)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
25	25	1	.069600	.595400	.595400	.467585	(33, .331, .314)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
26	26	1	.127000	1.451000	.716100	.350103	(27, .126, .502)	(41, .203, .712)	(0, .000, .000)	(0, .000, .000)						
27	27	1	.101700	1.097000	.502000	.370830	(28, .126, .502)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
28	28	1	.127000	1.451000	.716100	.350103	(29, .203, .712)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
29	29	1	.239500	1.478000	.651300	.648173	(30, .203, .712)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
30	30	1	.127000	1.451000	.716100	.350103	(31, .126, .502)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
31	31	1	.101700	1.097000	.502000	.370830	(32, .126, .502)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
32	32	1	.127000	1.451000	.716100	.350103	(33, .203, .712)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
33	33	1	.239500	1.478000	.651300	.648173	(34, .203, .712)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
34	34	1	.127000	1.451000	.716100	.350103	(35, .126, .502)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
35	35	1	.101700	1.097000	.502000	.370830	(36, .126, .502)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
36	36	1	.127000	1.451000	.716100	.350103	(37, .203, .712)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
37	37	1	.239500	1.478000	.651300	.648173	(38, .203, .712)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
38	38	1	.127000	1.451000	.716100	.350103	(39, .126, .502)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
39	39	1	.101700	1.097000	.502000	.370830	(40, .126, .502)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
40	40	1	.127000	1.451000	.716100	.350103	(41, .203, .712)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
41	41	1	.239500	1.478000	.651300	.648173	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
42	42	2	.205000	6.307000	0.000000	.130014	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
43	43	2	.205000	6.307000	0.000000	.130014	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
44	44	2	.205000	6.307000	0.000000	.130014	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						
45	45	2	.205000	6.307000	0.000000	.130014	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)	(0, .000, .000)						

INTRASSEMBLY THERMAL CONNECTION DATA FOR ASSEMBLY NUMBER 1

CONNECTION NO.	WALL AVERAGE HEAT CAPACITY (B/FT ² -F)	WIDTH OF CONNECTION (FT)	CHANNEL NO.	CONDUCTIVE RESISTANCE (FT ² -B-F/R)	CHANNEL NO.	CONDUCTIVE RESISTANCE (FT ² -B-F/R)	DELAY HEAT PARAMETER (FT)
1	1.320	.062	26	3.3000	42	3.3000	.001133
2	2.205	.042	27	5.0630	42	5.0630	.001133
3	1.320	.062	28	3.3000	42	3.3000	.001133
4	.815	.068	29	2.0380	42	2.0380	.001133
5	1.320	.062	30	3.3040	43	3.3000	.001133
6	2.025	.042	31	5.0630	43	5.0630	.001133
7	1.320	.062	32	3.3000	43	3.3000	.001133
8	.815	.068	33	2.0380	43	2.0380	.001133
9	1.320	.062	34	3.3000	44	3.3000	.001133
10	2.025	.042	35	5.0630	44	5.0630	.001133
11	1.320	.062	36	3.3000	44	3.3000	.001133
12	.815	.068	37	2.0380	44	2.0380	.001133
13	1.320	.062	38	3.3000	45	3.3000	.001133
14	2.025	.042	39	5.0630	45	5.0630	.001133
15	1.320	.062	40	3.3000	45	3.3000	.001133
16	.815	.068	41	2.0630	45	2.0630	.001133

ROD INPUT DATA FOR ASSEMBLY NUMBER 1

LOCAL ROD NO.	GLOBAL ROD NO.	TYPE NO.	DIAM (IN)	RADIAL POWER FACTOR
1	1	1	.3790	1.0400
2	2	1	.3790	.9700
3	3	1	.3790	.9800
4	4	1	.3790	1.0500
5	5	1	.3790	1.0500
6	6	1	.3790	.9600
7	7	1	.3790	.9200
8	8	1	.3790	.9300
9	9	1	.3790	.9800
10	10	1	.3790	1.0600
11	11	1	.3790	.9900
12	12	1	.3790	.9300
13	13	1	.3790	.9000
14	14	1	.3790	.9200
15	15	1	.3790	.9500
16	16	1	.3790	1.0100
17	17	1	.3790	1.0000
18	18	1	.3790	.9500
19	19	1	.3790	.9200
20	20	1	.3790	0.0000
21	21	1	.3790	.9600
22	22	1	.3790	1.0300
23	23	1	.3790	1.0900
24	24	1	.3790	1.0000
25	25	1	.3790	.9600
26	26	1	.3790	.9700
27	27	1	.3790	1.0300
28	28	1	.3790	1.1300
29	29	1	.3790	1.1000
30	30	1	.3790	1.0400
31	31	1	.3790	1.0500
32	32	1	.3790	1.1300

FRACTION OF POWER TO ADJACENT CHANNELS (ADJ. CHANNEL NO.)

.3510 (26)	.2500 (1)	.1250 (25)	.2740 (41)	-0.0000 (0)	-0.0000 (0)
.2500 (27)	.2500 (2)	.2500 (1)	.2500 (26)	-0.0000 (0)	-0.0000 (0)
.2500 (28)	.2500 (3)	.2500 (2)	.2500 (27)	-0.0000 (0)	-0.0000 (0)
.2740 (29)	.1250 (23)	.2500 (4)	.3510 (28)	-0.0000 (0)	-0.0000 (0)
.1250 (22)	.2500 (4)	.3510 (40)	.2740 (41)	-0.0000 (0)	-0.0000 (0)
.2500 (1)	.2500 (5)	.2500 (4)	.2500 (22)	-0.0000 (0)	-0.0000 (0)
.2500 (2)	.2500 (6)	.2500 (5)	.2500 (1)	-0.0000 (0)	-0.0000 (0)
.2500 (3)	.2500 (7)	.2500 (6)	.2500 (2)	-0.0000 (0)	-0.0000 (0)
.2500 (23)	.2500 (8)	.2500 (7)	.2500 (3)	-0.0000 (0)	-0.0000 (0)
.2740 (29)	.3510 (30)	.2500 (8)	.1250 (23)	-0.0000 (0)	-0.0000 (0)
.2500 (4)	.2500 (9)	.2500 (30)	.2500 (40)	-0.0000 (0)	-0.0000 (0)
.2500 (5)	.2500 (10)	.2500 (9)	.2500 (4)	-0.0000 (0)	-0.0000 (0)
.2500 (6)	.2500 (11)	.2500 (10)	.2500 (5)	-0.0000 (0)	-0.0000 (0)
.2500 (7)	.2500 (12)	.2500 (11)	.2500 (6)	-0.0000 (0)	-0.0000 (0)
.2500 (8)	.2500 (13)	.2500 (12)	.2500 (7)	-0.0000 (0)	-0.0000 (0)
.2500 (30)	.2500 (31)	.2500 (13)	.2500 (8)	-0.0000 (0)	-0.0000 (0)
.2500 (9)	.2500 (14)	.2500 (30)	.2500 (30)	-0.0000 (0)	-0.0000 (0)
.2500 (10)	.2500 (15)	.2500 (14)	.2500 (9)	-0.0000 (0)	-0.0000 (0)
.2500 (11)	.2500 (16)	.2500 (15)	.2500 (10)	-0.0000 (0)	-0.0000 (0)
.2500 (12)	.2500 (17)	.2500 (16)	.2500 (11)	-0.0000 (0)	-0.0000 (0)
.2500 (13)	.2500 (18)	.2500 (17)	.2500 (12)	-0.0000 (0)	-0.0000 (0)
.2500 (31)	.2500 (32)	.2500 (18)	.2500 (13)	-0.0000 (0)	-0.0000 (0)
.2500 (14)	.1250 (24)	.2740 (37)	.3510 (38)	-0.0000 (0)	-0.0000 (0)
.2500 (15)	.2500 (19)	.2500 (20)	.2500 (14)	-0.0000 (0)	-0.0000 (0)
.2500 (16)	.2500 (20)	.2500 (19)	.2500 (15)	-0.0000 (0)	-0.0000 (0)
.2500 (17)	.2500 (21)	.2500 (20)	.2500 (16)	-0.0000 (0)	-0.0000 (0)
.2500 (18)	.2500 (25)	.2500 (21)	.2500 (17)	-0.0000 (0)	-0.0000 (0)
.3510 (32)	.2740 (33)	.1250 (25)	.2500 (18)	-0.0000 (0)	-0.0000 (0)
.2500 (19)	.3510 (36)	.2740 (37)	.1250 (24)	-0.0000 (0)	-0.0000 (0)
.2500 (20)	.2500 (35)	.2500 (34)	.2500 (19)	-0.0000 (0)	-0.0000 (0)
.2500 (21)	.2500 (34)	.2500 (35)	.2500 (20)	-0.0000 (0)	-0.0000 (0)
.1250 (25)	.2740 (33)	.3510 (38)	.2500 (21)	-0.0000 (0)	-0.0000 (0)

ASSEMBLY NUMBER 2 INPUT DESCRIPTION

AXIAL HEAT FLUX PROFILE NUMBER 1
HEAT FLUX VS. TIME PROFILE NUMBER 0

HEAT TRANSFER CORRELATION NUMBER 2
INLET FLOW VS. TIME PROFILE NUMBER 0

SUBCHANNEL INPUT DATA FOR ASSEMBLY NUMBER 2

LOCAL CH NO	GLOBAL CH NO	FRICTN FACTOR	AREA (SQ-IN)	HEATED PERIM. (IN)	HEATED PERIM. (IN)	HYDRAULIC DIAMETER (IN)	(ADJACENT CHANNEL NO., SPACING, NOM. C. V. LENGTH)
1	46	2	10.000000	1.000000	0.000000	40.000000	(0,-.000,-.000)(0,-.000,-.000)(0,-.000,-.000)(0,-.000,-.000)

THERMAL PROPERTIES OF FUEL MATERIAL

3 ORDER OF COLLOCATION

FUEL PROPERTIES				CLAD PROPERTIES				GAP COND. COL GEOM SYM IDTYP			
TYPE NO.	COND. (B/HR-FT-F)	SP. HEAT (B/LB-F)	DENSITY (LB/FT3)	DIA. (IN.)	COND. (B/HR-FT-F)	SP. HEAT (B/LB-F)	DENSITY (LB/FT3)	THICK. (IN.)	GAP COND. (B/HR-FT2-F)	COL GEOM SYM	IDTYP
1	2.62	.0750	647.5	.3250	11.40	.0440	405.0	.0225	600.00	1	1

LOSS COEFFICIENT INPUT DATA

ASSEMBLY NO.	LOCAL CH NO.	GLOBAL CH NO.	AXIAL NODE	RELATIVE HEIGHT (X/L)	FORCING FUNCTION	LOSS COEFFICIENT	DIVERTED FLOW GAP NO.	OPTION FLOW PERCENT
1	1	1	2	.0140	0	.4	0	.0000
1	2	2	2	.0140	0	.4	0	.0000
1	3	3	2	.0140	0	.4	0	.0000
1	4	4	2	.0140	0	.4	0	.0000
1	5	5	2	.0140	0	.4	0	.0000
1	6	6	2	.0140	0	.4	0	.0000
1	7	7	2	.0140	0	.4	0	.0000
1	8	8	2	.0140	0	.4	0	.0000
1	9	9	2	.0140	0	.4	0	.0000
1	10	10	2	.0140	0	.4	0	.0000
1	11	11	2	.0140	0	.4	0	.0000
1	12	12	2	.0140	0	.4	0	.0000
1	13	13	2	.0140	0	.4	0	.0000
1	14	14	2	.0140	0	.4	0	.0000
1	15	15	2	.0140	0	.4	0	.0000
1	16	16	2	.0140	0	.4	0	.0000
1	17	17	2	.0140	0	.4	0	.0000
1	18	18	2	.0140	0	.4	0	.0000
1	19	19	2	.0140	0	.4	0	.0000
1	20	20	2	.0140	0	.4	0	.0000
1	21	21	2	.0140	0	.4	0	.0000
1	22	22	2	.0140	0	.4	0	.0000
1	23	23	2	.0140	0	.4	0	.0000
1	24	24	2	.0140	0	.4	0	.0000
1	25	25	2	.0140	0	.4	0	.0000
1	26	26	2	.0140	0	.4	0	.0000
1	27	27	2	.0140	0	.4	0	.0000
1	28	28	2	.0140	0	.4	0	.0000
1	29	29	2	.0140	0	.4	0	.0000
1	30	30	2	.0140	0	.4	0	.0000
1	31	31	2	.0140	0	.4	0	.0000

1	32	32	2	.0140	0	.A	0	-.0000
1	33	33	2	.0140	0	.A	0	-.0000
1	34	34	2	.0140	0	.A	0	-.0000
1	35	35	2	.0140	0	.A	0	-.0000
1	36	36	2	.0140	0	.A	0	-.0000
1	37	37	2	.0140	0	.A	0	-.0000
1	38	38	2	.0140	0	.A	0	-.0000
1	39	39	2	.0140	0	.A	0	-.0000
1	40	40	2	.0140	0	.A	0	-.0000
1	41	41	2	.0140	0	.A	0	-.0000
1	42	42	2	.0140	0	0.0	0	-.0000
1	43	43	2	.0140	0	0.0	0	-.0000
1	44	44	2	.0140	0	0.0	0	-.0000
1	45	45	2	.0140	0	0.0	0	-.0000
2	1	46	2	.0140	0	0.0	0	-.0000
1	1	1	15	.5560	0	.A	0	-.0000
1	2	2	15	.5560	0	.A	0	-.0000
1	3	3	15	.5560	0	.A	0	-.0000
1	4	4	15	.5560	0	.A	0	-.0000
1	5	5	15	.5560	0	.A	0	-.0000
1	6	6	15	.5560	0	.A	0	-.0000
1	7	7	15	.5560	0	.A	0	-.0000
1	8	8	15	.5560	0	.A	0	-.0000
1	9	9	15	.5560	0	.A	0	-.0000
1	10	10	15	.5560	0	.A	0	-.0000
1	11	11	15	.5560	0	.A	0	-.0000
1	12	12	15	.5560	0	.A	0	-.0000
1	13	13	15	.5560	0	.A	0	-.0000
1	14	14	15	.5560	0	.A	0	-.0000
1	15	15	15	.5560	0	.A	0	-.0000
1	16	16	15	.5560	0	.A	0	-.0000
1	17	17	15	.5560	0	.A	0	-.0000
1	18	18	15	.5560	0	.A	0	-.0000
1	19	19	15	.5560	0	.A	0	-.0000
1	20	20	15	.5560	0	.A	0	-.0000
1	21	21	15	.5560	0	.A	0	-.0000
1	22	22	15	.5560	0	.A	0	-.0000
1	23	23	15	.5560	0	.A	0	-.0000
1	24	24	15	.5560	0	.A	0	-.0000
1	25	25	15	.5560	0	.A	0	-.0000
1	26	26	15	.5560	0	.A	0	-.0000
1	27	27	15	.5560	0	.A	0	-.0000
1	28	28	15	.5560	0	.A	0	-.0000
1	29	29	15	.5560	0	.A	0	-.0000
1	30	30	15	.5560	0	.A	0	-.0000
1	31	31	15	.5560	0	.A	0	-.0000
1	32	32	15	.5560	0	.A	0	-.0000
1	33	33	15	.5560	0	.A	0	-.0000
1	34	34	15	.5560	0	.A	0	-.0000
1	35	35	15	.5560	0	.A	0	-.0000
1	36	36	15	.5560	0	.A	0	-.0000
1	37	37	15	.5560	0	.A	0	-.0000
1	38	38	15	.5560	0	.A	0	-.0000

1	39	39	15	.5560	0	.3	0	-.0000
1	40	40	15	.5560	0	.3	0	-.0000
1	41	41	15	.5560	0	.3	0	-.0000
1	42	42	15	.5560	0	0.3	0	-.0000
1	43	43	15	.5560	0	0.3	0	-.0000
1	44	44	15	.5560	0	0.3	0	-.0000
1	45	45	15	.5560	0	0.3	0	-.0000
2	1	46	15	.5560	0	0.3	0	-.0000
1	1	1	25	.9860	0	.3	0	-.0000
1	2	2	25	.9860	0	.3	0	-.0000
1	3	3	25	.9860	0	.3	0	-.0000
1	4	4	25	.9860	0	.3	0	-.0000
1	5	5	25	.9860	0	.3	0	-.0000
1	6	6	25	.9860	0	.3	0	-.0000
1	7	7	25	.9860	0	.3	0	-.0000
1	8	8	25	.9860	0	.3	0	-.0000
1	9	9	25	.9860	0	.3	0	-.0000
1	10	10	25	.9860	0	.3	0	-.0000
1	11	11	25	.9860	0	.3	0	-.0000
1	12	12	25	.9860	0	.3	0	-.0000
1	13	13	25	.9860	0	.3	0	-.0000
1	14	14	25	.9860	0	.3	0	-.0000
1	15	15	25	.9860	0	.3	0	-.0000
1	16	16	25	.9860	0	.3	0	-.0000
1	17	17	25	.9860	0	.3	0	-.0000
1	18	18	25	.9860	0	.3	0	-.0000
1	19	19	25	.9860	0	.3	0	-.0000
1	20	20	25	.9860	0	.3	0	-.0000
1	21	21	25	.9860	0	.3	0	-.0000
1	22	22	25	.9860	0	.3	0	-.0000
1	23	23	25	.9860	0	.3	0	-.0000
1	24	24	25	.9860	0	.3	0	-.0000
1	25	25	25	.9860	0	.3	0	-.0000
1	26	26	25	.9860	0	.3	0	-.0000
1	27	27	25	.9860	0	.3	0	-.0000
1	28	28	25	.9860	0	.3	0	-.0000
1	29	29	25	.9860	0	.3	0	-.0000
1	30	30	25	.9860	0	.3	0	-.0000
1	31	31	25	.9860	0	.3	0	-.0000
1	32	32	25	.9860	0	.3	0	-.0000
1	33	33	25	.9860	0	.3	0	-.0000
1	34	34	25	.9860	0	.3	0	-.0000
1	35	35	25	.9860	0	.3	0	-.0000
1	36	36	25	.9860	0	.3	0	-.0000
1	37	37	25	.9860	0	.3	0	-.0000
1	38	38	25	.9860	0	.3	0	-.0000
1	39	39	25	.9860	0	.3	0	-.0000
1	40	40	25	.9860	0	.3	0	-.0000
1	41	41	25	.9860	0	.3	0	-.0000
1	42	42	25	.9860	0	0.3	0	-.0000
1	43	43	25	.9860	0	0.3	0	-.0000
1	44	44	25	.9860	0	0.3	0	-.0000
1	45	45	25	.9860	0	0.3	0	-.0000
2	1	46	25	.9860	0	0.3	0	-.0000

INTERASSEMBLY THERMAL CONNECTION DATA			ASSEMBLY	CHANNEL	CONDUCTIVE	ASSEMBLY	CHANNEL	CONDUCTIVE	DECAY HEAT
CONNECTION NO.	WALL AVERAGE HEAT CAPACITY (R/FT ² -F)	WIDTH OF CONNECTION (FT)	NO.	NO.	RESISTANCE (FT ² -S-F/R)	NO.	NO.	RESISTANCE (FT ² -S-F/R)	PARAMETER (FT)
17	.485	.279	1	42	4.2860	2	1	4.2860	.000883
18	.485	.279	1	43	4.2860	2	1	4.2860	.000883
19	.485	.279	1	44	4.2860	2	1	4.2860	.000883
20	.485	.279	1	45	4.2860	2	1	4.2860	.000883

CALCULATION PARAMETERS

LATERAL RESISTANCE FACTOR	.5000
S/L PARAMETER	.5000
TURBULENT MOMENTUM FACTOR	-0.0000
CHANNEL ORIENTATION (DEGREES)	-0.0000
CHANNEL LENGTH (INCHES)	144.0000
NUMBER OF AXIAL NODES	24
TOTAL TRANSIENT TIME (SECONDS)	-0.0000
NUMBER OF TIME STEPS	-0
NOMINAL TIME STEP (SECONDS)	*****
ROLL OPTION (0 = NO ROLL)	0

DATA FOR IMPLICIT SOLUTION

EXTERNAL ITERATION LIMIT	20
INTERNAL ITERATION LIMIT	20
CONVERGENCE FACTORS	
EXTERNAL (DW/W)	.10000
INTERNAL (DP/P)	.00100
FLOW (DF/F)	.01000
ENERGY (DH/H)	.00100
ACCELERATION FACTORS	
CROSS FLOW SOLUTION	.80000
LATERAL DELTA-P FLOW	.70000

AXIAL NODING

NODE NO.	INTEGRAL HEIGHT (IN.)	NODAL LENGTH (IN.)	NODE NO.	INTEGRAL HEIGHT (IN.)	NODAL LENGTH (IN.)	NODE NO.	INTEGRAL HEIGHT (IN.)	NODAL LENGTH (IN.)
1	0.0- 6.0	6.000	2	6.0- 12.0	6.000	3	12.0- 18.0	6.000
4	18.0- 24.0	6.000	5	24.0- 30.0	6.000	6	30.0- 36.0	6.000
7	36.0- 42.0	6.000	8	42.0- 48.0	6.000	9	48.0- 54.0	6.000
10	54.0- 60.0	6.000	11	60.0- 66.0	6.000	12	66.0- 72.0	6.000
13	72.0- 78.0	6.000	14	78.0- 84.0	6.000	15	84.0- 90.0	6.000
16	90.0- 96.0	6.000	17	96.0- 102.0	6.000	18	102.0- 108.0	6.000
19	108.0- 114.0	6.000	20	114.0- 120.0	6.000	21	120.0- 126.0	6.000
22	126.0- 132.0	6.000	23	132.0- 138.0	6.000	24	138.0- 144.0	6.000

MOMENTUM EQUATIONS WILL BE SOLVED DIRECTLY AT EACH AXIAL LEVEL USING SCHEME

MIXING PARAMETERS				FORCED MIXING		CONDUCTION MIXING
ASSEMBLY TYPE NO.	MIXING CORRELATION	MIXING COEFFICIENTS		MODEL	DIRECTION	GEOMETRY FACTOR
		ABETA	BBETA		PARAMETER	
1	1	.015	-0.000	NONE	0.000	0.000
2	1	.015	-0.000	NONE	0.000	0.000

OPERATING CONDITIONS

SYSTEM PRESSURE = 225.0 PSIA
 INLET ENTHALPY = 325.0 BTU/LBM
 INLET TEMPERATURE = 0.000 DEGREES F
 NOMINAL MASS FLUX = .077 MILLION LBM/FT2-HR
 NOMINAL POWER DENSITY = 2.2702 MILLION BTU/HR-FT3

INDIVIDUAL SUBCHANNEL TEMPERATURE SPECIFIED (CHANNEL-TEMPERATURE)

(1 = 325.0) (2 = 325.0) (3 = 325.0) (4 = 325.0) (5 = 325.0) (6 = 325.0) (7 = 325.0) (8 = 325.0)
 (9 = 325.0) (10 = 325.0) (11 = 325.0) (12 = 325.0) (13 = 325.0) (14 = 325.0) (15 = 325.0) (16 = 325.0)
 (17 = 325.0) (18 = 325.0) (19 = 325.0) (20 = 325.0) (21 = 325.0) (22 = 325.0) (23 = 325.0) (24 = 325.0)
 (25 = 325.0) (26 = 325.0) (27 = 325.0) (28 = 325.0) (29 = 325.0) (30 = 325.0) (31 = 325.0) (32 = 325.0)
 (33 = 325.0) (34 = 325.0) (35 = 325.0) (36 = 325.0) (37 = 325.0) (38 = 325.0) (39 = 325.0) (40 = 325.0)
 (41 = 325.0) (42 = 325.0) (43 = 325.0) (44 = 325.0) (45 = 325.0) (46 = 100.0)

ASSEMBLY MASS FLUX FRACTIONS (ASSEMBLY = FLUX FRACTION)

(1 = 1.000E+00) (2 = 6.767E+00)

INDIVIDUAL SUBCHANNEL FLOWS SPECIFIED (CHANNEL-FLOW)

(1 = 2.057E-02) (2 = 2.057E-02) (3 = 2.057E-02) (4 = 2.057E-02) (5 = 2.057E-02) (6 = 2.057E-02)
 (7 = 2.057E-02) (8 = 2.057E-02) (9 = 2.057E-02) (10 = 2.057E-02) (11 = 2.057E-02) (12 = 2.057E-02)
 (13 = 2.057E-02) (14 = 2.057E-02) (15 = 2.057E-02) (16 = 2.057E-02) (17 = 2.057E-02) (18 = 2.057E-02)
 (19 = 2.057E-02) (20 = 2.057E-02) (21 = 2.057E-02) (22 = 1.029E-02) (23 = 1.029E-02) (24 = 1.029E-02)
 (25 = 1.029E-02) (26 = 1.877E-02) (27 = 1.503E-02) (28 = 1.877E-02) (29 = 3.539E-02) (30 = 1.877E-02)
 (31 = 1.503E-02) (32 = 1.877E-02) (33 = 3.539E-02) (34 = 1.877E-02) (35 = 1.503E-02) (36 = 1.877E-02)
 (37 = 3.539E-02) (38 = 1.877E-02) (39 = 1.503E-02) (40 = 1.877E-02) (41 = 3.539E-02) (42 = 2.044E-03)
 (43 = 2.044E-03) (44 = 2.044E-03) (45 = 2.044E-03) (46 = 1.000E+01)

DATA FROM ITERATIVE SOLUTION

ITERATION NO.	TOTAL INTERNAL ITERATIONS	LAST NODE OUT OF CONVERGENCE	MAXIMUM ERROR INTERNAL	EXTERNAL	FLOW	ENTHALPY
		W		F		
1	4306	0	25	0.0000	.0623	.0438
2	4320	15	25	0.0000	.1103	.1637
3	4320	0	25	0.0000	.0347	.0506
4	4320	0	25	0.0000	.0290	.0346
5	4320	0	24	0.0000	.0200	.0312
6	4320	0	24	0.0000	.0130	.0285
7	4320	0	19	0.0000	.0100	.0256
8	4320	0	20	0.0000	.0071	.0231
9	4320	0	21	0.0000	.0045	.0211
10	4320	0	21	0.0000	.0034	.0191
11	4320	0	10	0.0000	.0030	.0172
12	4320	0	11	0.0000	.0020	.0157
13	4320	0	11	0.0000	.0020	.0144
14	4320	0	12	0.0000	.0033	.0131
15	4320	0	12	0.0000	.0035	.0120
16	4320	0	13	0.0000	.0030	.0110
17	4320	0	12	0.0000	.0031	.0102
18	4223	0	0	0.0000	.0027	.0094

COBRA WHOLE CORE CODE RESULTS
CASE 1 NRU SAMPLE PROBLEM

DATE 05/21/80 0 TIME 22.27.27.2

ASSEMBLY AVERAGE RESULTS FOR ASSEMBLY 1 TIME = 0.00000

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (M1R/MR-FT2)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	5.3351	1199.05	325.00	.09	0.000	0.000	.8333	.0675	211.3655	4.40240
6.0	4.8274	1199.13	325.16	.09	0.000	0.000	.8333	.0675	210.6148	4.40240
12.0	4.7031	1199.58	326.04	.09	0.000	0.000	.8333	.0675	210.3773	4.40240
18.0	4.5749	1201.43	329.79	.09	0.000	0.000	.8333	.0675	211.3793	4.40240
24.0	4.4423	1204.65	336.25	.09	0.000	0.000	.8333	.0675	213.4450	4.40240
30.0	4.3056	1209.14	345.25	.09	0.000	0.000	.8333	.0675	216.4036	4.40240
36.0	4.1649	1214.71	356.44	.09	0.000	0.000	.8333	.0675	220.0309	4.40240
42.0	4.0200	1221.38	369.83	.08	0.000	0.000	.8333	.0675	224.3402	4.40240
48.0	3.8708	1229.10	385.35	.08	0.000	0.000	.8333	.0675	229.2741	4.40240
54.0	3.7172	1237.74	402.75	.08	0.000	0.000	.8333	.0675	234.7546	4.40240
60.0	3.5595	1247.12	422.06	.08	0.000	0.000	.8333	.0675	240.6208	4.40240
66.0	3.3979	1257.10	442.59	.08	0.000	0.000	.8333	.0675	246.7714	4.40240
72.0	3.2323	1267.50	464.00	.07	0.000	0.000	.8333	.0675	253.1012	4.40240
78.0	3.0627	1278.18	485.96	.07	0.000	0.000	.8333	.0675	259.5183	4.40240
84.0	2.8895	1288.96	508.15	.07	0.000	0.000	.8333	.0675	265.7352	4.40240
90.0	2.7143	1299.70	530.25	.07	0.000	0.000	.8333	.0675	271.9401	4.40240
96.0	2.5360	1310.24	551.94	.07	0.000	0.000	.8333	.0675	277.9551	4.40240
102.0	1.8731	1320.41	572.87	.07	0.000	0.000	.8333	.0675	283.6790	4.40240
108.0	1.6832	1330.07	592.73	.06	0.000	0.000	.8333	.0675	289.0114	4.40240
114.0	1.4917	1339.03	611.11	.06	0.000	0.000	.8333	.0675	293.8578	4.40240
120.0	1.2994	1347.15	627.74	.06	0.000	0.000	.8333	.0675	298.1382	4.40240
126.0	1.1077	1354.31	642.35	.06	0.000	0.000	.8333	.0675	301.7739	4.40240
132.0	.9175	1360.32	654.53	.06	0.000	0.000	.8333	.0675	304.6787	4.40240
138.0	.7297	1365.17	664.56	.06	0.000	0.000	.8333	.0675	306.8575	4.40240
144.0	0.0000	1368.98	672.35	.06	0.000	0.000	.8333	.0675	308.3270	4.40240

POD POWER DELIVERED TO THE COOLANT 133.993 BTU/SEC .14139 MW

ASSEMBLY AVERAGE RESULTS FOR ASSEMBLY P TIME = 0.00000

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (HR/HP-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	5.1929	67.99	100.00	62.31	0.000	0.000	10.0007	5184	2.3114	10.00000
6.0	4.9745	68.00	100.01	62.31	0.000	0.000	10.0007	5184	2.3114	10.00000
12.0	4.7601	68.02	100.03	62.30	0.000	0.000	10.0007	5184	2.3114	10.00000
18.0	4.5437	68.03	100.04	62.30	0.000	0.000	10.0007	5184	2.3114	10.00000
24.0	4.3273	68.05	100.06	62.30	0.000	0.000	10.0007	5184	2.3114	10.00000
30.0	4.1109	68.07	100.09	62.30	0.000	0.000	10.0007	5184	2.3114	10.00000
36.0	3.8945	68.09	100.10	62.30	0.000	0.000	10.0007	5184	2.3114	10.00000
42.0	3.6781	68.12	100.13	62.30	0.000	0.000	10.0007	5184	2.3114	10.00000
48.0	3.4618	68.15	100.14	62.30	0.000	0.000	10.0007	5184	2.3115	10.00000
54.0	3.2454	68.18	100.17	62.30	0.000	0.000	10.0007	5184	2.3115	10.00000
60.0	3.0290	68.21	100.22	62.30	0.000	0.000	10.0007	5184	2.3115	10.00000
66.0	2.8126	68.25	100.26	62.30	0.000	0.000	10.0007	5184	2.3115	10.00000
72.0	2.5963	68.29	100.30	62.30	0.000	0.000	10.0007	5184	2.3116	10.00000
78.0	2.3799	68.33	100.34	62.30	0.000	0.000	10.0007	5184	2.3116	10.00000
84.0	2.1635	68.37	100.39	62.30	0.000	0.000	10.0007	5184	2.3116	10.00000
90.0	1.9471	68.41	100.42	62.30	0.000	0.000	10.0007	5184	2.3117	10.00000
96.0	1.7308	68.45	100.46	62.30	0.000	0.000	10.0007	5184	2.3117	10.00000
102.0	1.5144	68.50	100.51	62.30	0.000	0.000	10.0007	5184	2.3117	10.00000
108.0	1.2981	68.54	100.55	62.29	0.000	0.000	10.0007	5184	2.3118	10.00000
114.0	1.0817	68.59	100.60	62.29	0.000	0.000	10.0007	5184	2.3118	10.00000
120.0	.8654	68.63	100.64	62.29	0.000	0.000	10.0007	5184	2.3118	10.00000
126.0	.6490	68.67	100.69	62.29	0.000	0.000	10.0007	5184	2.3118	10.00000
132.0	.4327	68.71	100.72	62.29	0.000	0.000	10.0007	5184	2.3119	10.00000
138.0	.2163	68.75	100.76	62.29	0.000	0.000	10.0007	5184	2.3119	10.00000
144.0	0.0000	68.78	100.79	62.29	0.000	0.000	10.0007	5184	2.3119	10.00000

P00 POWER DELIVERED TO THE COOLANT

0.000 BTU/SEC

0.00000 MW

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
 CHANNEL 11
 ASSEMBLY 1

PRESSURE = 225.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (MLB/HP-FT2)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	6.0907	1199.05	325.00	.09	0.000	0.000	.0204	.0765	239.9977	.13920
6.0	5.5093	1199.25	325.41	.09	0.000	0.000	.0204	.0768	240.5879	.13920
12.0	5.3676	1199.77	326.44	.09	0.000	0.000	.0207	.0770	241.8262	.13920
18.0	5.2214	1201.50	329.92	.09	0.000	0.000	.0207	.0773	243.6771	.13920
24.0	5.0703	1204.46	335.85	.09	0.000	0.000	.0208	.0774	246.2171	.13920
30.0	4.9145	1208.59	344.15	.09	0.000	0.000	.0208	.0775	249.4160	.13920
36.0	4.7541	1213.76	354.54	.09	0.000	0.000	.0209	.0776	253.1790	.13920
42.0	4.5889	1220.02	367.11	.08	0.000	0.000	.0209	.0776	257.5572	.13920
48.0	4.4188	1227.35	381.82	.08	0.000	0.000	.0209	.0776	262.5473	.13920
54.0	4.2437	1235.62	398.44	.08	0.000	0.000	.0209	.0776	268.1233	.13920
60.0	4.0640	1244.72	417.12	.08	0.000	0.000	.0209	.0776	274.1707	.13920
66.0	3.8797	1254.52	437.29	.08	0.000	0.000	.0209	.0776	280.6020	.13920
72.0	3.6910	1264.86	458.56	.07	0.000	0.000	.0209	.0777	287.3287	.13920
78.0	3.4977	1275.60	480.67	.07	0.000	0.000	.0207	.0772	294.2638	.13920
84.0	2.7670	1286.59	503.26	.07	0.000	0.000	.0204	.0768	300.1014	.13920
90.0	2.5617	1297.71	526.19	.07	0.000	0.000	.0204	.0769	307.4825	.13920
96.0	2.3520	1308.73	548.83	.07	0.000	0.000	.0207	.0769	315.3614	.13920
102.0	2.1386	1319.49	570.96	.07	0.000	0.000	.0204	.0769	322.4524	.13920
108.0	1.9222	1329.82	592.23	.06	0.000	0.000	.0204	.0769	329.0809	.13920
114.0	1.7039	1339.57	612.20	.06	0.000	0.000	.0204	.0767	335.1643	.13920
120.0	1.4848	1348.56	630.60	.06	0.000	0.000	.0204	.0766	340.6526	.13920
126.0	1.2643	1356.65	647.14	.06	0.000	0.000	.0205	.0765	345.4645	.13920
132.0	1.0496	1363.67	661.49	.06	0.000	0.000	.0205	.0764	349.5070	.13920
138.0	.8395	1369.56	673.54	.06	0.000	0.000	.0205	.0763	352.7554	.13920
144.0	0.0000	1374.40	683.43	.06	0.000	0.000	.0204	.0760	354.5669	.13920

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
 CHANNEL 39
 ASSEMBLY 1

PRESSURE = 229.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (MLB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	6.0909	1199.05	325.00	.09	0.000	0.000	.0150	.0766	239.9977	.10170
6.0	5.5094	1199.18	325.27	.09	0.000	0.000	.0148	.0754	239.1414	.10170
12.0	5.3676	1199.61	326.14	.09	0.000	0.000	.0144	.0736	239.7869	.10170
18.0	5.2213	1201.44	329.79	.09	0.000	0.000	.0141	.0721	227.4376	.10170
24.0	5.0703	1204.69	336.32	.09	0.000	0.000	.0139	.0710	225.8691	.10170
30.0	4.9144	1209.32	345.63	.09	0.000	0.000	.0137	.0701	225.8402	.10170
36.0	4.7540	1215.15	357.34	.08	0.000	0.000	.0136	.0693	227.0629	.10170
42.0	4.5884	1222.21	371.51	.08	0.000	0.000	.0135	.0688	229.4320	.10170
48.0	4.4187	1230.43	388.01	.08	0.000	0.000	.0134	.0683	232.8097	.10170
54.0	4.2436	1239.63	406.65	.08	0.000	0.000	.0133	.0679	237.0614	.10170
60.0	4.0639	1249.63	427.23	.08	0.000	0.000	.0133	.0676	241.9595	.10170
66.0	3.8797	1260.24	449.06	.08	0.000	0.000	.0132	.0673	247.3553	.10170
72.0	3.6910	1271.27	471.75	.07	0.000	0.000	.0132	.0671	253.1066	.10170
78.0	3.4973	1282.53	494.91	.07	0.000	0.000	.0131	.0670	259.1734	.10170
84.0	2.7676	1293.72	517.95	.07	0.000	0.000	.0130	.0703	278.9874	.10170
90.0	2.5616	1304.31	539.74	.07	0.000	0.000	.0130	.0695	282.0722	.10170
96.0	2.3520	1314.82	561.37	.07	0.000	0.000	.0135	.0688	285.5331	.10170
102.0	2.1385	1325.04	582.33	.07	0.000	0.000	.0134	.0682	289.4118	.10170
108.0	1.9222	1334.73	602.32	.06	0.000	0.000	.0133	.0678	293.2932	.10170
114.0	1.7039	1343.71	620.68	.06	0.000	0.000	.0132	.0675	297.0062	.10170
120.0	1.4848	1351.79	637.27	.06	0.000	0.000	.0132	.0672	300.4164	.10170
126.0	1.2663	1358.78	651.57	.06	0.000	0.000	.0131	.0669	303.3565	.10170
132.0	1.0496	1364.53	663.29	.06	0.000	0.000	.0131	.0667	305.6815	.10170
138.0	.8350	1369.00	672.39	.06	0.000	0.000	.0131	.0666	307.4420	.10170
144.0	0.0000	1372.29	679.12	.06	0.000	0.000	.0131	.0701	325.7470	.10170

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS

PRESSURE = 225.0 PSIA

CHANNEL 45
ASSEMBLY 1

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (HR/HP-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	.1904	1199.05	325.00	.09	0.000	0.000	.0021	.0053	16.5112	.20500
2.0	.1845	1188.35	303.52	.09	0.000	0.000	.0021	.0053	16.0070	.20500
4.0	.1787	1182.38	291.74	.09	0.000	0.000	.0021	.0053	15.7237	.20500
6.0	.1727	1182.83	292.67	.09	0.000	0.000	.0021	.0053	15.7059	.20500
8.0	.1666	1187.71	302.22	.09	0.000	0.000	.0021	.0053	15.9783	.20500
10.0	.1603	1195.50	317.86	.09	0.000	0.000	.0021	.0053	16.3494	.20500
12.0	.1539	1204.92	336.74	.09	0.000	0.000	.0021	.0053	16.7283	.20500
14.0	.1470	1215.76	358.55	.08	0.000	0.000	.0021	.0053	17.2943	.20500
16.0	.1399	1227.64	382.42	.08	0.000	0.000	.0021	.0053	17.8493	.20500
18.0	.1326	1239.99	407.39	.08	0.000	0.000	.0021	.0053	18.4303	.20500
20.0	.1250	1252.33	432.77	.08	0.000	0.000	.0021	.0053	19.0100	.20500
22.0	.1171	1264.37	457.53	.07	0.000	0.000	.0021	.0053	19.5753	.20500
24.0	.1090	1275.88	481.24	.07	0.000	0.000	.0021	.0053	20.1151	.20500
26.0	.1007	1286.67	503.43	.07	0.000	0.000	.0021	.0053	20.6200	.20500
28.0	.0921	1296.46	523.54	.07	0.000	0.000	.0021	.0053	21.0709	.20500
30.0	.0834	1305.23	541.63	.07	0.000	0.000	.0021	.0053	21.4674	.20500
32.0	.0745	1312.84	557.34	.07	0.000	0.000	.0021	.0053	21.8148	.20500
34.0	.0653	1319.28	570.52	.07	0.000	0.000	.0021	.0053	22.1066	.20500
36.0	.0560	1324.30	580.87	.07	0.000	0.000	.0021	.0053	22.3367	.20500
38.0	.0466	1327.83	588.13	.07	0.000	0.000	.0021	.0053	22.4989	.20500
40.0	.0372	1329.76	592.10	.06	0.000	0.000	.0021	.0053	22.5840	.20500
42.0	.0277	1330.00	592.59	.06	0.000	0.000	.0021	.0053	22.6023	.20500
44.0	.0183	1328.45	589.40	.06	0.000	0.000	.0021	.0053	22.5349	.20500
46.0	.0091	1325.39	583.11	.07	0.000	0.000	.0021	.0053	22.3995	.20500
48.0	0.0000	1321.38	574.86	.07	0.000	0.000	.0021	.0053	22.2213	.20500

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 1
ASSEMBLY 2

PRESSURE = 225.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (LBS/HP-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	5.1929	67.99	100.00	62.31	0.000	0.000	10.0007	.5184	2.3114	10.00000
6.0	4.9765	68.00	100.01	62.31	0.000	0.000	10.0007	.5184	2.3114	10.00000
12.0	4.7601	68.02	100.03	62.30	0.000	0.000	10.0007	.5184	2.3114	10.00000
18.0	4.5437	68.03	100.04	62.30	0.000	0.000	10.0007	.5184	2.3114	10.00000
24.0	4.3273	68.05	100.04	62.30	0.000	0.000	10.0007	.5184	2.3114	10.00000
30.0	4.1109	68.07	100.05	62.30	0.000	0.000	10.0007	.5184	2.3114	10.00000
36.0	3.8945	68.09	100.10	62.30	0.000	0.000	10.0007	.5184	2.3114	10.00000
42.0	3.6781	68.12	100.13	62.30	0.000	0.000	10.0007	.5184	2.3114	10.00000
48.0	3.4618	68.15	100.14	62.30	0.000	0.000	10.0007	.5184	2.3115	10.00000
54.0	3.2454	68.18	100.19	62.30	0.000	0.000	10.0007	.5184	2.3115	10.00000
60.0	3.0290	68.21	100.22	62.30	0.000	0.000	10.0007	.5184	2.3115	10.00000
66.0	2.8126	68.25	100.26	62.30	0.000	0.000	10.0007	.5184	2.3115	10.00000
72.0	2.5963	68.29	100.30	62.30	0.000	0.000	10.0007	.5184	2.3116	10.00000
78.0	2.3799	68.33	100.34	62.30	0.000	0.000	10.0007	.5184	2.3116	10.00000
84.0	2.1635	68.37	100.38	62.30	0.000	0.000	10.0007	.5184	2.3116	10.00000
90.0	1.9471	68.41	100.42	62.30	0.000	0.000	10.0007	.5184	2.3117	10.00000
96.0	1.7308	68.45	100.44	62.30	0.000	0.000	10.0007	.5184	2.3117	10.00000
102.0	1.5144	68.50	100.51	62.30	0.000	0.000	10.0007	.5184	2.3117	10.00000
108.0	1.2981	68.54	100.55	62.29	0.000	0.000	10.0007	.5184	2.3118	10.00000
114.0	1.0817	68.59	100.60	62.29	0.000	0.000	10.0007	.5184	2.3118	10.00000
120.0	.8654	68.63	100.64	62.29	0.000	0.000	10.0007	.5184	2.3118	10.00000
126.0	.6490	68.67	100.68	62.29	0.000	0.000	10.0007	.5184	2.3118	10.00000
132.0	.4327	68.71	100.72	62.29	0.000	0.000	10.0007	.5184	2.3119	10.00000
138.0	.2163	68.75	100.76	62.29	0.000	0.000	10.0007	.5184	2.3119	10.00000
144.0	0.0000	68.78	100.79	62.29	0.000	0.000	10.0007	.5184	2.3119	10.00000

WJD-WALL TEMPERATURE SUMMARY TIME = 0.0000 SECONDS
(ASSEMBLY NO. = CHANNEL NO.)

AXIAL LEVEL (INCHES)	(1- 27) (1- 42)	(1- 29) (1- 42)	(1- 31) (1- 43)	(1- 33) (1- 43)	(1- 35) (1- 44)	(1- 37) (1- 44)	(1- 39) (1- 45)	(1- 41) (1- 45)	(1- 43) (2- 1)	(1- 45) (2- 1)
6.0	323.09	322.90	323.11	322.92	323.12	323.01	323.10	322.90	244.99	244.79
12.0	323.46	322.98	323.51	323.03	323.54	323.00	323.49	322.96	241.79	241.78
18.0	331.74	330.22	331.92	330.39	332.02	330.32	331.23	330.18	262.13	262.12
24.0	343.48	340.12	343.88	340.50	344.10	340.34	343.67	340.05	287.92	287.85
30.0	358.11	352.21	358.82	352.87	350.20	350.60	358.45	352.07	316.78	316.64
36.0	374.55	365.56	375.62	366.58	376.21	366.17	375.07	365.25	345.26	345.03
42.0	393.57	381.00	395.08	382.45	395.91	381.89	390.32	380.70	376.22	375.88
48.0	414.68	398.11	416.68	400.05	417.79	399.32	415.70	397.70	407.97	407.48
54.0	437.20	416.27	439.79	418.76	441.25	417.84	438.54	415.74	438.47	437.81
60.0	460.86	435.17	464.03	438.26	465.84	437.15	462.53	434.52	467.02	466.19
66.0	484.93	454.73	488.70	458.52	490.87	457.19	486.96	454.02	492.99	491.07
72.0	509.00	474.60	513.36	479.05	515.91	477.54	511.39	473.65	515.95	514.73
78.0	532.68	494.40	537.63	499.52	540.55	497.83	535.45	493.22	535.63	534.20
84.0	555.40	513.37	560.80	519.16	564.07	517.31	558.53	512.20	551.60	549.89
90.0	576.22	533.07	582.11	539.52	585.71	537.52	570.70	531.78	563.95	562.16
96.0	596.01	551.64	602.35	558.71	606.26	556.40	599.22	550.24	572.41	570.84
102.0	614.34	568.90	621.08	576.54	625.30	574.35	618.48	567.02	576.82	574.69
108.0	630.82	584.61	637.87	592.77	642.34	590.33	635.24	583.07	576.99	574.72
114.0	644.96	598.54	652.26	607.15	656.97	604.89	640.63	596.95	572.71	570.31
120.0	656.53	610.49	663.99	619.46	668.90	617.22	661.43	608.86	563.98	561.89
126.0	665.21	620.19	672.74	629.43	677.80	627.26	670.39	618.54	550.64	548.09
132.0	670.70	627.39	678.19	636.77	683.34	634.70	675.88	625.75	532.61	530.83
138.0	673.46	632.49	680.82	641.95	686.01	640.02	678.71	630.87	511.97	509.29
144.0	674.38	635.98	681.36	645.42	686.52	643.64	679.60	634.42	491.56	489.03

CALCULATED ROD TEMPERATURES AT TIME = 0.0000 SECONDS

ROD NO. 13

ASSEMBLY 1

(FUEL TYPE 1 = CYLINDER)

ROD O.D. = .379 (IN.)

ZONE=(FUEL DIA.(IN.)) = 1-(.329)

AXIAL ZONE (IN.)	HEAT FLUX (MTU/HR-FT ²)	TYPE	HSURF (R/H-F-FT ²)	FLUID	CLAN	FUEL TEMPERATURE(F.) (RELATIVE RADTUS(R/DO))	
						T(1) (1.000)	T(2) (0.000)
0.0 - 6.0	.0004	1	91.5	325.5	329.6	330.5	331.6
6.0 - 12.0	.0009	1	91.7	326.7	337.1	339.1	341.9
12.0 - 18.0	.0032	1	91.9	330.9	345.7	372.6	382.3
18.0 - 24.0	.0054	1	92.1	337.8	396.3	407.9	424.2
24.0 - 30.0	.0074	1	92.2	347.4	428.1	444.1	446.5
30.0 - 36.0	.0092	1	92.2	359.3	458.8	474.6	506.2
36.0 - 42.0	.0110	1	92.2	373.5	492.5	516.1	549.2
42.0 - 48.0	.0127	1	92.3	390.0	527.5	554.8	593.1
48.0 - 54.0	.0142	1	92.3	408.6	562.2	592.7	635.4
54.0 - 60.0	.0154	1	92.7	429.1	595.3	628.4	674.8
60.0 - 66.0	.0164	1	93.2	451.0	626.7	661.9	711.3
66.0 - 72.0	.0171	1	93.7	473.9	656.3	693.0	744.5
72.0 - 78.0	.0176	1	94.2	497.4	683.7	721.4	774.3
78.0 - 84.0	.0178	1	94.7	521.2	708.6	748.7	800.2
84.0 - 90.0	.0177	1	95.6	544.9	730.0	768.1	821.4
90.0 - 96.0	.0174	1	95.5	568.2	748.5	785.8	838.3
96.0 - 102.0	.0168	1	97.3	590.6	763.6	799.8	850.5
102.0 - 108.0	.0160	1	98.1	611.7	775.0	809.8	857.6
108.0 - 114.0	.0149	1	98.9	631.3	782.2	814.3	859.3
114.0 - 120.0	.0136	1	99.7	649.0	785.4	814.6	855.6
120.0 - 126.0	.0120	1	100.4	664.6	784.3	810.1	846.4
126.0 - 132.0	.0102	1	101.0	677.6	778.7	800.6	831.4
132.0 - 138.0	.0083	1	101.4	688.1	770.4	788.3	813.5
138.0 - 144.0	.0067	1	101.6	696.2	761.9	776.2	796.3

ITERATIONS = 19

INPUT TRANSIENT TIME COMPLETED

COMMON DUMPED TO TAPE 8

19-PIN WIRE-WRAPPED ASSEMBLY

The COBRA-WC code retains the COBRA-IV-I code's capability to model grid-spaced or wire-wrapped assemblies. A 19-pin wire-wrapped assembly is modeled here to illustrate the use of the wire-wrap model and the auxiliary program GEOM for calculating the problem input.

A cross-sectional view of the bundle is given in Figure E.12. The sub-channels have been numbered to minimize the matrix bandwidth for the direct solution of the momentum equation at each level. The channel numbering is obtained by using the GEOM Option, which allows the standard GEOM numbering scheme to be changed. The geometry of this sample bundle is typical of an LMFBR fuel assembly. Listing of the GEOM input is given in Figure E.13 and the computed input for Card Groups 4, 7, and 8 is listed in Figure E.14. This input is generally written to a scratch file for subsequent use by the COBRA-WC code. Figure E.15 lists the cards for the COBRA-WC run. Note that input from sources

FIGURE E.12. Cross-Sectional View of a 19-Pin Wire-Wrapped Assembly with Subchannel Numbering

```

      1 11      2 17      3 21      4 26      5 20      6 14      7 3      8 4
17 31      10 7      11 12      12 18      13 24      14 27      15 32      16 34
25 1      26 2      27 9      28 16      29 23      30 29      31 36      32 35
33 28      34 22      35 15      36 8
19 PIN WIRE WRAPPED TEST PROBLEM
2
.266 .230-.0001.300 .056-.000
111050
19 .2300.000 0 0 01.000 0

```

FIGURE E.13. Card Input for GEOM for 19-Pin Wire-Wrapped Assembly Problem

```

*** GROUP 4 CARD IMAGES - WRITTEN TO TAPE10 ***

1      11.0146.3613.3613      17.0557.0548      14.0557.0548      6.0557.0548
2      17.0146.3613.3613      21.0557.0548      12.0557.0548
3      21.0146.3613.3613      26.0557.0548      27.0557.0548
4      26.0146.3613.3613      20.0557.0548      31.0557.0548
5      20.0146.3613.3613      14.0557.0548      25.0557.0548
6      14.0146.3613.3613      10.0557.0548
7      3.0146.3613.3613      6.0557.0548      5.0557.0548      1.0557.0548
8      6.0146.3613.3613      4.0557.0548
9      4.0146.3613.3613      7.0557.0548      2.0557.0548
10     7.0146.3613.3613      12.0557.0548      9.0557.0548
11     12.0146.3613.3613      18.0557.0548
12     18.0146.3613.3613      24.0557.0548      16.0557.0548
13     24.0146.3613.3613      27.0557.0548      23.0557.0548
14     27.0146.3613.3613      32.0557.0548
15     32.0146.3613.3613      34.0557.0548      29.0557.0548
16     34.0146.3613.3613      31.0557.0548      36.0557.0548
17     31.0146.3613.3613      33.0557.0548
18     33.0146.3613.3613      30.0557.0548      35.0557.0548
19     30.0146.3613.3613      25.0557.0548      28.0557.0548
20     25.0146.3613.3613      19.0557.0548
21     19.0146.3613.3613      13.0557.0548      22.0557.0548
22     13.0146.3613.3613      10.0557.0548      15.0557.0548
23     10.0146.3613.3613      5.0557.0548
24     5.0146.3613.3613      8.0557.0548
25     1.0265.7886.4215      2.0405.0652      8.0405.0652
26     2.0265.7886.4215      9.0405.0652
27     9.0265.7886.4215      16.0405.0652
28     16.0265.7886.4215      23.0405.0652
29     23.0265.7886.4215      29.0405.0652
30     29.0265.7886.4215      36.0405.0652
31     36.0265.7886.4215      33.0405.0652
32     33.0265.7886.4215      28.0405.0652
33     28.0265.7886.4215      22.0405.0652
34     22.0265.7886.4215      15.0405.0652
35     15.0265.7886.4215      8.0405.0652
36     8.0265.7886.4215

THE DIRECT SOLUTION OF THE MOMENTUM EQUATION WILL REQUIRE A MATRIX OF BANDWIDTH 15

```

FIGURE E.14a. GEOM Computed Input for Card Groups 4, 7, and 8

*** GROUP 7 CARD IMAGES - WRITTEN TO TAPE 9 ***

1	11.000-.917 .417									
2	21.000-.584 .084									
3	31.000 .250-.750									
4	41.000-.750 .250									
5	51.000 .084-.584									
6	61.000-.584 .084									
7	71.000-.917 .417									
8	81.000 .417-.917									
9	91.000-.750 .250									
10	101.000 .250-.750									
11	111.000-.584 .084									
12	121.000 .417-.917									
13	131.000-.917 .417									
14	141.000-.584 .084									
15	151.000 .250-.750									
16	161.000 .084-.584									
17	171.000-.917 .417									
18	181.000 .250-.750									
19	191.000-.750 .250									
20	201.000-.084 .584									
21	211.000-.917 .417									
22	221.000-.750 .250									
23	231.000 .084-.584									
24	241.000-.584 .084									
25	251.000 .917-.417									
26	261.000-.750 .250									
27	271.000-.584 .084									
28	281.000 .917-.417									
29	291.000 .417-.917									
30	301.000-.750 .250									
31	311.000-.584 .084									
32	321.000 .417-.917									
33	331.000-.750 .250									
34	341.000 .250-.750									
35	351.000 .584-.084									
36	361.000 .417-.917									
37	371.000 .250-.750									
38	381.000-.584 .084									
39	391.000 .084-.584									
40	401.000-.417 .917									
41	411.000 .250-.750									
42	421.000-.417 .917									
43	431.000-1.00									
44	441.000 .084									
45	451.000-.917									
46	461.000-.834									
47	471.000-.750									
48	481.000-.667									
49	491.000-.584									
50	501.000 .500									
51	511.000 .417									
52	521.000 .334									
53	531.000 .250									
54	541.000 .167									
55	2	1	1	1	0	0	0	1	1	1
56	1	1	0	0	1	1	0	0	1	1
57	1	0	0	1	0	0	0	0	0	1

FIGURE E.14b. GEOM Computed Input for Card Groups 4, 7, and 8 (contd)

*** GROUP 8 CARD IMAGER - WRITTEN TO TAPE11 ***

1	1.23001.020	11.1667	17.1667	21.1667	26.1667	20.1667	14.1667
2	2.23001.014	11.1667	14.1667	3.1667	6.1667	10.1667	5.1667
3	3.23001.014	11.1667	17.1667	6.1667	4.1667	7.1667	12.1667
4	4.23001.020	17.1667	21.1667	12.1667	18.1667	24.1667	27.1667
5	5.2300.9960	21.1667	26.1667	27.1667	32.1667	34.1667	31.1667
6	6.2300.9960	26.1667	20.1667	31.1667	33.1667	30.1667	25.1667
7	7.23001.020	20.1667	14.1667	25.1667	19.1667	13.1667	10.1667
8	8.23001.006	3.1667	5.1667	1.3333	8.3333		
9	9.23001.006	3.1667	6.1667	4.1667	1.2500	2.2500	
10	10.23001.006	4.1667	7.1667	2.3333	9.3333		
11	11.23001.014	7.1667	12.1667	18.1667	9.2500	16.2500	
12	12.23001.000	18.1667	24.1667	16.3333	23.3333		
13	13.2300.9960	24.1667	27.1667	32.1667	23.2500	29.2500	
14	14.2300.9550	32.1667	34.1667	29.3333	36.3333		
15	15.2300.9550	34.1667	31.1667	33.1667	36.2500	35.2500	
16	16.2300.9550	33.1667	30.1667	35.3333	28.3333		
17	17.2300.9960	30.1667	25.1667	19.1667	28.2500	22.2500	
18	18.23001.020	19.1667	13.1667	22.3333	15.3333		
19	19.23001.014	13.1667	10.1667	5.1667	15.2500	8.2500	

FIGURE E.14c. GEOM Computed Input for Card Groups 4, 7, and 8 (contd)

***** THE FOLLOWING IS AN IMAGE LISTING OF THE COBRA-WC INPUT CARDS *****
 GEOM GENERATED INPUT IS NOT INCLUDED

	0	1	2	3	4	5	6	7	8
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
2		1	1	FFM-5A	RUNDLE	TEST	2	RUN	101.
3		2	1	0	0				
4		.316	-.25	0.0	0.0	0.0	64.0	-1.0	0.0
5		3	1	4					
6		0.0	.8182	.8183	1.00				
7		1.222	1.222	0.0	0.0				
8		4	1	0	0	0			
9		1	1	36	10	1			
10		1	1	1	0	1			
11		2	1	2					
12		2	9	16					
13		2	23	29					
14		2	36	35					
15		2	28	22					
16		2	15	8					
17		7	1	54	0	3	9		
18		12.		.23		.056			
19		8	1	0	0	0	0		
20		1	1	19	11	0			
21		9		5	2	0	0		
22		35.	5.	1.E-5	.01		.6	.6	
23									
24		35							
25		10	1	1	1				
26		1.02	0.0	.3					
27		1	0	.1					
28		11	1						
29		130.		680.	4.491	104.88			
30		1210100	5	0	0	0	2		
31		1	1	3	1	18	1	26	1
32									
33									

	0	1	2	3	4	5	6	7	8
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890

FIGURE E.15. Card Input for COBRA-WC for 19-Pin
 Wire-Wrapped Assembly Problem

other than cards is requested in Card Groups 4, 7, and 8 to retrieve the GEOM results. A list of the edited input and the run results is given in Figure E.16 for the steady-state simulation. Only the heated length of the bundle (36 in.) was modeled using 18 axial nodes. The 0.056-in. wire wrap has a lead length of 12 in. A uniform radial power profile is used with a power density of 160.48 MBtu/hr-ft³. The inlet mass flux was specified as 4.491 Mlbm/hr-ft² at 680°F.

INPUT FOR CASE 1 FFM-5A BUNDLE TEST 2 RUN 101.

SUMMARY OF INPUT OPTIONS

GROUP	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14	N15
2	1	0	0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0
3	1	0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0
4	1	0	0	0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0
7	1	54	0	3	9	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0
8	1	0	0	0	0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0
9	-0	3	2	0	0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0
10	1	1	1	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0
11	1	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0
1210100	5	0	0	0	0	2	-0	-0	-0	-0	-0	-0	-0	-0	-0

FRICTION FACTOR CORRELATIONS

TYPE 1 $f = \text{MAX OF } (.316 \cdot \text{RE}^{.25} + 0.000 \cdot \text{RE}^{.75} + 0.0000) \text{ OR } (24.000 \cdot \text{RE}^{.16} + 0.000)$

HEAT TRANSFER CORRELATIONS

TYPE 1 $H = K/D (.025 \cdot \text{RE}^{.8} \cdot \text{PR}^{.4} + 7.000)$

HEAT FLUX DISTRIBUTION

X/L RELATIVE FLUX PROFILES

X/L	1
0.000	1.222
.218	1.222
.418	0.000
1.000	0.000

FIGURE E.16a. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

ASSEMBLY NUMBER 1 INPUT DESCRIPTION

AXIAL HEAT FLUX PROFILE NUMBER 1
HEAT FLUX VS. TIME PROFILE NUMBER 0

HEAT TRANSFER CORRELATION NUMBER 1
INLET FLOW VS. TIME PROFILE NUMBER 0

SUBCHANNEL INPUT DATA FOR ASSEMBLY NUMBER

LOCAL CH NO	GLOBAL CH NO	FRICTN TYPE	AREA (SQ-IN)	WETTED PERIM. (IN)	HEATED PERIM. (IN)	HYDRAULIC DIAMETER (IN)	(ADJACENT CHANNEL NO., SPACING, MOM. C. V. LENGTH)									
1	1	1	.026500	.788600	.421500	.134415	(2, .041, .065)	(8, .041, .065)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)					
2	2	1	.026500	.788600	.421500	.134415	(9, .041, .065)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
3	3	1	.014600	.361300	.361300	.161639	(6, .056, .055)	(5, .056, .055)	(1, .056, .055)	(0, -.000, 0.000)						
4	4	1	.014600	.361300	.361300	.161639	(7, .056, .055)	(2, .056, .055)	(0, -.000, -.000)	(0, -.000, 0.000)						
5	5	1	.014600	.361300	.361300	.161639	(8, .056, .055)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
6	6	1	.014600	.361300	.361300	.161639	(4, .056, .055)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
7	7	1	.014600	.361300	.361300	.161639	(12, .056, .055)	(9, .056, .055)	(0, -.000, -.000)	(0, -.000, 0.000)						
8	8	1	.026500	.788600	.421500	.134415	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
9	9	1	.026500	.788600	.421500	.134415	(16, .041, .065)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
10	10	1	.014600	.361300	.361300	.161639	(5, .056, .055)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
11	11	1	.014600	.361300	.361300	.161639	(17, .056, .055)	(14, .056, .055)	(6, .056, .055)	(0, -.000, 0.000)						
12	12	1	.014600	.361300	.361300	.161639	(18, .056, .055)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
13	13	1	.014600	.361300	.361300	.161639	(10, .056, .055)	(15, .056, .055)	(0, -.000, -.000)	(0, -.000, 0.000)						
14	14	1	.014600	.361300	.361300	.161639	(10, .056, .055)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
15	15	1	.026500	.788600	.421500	.134415	(8, .041, .065)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
16	16	1	.026500	.788600	.421500	.134415	(23, .041, .065)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
17	17	1	.014600	.361300	.361300	.161639	(21, .056, .055)	(12, .056, .055)	(0, -.000, -.000)	(0, -.000, 0.000)						
18	18	1	.014600	.361300	.361300	.161639	(24, .056, .055)	(16, .056, .055)	(0, -.000, -.000)	(0, -.000, 0.000)						
19	19	1	.014600	.361300	.361300	.161639	(13, .056, .055)	(22, .056, .055)	(0, -.000, -.000)	(0, -.000, 0.000)						
20	20	1	.014600	.361300	.361300	.161639	(14, .056, .055)	(25, .056, .055)	(0, -.000, -.000)	(0, -.000, 0.000)						
21	21	1	.014600	.361300	.361300	.161639	(26, .056, .055)	(27, .056, .055)	(0, -.000, -.000)	(0, -.000, 0.000)						
22	22	1	.026500	.788600	.421500	.134415	(15, .041, .065)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
23	23	1	.026500	.788600	.421500	.134415	(29, .041, .065)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
24	24	1	.014600	.361300	.361300	.161639	(27, .056, .055)	(23, .056, .055)	(0, -.000, -.000)	(0, -.000, 0.000)						
25	25	1	.014600	.361300	.361300	.161639	(19, .056, .055)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
26	26	1	.014600	.361300	.361300	.161639	(20, .056, .055)	(31, .056, .055)	(0, -.000, -.000)	(0, -.000, 0.000)						
27	27	1	.014600	.361300	.361300	.161639	(32, .056, .055)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
28	28	1	.026500	.788600	.421500	.134415	(22, .041, .065)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
29	29	1	.026500	.788600	.421500	.134415	(36, .041, .065)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
30	30	1	.014600	.361300	.361300	.161639	(25, .056, .055)	(28, .056, .055)	(0, -.000, -.000)	(0, -.000, 0.000)						
31	31	1	.014600	.361300	.361300	.161639	(33, .056, .055)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
32	32	1	.014600	.361300	.361300	.161639	(34, .056, .055)	(29, .056, .055)	(0, -.000, -.000)	(0, -.000, 0.000)						
33	33	1	.014600	.361300	.361300	.161639	(30, .056, .055)	(35, .056, .055)	(0, -.000, -.000)	(0, -.000, 0.000)						
34	34	1	.014600	.361300	.361300	.161639	(31, .056, .055)	(36, .056, .055)	(0, -.000, -.000)	(0, -.000, 0.000)						
35	35	1	.026500	.788600	.421500	.134415	(28, .041, .065)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						
36	36	1	.026500	.788600	.421500	.134415	(35, .041, .065)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, 0.000)						

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FIGURE E.16b. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

ROD INPUT DATA FOR ASSEMBLY NUMBER 1					FRACTION OF POWER TO ADJACENT CHANNELS (ADJ. CHANNEL NO.)					
LOCAL ROD NO.	GLOBAL ROD NO.	TYPE NO.	DIAM (IN)	RADIAL POWER FACTOR						
1	1	1	.2300	1.0200	.1667 (11)	.1667 (17)	.1667 (21)	.1667 (26)	.1667 (20)	.1667 (14)
2	2	1	.2300	1.0140	.1667 (11)	.1667 (14)	.1667 (7)	.1667 (6)	.1667 (10)	.1667 (5)
3	3	1	.2300	1.0140	.1667 (11)	.1667 (17)	.1667 (4)	.1667 (4)	.1667 (7)	.1667 (12)
4	4	1	.2300	1.0200	.1667 (17)	.1667 (21)	.1667 (12)	.1667 (18)	.1667 (24)	.1667 (27)
5	5	1	.2300	.9960	.1667 (21)	.1667 (26)	.1667 (27)	.1667 (32)	.1667 (34)	.1667 (31)
6	6	1	.2300	.9960	.1667 (26)	.1667 (20)	.1667 (31)	.1667 (33)	.1667 (30)	.1667 (25)
7	7	1	.2300	1.0200	.1667 (20)	.1667 (14)	.1667 (25)	.1667 (19)	.1667 (13)	.1667 (10)
8	8	1	.2300	1.0060	.1667 (3)	.1667 (5)	.3333 (1)	.3333 (4)	-0.0000 (0)	-0.0000 (0)
9	9	1	.2300	1.0060	.1667 (3)	.1667 (6)	.1667 (4)	.2500 (1)	.2500 (2)	-0.0000 (0)
10	10	1	.2300	1.0060	.1667 (4)	.1667 (7)	.3333 (2)	.3333 (9)	-0.0000 (0)	-0.0000 (0)
11	11	1	.2300	1.0140	.1667 (7)	.1667 (12)	.1667 (18)	.2500 (9)	.2500 (16)	-0.0000 (0)
12	12	1	.2300	1.0000	.1667 (16)	.1667 (24)	.3333 (14)	.3333 (23)	-0.0000 (0)	-0.0000 (0)
13	13	1	.2300	.9960	.1667 (24)	.1667 (27)	.1667 (32)	.2500 (23)	.2500 (29)	-0.0000 (0)
14	14	1	.2300	.9550	.1667 (32)	.1667 (34)	.3333 (20)	.3333 (36)	-0.0000 (0)	-0.0000 (0)
15	15	1	.2300	.9550	.1667 (34)	.1667 (31)	.1667 (34)	.2500 (36)	.2500 (35)	-0.0000 (0)
16	16	1	.2300	.9550	.1667 (33)	.1667 (30)	.3333 (35)	.3333 (28)	-0.0000 (0)	-0.0000 (0)
17	17	1	.2300	.9960	.1667 (30)	.1667 (25)	.1667 (10)	.2500 (28)	.2500 (22)	-0.0000 (0)
18	18	1	.2300	1.0200	.1667 (19)	.1667 (13)	.3333 (22)	.3333 (15)	-0.0000 (0)	-0.0000 (0)
19	19	1	.2300	1.0140	.1667 (13)	.1667 (10)	.1667 (5)	.2500 (15)	.2500 (8)	-0.0000 (0)

FIGURE E.16c. CORBA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

WIRE WRAP SPACER DATA FOR FORCED DIVERSION CROSSFLOW MIXING

WRAP PITCH = 12.0 INCHES
 WRAP THICKNESS = .0560 INCHES
 PIN DIAMETER = .2300 INCHES

WRAP CROSSING DATA			MIXING PARAMETER	RELATIVE LOCATION OF WRAP CROSSINGS	
GAP NO.	SUBCHANNEL PAIR NO.	NO.			
1	(11, 17)	1.0000	-.9170	.4170	
2	(11, 14)	1.0000	-.5840	.0840	
3	(6, 11)	1.0000	-.2500	-.7500	
4	(17, 21)	1.0000	-.7500	.2500	
5	(12, 17)	1.0000	-.0840	-.5840	
6	(21, 26)	1.0000	-.5840	.0840	
7	(21, 27)	1.0000	-.9170	.4170	
8	(20, 26)	1.0000	-.4170	-.9170	
9	(26, 31)	1.0000	-.7500	.2500	
10	(14, 20)	1.0000	-.2500	-.7500	
11	(20, 25)	1.0000	-.5840	.0840	
12	(10, 14)	1.0000	-.4170	-.9170	
13	(3, 6)	1.0000	-.9170	.4170	
14	(3, 5)	1.0000	-.5840	.0840	
15	(1, 3)	1.0000	-.2500	-.7500	
16	(4, 6)	1.0000	-.0840	-.5840	
17	(4, 7)	1.0000	-.9170	.4170	
18	(2, 4)	1.0000	-.2500	-.7500	
19	(7, 12)	1.0000	-.7500	.2500	
20	(7, 9)	1.0000	-.0840	.5840	
21	(12, 18)	1.0000	-.9170	.4170	
22	(18, 24)	1.0000	-.7500	.2500	
23	(16, 18)	1.0000	-.0840	-.5840	
24	(24, 27)	1.0000	-.5840	.0840	
25	(23, 24)	1.0000	-.9170	-.4170	
26	(27, 32)	1.0000	-.7500	.2500	
27	(32, 34)	1.0000	-.5840	.0840	
28	(29, 32)	1.0000	-.9170	-.4170	
29	(31, 34)	1.0000	-.4170	-.9170	
30	(34, 36)	1.0000	-.7500	.2500	
31	(31, 33)	1.0000	-.5840	.0840	
32	(30, 33)	1.0000	-.4170	-.9170	
33	(33, 35)	1.0000	-.7500	.2500	
34	(25, 30)	1.0000	-.2500	-.7500	
35	(28, 30)	1.0000	-.5840	-.0840	
36	(19, 25)	1.0000	-.4170	-.9170	
37	(13, 19)	1.0000	-.2500	-.7500	
38	(19, 22)	1.0000	-.5840	.0840	
39	(10, 13)	1.0000	-.0840	-.5840	
40	(13, 15)	1.0000	-.4170	.9170	
41	(5, 10)	1.0000	-.2500	-.7500	
42	(5, 8)	1.0000	-.4170	.9170	
43	(1, 2)	1.0000	-1.0000	-0.0000	
44	(1, 8)	1.0000	-.0840	-0.0000	
45	(2, 9)	1.0000	-.9170	-0.0000	
46	(9, 16)	1.0000	-.8340	-0.0000	
47	(16, 23)	1.0000	-.7500	-0.0000	
48	(23, 29)	1.0000	-.6670	-0.0000	
49	(29, 36)	1.0000	-.5840	-0.0000	
50	(35, 36)	1.0000	-.5000	-0.0000	
51	(28, 35)	1.0000	-.4170	-0.0000	
52	(22, 28)	1.0000	-.3340	-0.0000	
53	(15, 22)	1.0000	-.2500	-0.0000	
54	(8, 15)	1.0000	-.1670	-0.0000	
INITIAL WRAP INVENTORY FOR EACH SUBCHANNEL					
1	1	1	0	0	1
2	1	0	1	1	0
3	0	0	1	0	0
4	1	0	0	0	0

FIGURE E.16d. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Program

CALCULATION PARAMETERS
 LATERAL RESISTANCE FACTOR .5000
 R/L PARAMETER .5000
 TURBULENT MOMENTUM FACTOR -0.0000
 CHANNEL ORIENTATION (DEGREES) -0.0000
 CHANNEL LENGTH (INCHES) 35.0000
 NUMBER OF AXIAL NODES 35
 TOTAL TRANSIENT TIME (SECONDS) 5.0000
 NUMBER OF TIME STEPS -0
 NOMINAL TIME STEP (SECONDS) *****
 POLL OPTION (0 = NO POLL) 0

DATA FOR IMPLICIT SOLUTION
 EXTERNAL ITERATION LIMIT 20
 INTERNAL ITERATION LIMIT 20
 CONVERGENCE FACTORS
 EXTERNAL (DW/H) .10000
 INTERNAL (DP/P) .00001
 FLOW (DP/P) .01000
 ENERGY (DW/H) .00100
 ACCELERATION FACTORS
 CROSS FLOW SOLUTION 1.60000
 LATERAL DELTA-P .60000
 FLOW .60000

AXIAL NODING

NODE NO.	INTEGRAL HEIGHT (IN.)	NODAL LENGTH (IN.)	NODE NO.	INTEGRAL HEIGHT (IN.)	NODAL LENGTH (IN.)	NODE NO.	INTEGRAL HEIGHT (IN.)	NODAL LENGTH (IN.)
1	0.0	1.0	2	1.0	1.000	3	2.0	1.000
4	3.0	1.000	5	4.0	1.000	6	5.0	1.000
7	6.0	1.000	8	7.0	1.000	9	8.0	1.000
10	9.0	1.000	11	10.0	1.000	12	11.0	1.000
13	12.0	1.000	14	13.0	1.000	15	14.0	1.000
16	15.0	1.000	17	16.0	1.000	18	17.0	1.000
19	18.0	1.000	20	19.0	1.000	21	20.0	1.000
22	21.0	1.000	23	22.0	1.000	24	23.0	1.000
25	24.0	1.000	26	25.0	1.000	27	26.0	1.000
28	27.0	1.000	29	28.0	1.000	30	29.0	1.000
31	30.0	1.000	32	31.0	1.000	33	32.0	1.000
34	33.0	1.000	35	34.0	1.000			

MOMENTUM EQUATIONS WILL BE SOLVED DIRECTLY AT EACH AXIAL LEVEL USING SCHEME

MIXING PARAMETERS		MIXING COEFFICIENTS		FORCED MIXING		CONDUCTION MIXING
ASSEMBLY TYPE NO.	MIXING CORRELATION	ABETA	BBETA	MODEL	DIRECTION	PARAMETER
1	1	.020	0.000	N.W.		0.000

CONDUCTION MIXING GEOMETRY FACTOR .300

OPERATING CONDITIONS
 SYSTEM PRESSURE = 130.0 PSIA
 INLET ENTHALPY = 359.7 BTU/LBM
 INLET TEMPERATURE = 480.000 DEGREES F
 NOMINAL MASS FLUX = 8.491 MILLION LBM/FT²-HR
 NOMINAL POWER DENSITY = 104.8800 MILLION BTU/HR-FT³
 UNIFORM INLET TEMPERATURE

UNIFORM INLET MASS VELOCITY

FIGURE E.16e. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

FORCE POINT SUMMARY

JX	*	GAP8 FORCED AT JX												
3	*	2	5	6	11	14	16	20	23	24	27	31	35	38
4	*	54												
5	*	3	4	9	10	15	18	19	22	26	30	33	34	37
6	*	52												
7	*	1	7	8	12	13	17	21	25	28	29	32	36	40
8	*	50												
9	*	2	5	6	11	14	16	20	23	24	27	31	35	38
10	*	48												
11	*	3	4	9	10	15	18	19	22	26	30	33	34	37
12	*	46												
13	*	1	7	8	12	13	17	21	25	28	29	32	36	40
14	*	43												
15	*	2	5	6	11	14	16	20	23	24	27	31	35	38
16	*	54												
17	*	3	4	9	10	15	18	19	22	26	30	33	34	37
18	*	52												
19	*	1	7	8	12	13	17	21	25	28	29	32	36	40
20	*	50												
21	*	2	5	6	11	14	16	20	23	24	27	31	35	38
22	*	48												
23	*	3	4	9	10	15	18	19	22	26	30	33	34	37
24	*	46												
25	*	1	7	8	12	13	17	21	25	28	29	32	36	40
26	*	43												
27	*	2	5	6	11	14	16	20	23	24	27	31	35	38
28	*	54												
29	*	3	4	9	10	15	18	19	22	26	30	33	34	37
30	*	52												
31	*	1	7	8	12	13	17	21	25	28	29	32	36	40
32	*	50												
33	*	2	5	6	11	14	16	20	23	24	27	31	35	38
34	*	48												
35	*	3	4	9	10	15	18	19	22	26	30	33	34	37

DATA FROM ITERATIVE SOLUTION

ITERATION NO.	TOTAL INTERNAL ITERATIONS	LAST NODE OUT OF CONVERGENCE		MAXIMUM ERROR		FLOW	ENTHALPY
		W	F	INTERNAL	EXTERNAL		
1	*****	36	36	0.0000	1.0000	.1024	.0121
2	*****	36	36	0.0000	3.2125	.0985	.0147
3	*****	36	36	0.0000	.8640	.1256	.0070
4	*****	36	36	0.0000	1.5340	.0630	.0047
5	*****	36	36	0.0000	.4825	.0627	.0039
6	*****	36	36	0.0000	.7273	.0389	.0036
7	*****	36	36	0.0000	.0432	.0258	.0011
8	*****	36	36	0.0000	.2997	.0194	.0017
9	*****	36	34	0.0000	.1812	.0141	.0006
10	*****	18	36	0.0000	.1100	.0140	.0004
11	*****	0	36	0.0000	.0677	.0132	.0007
12	*****	0	36	0.0000	.0371	.0121	.0002
13	*****	0	36	0.0000	.0296	.0107	.0002
14	*****	0	0	0.0000	.0190	.0095	.0001

FIGURE E.16f. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

COBRA WHOLE CORE CODE RESULTS
CASE 1 PFM-RA SINGLE TEST 2 RUN 101.

ASSEMBLY AVERAGE RESULTS FOR ASSEMBLY 1 TIME = 0.00000

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (MT/LB-HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	20.6022	359.73	680.00	54.05	0.000	0.000	5.3851	4.4910	23.0422	.62160
1.0	19.9968	362.75	689.83	53.96	0.000	0.000	5.3851	4.4910	23.1169	.62160
2.0	19.4062	365.77	699.67	53.88	0.000	0.000	5.3851	4.4910	23.1916	.62160
3.0	18.8111	368.79	709.51	53.80	0.000	0.000	5.3851	4.4910	23.1868	.62160
4.0	18.2131	371.81	719.37	53.72	0.000	0.000	5.3851	4.4910	23.2220	.62160
5.0	17.6213	374.83	729.24	53.64	0.000	0.000	5.3851	4.4910	23.2571	.62160
6.0	17.0222	377.85	739.11	53.56	0.000	0.000	5.3851	4.4910	23.2927	.62160
7.0	16.4297	380.88	749.00	53.48	0.000	0.000	5.3851	4.4910	23.3282	.62160
8.0	15.8332	383.90	758.89	53.39	0.000	0.000	5.3851	4.4910	23.3641	.62160
9.0	15.2347	386.92	768.80	53.31	0.000	0.000	5.3851	4.4910	23.3999	.62160
10.0	14.6459	389.94	778.71	53.23	0.000	0.000	5.3851	4.4910	23.4360	.62160
11.0	14.0504	392.96	788.63	53.15	0.000	0.000	5.3851	4.4910	23.4722	.62160
12.0	13.4605	395.98	798.55	53.07	0.000	0.000	5.3851	4.4910	23.5086	.62160
13.0	12.8661	399.00	808.49	52.98	0.000	0.000	5.3851	4.4910	23.5450	.62160
14.0	12.2768	402.02	818.43	52.90	0.000	0.000	5.3851	4.4910	23.5819	.62160
15.0	11.6841	405.04	828.38	52.82	0.000	0.000	5.3851	4.4910	23.6184	.62160
16.0	11.0940	408.06	838.34	52.74	0.000	0.000	5.3851	4.4910	23.6558	.62160
17.0	10.5035	411.08	848.31	52.65	0.000	0.000	5.3851	4.4910	23.6924	.62160
18.0	9.9146	414.11	858.29	52.57	0.000	0.000	5.3851	4.4910	23.7303	.62160
19.0	9.3240	417.13	868.26	52.49	0.000	0.000	5.3851	4.4910	23.7675	.62160
20.0	8.7358	420.15	878.24	52.40	0.000	0.000	5.3851	4.4910	23.8054	.62160
21.0	8.1455	423.17	888.24	52.32	0.000	0.000	5.3851	4.4910	23.8431	.62160
22.0	7.5530	426.19	898.23	52.24	0.000	0.000	5.3851	4.4910	23.8811	.62160
23.0	6.9682	429.21	908.24	52.15	0.000	0.000	5.3851	4.4910	23.9192	.62160
24.0	6.3816	432.23	918.24	52.07	0.000	0.000	5.3851	4.4910	23.9575	.62160
25.0	5.7922	435.25	928.26	51.99	0.000	0.000	5.3851	4.4910	23.9957	.62160
26.0	5.2060	438.27	938.29	51.90	0.000	0.000	5.3851	4.4910	24.0345	.62160
27.0	4.6168	441.29	948.30	51.82	0.000	0.000	5.3851	4.4910	24.0728	.62160
28.0	4.0314	444.31	958.33	51.74	0.000	0.000	5.3851	4.4910	24.1121	.62160
29.0	3.4428	447.34	968.37	51.65	0.000	0.000	5.3851	4.4910	24.1507	.62160
30.0	2.8677	447.34	968.37	51.65	0.000	0.000	5.3851	4.4910	24.1512	.62160
31.0	2.2895	447.34	968.37	51.65	0.000	0.000	5.3851	4.4910	24.1509	.62160
32.0	1.7149	447.34	968.37	51.65	0.000	0.000	5.3851	4.4910	24.1513	.62160
33.0	1.1380	447.34	968.37	51.65	0.000	0.000	5.3851	4.4910	24.1512	.62160
34.0	.5621	447.34	968.37	51.65	0.000	0.000	5.3851	4.4910	24.1514	.62160
35.0	0.0000	447.34	968.37	51.65	0.000	0.000	5.3851	4.4910	24.1514	.62160

POD POWER DELIVERED TO THE COOLANT 471.769 BTU/SEC .49781 MW

FIGURE E.16g. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 1
ASSEMBLY 1

PRESSURE = 130.0 PSI

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (M/LB-HR-FTS)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	20.6002	359.73	680.00	54.05	0.000	0.000	.1869	4.4910	23.0822	.02157
1.0	19.4349	362.45	688.84	53.97	0.000	0.000	.1907	4.5831	23.5876	.02157
2.0	19.2919	365.38	698.39	53.89	0.000	0.000	.1960	4.7267	21.7840	.02404
3.0	18.2277	368.37	708.15	53.81	0.000	0.000	.2108	4.9401	23.4355	.02404
4.0	18.1244	370.77	715.98	53.75	0.000	0.000	.2170	4.2617	22.0249	.02650
5.0	17.1846	373.11	723.62	53.69	0.000	0.000	.2346	4.9893	23.7459	.02650
6.0	16.9907	375.13	730.20	53.63	0.000	0.000	.2264	4.4330	22.9606	.02650
7.0	16.5963	377.37	737.52	53.57	0.000	0.000	.2233	4.3687	22.6531	.02650
8.0	15.9114	380.39	747.42	53.49	0.000	0.000	.2324	4.5504	23.6310	.02650
9.0	15.7722	382.93	755.71	53.42	0.000	0.000	.2222	4.3460	22.5987	.02650
10.0	14.7559	386.41	767.15	53.33	0.000	0.000	.2114	4.5596	23.7518	.02404
11.0	14.5442	389.52	777.35	53.24	0.000	0.000	.1976	4.2626	22.2796	.02404
12.0	13.5495	392.48	787.04	53.16	0.000	0.000	.2080	4.4865	23.4432	.02404
13.0	12.3719	395.35	796.47	53.08	0.000	0.000	.1910	4.6106	24.1271	.02157
14.0	12.1743	398.94	808.30	52.98	0.000	0.000	.1889	4.2892	22.4868	.02404
15.0	11.1044	402.73	820.76	52.88	0.000	0.000	.2127	4.5867	24.0937	.02404
16.0	11.0077	405.33	829.34	52.81	0.000	0.000	.2201	4.3052	22.6454	.02650
17.0	10.0696	407.86	837.66	52.74	0.000	0.000	.2360	4.6164	24.3165	.02650
18.0	9.8828	410.03	844.83	52.68	0.000	0.000	.2267	4.4344	23.3820	.02650
19.0	9.4937	412.38	852.57	52.62	0.000	0.000	.2224	4.3504	22.9670	.02650
20.0	8.8149	415.66	863.42	52.53	0.000	0.000	.2305	4.5099	23.8503	.02650
21.0	8.6837	418.30	872.14	52.45	0.000	0.000	.2196	4.2954	22.7874	.02650
22.0	7.6699	422.02	884.44	52.35	0.000	0.000	.2092	4.5128	23.9040	.02404
23.0	7.4701	425.26	895.15	52.26	0.000	0.000	.1954	4.2175	22.4166	.02404
24.0	6.4725	428.31	905.26	52.18	0.000	0.000	.2060	4.4517	23.6992	.02404
25.0	5.2890	431.24	914.94	52.10	0.000	0.000	.1908	4.3844	24.4035	.02157
26.0	5.1012	434.94	927.21	52.00	0.000	0.000	.1970	4.2675	22.8000	.02404
27.0	4.0285	438.84	940.17	51.89	0.000	0.000	.2120	4.5717	24.4745	.02404
28.0	3.9424	441.46	948.85	51.81	0.000	0.000	.2193	4.2892	22.9941	.02650
29.0	3.0034	444.00	957.27	51.74	0.000	0.000	.2352	4.6001	24.8944	.02650
30.0	2.8352	443.91	956.99	51.75	0.000	0.000	.2256	4.4125	23.8861	.02650
31.0	2.8608	443.88	956.90	51.75	0.000	0.000	.2211	4.3257	23.2198	.02650
32.0	1.7930	444.33	958.39	51.74	0.000	0.000	.2294	4.4867	24.0898	.02650
33.0	1.6601	444.45	958.79	51.73	0.000	0.000	.2180	4.2823	22.9941	.02650
34.0	.6074	445.00	960.60	51.72	0.000	0.000	.2100	4.5286	24.7230	.02404
35.0	0.0000	445.41	961.97	51.71	0.000	0.000	.2077	4.4800	24.0680	.02404

FIGURE E.16h. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 3
ASSEMBLY 1

PRESSURE = 130.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	20.6007	159.73	680.00	54.05	0.000	0.000	.1051	4.4010	23.0828	.01214
1.0	19.4577	163.55	692.44	53.94	0.000	0.000	.1093	4.4665	24.0300	.01214
2.0	19.3088	167.00	703.67	53.85	0.000	0.000	.1273	4.5199	23.3145	.01460
3.0	18.3670	170.36	714.63	53.76	0.000	0.000	.1369	4.8595	25.1091	.01460
4.0	18.1293	172.95	723.09	53.69	0.000	0.000	.1057	4.5143	23.3560	.01214
5.0	17.1499	176.29	733.99	53.60	0.000	0.000	.1077	4.5985	23.4315	.01214
6.0	16.9941	178.59	741.52	53.54	0.000	0.000	.1242	4.4113	22.8878	.01460
7.0	16.6551	181.13	749.83	53.47	0.000	0.000	.1233	4.3791	22.7499	.01460
8.0	15.8876	184.47	760.76	53.38	0.000	0.000	.1021	4.3626	22.7030	.01214
9.0	15.6299	188.26	773.20	53.27	0.000	0.000	.0948	4.0882	21.1074	.01214
10.0	14.7427	192.45	786.95	53.16	0.000	0.000	.1261	4.4763	23.3896	.01460
11.0	14.5326	195.51	796.99	53.08	0.000	0.000	.1227	4.3550	22.7916	.01460
12.0	13.5083	199.00	808.50	52.98	0.000	0.000	.1061	4.5298	23.7889	.01214
13.0	12.4156	400.88	814.68	52.93	0.000	0.000	.1097	4.5865	24.5946	.01214
14.0	12.1897	405.03	828.33	52.82	0.000	0.000	.1297	4.6041	24.2140	.01460
15.0	11.2419	408.64	840.24	52.72	0.000	0.000	.1392	4.9413	26.0363	.01460
16.0	11.0121	410.41	846.07	52.67	0.000	0.000	.1074	4.5876	24.1947	.01214
17.0	10.0382	413.37	855.87	52.59	0.000	0.000	.1091	4.6584	24.6059	.01214
18.0	9.8903	415.00	861.23	52.54	0.000	0.000	.1250	4.4533	23.5426	.01460
19.0	9.5515	417.26	868.70	52.48	0.000	0.000	.1242	4.4094	23.3328	.01460
20.0	8.7909	420.59	879.63	52.39	0.000	0.000	.1030	4.4001	23.3296	.01214
21.0	8.5417	424.35	892.15	52.29	0.000	0.000	.0957	4.0877	21.7158	.01214
22.0	7.6366	428.81	906.91	52.16	0.000	0.000	.1273	4.5183	24.0602	.01460
23.0	7.4589	431.84	916.96	52.08	0.000	0.000	.1238	4.3961	23.4469	.01460
24.0	6.4304	435.44	928.89	51.98	0.000	0.000	.1069	4.5672	24.4059	.01214
25.0	5.3353	437.20	934.72	51.93	0.000	0.000	.1103	4.7119	25.2030	.01214
26.0	5.1172	441.52	949.06	51.81	0.000	0.000	.1300	4.6292	24.8179	.01460
27.0	4.1678	445.24	961.39	51.71	0.000	0.000	.1398	4.9640	26.6657	.01460
28.0	3.9476	446.91	966.95	51.66	0.000	0.000	.1079	4.6082	24.7764	.01214
29.0	2.9679	449.84	976.69	51.58	0.000	0.000	.1095	4.5762	25.1818	.01214
30.0	2.8433	448.03	970.69	51.63	0.000	0.000	.1256	4.4608	23.9984	.01460
31.0	2.9220	447.26	968.10	51.65	0.000	0.000	.1249	4.4102	23.7160	.01460
32.0	1.7697	447.25	968.08	51.66	0.000	0.000	.1033	4.4101	23.7156	.01214
33.0	1.5171	447.21	967.95	51.66	0.000	0.000	.0963	4.1130	22.1176	.01214
34.0	.8040	447.86	970.09	51.64	0.000	0.000	.1297	4.5703	24.5850	.01460
35.0	0.0000	448.05	970.75	51.63	0.000	0.000	.1323	4.6992	25.2811	.01460

FIGURE E.16i. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
 CHANNEL 18
 ASSEMBLY 1

PRESSURE = 130.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (M/LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	20.5612	159.73	680.00	54.05	0.000	0.000	1.265	4.4910	23.0822	.01460
1.0	19.5848	163.19	691.26	53.95	0.000	0.000	1.364	4.4447	24.9431	.01460
2.0	19.3568	165.97	700.30	53.88	0.000	0.000	1.059	4.5221	23.3145	.01214
3.0	18.5595	169.36	711.38	53.79	0.000	0.000	1.055	4.5044	23.2627	.01214
4.0	18.2459	172.04	720.11	53.71	0.000	0.000	1.259	4.4693	23.1123	.01460
5.0	18.0465	174.76	729.01	53.64	0.000	0.000	1.229	4.3655	22.6067	.01460
6.0	17.1100	178.69	741.86	53.53	0.000	0.000	1.043	4.4557	23.1196	.01214
7.0	16.8506	182.53	754.43	53.43	0.000	0.000	.0967	4.1304	21.4752	.01214
8.0	15.9132	186.56	767.63	53.32	0.000	0.000	1.292	4.5864	23.8944	.01460
9.0	15.6893	189.51	777.32	53.24	0.000	0.000	1.263	4.4851	23.4007	.01460
10.0	14.5705	191.94	785.29	53.17	0.000	0.000	1.087	4.6414	24.2463	.01214
11.0	13.5342	195.71	797.66	53.07	0.000	0.000	1.125	4.8071	25.1600	.01214
12.0	13.3726	198.59	807.14	52.99	0.000	0.000	1.300	4.6177	24.2046	.01460
13.0	12.4467	401.41	816.42	52.92	0.000	0.000	1.335	4.9171	25.8119	.01460
14.0	12.2253	403.27	822.56	52.87	0.000	0.000	1.069	4.5663	23.9932	.01214
15.0	11.4266	405.95	831.38	52.79	0.000	0.000	1.057	4.5142	23.7521	.01214
16.0	11.1259	408.00	838.12	52.74	0.000	0.000	1.255	4.4566	23.4744	.01460
17.0	10.9257	410.48	846.31	52.67	0.000	0.000	1.223	4.3411	22.8952	.01460
18.0	10.0031	414.84	860.70	52.55	0.000	0.000	1.040	4.4416	23.4788	.01214
19.0	9.7470	418.79	873.75	52.44	0.000	0.000	.0966	4.1260	21.8554	.01214
20.0	4.8172	422.97	887.59	52.33	0.000	0.000	1.291	4.5857	24.3439	.01460
21.0	8.6004	425.91	897.31	52.24	0.000	0.000	1.263	4.4837	23.8395	.01460
22.0	7.4813	428.21	904.93	52.18	0.000	0.000	1.086	4.6374	24.6865	.01214
23.0	6.4418	432.07	917.72	52.07	0.000	0.000	1.127	4.8117	25.6666	.01214
24.0	6.2916	434.92	927.16	52.00	0.000	0.000	1.301	4.6206	24.6849	.01460
25.0	5.3652	437.72	936.41	51.92	0.000	0.000	1.335	4.9185	26.3155	.01460
26.0	5.1535	439.46	942.21	51.87	0.000	0.000	1.069	4.5661	24.4631	.01214
27.0	4.3555	442.03	950.76	51.80	0.000	0.000	1.057	4.5166	24.2204	.01214
28.0	4.0626	444.00	957.28	51.74	0.000	0.000	1.254	4.4540	23.9101	.01460
29.0	3.8699	446.44	965.40	51.68	0.000	0.000	1.221	4.3351	23.3023	.01460
30.0	2.9564	447.31	968.29	51.65	0.000	0.000	1.040	4.4404	23.8793	.01214
31.0	2.7159	447.42	968.65	51.65	0.000	0.000	.0967	4.1284	22.2030	.01214
32.0	1.7963	447.95	970.39	51.64	0.000	0.000	1.292	4.5875	24.6790	.01460
33.0	1.5918	447.83	970.01	51.64	0.000	0.000	1.265	4.4908	24.1570	.01460
34.0	.5686	447.42	968.65	51.65	0.000	0.000	1.075	4.5925	24.6986	.01214
35.0	0.0000	447.17	967.81	51.66	0.000	0.000	1.035	4.4205	23.7706	.01214

FIGURE E.16.j. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 26
ASSEMBLY 1

PRESSURE = 130.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (M.LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	20.6115	359.73	680.00	54.05	0.000	0.000	.1265	4.4910	23.0422	.01460
1.0	20.2958	363.27	691.53	53.95	0.000	0.000	.1202	4.4110	22.7112	.01460
2.0	19.4430	366.93	703.44	53.85	0.000	0.000	.1041	4.4461	22.9337	.01214
3.0	19.1085	370.97	716.61	53.74	0.000	0.000	.0976	4.1706	21.5561	.01214
4.0	18.2559	374.85	729.29	53.64	0.000	0.000	.1294	4.5725	23.4796	.01460
5.0	17.9761	378.17	740.13	53.55	0.000	0.000	.1265	4.4928	23.3061	.01460
6.0	17.0190	381.56	751.23	53.46	0.000	0.000	.1075	4.5929	23.8659	.01214
7.0	16.1060	385.30	763.49	53.36	0.000	0.000	.1091	4.6594	24.2575	.01214
8.0	15.4003	388.59	774.29	53.27	0.000	0.000	.1282	4.9532	23.7447	.01460
9.0	14.9970	391.79	784.78	53.18	0.000	0.000	.1337	4.7466	24.7939	.01460
10.0	14.6153	394.50	793.70	53.10	0.000	0.000	.1057	4.5143	23.6133	.01214
11.0	13.7760	397.95	805.03	53.01	0.000	0.000	.1051	4.4895	23.5248	.01214
12.0	13.4691	400.50	813.43	52.94	0.000	0.000	.1259	4.4570	23.3555	.01460
13.0	13.1545	403.29	822.62	52.87	0.000	0.000	.1233	4.3772	22.9996	.01460
14.0	12.3126	406.82	834.25	52.77	0.000	0.000	.1033	4.4142	23.2766	.01214
15.0	11.9795	410.76	847.23	52.66	0.000	0.000	.0973	4.1539	21.9110	.01214
16.0	11.1372	414.84	860.71	52.55	0.000	0.000	.1277	4.5342	23.9683	.01460
17.0	10.8585	417.98	871.09	52.46	0.000	0.000	.1256	4.4589	23.6085	.01460
18.0	9.9108	421.21	881.75	52.37	0.000	0.000	.1064	4.5611	24.1911	.01214
19.0	8.9982	424.67	893.20	52.28	0.000	0.000	.1095	4.6362	24.6340	.01214
20.0	8.7016	427.74	903.35	52.19	0.000	0.000	.1277	4.5352	24.1364	.01460
21.0	7.9001	430.68	913.12	52.11	0.000	0.000	.1333	4.7315	25.2204	.01460
22.0	7.5261	432.92	920.52	52.05	0.000	0.000	.1055	4.5055	24.0843	.01214
23.0	6.6874	436.04	930.87	51.97	0.000	0.000	.1051	4.4895	23.9955	.01214
24.0	6.3894	438.06	937.54	51.91	0.000	0.000	.1254	4.4526	23.8268	.01460
25.0	6.0880	440.60	946.01	51.84	0.000	0.000	.1231	4.3702	23.4174	.01460
26.0	5.2413	444.07	957.53	51.74	0.000	0.000	.1033	4.4104	23.6771	.01214
27.0	4.8065	447.96	970.45	51.64	0.000	0.000	.0972	4.1530	22.3418	.01214
28.0	4.0735	452.06	984.09	51.52	0.000	0.000	.1276	4.5315	24.4316	.01460
29.0	3.8014	455.14	994.32	51.44	0.000	0.000	.1235	4.4553	24.0606	.01460
30.0	2.8631	454.76	993.06	51.45	0.000	0.000	.1064	4.5628	24.6363	.01214
31.0	1.9596	454.23	991.28	51.46	0.000	0.000	.1087	4.6413	25.0524	.01214
32.0	1.6804	453.73	989.61	51.48	0.000	0.000	.1279	4.5398	24.4984	.01460
33.0	.8995	453.24	987.99	51.49	0.000	0.000	.1334	4.7318	25.5277	.01460
34.0	.5440	452.32	984.94	51.51	0.000	0.000	.1055	4.5070	24.3052	.01214
35.0	0.0000	451.60	982.55	51.53	0.000	0.000	.1026	4.3837	23.6286	.01214

FIGURE E.16k. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
 CHANNEL 35
 ASSEMBLY 1

PRESSURE = 130.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (HR/HR-FT2)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	20.6285	359.73	680.00	54.05	0.000	0.000	.2294	4.4910	23.0822	.02650
1.0	20.3811	361.86	686.94	53.99	0.000	0.000	.2214	4.3317	22.2869	.02650
2.0	19.5131	364.51	695.55	53.92	0.000	0.000	.2342	4.5809	23.6005	.02650
3.0	19.3464	366.93	703.44	53.85	0.000	0.000	.2224	4.3555	22.4664	.02650
4.0	18.3078	369.94	713.27	53.77	0.000	0.000	.2125	4.1583	21.6795	.02404
5.0	18.1046	372.70	722.26	53.70	0.000	0.000	.1991	4.1294	22.2162	.02404
6.0	16.9011	375.41	731.14	53.62	0.000	0.000	.1854	4.1549	23.0770	.02157
7.0	15.9150	378.95	742.69	53.53	0.000	0.000	.2162	4.1618	24.1922	.02404
8.0	15.7293	381.74	751.81	53.45	0.000	0.000	.2020	4.3573	22.6438	.02404
9.0	14.6775	384.88	762.11	53.37	0.000	0.000	.2147	4.6296	24.0975	.02404
10.0	14.5827	387.11	769.44	53.31	0.000	0.000	.2224	4.3494	22.6646	.02650
11.0	13.8337	389.36	776.81	53.24	0.000	0.000	.2304	4.5117	23.5376	.02650
12.0	13.4790	391.83	784.93	53.18	0.000	0.000	.2271	4.4426	23.2865	.02650
13.0	13.2442	394.32	793.10	53.11	0.000	0.000	.2184	4.2758	22.3633	.02650
14.0	12.3811	397.62	803.94	53.02	0.000	0.000	.2324	4.5460	23.8170	.02650
15.0	12.2381	400.29	812.72	52.95	0.000	0.000	.2209	4.3219	22.6740	.02650
16.0	11.1896	403.89	824.60	52.85	0.000	0.000	.2116	4.5633	23.9853	.02404
17.0	10.9889	406.94	834.64	52.77	0.000	0.000	.1987	4.2860	22.5632	.02404
18.0	9.7934	409.82	844.14	52.69	0.000	0.000	.1851	4.4475	23.4486	.02157
19.0	8.8051	413.80	857.26	52.58	0.000	0.000	.2161	4.6596	24.6177	.02404
20.0	8.6306	416.81	867.20	52.49	0.000	0.000	.2020	4.3950	23.0496	.02404
21.0	7.5759	420.22	878.47	52.40	0.000	0.000	.2147	4.6295	24.5810	.02404
22.0	7.4939	422.51	886.04	52.34	0.000	0.000	.2223	4.3497	23.0853	.02650
23.0	6.7468	424.80	893.62	52.27	0.000	0.000	.2304	4.5117	23.9716	.02650
24.0	6.4002	427.35	902.07	52.20	0.000	0.000	.2270	4.4415	23.6331	.02650
25.0	6.1762	429.89	910.49	52.13	0.000	0.000	.2144	4.2717	22.7602	.02650
26.0	5.3112	433.31	921.80	52.04	0.000	0.000	.2320	4.5381	24.2229	.02650
27.0	5.1788	436.02	930.82	51.97	0.000	0.000	.2204	4.3106	23.0423	.02650
28.0	4.1265	439.74	943.14	51.86	0.000	0.000	.2111	4.5530	24.3856	.02404
29.0	3.9341	442.84	953.44	51.78	0.000	0.000	.1943	4.2773	22.9482	.02404
30.0	2.7443	443.27	958.83	51.77	0.000	0.000	.1840	4.4426	23.9395	.02157
31.0	1.7650	444.43	958.71	51.73	0.000	0.000	.2158	4.6833	24.9859	.02404
32.0	1.6106	444.98	960.55	51.72	0.000	0.000	.2017	4.3494	23.3611	.02404
33.0	.5823	445.63	962.70	51.70	0.000	0.000	.2138	4.6115	24.7774	.02404
34.0	.5226	445.76	963.12	51.70	0.000	0.000	.2213	4.3286	23.2588	.02650
35.0	0.0000	445.84	963.40	51.69	0.000	0.000	.2242	4.3850	23.5680	.02650

FIGURE E.161. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

CROSSFLOW BETWEEN ADJACENT CHANNELS AT TIME = 0.0000 SECONDS

ASSEMBLY NUMBER	1	1	1	1	1	1	1	1	1	1
AXIAL ZONE	W(1, 17)	W(1, 14)	W(4, 11)	W(17, 21)	W(17, 17)	W(21, 24)	W(21, 27)	W(20, 26)	W(24, 31)	W(14, 20)
0.0 - 1.0	.17459	-.31544	-.11433	-.12911	-.20039	-.28964	.14627	.17841	-.08414	-.09443
1.0 - 2.0	-.84649	.42989	-.19977	-.06299	.43216	.42891	-.71797	.08067	.71121	.84495
2.0 - 3.0	-.61430	-.07242	-.61051	-.54435	.46192	-.03659	-.47470	.11092	.15177	.02981
3.0 - 4.0	-.00405	.76574	.43055	.42851	.47173	.06031	.40221	.75455	.44124	.43103
4.0 - 5.0	-.50564	.35402	.04572	-.04629	.42923	-.03937	.46753	-.02644	-.03489	-.06863
5.0 - 6.0	.42423	.00444	.66683	.08051	-.47904	-.73181	.43421	.43736	-.06639	.77530
6.0 - 7.0	-.05262	.49563	.41658	-.03148	-.45131	.03162	-.43411	-.05644	-.04350	.55379
7.0 - 8.0	.07118	-.42404	-.53587	-.73711	-.43779	-.43939	-.47204	.78049	.11173	.00420
8.0 - 9.0	-.03762	.04449	-.06380	.01965	.43373	.04607	-.04470	.55932	.44001	.48942
9.0 - 10.0	-.73132	-.07511	-.43590	-.43861	.46774	-.74324	.11251	.00475	-.44263	-.42783
10.0 - 11.0	.02341	.03137	.03146	.04443	.44121	-.56102	.43440	.48687	-.06716	.03619
11.0 - 12.0	-.43877	.72209	.06008	-.74597	-.11486	-.00757	-.44294	-.43004	-.68265	-.08154
12.0 - 13.0	.04426	-.02990	.03534	-.56121	-.43807	-.49609	-.06442	.03030	-.42879	.02476
13.0 - 14.0	-.78788	.43798	-.11696	-.01042	.44214	.43005	-.44463	-.08443	.58477	.71796
14.0 - 15.0	-.56262	-.04463	-.53932	-.48755	.46946	-.02959	-.43148	.02069	.06524	-.03451
15.0 - 16.0	-.01138	.78728	.44178	.43019	.48503	.08544	.44444	.71730	.43756	.43689
16.0 - 17.0	-.48964	.56281	.04826	-.02952	.43206	-.01915	.06271	-.03700	-.03068	-.04725
17.0 - 18.0	.42991	.01043	.48385	.08549	-.48294	-.71814	.43766	.43703	-.05563	.78386
18.0 - 19.0	-.03127	.49006	.43085	-.02027	-.46190	.03635	-.03100	-.04749	-.03224	.56129
19.0 - 20.0	.08459	-.42931	-.53315	-.71917	-.43780	-.43762	-.05430	.78528	.11747	.00968
20.0 - 21.0	-.02174	.03171	-.06259	.03411	.43029	.04599	-.03401	.56123	.54087	.48465
21.0 - 22.0	-.72004	-.08336	-.43765	-.43787	.45698	-.78495	.11671	.00893	-.44278	-.42932
22.0 - 23.0	.03288	.02263	.02994	.04483	.43312	-.56125	.43099	.48405	-.06854	.03131
23.0 - 24.0	-.43805	.71846	.05593	-.78593	-.11728	-.00946	-.44444	-.42966	-.48277	-.08418
24.0 - 25.0	.04400	-.03288	.03231	-.56225	-.44002	-.49767	-.06995	.03000	-.42981	.02144
25.0 - 26.0	-.78560	.43808	-.11689	-.00951	.44261	.43001	-.48438	-.08441	.58304	.71743
26.0 - 27.0	-.56144	-.04354	-.53916	-.48753	.46942	-.02920	-.43443	.02087	.06399	-.03416
27.0 - 28.0	-.01065	.78703	.44360	.43008	.48373	.08447	.44444	.71756	.43733	.43791
28.0 - 29.0	-.48774	.56298	.07103	-.02834	.43117	-.02077	.08463	.03345	-.02946	-.04367
29.0 - 30.0	.43011	.01045	.68463	.08600	-.48132	.71601	.43748	.43783	-.05438	.74541
30.0 - 31.0	-.02834	.48789	.43203	-.01926	-.46282	.03422	-.02800	-.04310	-.03090	.56175
31.0 - 32.0	.08532	-.43045	-.58342	-.71743	-.43744	-.43815	-.05521	.78589	.11740	.00995
32.0 - 33.0	-.02992	.02629	-.07430	.01792	-.02446	.03984	-.04174	.55715	.53211	.47801
33.0 - 34.0	-.73427	-.07063	-.43867	-.43740	.06800	-.74401	.07799	-.03010	-.44129	-.43164
34.0 - 35.0	-.41698	.13034	-.24522	-.18891	.19655	-.40758	.18698	.12063	-.25217	-.16740

FIGURE E.16m. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

CROSSFLOW BETWEEN ADJACENT CHANNELS AT TIME = 0.0000 SECONDS

ASSEMBLY NUMBER	1	1	1	1	1	1	1	1	1	1
AXIAL ZONE	W(20, 24)	W(10, 14)	W(3, 6)	W(3, 5)	W(1, 3)	W(4, 6)	W(0, 7)	W(2, 4)	W(7, 12)	W(7, 9)
0.0 - 1.0	-.19431	.17281	.20844	-.24657	-.02882	-.19737	.12723	-.01224	-.06360	.06116
1.0 - 2.0	.44103	.19822	-1.00202	.43616	-.44930	.43481	-.72060	-.09162	-.07482	-.43229
2.0 - 3.0	-.05459	.12877	-.77646	.20159	-.06007	.19169	-.58152	-.28016	-.42910	-.27935
3.0 - 4.0	-.09239	-.10608	-.10411	.88939	.01125	.74101	.05150	.42361	.43135	-.58853
4.0 - 5.0	-.06175	-.55127	-.43084	.65175	.24456	.54809	-.44772	.19455	.01532	-.35177
5.0 - 6.0	.11272	.47700	.42570	-.05607	.46853	-.08931	.42829	.58081	.19317	.49483
6.0 - 7.0	.54417	.05288	.00568	.33845	.33324	.34336	.01232	.32155	-.00020	.10823
7.0 - 8.0	-.04015	.67109	.18120	-.42329	-.49637	-.43278	.46555	-.28923	-.44522	.43506
8.0 - 9.0	-.06187	.41920	-.01529	-.00835	-.11198	-.08147	.17444	.00374	.00529	.21142
9.0 - 10.0	-.47764	-.58627	-.45109	-.35636	-.43196	-.20335	-.62439	-.44099	-.45231	.03014
10.0 - 11.0	-.42390	-.06618	-.00139	-.16994	-.20954	-.05173	-.10028	-.18591	.41864	-.46150
11.0 - 12.0	.48517	-.43498	-.45159	.62120	-.02959	.91084	-.04560	.23601	-.92068	.23628
12.0 - 13.0	.06682	.03086	.31737	.09601	.45742	-.18570	-.01650	-.35470	-.70689	.37746
13.0 - 14.0	.43643	.05693	-.92049	.44427	-.23688	.44433	-.89209	-.23810	-.09345	-.41604
14.0 - 15.0	-.03040	.03184	-.70687	.21558	-.37731	.18394	-.64792	.34021	.01029	-.25642
15.0 - 16.0	-.05555	-.11836	-.09411	.89064	.01543	.74602	.08540	.42178	.43009	-.57325
16.0 - 17.0	-.03165	-.54201	-.41240	.64790	.25538	.54504	-.43117	.20005	.02299	-.33867
17.0 - 18.0	.11824	.44169	.42961	-.05251	.47339	-.08274	.02959	.58491	.18064	.49360
18.0 - 19.0	.44166	.06692	.02108	.33278	.43868	.33864	.01086	.31980	-.00378	.11375
19.0 - 20.0	-.44240	.68193	.18898	-.42853	-.49321	-.43483	.46472	-.29000	-.44812	.43634
20.0 - 21.0	-.06803	.42934	-.00638	-.01843	-.11259	-.09086	.17711	-.00209	.00482	.21372
21.0 - 22.0	-.68187	.58376	-.44767	-.36664	-.43571	-.21439	-.61828	-.44282	-.45020	.03919
22.0 - 23.0	-.42913	-.06365	.00532	-.17709	-.21309	-.05827	-.09806	-.18673	.31813	-.45309
23.0 - 24.0	.48338	.43732	-.45445	.61789	-.03914	.90640	-.04456	.24758	.02350	.23749
24.0 - 25.0	.06363	.02874	.31644	.09428	.45138	-.19012	-.21874	-.35958	-.71026	.37927
25.0 - 26.0	.43716	.05904	-.92302	.44631	-.23601	.44618	-.89271	-.23780	-.09498	-.41424
26.0 - 27.0	-.02932	.03080	-.70938	.21800	-.47823	.18731	-.64438	-.36055	-.41244	-.25392
27.0 - 28.0	-.05546	.11839	-.09460	.89112	.01353	.74885	.04086	.42017	.02884	-.57455
28.0 - 29.0	-.03190	-.54048	-.41229	.64701	.25384	.54621	-.43265	.19889	.02291	-.33880
29.0 - 30.0	.11678	.44257	.42998	-.05066	.47313	-.08146	.02072	.58456	.19033	.49127
30.0 - 31.0	.43866	.07013	.02408	.33179	.43875	.33731	.02143	.31836	-.00551	.11388
31.0 - 32.0	-.44377	.68375	.18910	-.42939	-.49174	-.44032	.46486	-.29310	-.44878	.43623
32.0 - 33.0	-.07464	.42662	-.01083	-.02101	-.11530	-.09476	.14089	-.00910	-.00680	.21533
33.0 - 34.0	-.65083	-.59774	-.45680	-.37212	-.43998	-.20557	-.63222	-.44545	-.45098	.02248
34.0 - 35.0	-.42777	-.32810	-.21545	-.13647	-.40835	-.06090	-.43896	-.36046	-.28498	-.02385

FIGURE E.16n. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

CROSSFLOW BETWEEN ADJACENT CHANNELS AT TIME = 0.0000 SECONDS

ASSEMBLY NUMBER	1	1	1	1	1	1	1	1	1	1
AXIAL ZONE	W(12, 1A)	W(18, 24)	W(18, 18)	W(24, 27)	W(24, 24)	W(27, 32)	W(32, 34)	W(32, 32)	W(31, 34)	W(34, 36)
0.0 - 1.0	.09274	.08895	-.06219	-.18982	-.06249	-.13155	-.22041	-.08577	.17748	-.03434
1.0 - 2.0	-.46488	.23486	.43289	.43169	.40854	.05663	.43111	.61547	-.06639	.62364
2.0 - 3.0	-.46256	-.23770	.21998	.03289	.26048	-.37127	.01671	.35377	.08808	.19519
3.0 - 4.0	.09194	.43130	.58430	.17165	-.22012	.43672	.36791	-.29241	.45081	.43859
4.0 - 5.0	-.34402	.01835	.27331	-.01493	-.12571	.08821	.14114	.00079	-.00514	.21910
5.0 - 6.0	.43428	.37319	-.28465	-.44184	-.03621	.21809	-.61868	-.40338	.45392	.04037
6.0 - 7.0	.08188	.18062	.00746	.01101	-.21285	.05692	-.09430	-.18620	-.33117	-.46386
7.0 - 8.0	.21199	-.62025	-.44262	-.45364	-.03624	-.92626	-.04708	.26667	.92053	.73382
8.0 - 9.0	.05410	-.09793	-.18599	.32448	.46337	.18210	-.21849	-.35385	.71011	.37889
9.0 - 10.0	-.92002	-.44603	.56219	-.92027	-.23511	-.44619	-.09417	-.23647	.09329	-.41416
10.0 - 11.0	.18122	-.21837	-.45306	-.70849	-.37727	-.18672	-.44834	-.38087	.41226	-.25297
11.0 - 12.0	.44556	-.89250	-.23688	-.09256	.41608	.74690	.05351	.42032	.42989	-.57232
12.0 - 13.0	-.18657	-.64767	-.35989	-.40989	.25604	-.58370	-.32065	.19859	-.02240	-.33678
13.0 - 14.0	-.74631	.05367	.42107	.42993	.47269	.08332	.02996	.58432	-.18809	.49549
14.0 - 15.0	-.54423	-.32981	.19977	.02369	.33817	-.33621	.02129	.31842	.00672	.11591
15.0 - 16.0	.08252	.43004	.58545	.18947	-.09415	.43956	.36697	-.29168	.04835	.43636
16.0 - 17.0	-.33776	.07104	.31974	-.00526	-.11433	.09209	.17796	-.00276	-.00549	.21361
17.0 - 18.0	.43908	.36783	-.29050	-.44806	-.03644	.21525	-.61837	-.40275	.45441	.03985
18.0 - 19.0	.09091	.17812	-.00147	.00582	-.21351	.05825	-.09356	-.18621	-.31968	-.45357
19.0 - 20.0	.21460	-.61847	-.04246	-.45474	-.03967	.90737	-.04441	.24792	.02413	.23781
20.0 - 21.0	.05759	-.09451	-.18656	.31860	.45327	.19135	-.21790	-.38024	.71070	.37995
21.0 - 22.0	-.90717	-.44670	.24801	-.92359	-.23648	-.44593	-.29039	-.23735	.09438	-.41398
22.0 - 23.0	.19065	-.21834	-.36002	-.71034	-.37889	-.18657	-.64822	-.36103	.41291	-.25329
23.0 - 24.0	-.44541	-.89192	-.23674	-.09448	.41364	-.74643	.05072	.42004	.42953	-.57366
24.0 - 25.0	-.18675	-.64781	-.36035	-.41264	.25349	-.54536	-.33042	.19783	-.02156	-.33770
25.0 - 26.0	-.74770	.05138	.42020	.42996	.57257	.08338	.02931	.58285	-.18833	.49402
26.0 - 27.0	-.54460	-.33172	.19841	.02279	.33748	-.33647	.02009	.31651	.00746	.11491
27.0 - 28.0	.08285	.42960	.58312	.18796	-.09346	.43969	.36358	-.29393	.44871	.43553
28.0 - 29.0	-.33751	.02123	.31855	-.00583	-.11390	.09372	.17553	-.00562	-.00361	.21384
29.0 - 30.0	.43923	.36881	-.28800	-.44717	-.03675	.21483	-.61594	-.40205	.45398	.04004
30.0 - 31.0	.09193	.17984	.00027	.00599	-.21452	.06020	-.09053	-.18732	.31576	-.45068
31.0 - 32.0	.21344	-.61904	-.44193	-.45514	-.03895	-.90443	-.04594	.24656	.02223	.23783
32.0 - 33.0	.04998	-.10606	-.18873	.30922	.05080	.17647	-.22046	-.35131	.70852	.37637
33.0 - 34.0	-.90189	-.44255	.23187	-.88368	-.21306	-.44228	-.66649	-.22648	.06996	-.41127
34.0 - 35.0	-.51402	-.25618	.20993	-.50596	-.20434	-.27482	-.51195	-.20811	.12121	-.33923

FIGURE E.160. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

CROSSFLOW BETWEEN ADJACENT CHANNELS AT TIME = 0.0000 SECONDS

ASSEMBLY NUMBER	1	1	1	1	1	1	1	1	1	1
AXIAL ZONE	W(3j, 3j)	W(30, 33)	W(33, 35)	W(25, 30)	W(28, 30)	W(19, 25)	W(17, 19)	W(19, 22)	W(10, 13)	W(13, 15)
0.0 - 1.0	-.19060	.13779	-.01263	-.03235	.07272	.11698	-.05507	-.06558	-.18083	-.07096
1.0 - 2.0	.43720	-.23368	.42941	.58431	-.84039	-.07197	.76770	.44288	.44691	-.11803
2.0 - 3.0	.09706	-.08353	.10402	.12296	-.24630	.04204	.21820	.15665	-.01124	-.66972
3.0 - 4.0	.21430	.62351	.44393	.45063	-.03841	.94938	.83913	-.29586	.89761	.22308
4.0 - 5.0	.05206	.09775	.18554	-.35281	.48667	-.19302	.20744	.35445	.70201	.37822
5.0 - 6.0	-.02196	.44677	-.26281	.91913	-.23507	.44473	.88767	.23380	.08953	-.41035
6.0 - 7.0	.19176	.21403	.35904	.70908	-.28288	.18123	.64227	.36121	.41530	-.24625
7.0 - 8.0	-.04632	.89197	.23589	.00343	.01163	.74416	-.05160	-.41695	-.02420	-.56841
8.0 - 9.0	-.18596	.64777	.36120	.41465	.24908	.54207	.27417	-.19115	-.00984	-.33166
9.0 - 10.0	-.74713	-.05280	-.41973	-.42872	.57135	-.08699	-.42876	-.58068	-.18306	.49486
10.0 - 11.0	-.44387	.33145	-.19653	-.01832	.23455	.33529	-.01433	-.31385	.01261	.11557
11.0 - 12.0	.08526	-.42993	-.58266	-.18581	-.09600	.43794	-.26228	.29388	.45078	.43306
12.0 - 13.0	-.23496	-.02023	-.31672	.00902	.11658	-.09133	-.17039	.00472	-.00262	.21148
13.0 - 14.0	.43935	-.36660	.29204	.48886	-.03584	-.21270	.61773	.48173	.85243	.03652
14.0 - 15.0	.09273	-.17806	.00317	-.00523	-.21321	-.05795	.09747	.18548	-.21010	-.45468
15.0 - 16.0	.21491	.61818	.44251	.45364	-.03951	.90574	.44448	-.24866	.92140	.23772
16.0 - 17.0	.05834	.09353	.18618	-.31994	.45356	-.19319	.21549	.35980	.70869	.37919
17.0 - 18.0	-.00657	.44604	-.24735	.92392	-.23798	.44478	.89109	.23780	.09451	-.41387
18.0 - 19.0	.19289	.21697	.36092	.71047	-.28014	.18518	.64765	.36130	.41333	-.25329
19.0 - 20.0	-.04539	.89180	.23708	.09457	.41331	.74716	-.05118	-.41988	-.02889	-.57305
20.0 - 21.0	-.18597	.64782	.36091	.41332	.25264	.54470	.23295	-.19721	-.01499	-.33746
21.0 - 22.0	-.74763	-.05139	-.41989	-.42963	.57277	-.08421	-.02893	-.58215	-.18782	.49375
22.0 - 23.0	-.44472	.33262	-.19743	-.02123	.23741	.33687	-.01027	-.31654	.00792	.11461
23.0 - 24.0	.08387	-.42462	-.58279	-.18828	-.09316	-.43914	-.26785	.29312	.44844	.43555
24.0 - 25.0	-.33736	-.02000	-.31773	.00595	-.11305	-.09241	-.17587	.00426	-.00360	.21386
25.0 - 26.0	.43918	-.36790	.28960	.44742	-.03603	-.21457	.61719	.44227	.85376	.03859
26.0 - 27.0	.09147	-.17840	.00091	-.00577	-.21355	-.05906	.09717	.18666	-.21896	-.45251
27.0 - 28.0	.21346	.61782	.44161	.45447	-.03965	.90509	.44431	-.24882	.92302	.23801
28.0 - 29.0	.05774	.09443	.18677	-.31584	.45045	-.19003	.21873	.35914	.70063	.37895
29.0 - 30.0	-.00340	.44682	-.24524	.92220	-.23449	.44617	.89222	.23670	.09557	-.41495
30.0 - 31.0	.19032	.21928	.36009	.70973	-.27685	.18812	.64895	.35989	.41209	-.25563
31.0 - 32.0	-.44472	.89001	.23525	.09449	.41242	.74872	-.04939	-.41990	-.03008	-.57565
32.0 - 33.0	-.18817	.64265	.35602	.40374	.25557	.54044	.22773	-.20203	-.02857	-.33695
33.0 - 34.0	-.71917	-.07706	-.41860	-.43179	.55285	-.11334	-.03242	.56684	-.18516	.49566
34.0 - 35.0	-.40232	.02385	-.22863	-.23165	.28052	.05770	-.16271	-.26072	.05490	.24859

FIGURE E.16p. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

CROSSFLOW BETWEEN ADJACENT CHANNELS AT TIME = 0.0000 SECONDS

ASSEMBLY NUMBER	1	1	1	1	1	1	1	1	1	1	1
AXIAL ZONE	W(5, 10)	W(5, 8)	W(1, 2)	W(1, 8)	W(2, 9)	W(9, 16)	W(16, 23)	W(23, 29)	W(29, 36)	W(35, 36)	
0.0 = 1.0	-.10345	-.10939	-.23399	-.25117	.10787	-.01995	-.05548	-.17681	-.20042	-.20291	
1.0 = 2.0	1.04397	-.42012	-.01015	-.29657	.27572	-.25663	-.80479	-.10387	-.1.86133	1.11464	
2.0 = 3.0	-.18287	.32889	-.07759	.36326	.06138	-.39413	-.70837	-.90529	-.1.14191	.81017	
3.0 = 4.0	.43338	.25017	-.23364	-.26567	-.76587	1.24534	1.78858	1.34367	1.19549	.61887	
4.0 = 5.0	.16881	.37326	-.37107	-.07445	-.47433	-.96829	1.18246	-.91209	-.76183	.37116	
5.0 = 6.0	.73227	-.41441	1.22848	.75581	1.78888	1.38055	1.25824	-.67193	-.10766	.19909	
6.0 = 7.0	.43433	-.18610	-.95670	.66292	1.18064	-.93035	-.79007	-.40334	-.85653	.32710	
7.0 = 8.0	-.08653	-.37545	1.38472	1.76967	1.25959	-.68135	-.11479	-.20264	-.29866	.14973	
8.0 = 9.0	.33938	-.31174	-.92970	1.16703	-.79308	-.40871	-.06847	-.32777	-.84153	.13053	
9.0 = 10.0	-.43591	.29349	-.68901	1.24987	-.12096	-.21278	-.30170	-.14988	.25722	.24550	
10.0 = 11.0	-.08633	.00309	-.40983	.78466	-.06553	-.32852	-.74279	-.12917	-.08067	.36486	
11.0 = 12.0	-.20658	.43833	-.22168	.12669	-.70166	-.28006	-.28006	-.28006	-.28006	1.21707	
12.0 = 13.0	-.05418	.18333	-.32931	.06571	-.34110	-.12740	-.08802	-.36323	-.46118	.94734	
13.0 = 14.0	.90491	-.25153	-.14812	.30096	.26199	-.24289	-.75758	1.21625	1.75836	1.36245	
14.0 = 15.0	-.19141	.35729	-.12829	.34005	.08391	-.36289	-.86178	-.94749	1.16293	.91774	
15.0 = 16.0	.44290	.23881	-.24129	-.26295	-.75705	1.21647	1.75997	1.36311	1.23757	.67892	
16.0 = 17.0	.18395	.36137	-.36397	-.08258	-.86237	-.94843	1.18025	-.91880	-.77856	.40166	
17.0 = 18.0	.74546	-.42051	1.21779	.75631	1.76123	1.36477	1.23912	-.67939	1.2440	.21516	
18.0 = 19.0	.54400	-.19790	-.94960	.66242	1.16516	-.91993	-.77075	-.40226	-.06175	.32710	
19.0 = 20.0	-.08343	-.58304	1.35561	1.76098	1.23971	-.68043	-.18498	-.21573	-.29952	.14688	
20.0 = 21.0	.33843	-.31809	-.92044	1.16460	-.78059	-.40350	-.06256	-.32728	-.33861	.12795	
21.0 = 22.0	-.43862	.29003	-.68044	1.24014	-.12825	-.21546	-.28026	1.4801	.25833	.24311	
22.0 = 23.0	-.09037	.00119	-.40312	.78048	-.06230	-.32745	-.33850	1.2883	.88029	.36477	
23.0 = 24.0	-.21264	.44109	-.21770	.12656	-.29980	-.14778	.25788	-.24304	-.75566	1.21649	
24.0 = 25.0	-.053747	.18642	-.32742	.06358	-.33913	-.12869	.08814	-.36440	-.86118	.94831	
25.0 = 26.0	.90349	-.24621	-.14837	.29917	.25791	-.24355	-.75574	1.21481	1.75884	1.36430	
26.0 = 27.0	-.19177	.36040	-.12888	.33800	-.08028	-.36454	-.86100	-.98703	1.18361	.91931	
27.0 = 28.0	.44422	.23773	-.24296	-.25793	-.75544	1.21622	1.75497	1.36285	1.23791	.68070	
28.0 = 29.0	.18592	.36053	-.36421	-.08035	-.86083	-.94789	1.18109	-.91885	-.77959	.40363	
29.0 = 30.0	.74758	-.42069	1.21363	.75558	1.75826	1.36439	1.23793	-.68105	-.12469	.21466	
30.0 = 31.0	.54504	-.19960	-.94664	.66113	1.16817	-.91981	-.77017	-.40286	-.06248	.32729	
31.0 = 32.0	-.08184	-.58468	1.36089	1.75386	1.23861	-.68241	-.18007	-.22106	-.30063	.14682	
32.0 = 33.0	.33162	-.31659	-.91922	1.15987	-.78285	-.41081	-.07140	-.32698	-.33851	.12251	
33.0 = 34.0	-.44233	.28349	-.68879	1.23581	-.14187	-.26503	-.29382	1.4056	.27311	.20954	
34.0 = 35.0	-.23442	.12371	-.43758	.77294	-.05292	-.04957	-.18219	.04705	.27960	.09775	

FIGURE E.16q. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

ASSEMBLY NUMBER	1	1	1	1
AXIAL ZONE	W(24, 34)	W(22, 28)	W(14, 22)	W(8, 15)
0.0 - 1.0	.11780	.09110	-.02977	-.15105
1.0 - 2.0	.83818	.27339	-.26871	-.00749
2.0 - 3.0	.86788	.19655	-.16492	.32088
3.0 - 4.0	.05362	.14933	.24597	.15407
4.0 - 5.0	.02470	.32391	.34381	.13834
5.0 - 6.0	.29710	.14529	-.25644	.24260
6.0 - 7.0	.33721	.12662	-.07827	.36562
7.0 - 8.0	-.25560	.24475	.75495	1.21696
8.0 - 9.0	-.07914	.36528	.66064	.94753
9.0 - 10.0	.75727	1.21634	1.76117	1.37107
10.0 - 11.0	.66098	.94665	1.15263	.92142
11.0 - 12.0	1.75735	1.36332	1.23947	.68331
12.0 - 13.0	1.16170	.91762	.77835	.40408
13.0 - 14.0	1.23618	.67937	.12421	.21695
14.0 - 15.0	.77709	.40126	.06170	.32770
15.0 - 16.0	.12435	.21603	.29937	.14643
16.0 - 17.0	.06114	.32709	.33858	.12822
17.0 - 18.0	.29884	.14607	-.25113	.24102
18.0 - 19.0	.33775	.12779	-.08181	.36414
19.0 - 20.0	-.25916	.24172	.75514	1.21727
20.0 - 21.0	-.08072	.36421	.66136	.94923
21.0 - 22.0	.75528	1.21551	1.75982	1.36674
22.0 - 23.0	.66130	.94782	1.16415	.92087
23.0 - 24.0	1.75653	1.36352	1.23908	.68159
24.0 - 25.0	1.16191	.91897	.77999	.40421
25.0 - 26.0	1.23807	.68108	.12468	.21591
26.0 - 27.0	.77890	.40286	.06283	.32804
27.0 - 28.0	.12815	.21974	.00063	.14845
28.0 - 29.0	.06359	.32743	.33989	.12892
29.0 - 30.0	.29847	.14924	-.25715	.24403
30.0 - 31.0	.33776	.12987	-.08029	.36463
31.0 - 32.0	-.25753	.24022	.75284	1.21582
32.0 - 33.0	-.08767	.35330	.65354	.94482
33.0 - 34.0	.71751	1.16896	1.72112	1.34361
34.0 - 35.0	.86154	.77796	1.07803	.87043

ITERATIONS = 15

SPECIFIED NUMBER OF TIME STEPS COMPLETED

COMMON DUMPED TO TAPE 8

FIGURE E.16r. COBRA-WC Output for 19-Pin Wire-Wrapped Assembly Problem

BLOCKAGE SAMPLE PROBLEM

A 19-pin bundle similar to that used for the wire-wrap sample problem is used to illustrate the COBRA-WC blockage capability. Figure E.17 shows a cross section of the assembly and the location of a plate blockage 4 in. from the assembly inlet. This bundle and blockage arrangement is similar to the bundle used in the ORNL FFM-5A blockages tests. The wire wraps in the FFM-5A bundle were not included in this simulation since some of the wires were shaved and could not be modeled by COBRA-WC input. The shaved wires could be modeled using minor code modifications but were neglected for this sample problem since the intent of the sample problems is to illustrate the use of the code through input only. An axial length of 22 in. is modeled using 22 axial nodes. The power density is uniform radially at $47.48 \text{ MBtu/hr-ft}^3$. An inlet mass flux of $4.491 \text{ Mlbm/hr-ft}^2$ is specified at an inlet temperature of 610°F . GEOM was used to generate input for Card Groups 4 and 8. The input cards, the edited input, and the calculated problem results are provided in the computer printout.

FFM - 5A BUNDLE

FLOW: 41.93 gpm
 POWER: 139.9 kw
 P/D: 1.24
 SKEW: 1.0

FIGURE E.17. Cross Section and Location of Plate Blockage for Blockage Sample Problem

1	11	2	17	3	21	4	26	5	20	6	14	7	3	8	34
17	31	10	7	11	12	12	18	13	24	14	27	15	22	16	34
25	1	26	2	27	9	24	16	29	23	30	29	31	26	22	35
33	28	34	22	35	15	26	8								

FFM-5A BUNOLE TEST 2 RUN 101.

2

.226 .230-.0001.3341.000-.000

101050

19 .2300.000 0 0 01.000 0

*** GROUP 4 CARD IMAGES - WRITTEN TO TAPE10 ***

1	11.0140.3613.3613	17.0571.0555	14.0571.0555	6.0571.0555
2	17.0140.3613.3613	21.0571.0555	12.0571.0555	
3	21.0140.3613.3613	26.0571.0555	27.0571.0555	
4	26.0140.3613.3613	20.0571.0555	31.0571.0555	
5	20.0140.3613.3613	14.0571.0555	25.0571.0555	
6	14.0140.3613.3613	10.0571.0555		
7	3.0140.3613.3613	6.0571.0555	5.0571.0555	1.0571.0555
8	6.0140.3613.3613	4.0571.0555		
9	4.0140.3613.3613	7.0571.0555	2.0571.0555	
10	7.0140.3613.3613	12.0571.0555	9.0571.0555	
11	12.0140.3613.3613	18.0571.0555		
12	18.0140.3613.3613	24.0571.0555	16.0571.0555	
13	24.0140.3613.3613	27.0571.0555	23.0571.0555	
14	27.0140.3613.3613	32.0571.0555		
15	32.0140.3613.3613	34.0571.0555	29.0571.0555	
16	34.0140.3613.3613	31.0571.0555	36.0571.0555	
17	31.0140.3613.3613	33.0571.0555		
18	33.0140.3613.3613	30.0571.0555	35.0571.0555	
19	30.0140.3613.3613	25.0571.0555	28.0571.0555	
20	25.0140.3613.3613	19.0571.0555		
21	19.0140.3613.3613	13.0571.0555	22.0571.0555	
22	13.0140.3613.3613	10.0571.0555	15.0571.0555	
23	10.0140.3613.3613	5.0571.0555		
24	5.0140.3613.3613	8.0571.0555		
25	1.0330.79A8.4215	2.0571.0759	8.0571.0759	
26	2.0330.79A8.4215	9.0571.0759		
27	9.0330.79A8.4215	16.0571.0759		
28	16.0330.79A8.4215	23.0571.0759		
29	23.0330.79A8.4215	29.0571.0759		
30	29.0330.79A8.4215	36.0571.0759		
31	36.0330.79A8.4215	35.0571.0759		
32	35.0330.79A8.4215	28.0571.0759		
33	28.0330.79A8.4215	22.0571.0759		
34	22.0330.79A8.4215	15.0571.0759		
35	15.0330.79A8.4215	8.0571.0759		
36	8.0330.79A8.4215			

THE DIRECT SOLUTION OF THE MOMENTUM EQUATION WILL REQUIRE A MATRIX OF BANDWIDTH 15

*** GROUP 8 CARD IMAGES - WRITTEN TO TAPE11 ***

1	1.23001.020	11.1667	17.1667	21.1667	26.1667	20.1667	14.1667
2	2.23001.014	11.1667	14.1667	3.1667	6.1667	10.1667	5.1667
3	3.23001.014	11.1667	17.1667	6.1667	4.1667	7.1667	12.1667
4	4.23001.020	17.1667	21.1667	12.1667	18.1667	24.1667	27.1667
5	5.2300.9960	21.1667	26.1667	27.1667	32.1667	34.1667	31.1667
6	6.2300.9960	26.1667	20.1667	31.1667	33.1667	30.1667	25.1667
7	7.23001.020	20.1667	14.1667	25.1667	19.1667	13.1667	10.1667
8	8.23001.006	3.1667	5.1667	1.3333	8.3333		
9	9.23001.006	3.1667	6.1667	4.1667	1.2500	2.2500	
10	10.23001.006	4.1667	7.1667	2.3333	9.3333		
11	11.23001.014	7.1667	12.1667	18.1667	9.2500	14.2500	
12	12.23001.000	18.1667	24.1667	16.3333	23.3333		
13	13.2300.9960	24.1667	27.1667	32.1667	23.2500	29.2500	
14	14.2300.9550	32.1667	34.1667	29.3333	36.3333		
15	15.2300.9550	34.1667	31.1667	33.1667	36.2500	35.2500	
16	16.2300.9550	33.1667	30.1667	35.3333	24.3333		
17	17.2300.9960	30.1667	25.1667	19.1667	28.2500	22.2500	
18	18.23001.020	19.1667	13.1667	22.3333	14.3333		
19	19.23001.014	13.1667	10.1667	5.1667	15.2500	8.2500	

 THIS IS THE COBRA-WHOLE CONE CODE FOR MULTIASSEMBLY LMFRR ANALYSIS
 WRITTEN AT PACIFIC NORTHWEST LABORATORY DURING 1977-1980
 DOE CONTRACT AG102044 AND CRRP CONTRACT D1813-40761

CREATION DATE FOR THIS CYCLE - 2-1-80

COBRA DIMENSION PARAMETERS

MA= 1	MC= 95	ME= 36	MG= 160
MI= 7	MT= 4	MK= 20	ML= 1
MM= 60	MN= 5	MO= 11	MP= 60
MR= 61	MS= 1	MT= 10	MV= 2
MW= 35	MX= 36	MY= 4	MZ= 1
MI= 2425	NJ= 12	NI= 9	IA= 61
JE= 21	IR= 6	IT= 8	IU= 8
JV= 4	IW= 7	IH= 6	IX= 20

FRICITION FACTOR CORRELATIONS

TYPE 1 $f = \max \left(\left(.316 \cdot RE^{**}(-.230) + 0.000 \cdot RE^{**}(0.000) + 0.00001 \right) \text{ OR } \left(.447 \cdot \ln(0.000 \cdot RE^{**}(-1.000) + 0.000) \right) \right)$

HEAT TRANSFER CORRELATIONS

TYPE 1 $h = k/0 \left(.025 \cdot RE^{**}(.800) \cdot PR^{**}(.800) + 7.000 \right)$

HEAT FLUX DISTRIBUTION

X/I RELATIVE FLUX PROFILES

	1
0.000	1.222
.A18	1.222
.A18	0.000
1.000	0.000

ASSEMBLY NUMBER 1 INPUT DESCRIPTION

AXIAL HEAT FLUX PROFILE NUMBER 1
HEAT FLUX VS. TIME PROFILE NUMBER 0

HEAT TRANSFER CORRELATION NUMBER 1
INLET FLOW VS. TIME PROFILE NUMBER 0

SUBCHANNEL INPUT DATA FOR ASSEMBLY NUMBER

LOCAL CH NO	GLOBAL CH NO	FRICTN FACTOR TYPE	AREA (SQ-IN)	WETTED PERIM. (IN)	HEATED PERIM. (IN)	HYDRAULIC DIAMETER (IN)	(ADJACENT CHANNEL NO., SPACING, MOM. C. V. LENGTH)			
1	1	1	.033000	.798800	.421500	.165248	(2, .057, .074)	(8, .057, .074)	(0, -.000, -.000)	(0, -.000, -.000)
2	2	1	.033000	.798800	.421500	.165248	(9, .057, .074)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
3	3	1	.014900	.361300	.361300	.164960	(6, .057, .054)	(5, .057, .054)	(1, .057, .054)	(0, -.000, -.000)
4	4	1	.014900	.361300	.361300	.164960	(7, .057, .054)	(2, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)
5	5	1	.014900	.361300	.361300	.164960	(8, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
6	6	1	.014900	.361300	.361300	.164960	(4, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
7	7	1	.014900	.361300	.361300	.164960	(12, .057, .054)	(9, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)
8	8	1	.033000	.798800	.421500	.165248	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
9	9	1	.033000	.798800	.421500	.165248	(16, .057, .074)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
10	10	1	.014900	.361300	.361300	.164960	(5, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
11	11	1	.014900	.361300	.361300	.164960	(17, .057, .054)	(14, .057, .054)	(6, .057, .054)	(0, -.000, -.000)
12	12	1	.014900	.361300	.361300	.164960	(18, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
13	13	1	.014900	.361300	.361300	.164960	(10, .057, .054)	(15, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)
14	14	1	.014900	.361300	.361300	.164960	(10, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
15	15	1	.033000	.798800	.421500	.165248	(8, .057, .074)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
16	16	1	.033000	.798800	.421500	.165248	(23, .057, .074)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
17	17	1	.014900	.361300	.361300	.164960	(21, .057, .054)	(12, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)
18	18	1	.014900	.361300	.361300	.164960	(24, .057, .054)	(16, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)
19	19	1	.014900	.361300	.361300	.164960	(17, .057, .054)	(22, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)
20	20	1	.014900	.361300	.361300	.164960	(14, .057, .054)	(25, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)
21	21	1	.014900	.361300	.361300	.164960	(26, .057, .054)	(27, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)
22	22	1	.033000	.798800	.421500	.165248	(15, .057, .074)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
23	23	1	.033000	.798800	.421500	.165248	(29, .057, .074)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
24	24	1	.014900	.361300	.361300	.164960	(27, .057, .054)	(23, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)
25	25	1	.014900	.361300	.361300	.164960	(19, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
26	26	1	.014900	.361300	.361300	.164960	(20, .057, .054)	(11, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)
27	27	1	.014900	.361300	.361300	.164960	(32, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
28	28	1	.033000	.798800	.421500	.165248	(22, .057, .074)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
29	29	1	.033000	.798800	.421500	.165248	(36, .057, .074)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
30	30	1	.014900	.361300	.361300	.164960	(25, .057, .054)	(28, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)
31	31	1	.014900	.361300	.361300	.164960	(33, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
32	32	1	.014900	.361300	.361300	.164960	(34, .057, .054)	(29, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)
33	33	1	.014900	.361300	.361300	.164960	(30, .057, .054)	(15, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)
34	34	1	.014900	.361300	.361300	.164960	(31, .057, .054)	(16, .057, .054)	(0, -.000, -.000)	(0, -.000, -.000)
35	35	1	.033000	.798800	.421500	.165248	(28, .057, .074)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)
36	36	1	.033000	.798800	.421500	.165248	(35, .057, .074)	(0, -.000, -.000)	(0, -.000, -.000)	(0, -.000, -.000)

ROD INPUT DATA FOR ASSEMBLY NUMBER 1

LOCAL ROD NO.	GLOBAL ROD NO.	TYPE NO.	DIAM (IN)	RADIAL POWER FACTOR
1	1	1	.2300	1.0200
2	2	1	.2300	1.0140
3	3	1	.2300	1.0140
4	4	1	.2300	1.0200
5	5	1	.2300	.9960
6	6	1	.2300	.9960
7	7	1	.2300	1.0200
8	8	1	.2300	1.0060
9	9	1	.2300	1.0060
10	10	1	.2300	1.0060
11	11	1	.2300	1.0140
12	12	1	.2300	1.0000
13	13	1	.2300	.9960
14	14	1	.2300	.9550
15	15	1	.2300	.9550
16	16	1	.2300	.9550
17	17	1	.2300	.9960
18	18	1	.2300	1.0200
19	19	1	.2300	1.0140

FRACTION OF POWER TO ADJACENT CHANNELS (ADJ. CHANNEL NO.)

.1667 (11)	.1667 (17)	.1667 (21)	.1667 (26)	.1667 (20)	.1667 (14)
.1667 (11)	.1667 (14)	.1667 (3)	.1667 (6)	.1667 (10)	.1667 (5)
.1667 (11)	.1667 (17)	.1667 (6)	.1667 (4)	.1667 (7)	.1667 (12)
.1667 (17)	.1667 (21)	.1667 (12)	.1667 (19)	.1667 (24)	.1667 (27)
.1667 (21)	.1667 (26)	.1667 (27)	.1667 (32)	.1667 (34)	.1667 (31)
.1667 (26)	.1667 (20)	.1667 (31)	.1667 (33)	.1667 (30)	.1667 (25)
.1667 (20)	.1667 (14)	.1667 (25)	.1667 (19)	.1667 (13)	.1667 (10)
.1667 (3)	.1667 (5)	.3333 (1)	.3333 (8)	-0.0000 (0)	-0.0000 (0)
.1667 (3)	.1667 (6)	.1667 (4)	.2500 (1)	.2500 (2)	-0.0000 (0)
.1667 (4)	.1667 (7)	.3333 (5)	.3333 (9)	-0.0000 (0)	-0.0000 (0)
.1667 (7)	.1667 (12)	.1667 (18)	.2500 (9)	.2500 (16)	-0.0000 (0)
.1667 (18)	.1667 (24)	.3333 (16)	.3333 (23)	-0.0000 (0)	-0.0000 (0)
.1667 (24)	.1667 (27)	.1667 (32)	.2500 (23)	.2500 (29)	-0.0000 (0)
.1667 (32)	.1667 (34)	.3333 (20)	.3333 (36)	-0.0000 (0)	-0.0000 (0)
.1667 (34)	.1667 (31)	.1667 (33)	.2500 (36)	.2500 (33)	-0.0000 (0)
.1667 (33)	.1667 (30)	.3333 (35)	.3333 (38)	-0.0000 (0)	-0.0000 (0)
.1667 (30)	.1667 (25)	.1667 (10)	.2500 (38)	.2500 (22)	-0.0000 (0)
.1667 (19)	.1667 (13)	.3333 (22)	.3333 (15)	-0.0000 (0)	-0.0000 (0)
.1667 (13)	.1667 (10)	.1667 (5)	.2500 (15)	.2500 (8)	-0.0000 (0)

BLOCKED CHANNEL INFORMATION

AXIAL LEVEL	ASSEMBLY NO.	CHANNEL NO.
5	1	1
5	1	3
5	1	5
5	1	8
5	1	10
5	1	13
5	1	15
5	1	19
5	1	22
5	1	25
5	1	28
5	1	30

CALCULATION PARAMETERS

LATERAL RESISTANCE FACTOR	.5000
S/L PARAMETER	.5000
TURBULENT MOMENTUM FACTOR	-0.0000
CHANNEL ORIENTATION (DEGREES)	90.0000
CHANNEL LENGTH (INCHES)	22.0000
NUMBER OF AXIAL NODES	22
TOTAL TRANSIENT TIME (SECONDS)	0.0000
NUMBER OF TIME STEPS	-0
NOMINAL TIME STEP (SECONDS)	*****
POLL OPTION (0 = NO POLL)	0

DATA FOR IMPLICIT SOLUTION

EXTERNAL ITERATION LIMIT	60
INTERNAL ITERATION LIMIT	20
CONVERGENCE FACTORS	
EXTERNAL (DW/W)	.10000
INTERNAL (DP/P)	.00001
FLOW (DF/F)	.01000
ENERGY (DH/H)	.00100
ACCELERATION FACTORS	
CROSS FLOW SOLUTION	1.60000
LATERAL DELTA-P	.80000
FLOW	.60000

AXIAL NODING

NODE NO.	INTEGRAL HEIGHT (IN.)	NODAL LENGTH (IN.)	NODE NO.	INTEGRAL HEIGHT (IN.)	NODAL LENGTH (IN.)	NODE NO.	INTEGRAL HEIGHT (IN.)	NODAL LENGTH (IN.)
1	0.0- 1.0	1.000	2	1.0- 2.0	1.000	3	2.0- 3.0	1.000
4	3.0- 4.0	1.000	5	4.0- 5.0	1.000	6	5.0- 6.0	1.000
7	6.0- 7.0	1.000	8	7.0- 8.0	1.000	9	8.0- 9.0	1.000
10	9.0- 10.0	1.000	11	10.0- 11.0	1.000	12	11.0- 12.0	1.000
13	12.0- 13.0	1.000	14	13.0- 14.0	1.000	15	14.0- 15.0	1.000
16	15.0- 16.0	1.000	17	16.0- 17.0	1.000	18	17.0- 18.0	1.000
19	18.0- 19.0	1.000	20	19.0- 20.0	1.000	21	20.0- 21.0	1.000
22	21.0- 22.0	1.000						

MIXING PARAMETERS

ASSEMBLY TYPE NO.	MIXING CORRELATION	MIXING COEFFICIENTS		FORCED MIXING MODEL DIRECTION		PARAMETER	CONDUCTION MIXING GEOMETRY FACTOR
1	1	ABETA	BBETA	NONE		0.000	.300
		.020	0.000				

OPERATING CONDITIONS

SYSTEM PRESSURE = 130.0 PSIA
 INLET ENTHALPY = 334.1 BTU/LBM
 INLET TEMPERATURE = 610.000 DEGREES F
 NOMINAL MASS FLUX = 4.491 MILLION LBM/FT2*HR
 NOMINAL POWER DENSITY = 47.4800 MILLION BTU/HR*FT3
 UNIFORM INLET TEMPERATURE

UNIFORM INLET MASS VELOCITY

DATA FROM ITERATIVE SOLUTION USING THE RECIRCULATION MODULE

TIME = 0.0000 DT = ***** IMPLICIT DT = 0.0000 EXPLICIT DT = .0020 MORE = 0

ITERATION NO.	PRESSURE SHEFFS	FLOW ERROR	ENERGY ERROR	EMAXI	EMAXJ
1	12	.0561	.0707	14	7
2	12	4.6555	.1703	22	6
3	8	2.1072	.0085	15	6
4	11	7.6210	.0093	8	6
5	14	*****	.0088	13	6
6	11	6.0808	.0081	13	6
7	11	3.9348	.0081	15	7
8	11	2.8640	.0082	15	7
9	8	1.0997	.0084	19	6
10	8	1.1644	.0087	19	6
11	9	2.1502	.0070	19	6
12	9	2.5274	.0037	19	6
13	9	4.3464	.0027	19	6
14	11	*****	.0019	19	6
15	11	3.3859	.0018	19	6
16	9	1.6485	.0017	19	6
17	8	1.7018	.0015	5	6
18	8	2.4630	.0014	5	6
19	8	3.7990	.0013	5	6
20	9	*****	.0012	5	6
21	11	7.6180	.0011	5	6
22	11	2.6419	.0010	5	6
23	9	1.4658	.0010	5	6
24	8	.9441	.0009	5	6
25	8	.6444	.0008	5	6
26	8	.4611	.0007	5	6
27	8	.3332	.0006	5	6
28	8	.2446	.0006	5	6
29	6	.1830	.0005	5	6
30	6	.1371	.0005	5	6
31	6	.1025	.0004	5	6
32	5	.0769	.0004	5	6
33	5	.0575	.0003	5	6
34	5	.0429	.0003	5	6
35	5	.0319	.0002	5	6
36	5	.0236	.0002	5	6
37	5	.0174	.0002	5	6
38	5	.0127	.0002	5	6
39	5	.0099	.0001	13	23

COBRA WHOLE CORE CODE RESULTS

CASE 1 KFM-RA BUNDLE TEST 2 RUN 101.

DATE 05/09/80 0 TIME 22.14.43.2

ASSEMBLY AVERAGE RESULTS FOR ASSEMBLY 1 TIME = 0.00000

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (M/R/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4879	338.12	610.00	54.62	0.000	0.000	6.5284	4.4910	22.8383	.75360
1.0	12.1326	339.24	613.64	54.59	0.000	0.000	6.5284	4.4910	22.8509	.75360
2.0	11.7721	340.37	617.29	54.56	0.000	0.000	6.5284	4.4910	22.8634	.75360
3.0	11.4168	341.50	620.92	54.53	0.000	0.000	6.5284	4.4910	22.8760	.75360
4.0	3.2497	342.63	624.57	54.51	0.000	0.000	6.5284	4.4910	22.8889	.75360
5.0	3.3051	343.58	627.63	54.35	0.000	0.000	6.5284	4.4910	22.9531	.75360
6.0	3.0876	344.87	631.81	54.38	0.000	0.000	6.5284	4.4910	22.9422	.75360
7.0	4.2218	346.01	635.51	54.36	0.000	0.000	6.5284	4.4910	22.9468	.75360
8.0	4.1804	347.14	639.16	54.34	0.000	0.000	6.5284	4.4910	22.9572	.75360
9.0	4.0254	348.27	642.81	54.32	0.000	0.000	6.5284	4.4910	22.9678	.75360
10.0	3.8093	349.40	646.47	54.29	0.000	0.000	6.5284	4.4910	22.9788	.75360
11.0	3.5552	350.53	650.12	54.26	0.000	0.000	6.5284	4.4910	22.9900	.75360
12.0	3.2757	351.65	653.78	54.24	0.000	0.000	6.5284	4.4910	23.0014	.75360
13.0	2.9786	352.78	657.44	54.21	0.000	0.000	6.5284	4.4910	23.0130	.75360
14.0	2.6687	353.91	661.10	54.18	0.000	0.000	6.5284	4.4910	23.0248	.75360
15.0	2.3494	355.04	664.74	54.15	0.000	0.000	6.5284	4.4910	23.0366	.75360
16.0	2.0234	356.17	668.42	54.12	0.000	0.000	6.5284	4.4910	23.0486	.75360
17.0	1.6927	357.29	672.09	54.10	0.000	0.000	6.5284	4.4910	23.0606	.75360
18.0	1.3597	358.42	675.75	54.07	0.000	0.000	6.5284	4.4910	23.0727	.75360
19.0	1.0241	359.42	675.75	54.07	0.000	0.000	6.5284	4.4910	23.0718	.75360
20.0	.6857	358.42	675.75	54.07	0.000	0.000	6.5284	4.4910	23.0711	.75360
21.0	.3449	358.42	675.75	54.07	0.000	0.000	6.5284	4.4910	23.0704	.75360
22.0	0.0000	358.42	675.75	54.07	0.000	0.000	6.5284	4.4910	23.0698	.75360

POD POWER DELIVERED TO THE COOLANT 132.563 BTU/SEC .13988 MW

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS PRESSURE = 130.0 PSIA

CHANNEL 1
ASSEMBLY 1

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (M/R/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4883	338.12	610.00	54.62	0.000	0.000	.2859	4.4910	22.8383	.03300
1.0	12.1381	338.94	612.63	54.60	0.000	0.000	.2857	4.4885	22.8346	.03300
2.0	11.8494	339.78	615.35	54.58	0.000	0.000	.2829	4.4838	22.8168	.03300
3.0	12.1344	340.64	618.13	54.56	0.000	0.000	.2507	3.9353	20.0521	.03300
4.0	2.8309	341.58	621.17	54.53	0.000	0.000	0.0000	0.0000	0.0000	.03300
5.0	3.2296	352.37	656.09	54.24	0.000	0.000	.1448	2.2747	11.6488	.03300
6.0	3.9976	349.39	646.44	54.32	0.000	0.000	.1634	2.5673	13.1280	.03300
7.0	4.2325	348.77	648.43	54.34	0.000	0.000	.1801	2.8286	14.4594	.03300
8.0	4.1854	349.07	645.42	54.33	0.000	0.000	.1952	3.0665	15.6779	.03300
9.0	4.0282	349.71	647.47	54.31	0.000	0.000	.2072	3.2557	16.6503	.03300
10.0	3.8112	350.49	650.02	54.29	0.000	0.000	.2171	3.4102	17.4472	.03300
11.0	3.5566	351.36	652.84	54.27	0.000	0.000	.2253	3.5397	18.1177	.03300
12.0	3.2769	352.28	655.83	54.25	0.000	0.000	.2324	3.6503	18.6933	.03300
13.0	2.9705	353.24	658.92	54.22	0.000	0.000	.2385	3.7468	19.1955	.03300
14.0	2.6695	354.22	662.03	54.19	0.000	0.000	.2430	3.8317	19.6397	.03300
15.0	2.3502	355.21	665.31	54.17	0.000	0.000	.2487	3.9074	20.0376	.03300
16.0	2.0240	356.21	668.56	54.14	0.000	0.000	.2531	3.9758	20.3983	.03300
17.0	1.6933	357.22	671.84	54.11	0.000	0.000	.2570	4.0380	20.7278	.03300
18.0	1.3602	358.23	675.13	54.09	0.000	0.000	.2607	4.0949	21.0307	.03300
19.0	1.0246	358.35	675.52	54.08	0.000	0.000	.2640	4.1477	21.3030	.03300
20.0	.6861	358.46	675.87	54.08	0.000	0.000	.2672	4.1970	21.5573	.03300
21.0	.3454	358.56	676.20	54.08	0.000	0.000	.2701	4.2430	21.7950	.03300
22.0	0.0000	358.65	676.51	54.08	0.000	0.000	.2728	4.2850	22.0117	.03300

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 2
ASSEMBLY 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4879	134.12	610.00	54.62	0.000	0.000	.2850	4.4910	22.8383	.03300
1.0	12.1323	134.94	612.65	54.60	0.000	0.000	.2850	4.4910	22.8523	.03300
2.0	11.7718	139.78	615.36	54.58	0.000	0.000	.2850	4.4908	22.8561	.03300
3.0	10.8788	140.64	618.15	54.56	0.000	0.000	.2837	4.4564	22.8001	.03300
4.0	3.1471	141.56	621.11	54.53	0.000	0.000	.3720	5.8039	29.7484	.03300
5.0	3.3355	142.49	624.11	54.51	0.000	0.000	.3613	5.6758	28.6251	.03300
6.0	4.0013	143.29	626.73	54.49	0.000	0.000	.3340	5.2501	26.7461	.03300
7.0	4.2260	144.10	629.32	54.46	0.000	0.000	.3144	5.0014	25.5095	.03300
8.0	4.1930	144.94	632.03	54.44	0.000	0.000	.3101	4.8708	24.8526	.03300
9.0	4.0270	145.80	634.81	54.42	0.000	0.000	.3048	4.7876	24.4379	.03300
10.0	3.8103	146.68	637.65	54.40	0.000	0.000	.3010	4.7292	24.1505	.03300
11.0	3.5559	147.57	640.55	54.37	0.000	0.000	.2983	4.6884	23.9421	.03300
12.0	3.2762	148.48	643.51	54.35	0.000	0.000	.2963	4.6530	23.7870	.03300
13.0	2.9789	149.41	646.51	54.32	0.000	0.000	.2947	4.6288	23.6695	.03300
14.0	2.6690	150.35	649.56	54.30	0.000	0.000	.2934	4.6091	23.5794	.03300
15.0	2.3497	151.31	652.66	54.27	0.000	0.000	.2924	4.5934	23.5105	.03300
16.0	2.0235	152.27	655.77	54.25	0.000	0.000	.2914	4.5809	23.4570	.03300
17.0	1.6929	153.25	658.97	54.22	0.000	0.000	.2910	4.5706	23.4160	.03300
18.0	1.3598	154.24	662.19	54.19	0.000	0.000	.2904	4.5619	23.3820	.03300
19.0	1.0242	154.43	662.80	54.19	0.000	0.000	.2899	4.5546	23.3476	.03300
20.0	.6858	154.61	663.38	54.18	0.000	0.000	.2898	4.5484	23.3179	.03300
21.0	.3449	154.78	663.92	54.18	0.000	0.000	.2892	4.5431	23.2927	.03300
22.0	0.0000	154.94	664.43	54.17	0.000	0.000	.2889	4.5384	23.2706	.03300

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 3
ASSEMBLY 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4883	134.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1379	139.58	614.72	54.58	0.000	0.000	.1290	4.4870	22.8343	.01490
2.0	11.8476	141.00	619.31	54.55	0.000	0.000	.1277	4.4421	22.6215	.01490
3.0	12.1189	142.34	623.65	54.51	0.000	0.000	.1131	3.9335	20.0442	.01490
4.0	2.8381	142.99	628.75	54.49	0.000	0.000	0.0000	0.0000	0.0000	.01490
5.0	3.2244	154.24	662.15	54.19	0.000	0.000	.0750	2.6098	13.3772	.01490
6.0	3.9981	151.00	651.67	54.28	0.000	0.000	.0867	3.0165	15.4368	.01490
7.0	4.2328	150.77	650.90	54.29	0.000	0.000	.0944	3.2844	16.8071	.01490
8.0	4.1854	151.48	653.22	54.27	0.000	0.000	.1005	3.4972	17.9015	.01490
9.0	4.0282	152.50	656.51	54.24	0.000	0.000	.1051	3.6556	18.7212	.01490
10.0	3.8112	153.63	660.19	54.21	0.000	0.000	.1086	3.7785	19.3614	.01490
11.0	3.5566	154.81	664.02	54.18	0.000	0.000	.1114	3.8775	19.8905	.01490
12.0	3.2768	156.02	667.94	54.15	0.000	0.000	.1138	3.9594	20.3134	.01490
13.0	2.9794	157.24	671.93	54.11	0.000	0.000	.1158	4.0293	20.6830	.01490
14.0	2.6694	158.46	675.87	54.08	0.000	0.000	.1175	4.0897	21.0065	.01490
15.0	2.3502	159.68	679.84	54.05	0.000	0.000	.1191	4.1433	21.2943	.01490
16.0	2.0239	160.89	683.73	54.01	0.000	0.000	.1205	4.1914	21.5557	.01490
17.0	1.6932	162.10	687.72	53.98	0.000	0.000	.1219	4.2340	21.7973	.01490
18.0	1.3602	163.30	691.62	53.95	0.000	0.000	.1229	4.2775	22.0239	.01490
19.0	1.0245	162.95	690.48	53.96	0.000	0.000	.1241	4.3162	22.2194	.01490
20.0	.6841	162.65	689.50	53.97	0.000	0.000	.1251	4.3520	22.4002	.01490
21.0	.3454	162.38	688.64	53.98	0.000	0.000	.1260	4.3845	22.5647	.01490
22.0	0.0000	162.15	687.89	53.98	0.000	0.000	.1268	4.4123	22.7049	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
 CHANNEL 4
 ASSEMBLY 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4874	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1314	339.58	614.72	54.58	0.000	0.000	.1291	4.4907	22.8531	.01490
2.0	11.7654	341.00	619.31	54.55	0.000	0.000	.1291	4.4933	22.8820	.01490
3.0	10.7917	342.34	623.63	54.51	0.000	0.000	.1307	4.5489	23.1906	.01490
4.0	3.2182	343.14	624.23	54.49	0.000	0.000	.1974	4.8697	35.0204	.01490
5.0	3.3383	344.10	629.32	54.46	0.000	0.000	.1898	4.5943	33.6323	.01490
6.0	3.9984	345.05	632.39	54.44	0.000	0.000	.1748	4.0811	31.0294	.01490
7.0	4.2242	346.04	635.61	54.41	0.000	0.000	.1651	5.7453	29.3304	.01490
8.0	4.1821	347.09	639.00	54.38	0.000	0.000	.1590	5.5328	28.2600	.01490
9.0	4.0265	348.17	642.49	54.36	0.000	0.000	.1545	5.3771	27.4769	.01490
10.0	3.8100	349.27	646.05	54.33	0.000	0.000	.1510	5.2547	26.8481	.01490
11.0	3.5596	350.39	649.67	54.30	0.000	0.000	.1482	5.1552	26.3737	.01490
12.0	3.2760	351.52	653.34	54.27	0.000	0.000	.1458	5.0724	25.9647	.01490
13.0	2.9787	352.66	657.03	54.24	0.000	0.000	.1438	5.0024	25.6208	.01490
14.0	2.6688	353.82	660.79	54.20	0.000	0.000	.1421	4.9423	25.3276	.01490
15.0	2.3496	354.98	664.56	54.17	0.000	0.000	.1406	4.8901	25.0746	.01490
16.0	2.0234	356.14	668.34	54.14	0.000	0.000	.1392	4.8443	24.8536	.01490
17.0	1.6927	357.31	672.13	54.11	0.000	0.000	.1381	4.8036	24.6599	.01490
18.0	1.3597	358.49	675.96	54.08	0.000	0.000	.1370	4.7678	24.4876	.01490
19.0	1.0242	358.88	675.30	54.08	0.000	0.000	.1361	4.7348	24.3153	.01490
20.0	.6857	359.11	674.73	54.09	0.000	0.000	.1352	4.7037	24.1560	.01490
21.0	.3449	357.96	674.24	54.09	0.000	0.000	.1348	4.6750	24.0070	.01490
22.0	0.0000	357.83	673.83	54.10	0.000	0.000	.1336	4.6486	23.8696	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
 CHANNEL 5
 ASSEMBLY 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4883	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1401	339.58	614.73	54.58	0.000	0.000	.1289	4.4858	22.8280	.01490
2.0	11.8710	341.00	619.30	54.55	0.000	0.000	.1273	4.4282	22.5506	.01490
3.0	12.3030	342.22	623.25	54.51	0.000	0.000	.1105	3.8454	19.5966	.01490
4.0	2.8601	342.73	624.89	54.50	0.000	0.000	0.0000	0.0000	0.0000	.01490
5.0	3.1604	360.49	682.48	54.03	0.000	0.000	-.0035	-.1224	-.6274	.01490
6.0	3.9891	353.58	660.03	54.21	0.000	0.000	.0361	1.2560	6.4358	.01490
7.0	4.2331	354.04	661.52	54.20	0.000	0.000	.0526	1.8295	9.3763	.01490
8.0	4.1852	355.12	665.04	54.17	0.000	0.000	.0630	2.2632	11.6056	.01490
9.0	4.0280	356.30	668.86	54.14	0.000	0.000	.0748	2.5875	13.2765	.01490
10.0	3.8112	357.50	672.75	54.11	0.000	0.000	.0817	2.8437	14.5990	.01490
11.0	3.5567	358.70	676.65	54.07	0.000	0.000	.0878	3.0532	15.6844	.01490
12.0	3.2770	359.90	680.54	54.04	0.000	0.000	.0928	3.2287	16.5950	.01490
13.0	2.9796	361.09	684.42	54.01	0.000	0.000	.0971	3.3783	17.3762	.01490
14.0	2.6696	362.27	688.26	53.98	0.000	0.000	.1008	3.5085	18.0552	.01490
15.0	2.3503	363.44	692.08	53.95	0.000	0.000	.1041	3.6230	18.6554	.01490
16.0	2.0241	364.60	695.86	53.92	0.000	0.000	.1071	3.7255	19.1942	.01490
17.0	1.6934	365.75	699.60	53.88	0.000	0.000	.1098	3.8188	19.6850	.01490
18.0	1.3603	366.89	703.31	53.85	0.000	0.000	.1122	3.9050	20.1412	.01490
19.0	1.0247	368.34	707.52	53.87	0.000	0.000	.1146	3.9856	20.5518	.01490
20.0	.6863	365.87	699.99	53.88	0.000	0.000	.1167	4.0613	20.9372	.01490
21.0	.3453	365.47	698.67	53.89	0.000	0.000	.1188	4.1322	21.2985	.01490
22.0	0.0000	365.11	697.52	53.90	0.000	0.000	.1204	4.1964	21.6267	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS

PRESSURE = 130.0 PSIA

CHANNEL 6
ASSEMBLY 1

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4881	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8787	.01490
1.0	12.1346	339.63	614.88	54.58	0.000	0.000	.1290	4.4888	22.8441	.01490
2.0	11.8000	341.12	619.71	54.54	0.000	0.000	.1288	4.4674	22.7517	.01490
3.0	11.2771	342.55	624.37	54.51	0.000	0.000	.1282	4.4203	21.4112	.01490
4.0	2.9904	343.30	626.74	54.49	0.000	0.000	.1328	4.6108	23.5071	.01490
5.0	3.2932	345.16	632.75	54.44	0.000	0.000	.1406	4.8909	24.9550	.01490
6.0	4.0032	346.28	636.38	54.41	0.000	0.000	.1365	4.7504	24.2541	.01490
7.0	4.2304	347.43	640.09	54.38	0.000	0.000	.1348	4.6717	23.8637	.01490
8.0	4.1849	348.64	644.03	54.34	0.000	0.000	.1338	4.6426	23.7310	.01490
9.0	4.0280	349.89	648.06	54.31	0.000	0.000	.1320	4.6242	23.6516	.01490
10.0	3.8110	351.15	652.15	54.28	0.000	0.000	.1328	4.6098	23.5928	.01490
11.0	3.5564	352.43	656.28	54.24	0.000	0.000	.1322	4.5979	23.5466	.01490
12.0	3.2766	353.71	660.45	54.21	0.000	0.000	.1319	4.5882	23.5114	.01490
13.0	2.9792	355.00	664.63	54.17	0.000	0.000	.1316	4.5802	23.4856	.01490
14.0	2.6692	356.29	668.84	54.14	0.000	0.000	.1315	4.5739	23.4683	.01490
15.0	2.3500	357.59	673.05	54.10	0.000	0.000	.1313	4.5691	23.4586	.01490
16.0	2.0237	358.89	677.27	54.07	0.000	0.000	.1312	4.5656	23.4538	.01490
17.0	1.6930	360.18	681.48	54.03	0.000	0.000	.1312	4.5634	23.4596	.01490
18.0	1.3600	361.48	685.69	54.00	0.000	0.000	.1311	4.5624	23.4693	.01490
19.0	1.0244	361.29	689.04	54.00	0.000	0.000	.1311	4.5618	23.4640	.01490
20.0	.6859	361.10	692.47	54.01	0.000	0.000	.1311	4.5610	23.4578	.01490
21.0	.3451	360.93	695.91	54.01	0.000	0.000	.1311	4.5595	23.4481	.01490
22.0	0.0000	360.78	699.40	54.02	0.000	0.000	.1310	4.5567	23.4318	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS

PRESSURE = 130.0 PSIA

CHANNEL 7
ASSEMBLY 1

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4876	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8787	.01490
1.0	12.1284	339.58	614.74	54.58	0.000	0.000	.1291	4.4927	22.8638	.01490
2.0	11.7146	341.01	619.33	54.55	0.000	0.000	.1301	4.5247	23.0022	.01490
3.0	10.2581	342.37	623.74	54.51	0.000	0.000	.1407	4.8957	24.9481	.01490
4.0	3.4918	343.32	626.80	54.48	0.000	0.000	.2178	7.5770	38.6296	.01490
5.0	3.3410	344.14	629.44	54.46	0.000	0.000	.2092	7.2793	37.1267	.01490
6.0	3.0913	344.91	631.95	54.44	0.000	0.000	.1920	6.6802	34.0842	.01490
7.0	4.2167	345.76	634.71	54.42	0.000	0.000	.1800	6.2609	31.9579	.01490
8.0	4.1786	346.69	637.69	54.39	0.000	0.000	.1719	5.9798	30.5369	.01490
9.0	4.0245	347.65	640.82	54.37	0.000	0.000	.1658	5.7685	29.4717	.01490
10.0	3.8086	348.65	644.04	54.34	0.000	0.000	.1600	5.5995	28.6226	.01490
11.0	3.5546	349.68	647.39	54.31	0.000	0.000	.1560	5.4600	27.9230	.01490
12.0	3.2752	350.73	650.87	54.29	0.000	0.000	.1538	5.3422	27.3353	.01490
13.0	2.9781	351.80	654.27	54.26	0.000	0.000	.1506	5.2411	26.8323	.01490
14.0	2.6683	352.89	657.73	54.23	0.000	0.000	.1481	5.1531	26.3056	.01490
15.0	2.3492	353.99	661.36	54.20	0.000	0.000	.1450	5.0753	26.0114	.01490
16.0	2.0231	355.10	664.97	54.17	0.000	0.000	.1430	5.0057	25.6689	.01490
17.0	1.6924	356.23	668.62	54.14	0.000	0.000	.1421	4.9430	25.3614	.01490
18.0	1.3595	357.36	672.29	54.11	0.000	0.000	.1408	4.8861	25.0833	.01490
19.0	1.0239	357.15	675.62	54.12	0.000	0.000	.1380	4.8337	24.8120	.01490
20.0	.6855	356.97	678.05	54.12	0.000	0.000	.1375	4.7852	24.5405	.01490
21.0	.3446	356.83	679.57	54.12	0.000	0.000	.1362	4.7401	24.3276	.01490
22.0	0.0000	356.70	679.16	54.13	0.000	0.000	.1351	4.6992	24.1158	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 8
ASSEMBLY 1

PRESSURE = 130.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (MIL/HP-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4844	338.12	610.00	54.62	0.000	0.000	.2859	4.4910	22.8383	.03300
1.0	12.1413	338.94	612.65	54.60	0.000	0.000	.2854	4.4865	22.8245	.03300
2.0	11.8830	339.78	615.38	54.58	0.000	0.000	.2848	4.4827	22.8092	.03300
3.0	12.3848	340.65	618.17	54.56	0.000	0.000	.2841	4.4800	19.3632	.03300
4.0	2.8752	341.60	621.24	54.53	0.000	0.000	0.0000	0.0000	0.0000	.03300
5.0	3.1476	357.07	671.35	54.12	0.000	0.000	-.0757	-1.1884	-6.0860	.03300
6.0	3.9820	352.45	656.35	54.24	0.000	0.000	.0274	.4305	2.2048	.03300
7.0	4.2324	352.97	658.05	54.23	0.000	0.000	.0707	1.1101	5.6465	.03300
8.0	4.1847	354.05	661.55	54.20	0.000	0.000	.1045	1.6422	8.4164	.03300
9.0	4.0277	355.10	664.95	54.17	0.000	0.000	.1294	2.0385	10.4531	.03300
10.0	3.8110	356.12	668.27	54.14	0.000	0.000	.1490	2.3541	12.0776	.03300
11.0	3.5567	357.12	671.53	54.12	0.000	0.000	.1664	2.6147	13.4211	.03300
12.0	3.2770	358.11	674.73	54.09	0.000	0.000	.1804	2.8344	14.5571	.03300
13.0	2.9797	359.09	677.93	54.06	0.000	0.000	.1924	3.0231	15.5330	.03300
14.0	2.6697	360.06	681.09	54.04	0.000	0.000	.2029	3.1869	16.3824	.03300
15.0	2.3504	361.03	684.22	54.01	0.000	0.000	.2120	3.3300	17.1307	.03300
16.0	2.0242	361.98	687.33	53.99	0.000	0.000	.2202	3.4590	17.7978	.03300
17.0	1.6935	362.93	690.42	53.96	0.000	0.000	.2275	3.5740	18.3985	.03300
18.0	1.3604	363.87	693.49	53.93	0.000	0.000	.2342	3.6784	18.9454	.03300
19.0	1.0247	363.80	693.24	53.94	0.000	0.000	.2403	3.7751	19.4420	.03300
20.0	.6863	363.73	693.02	53.94	0.000	0.000	.2461	3.8654	19.9070	.03300
21.0	.3456	363.65	692.76	53.94	0.000	0.000	.2515	3.9509	20.3458	.03300
22.0	0.0000	363.57	692.50	53.94	0.000	0.000	.2566	4.0309	20.7571	.03300

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 9
ASSEMBLY 1

PRESSURE = 130.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (MIL/HP-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4874	338.12	610.00	54.62	0.000	0.000	.2859	4.4910	22.8383	.03300
1.0	12.1271	338.94	612.66	54.60	0.000	0.000	.2861	4.4951	22.8681	.03300
2.0	11.6988	339.79	615.40	54.58	0.000	0.000	.2860	4.5394	23.0081	.03300
3.0	10.1717	340.74	618.43	54.55	0.000	0.000	.3183	5.0000	25.4615	.03300
4.0	3.5634	341.72	621.65	54.53	0.000	0.000	.4790	7.5387	38.4057	.03300
5.0	3.3955	342.28	623.45	54.51	0.000	0.000	.4629	7.2703	37.0473	.03300
6.0	3.9888	342.85	625.29	54.50	0.000	0.000	.4256	6.6850	34.0748	.03300
7.0	4.2140	343.48	627.31	54.48	0.000	0.000	.3991	6.2694	31.8668	.03300
8.0	4.1773	344.15	629.49	54.46	0.000	0.000	.3813	5.9900	30.5509	.03300
9.0	4.0238	344.87	631.81	54.44	0.000	0.000	.3679	5.7795	29.4877	.03300
10.0	3.8081	345.62	634.23	54.42	0.000	0.000	.3572	5.6110	28.6385	.03300
11.0	3.5543	346.40	636.75	54.40	0.000	0.000	.3483	5.4716	27.9376	.03300
12.0	3.2749	347.20	639.37	54.38	0.000	0.000	.3408	5.3537	27.3466	.03300
13.0	2.9779	348.04	642.04	54.36	0.000	0.000	.3344	5.2524	26.8401	.03300
14.0	2.6681	348.89	644.83	54.34	0.000	0.000	.3287	5.1640	26.3994	.03300
15.0	2.3490	349.77	647.67	54.31	0.000	0.000	.3237	5.0858	26.0100	.03300
16.0	2.0229	350.67	650.53	54.29	0.000	0.000	.3193	5.0158	25.6640	.03300
17.0	1.6923	351.58	653.54	54.26	0.000	0.000	.3152	4.9521	25.3499	.03300
18.0	1.3598	352.51	656.57	54.24	0.000	0.000	.3115	4.8936	25.0616	.03300
19.0	1.0238	352.71	657.19	54.23	0.000	0.000	.3081	4.8393	24.7861	.03300
20.0	.6854	352.89	657.77	54.23	0.000	0.000	.3049	4.7880	24.5302	.03300
21.0	.3445	353.05	658.32	54.22	0.000	0.000	.3019	4.7422	24.2929	.03300
22.0	0.0000	353.21	658.83	54.22	0.000	0.000	.2992	4.6990	24.0770	.03300

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS

PRESSURE = 130.0 Psia

CHANNEL 10

ASSEMBLY 1

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (M/R/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4885	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1399	339.63	614.90	54.58	0.000	0.000	.1289	4.4857	22.8281	.01490
2.0	11.8689	341.14	619.74	54.54	0.000	0.000	.1273	4.4285	22.5535	.01490
3.0	12.2861	342.58	624.39	54.50	0.000	0.000	.1105	3.8450	19.6002	.01490
4.0	2.8601	343.45	627.21	54.48	0.000	0.000	0.0000	0.0000	0.0000	.01490
5.0	3.1601	343.12	631.04	53.95	0.000	0.000	.0234	.8140	4.1908	.01490
6.0	3.9884	344.56	663.22	54.18	0.000	0.000	.0537	1.8679	9.5758	.01490
7.0	4.2339	354.04	661.53	54.20	0.000	0.000	.0684	2.3042	12.2700	.01490
8.0	4.1854	354.92	664.38	54.17	0.000	0.000	.0795	2.7855	14.1799	.01490
9.0	4.0281	356.12	658.28	54.14	0.000	0.000	.0872	3.0332	15.5617	.01490
10.0	3.8112	357.43	672.52	54.11	0.000	0.000	.0931	3.2401	16.6343	.01490
11.0	3.5567	358.78	674.90	54.07	0.000	0.000	.0970	3.4072	17.5034	.01490
12.0	3.2770	360.14	681.34	54.03	0.000	0.000	.1019	3.5461	18.2294	.01490
13.0	2.9796	361.51	685.78	54.00	0.000	0.000	.1053	3.6645	18.8900	.01490
14.0	2.6696	362.86	690.20	53.96	0.000	0.000	.1083	3.7678	19.3952	.01490
15.0	2.3503	364.21	694.59	53.93	0.000	0.000	.1109	3.8598	19.8822	.01490
16.0	2.0241	365.54	698.90	53.89	0.000	0.000	.1133	3.9435	20.3265	.01490
17.0	1.6933	366.84	703.16	53.86	0.000	0.000	.1156	4.0209	20.7393	.01490
18.0	1.3603	368.13	707.36	53.82	0.000	0.000	.1177	4.0934	21.1277	.01490
19.0	1.0247	367.73	706.04	53.83	0.000	0.000	.1196	4.1618	21.4755	.01490
20.0	.6862	367.35	704.82	53.84	0.000	0.000	.1214	4.2259	21.7984	.01490
21.0	.3455	366.99	703.64	53.85	0.000	0.000	.1231	4.2829	22.0920	.01490
22.0	0.0000	366.65	702.54	53.86	0.000	0.000	.1245	4.3328	22.3437	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS

PRESSURE = 130.0 Psia

CHANNEL 11

ASSEMBLY 1

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (M/R/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4880	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1339	339.64	614.92	54.58	0.000	0.000	.1290	4.4892	22.8464	.01490
2.0	11.7947	341.16	619.84	54.54	0.000	0.000	.1286	4.4738	22.7848	.01490
3.0	11.1171	342.67	624.71	54.50	0.000	0.000	.1250	4.3498	22.1694	.01490
4.0	3.1284	343.74	628.17	54.47	0.000	0.000	.1888	6.5690	33.4073	.01490
5.0	3.2906	345.21	632.91	54.43	0.000	0.000	.1815	6.3156	32.2282	.01490
6.0	3.9963	346.26	636.31	54.41	0.000	0.000	.1679	5.8411	29.8227	.01490
7.0	4.2268	347.37	639.91	54.38	0.000	0.000	.1595	5.5805	28.3490	.01490
8.0	4.1831	348.56	643.77	54.34	0.000	0.000	.1544	5.3722	27.4595	.01490
9.0	4.0269	349.80	647.77	54.31	0.000	0.000	.1507	5.2432	26.8163	.01490
10.0	3.8103	351.07	651.89	54.28	0.000	0.000	.1478	5.1420	26.3152	.01490
11.0	3.5559	352.37	656.09	54.24	0.000	0.000	.1454	5.0598	25.9105	.01490
12.0	3.2762	353.69	660.37	54.21	0.000	0.000	.1435	4.9914	25.5773	.01490
13.0	2.9789	355.02	664.71	54.17	0.000	0.000	.1418	4.9336	25.2981	.01490
14.0	2.6690	356.37	669.09	54.14	0.000	0.000	.1404	4.8843	25.0616	.01490
15.0	2.3498	357.73	673.51	54.10	0.000	0.000	.1392	4.8416	24.8595	.01490
16.0	2.0235	359.10	677.96	54.06	0.000	0.000	.1381	4.8043	24.6848	.01490
17.0	1.6928	360.47	682.42	54.03	0.000	0.000	.1371	4.7715	24.5331	.01490
18.0	1.3598	361.85	686.90	53.99	0.000	0.000	.1363	4.7425	24.4008	.01490
19.0	1.0243	361.78	686.67	53.99	0.000	0.000	.1355	4.7159	24.2828	.01490
20.0	.6858	361.70	686.40	53.99	0.000	0.000	.1348	4.6908	24.1822	.01490
21.0	.3450	361.61	686.12	54.00	0.000	0.000	.1341	4.6667	24.0977	.01490
22.0	0.0000	361.52	685.82	54.00	0.000	0.000	.1335	4.6437	23.9881	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 12
ASSEMBLY 1

PRESSURE = 130.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (M/LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4875	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1270	339.63	614.90	54.58	0.000	0.000	.1292	4.4934	22.8676	.01490
2.0	11.6968	341.14	619.75	54.54	0.000	0.000	.1304	4.5369	23.1056	.01490
3.0	10.1312	342.60	624.48	54.50	0.000	0.000	.1440	5.0429	25.7012	.01490
4.0	3.6077	343.75	628.21	54.47	0.000	0.000	.2227	7.7498	39.5134	.01490
5.0	3.3908	344.59	630.90	54.45	0.000	0.000	.2151	7.4832	38.1750	.01490
6.0	3.9856	345.39	633.50	54.43	0.000	0.000	.1980	6.8902	35.1639	.01490
7.0	4.2125	346.26	636.32	54.41	0.000	0.000	.1858	6.4641	33.0034	.01490
8.0	4.1745	347.20	639.36	54.38	0.000	0.000	.1774	6.1719	31.5260	.01490
9.0	4.0232	348.19	642.54	54.35	0.000	0.000	.1710	5.9488	30.3995	.01490
10.0	3.8078	349.22	645.89	54.33	0.000	0.000	.1654	5.7672	29.4878	.01490
11.0	3.5540	350.28	649.32	54.30	0.000	0.000	.1614	5.6154	28.7265	.01490
12.0	3.2747	351.37	652.85	54.27	0.000	0.000	.1577	5.4856	28.0778	.01490
13.0	2.9777	352.48	656.45	54.24	0.000	0.000	.1544	5.3729	27.5161	.01490
14.0	2.6680	353.61	660.12	54.21	0.000	0.000	.1514	5.2737	27.0229	.01490
15.0	2.3489	354.76	663.86	54.18	0.000	0.000	.1490	5.1851	26.5942	.01490
16.0	2.0228	355.93	667.65	54.15	0.000	0.000	.1467	5.1051	26.1891	.01490
17.0	1.6922	357.11	671.48	54.12	0.000	0.000	.1446	5.0322	25.8303	.01490
18.0	1.3593	358.30	675.36	54.08	0.000	0.000	.1427	4.9654	25.5020	.01490
19.0	1.0237	358.13	674.81	54.09	0.000	0.000	.1409	4.9033	25.1814	.01490
20.0	.6853	357.97	674.27	54.09	0.000	0.000	.1393	4.8451	24.8805	.01490
21.0	.3444	357.81	673.76	54.10	0.000	0.000	.1377	4.7904	24.5986	.01490
22.0	0.0000	357.66	673.29	54.10	0.000	0.000	.1363	4.7405	24.3394	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 13
ASSEMBLY 1

PRESSURE = 130.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (M/LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4887	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1416	339.59	614.76	54.58	0.000	0.000	.1289	4.4848	22.8231	.01490
2.0	11.8897	341.01	619.35	54.55	0.000	0.000	.1270	4.4188	22.5014	.01490
3.0	12.3980	342.27	623.42	54.51	0.000	0.000	.1090	3.7920	19.3227	.01490
4.0	2.8807	343.01	628.81	54.49	0.000	0.000	0.0000	0.0000	0.0000	.01490
5.0	3.1437	343.36	635.31	54.00	0.000	0.000	-.0393	-1.3673	-7.0214	.01490
6.0	3.9760	358.00	674.37	54.09	0.000	0.000	.0073	.2553	1.3110	.01490
7.0	4.2341	357.33	672.19	54.11	0.000	0.000	.0334	1.1607	5.9584	.01490
8.0	4.1849	358.85	677.13	54.07	0.000	0.000	.0489	1.7018	8.7431	.01490
9.0	4.0278	360.25	681.68	54.03	0.000	0.000	.0604	2.1001	10.7968	.01490
10.0	3.8111	361.56	685.97	54.00	0.000	0.000	.0694	2.4153	12.4250	.01490
11.0	3.5567	362.83	690.09	53.96	0.000	0.000	.0740	2.6738	13.7636	.01490
12.0	3.2770	364.05	694.07	53.93	0.000	0.000	.0831	2.8909	14.8900	.01490
13.0	2.9797	365.25	697.95	53.90	0.000	0.000	.0884	3.0764	15.8551	.01490
14.0	2.6697	366.41	701.74	53.87	0.000	0.000	.0931	3.2375	16.6950	.01490
15.0	2.3505	367.55	705.45	53.84	0.000	0.000	.0971	3.3795	17.4373	.01490
16.0	2.0242	368.66	709.09	53.81	0.000	0.000	.1008	3.5068	18.1039	.01490
17.0	1.6935	369.75	712.65	53.78	0.000	0.000	.1041	3.6227	18.7127	.01490
18.0	1.3604	370.82	716.15	53.75	0.000	0.000	.1072	3.7302	19.2783	.01490
19.0	1.0248	370.11	713.82	53.77	0.000	0.000	.1101	3.8311	19.7920	.01490
20.0	.6864	369.49	711.79	53.78	0.000	0.000	.1129	3.9263	20.2780	.01490
21.0	.3456	368.93	709.97	53.80	0.000	0.000	.1154	4.0159	20.7351	.01490
22.0	0.0000	368.43	708.35	53.81	0.000	0.000	.1178	4.0982	21.1947	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 14
ASSEMBLY 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4843	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1348	339.64	614.93	54.58	0.000	0.000	.1290	4.4875	22.8373	.01490
2.0	11.8315	341.17	619.88	54.54	0.000	0.000	.1279	4.4501	22.6842	.01490
3.0	11.6147	342.67	624.69	54.50	0.000	0.000	.1169	4.0666	20.7260	.01490
4.0	2.9458	343.70	628.02	54.47	0.000	0.000	.1242	4.3921	22.3960	.01490
5.0	3.2300	348.89	644.83	54.34	0.000	0.000	.1215	4.2283	21.6160	.01490
6.0	3.9972	349.08	645.49	54.33	0.000	0.000	.1174	4.0851	20.8860	.01490
7.0	4.2323	349.79	647.73	54.31	0.000	0.000	.1175	4.0872	20.9041	.01490
8.0	4.1853	350.86	651.21	54.28	0.000	0.000	.1149	4.1361	21.1653	.01490
9.0	4.0282	352.08	655.17	54.25	0.000	0.000	.1202	4.1835	21.4207	.01490
10.0	3.8112	353.38	659.37	54.22	0.000	0.000	.1214	4.2250	21.6467	.01490
11.0	3.5566	354.72	663.72	54.18	0.000	0.000	.1225	4.2600	21.8455	.01490
12.0	3.2768	356.09	668.16	54.14	0.000	0.000	.1234	4.2925	22.0224	.01490
13.0	2.9794	357.47	672.66	54.11	0.000	0.000	.1242	4.3200	22.1831	.01490
14.0	2.6694	358.87	677.20	54.07	0.000	0.000	.1249	4.3470	22.3324	.01490
15.0	2.3501	360.27	681.74	54.03	0.000	0.000	.1254	4.3715	22.4741	.01490
16.0	2.0239	361.67	686.32	53.99	0.000	0.000	.1263	4.3950	22.6105	.01490
17.0	1.6931	363.07	690.84	53.96	0.000	0.000	.1270	4.4177	22.7432	.01490
18.0	1.3601	364.47	695.42	53.92	0.000	0.000	.1276	4.4398	22.8725	.01490
19.0	1.0245	364.32	694.93	53.92	0.000	0.000	.1282	4.4604	22.9771	.01490
20.0	.6861	364.17	694.44	53.93	0.000	0.000	.1287	4.4788	23.0704	.01490
21.0	.3453	364.02	693.96	53.93	0.000	0.000	.1292	4.4944	23.1488	.01490
22.0	0.0000	363.87	693.49	53.94	0.000	0.000	.1295	4.5062	23.2070	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 15
ASSEMBLY 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4887	338.12	610.00	54.62	0.000	0.000	.2850	4.4910	22.8383	.03300
1.0	12.1428	338.95	612.67	54.60	0.000	0.000	.2855	4.4854	22.8202	.03300
2.0	11.8952	339.80	615.42	54.58	0.000	0.000	.2810	4.4140	22.4697	.03300
3.0	12.4327	340.67	618.23	54.56	0.000	0.000	.2403	3.7756	19.2240	.03300
4.0	2.8898	341.63	621.34	54.53	0.000	0.000	0.0000	0.0000	0.0000	.03300
5.0	3.1463	359.74	680.04	54.05	0.000	0.000	-.1099	-1.7265	-8.8451	.03300
6.0	3.9622	357.77	673.63	54.10	0.000	0.000	-.0840	-1.3191	-6.7491	.03300
7.0	4.2327	356.52	669.58	54.13	0.000	0.000	.0211	.3311	1.4990	.03300
8.0	4.1802	359.15	678.13	54.06	0.000	0.000	.0634	.9990	5.1328	.03300
9.0	4.0274	360.43	682.29	54.03	0.000	0.000	.0930	1.4756	7.5866	.03300
10.0	3.8109	361.47	685.67	54.00	0.000	0.000	.1142	1.8567	9.5510	.03300
11.0	3.5566	362.41	688.71	53.97	0.000	0.000	.1343	2.1725	11.1807	.03300
12.0	3.2770	363.29	691.58	53.95	0.000	0.000	.1553	2.4390	12.5800	.03300
13.0	2.9794	364.14	694.35	53.93	0.000	0.000	.1690	2.6883	13.7442	.03300
14.0	2.6698	364.97	697.05	53.91	0.000	0.000	.1825	2.8667	14.7720	.03300
15.0	2.3506	365.78	699.71	53.88	0.000	0.000	.1935	3.0405	15.6743	.03300
16.0	2.0243	366.59	702.34	53.86	0.000	0.000	.2033	3.1942	16.4734	.03300
17.0	1.6936	367.39	704.95	53.84	0.000	0.000	.2121	3.3315	17.1881	.03300
18.0	1.3605	368.19	707.55	53.82	0.000	0.000	.2200	3.4554	17.8346	.03300
19.0	1.0248	367.91	708.63	53.83	0.000	0.000	.2272	3.5694	18.4204	.03300
20.0	.6864	367.64	708.75	53.83	0.000	0.000	.2340	3.6762	18.9687	.03300
21.0	.3457	367.37	708.89	53.84	0.000	0.000	.2405	3.7773	19.4882	.03300
22.0	0.0000	367.12	708.07	53.85	0.000	0.000	.2466	3.8743	19.9858	.03300

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
 CHANNEL 16
 ASSEMBLY 1

PRESSURE = 130.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (MR/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4871	338.12	610.00	54.62	0.000	0.000	.2850	4.4010	22.8388	.03300
1.0	12.1226	338.94	612.63	54.60	0.000	0.000	.2863	4.4070	22.8822	.03300
2.0	11.6373	339.79	615.39	54.58	0.000	0.000	.2915	4.5796	23.3076	.03300
3.0	9.8144	340.73	618.42	54.55	0.000	0.000	.3404	5.3480	27.2310	.03300
4.0	3.8447	341.72	621.63	54.53	0.000	0.000	.4973	7.8123	39.7970	.03300
5.0	3.4350	342.25	623.33	54.51	0.000	0.000	.4848	7.4101	38.7780	.03300
6.0	3.9770	342.80	625.11	54.50	0.000	0.000	.4471	7.0233	35.7976	.03300
7.0	4.2036	343.39	627.02	54.48	0.000	0.000	.4191	6.5834	33.5652	.03300
8.0	4.1720	344.02	629.07	54.47	0.000	0.000	.3996	6.2772	32.0137	.03300
9.0	4.0207	344.69	631.24	54.45	0.000	0.000	.3847	6.0425	30.8271	.03300
10.0	3.8061	345.39	633.50	54.43	0.000	0.000	.3725	5.8517	29.8640	.03300
11.0	3.5527	346.12	635.86	54.41	0.000	0.000	.3623	5.6914	29.0573	.03300
12.0	3.2738	346.87	638.30	54.39	0.000	0.000	.3534	5.5544	28.3674	.03300
13.0	2.9770	347.65	640.82	54.37	0.000	0.000	.3460	5.4350	27.7681	.03300
14.0	2.6674	348.46	643.42	54.35	0.000	0.000	.3393	5.3296	27.2401	.03300
15.0	2.3484	349.28	646.09	54.33	0.000	0.000	.3333	5.2352	26.7686	.03300
16.0	2.0224	350.12	648.82	54.30	0.000	0.000	.3278	5.1497	26.3422	.03300
17.0	1.6919	350.99	651.62	54.28	0.000	0.000	.3228	5.0711	25.9512	.03300
18.0	1.3590	351.87	654.49	54.26	0.000	0.000	.3182	4.9970	25.5879	.03300
19.0	1.0234	352.04	655.02	54.25	0.000	0.000	.3138	4.9293	25.2389	.03300
20.0	.6850	352.19	655.52	54.25	0.000	0.000	.3097	4.8649	24.9110	.03300
21.0	.3441	352.33	655.99	54.24	0.000	0.000	.3059	4.8047	24.6041	.03300
22.0	0.0000	352.47	656.41	54.24	0.000	0.000	.3023	4.7493	24.3224	.03300

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
 CHANNEL 17
 ASSEMBLY 1

PRESSURE = 130.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (MR/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4877	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8388	.01490
1.0	12.1298	339.64	614.93	54.58	0.000	0.000	.1291	4.4917	22.8589	.01490
2.0	11.7336	341.17	619.85	54.54	0.000	0.000	.1296	4.5094	22.9671	.01490
3.0	10.3877	342.68	624.72	54.50	0.000	0.000	.1357	4.7205	24.0587	.01490
4.0	3.4383	343.86	628.56	54.47	0.000	0.000	.2126	7.3953	37.7130	.01490
5.0	3.1571	344.80	631.54	54.45	0.000	0.000	.2040	7.1127	36.2988	.01490
6.0	3.0913	345.72	634.56	54.42	0.000	0.000	.1880	6.5406	33.3840	.01490
7.0	4.2187	346.71	637.77	54.39	0.000	0.000	.1767	6.1490	31.4013	.01490
8.0	4.1705	347.77	641.20	54.37	0.000	0.000	.1693	5.8894	30.0924	.01490
9.0	4.0250	348.88	644.79	54.34	0.000	0.000	.1637	5.6948	29.1126	.01490
10.0	3.8090	350.03	648.51	54.31	0.000	0.000	.1502	5.3388	28.3313	.01490
11.0	3.5549	351.21	652.33	54.27	0.000	0.000	.1555	5.4099	27.6874	.01490
12.0	3.2754	352.41	656.23	54.24	0.000	0.000	.1520	5.3008	27.1056	.01490
13.0	2.9783	353.64	660.22	54.21	0.000	0.000	.1497	5.2071	26.6821	.01490
14.0	2.6684	354.89	664.27	54.18	0.000	0.000	.1473	5.1255	26.2800	.01490
15.0	2.3493	356.15	668.39	54.14	0.000	0.000	.1452	5.0530	25.9267	.01490
16.0	2.0231	357.44	672.59	54.11	0.000	0.000	.1434	4.9889	25.6123	.01490
17.0	1.6925	358.73	676.75	54.07	0.000	0.000	.1417	4.9308	25.3302	.01490
18.0	1.3595	360.04	681.00	54.04	0.000	0.000	.1402	4.8780	25.0753	.01490
19.0	1.0240	359.95	680.71	54.04	0.000	0.000	.1388	4.8293	24.8233	.01490
20.0	.6855	359.85	680.40	54.04	0.000	0.000	.1375	4.7836	24.5878	.01490
21.0	.3447	359.76	680.09	54.05	0.000	0.000	.1363	4.7408	24.3663	.01490
22.0	0.0000	359.66	679.77	54.05	0.000	0.000	.1351	4.7012	24.1618	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 18
ASSEMBLY 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (M/LB-HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4872	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1237	339.58	614.74	54.58	0.000	0.000	.1292	4.4956	22.8780	.01490
2.0	11.6495	341.01	619.34	54.55	0.000	0.000	.1313	4.5674	23.2594	.01490
3.0	9.8590	342.42	623.89	54.51	0.000	0.000	.1518	5.2821	26.9174	.01490
4.0	3.7969	343.62	627.74	54.48	0.000	0.000	.2248	7.8198	39.8732	.01490
5.0	3.4252	344.34	630.09	54.46	0.000	0.000	.2185	7.6017	38.7750	.01490
6.0	3.9793	344.99	632.21	54.44	0.000	0.000	.2015	7.0100	35.7700	.01490
7.0	4.2059	345.73	634.58	54.42	0.000	0.000	.1889	6.5710	33.5403	.01490
8.0	4.1732	346.53	637.20	54.40	0.000	0.000	.1801	6.2658	31.9949	.01490
9.0	4.0214	347.39	639.98	54.38	0.000	0.000	.1738	6.0318	30.8131	.01490
10.0	3.8065	348.29	642.88	54.35	0.000	0.000	.1679	5.8415	29.8542	.01490
11.0	3.5531	349.22	645.89	54.33	0.000	0.000	.1633	5.6818	29.0514	.01490
12.0	3.2740	350.18	648.99	54.30	0.000	0.000	.1594	5.5451	28.3655	.01490
13.0	2.9772	351.16	652.17	54.28	0.000	0.000	.1560	5.4260	27.7700	.01490
14.0	2.6675	352.16	655.42	54.25	0.000	0.000	.1529	5.3210	27.2458	.01490
15.0	2.3486	353.18	658.72	54.22	0.000	0.000	.1502	5.2270	26.7783	.01490
16.0	2.0225	354.22	662.09	54.19	0.000	0.000	.1478	5.1420	26.3560	.01490
17.0	1.6920	355.27	665.50	54.17	0.000	0.000	.1456	5.0643	25.9713	.01490
18.0	1.3590	356.33	668.97	54.14	0.000	0.000	.1435	4.9928	25.6182	.01490
19.0	1.0235	356.40	668.20	54.14	0.000	0.000	.1416	4.9262	25.2734	.01490
20.0	.6851	355.90	667.53	54.15	0.000	0.000	.1398	4.8637	24.9501	.01490
21.0	.3442	355.73	667.00	54.15	0.000	0.000	.1381	4.8050	24.6474	.01490
22.0	0.0000	355.59	666.55	54.16	0.000	0.000	.1364	4.7511	24.3658	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 19
ASSEMBLY 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (M/LB-HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4886	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1410	339.58	614.74	54.58	0.000	0.000	.1292	4.4956	22.8248	.01490
2.0	11.8805	341.00	619.31	54.55	0.000	0.000	.1271	4.4217	22.9177	.01490
3.0	12.3869	342.29	623.46	54.51	0.000	0.000	.1093	3.8000	19.3638	.01490
4.0	2.8758	343.05	625.94	54.49	0.000	0.000	0.0000	0.0000	0.0000	.01490
5.0	3.1489	346.47	682.41	54.03	0.000	0.000	-.0211	-.7356	-3.7712	.01490
6.0	3.9825	354.57	663.22	54.18	0.000	0.000	.0371	1.2923	6.6240	.01490
7.0	4.2327	354.87	664.22	54.18	0.000	0.000	.0521	1.8126	9.2740	.01490
8.0	4.1846	356.02	667.93	54.15	0.000	0.000	.0643	2.2340	11.4611	.01490
9.0	4.0276	357.10	672.12	54.11	0.000	0.000	.0738	2.5532	13.1070	.01490
10.0	3.8109	358.61	676.37	54.08	0.000	0.000	.0807	2.8077	14.4225	.01490
11.0	3.5566	359.91	680.60	54.04	0.000	0.000	.0847	3.0173	15.5091	.01490
12.0	3.2769	361.20	684.79	54.01	0.000	0.000	.0818	3.1939	16.4270	.01490
13.0	2.9796	362.47	688.91	53.97	0.000	0.000	.0961	3.3451	17.2163	.01490
14.0	2.6696	363.72	692.97	53.94	0.000	0.000	.0990	3.4770	17.9058	.01490
15.0	2.3504	364.94	696.94	53.91	0.000	0.000	.1033	3.5938	18.5174	.01490
16.0	2.0241	366.14	700.87	53.87	0.000	0.000	.1063	3.6982	19.0680	.01490
17.0	1.6934	367.32	704.71	53.84	0.000	0.000	.1090	3.7936	19.5715	.01490
18.0	1.3603	368.47	708.44	53.81	0.000	0.000	.1114	3.8810	20.0386	.01490
19.0	1.0247	367.91	706.65	53.83	0.000	0.000	.1130	3.9644	20.4565	.01490
20.0	.6863	367.42	705.04	53.84	0.000	0.000	.1142	4.0417	20.8923	.01490
21.0	.3456	366.98	703.61	53.85	0.000	0.000	.1192	4.1132	21.2202	.01490
22.0	0.0000	366.59	702.32	53.86	0.000	0.000	.1201	4.1795	21.5502	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 20
ASSFMBLV 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4842	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8388	.01490
1.0	12.1360	339.63	614.90	54.58	0.000	0.000	.1290	4.4880	22.8399	.01490
2.0	11.8230	341.15	619.79	54.54	0.000	0.000	.1281	4.4567	22.6973	.01490
3.0	11.5470	342.64	624.61	54.50	0.000	0.000	.1190	4.1408	21.1040	.01490
4.0	2.9741	343.70	628.04	54.47	0.000	0.000	.1497	5.1738	26.3823	.01490
5.0	3.2580	346.10	635.75	54.41	0.000	0.000	.1457	5.0704	25.8865	.01490
6.0	3.9966	347.19	639.31	54.38	0.000	0.000	.1386	4.8211	24.6257	.01490
7.0	4.2300	348.33	643.02	54.35	0.000	0.000	.1353	4.7057	24.0097	.01490
8.0	4.1843	349.59	647.08	54.32	0.000	0.000	.1340	4.6611	23.8364	.01490
9.0	4.0275	350.89	651.29	54.28	0.000	0.000	.1332	4.6340	23.7155	.01490
10.0	3.8107	352.22	655.61	54.25	0.000	0.000	.1327	4.6156	23.6347	.01490
11.0	3.5562	353.57	659.99	54.21	0.000	0.000	.1323	4.6015	23.5782	.01490
12.0	3.2765	354.94	664.43	54.17	0.000	0.000	.1319	4.5907	23.5387	.01490
13.0	2.9792	356.31	668.90	54.14	0.000	0.000	.1317	4.5825	23.5127	.01490
14.0	2.6692	357.70	673.41	54.10	0.000	0.000	.1315	4.5766	23.4983	.01490
15.0	2.3499	359.09	677.93	54.06	0.000	0.000	.1314	4.5725	23.4934	.01490
16.0	2.0217	360.49	682.46	54.03	0.000	0.000	.1314	4.5700	23.4968	.01490
17.0	1.6930	361.88	686.99	53.99	0.000	0.000	.1313	4.5688	23.5068	.01490
18.0	1.3600	363.27	691.52	53.95	0.000	0.000	.1313	4.5685	23.5218	.01490
19.0	1.0244	363.16	691.15	53.95	0.000	0.000	.1313	4.5683	23.5194	.01490
20.0	.6860	363.04	690.79	53.96	0.000	0.000	.1313	4.5673	23.5131	.01490
21.0	.3452	362.93	690.40	53.96	0.000	0.000	.1312	4.5651	23.5002	.01490
22.0	0.0000	362.81	690.02	53.96	0.000	0.000	.1311	4.5613	23.4790	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 21
ASSFMBLV 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4876	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8388	.01490
1.0	12.1288	339.63	614.90	54.58	0.000	0.000	.1291	4.4921	22.8610	.01490
2.0	11.7224	341.15	619.79	54.54	0.000	0.000	.1299	4.5193	23.0161	.01490
3.0	10.3102	342.65	624.63	54.50	0.000	0.000	.1394	4.8580	24.7591	.01490
4.0	3.5046	343.90	628.68	54.47	0.000	0.000	.2181	7.5860	38.6012	.01490
5.0	3.3702	344.79	631.54	54.45	0.000	0.000	.2101	7.3095	37.2924	.01490
6.0	3.9883	345.67	634.39	54.42	0.000	0.000	.1933	6.7266	34.3332	.01490
7.0	4.2160	346.62	637.47	54.40	0.000	0.000	.1814	6.3175	32.2606	.01490
8.0	4.1781	347.64	640.77	54.37	0.000	0.000	.1734	6.0418	30.2658	.01490
9.0	4.0242	348.71	644.24	54.34	0.000	0.000	.1674	5.8316	29.0097	.01490
10.0	3.8084	349.82	647.83	54.31	0.000	0.000	.1627	5.6622	28.0595	.01490
11.0	3.5545	350.96	651.54	54.28	0.000	0.000	.1587	5.5210	28.2532	.01490
12.0	3.2751	352.13	655.34	54.25	0.000	0.000	.1552	5.4000	27.6542	.01490
13.0	2.9780	353.33	659.22	54.22	0.000	0.000	.1522	5.2968	27.1379	.01490
14.0	2.6682	354.55	663.19	54.18	0.000	0.000	.1496	5.2056	26.6867	.01490
15.0	2.3491	355.79	667.21	54.15	0.000	0.000	.1473	5.1245	26.2870	.01490
16.0	2.0230	357.05	671.29	54.12	0.000	0.000	.1452	5.0515	25.9283	.01490
17.0	1.6924	358.32	675.41	54.08	0.000	0.000	.1433	4.9851	25.6034	.01490
18.0	1.3594	359.60	679.59	54.05	0.000	0.000	.1415	4.9243	25.3074	.01490
19.0	1.0239	359.51	679.29	54.05	0.000	0.000	.1390	4.8677	25.0158	.01490
20.0	.6854	359.42	678.99	54.05	0.000	0.000	.1380	4.8446	24.7413	.01490
21.0	.3445	359.32	678.67	54.06	0.000	0.000	.1362	4.7646	24.4836	.01490
22.0	0.0000	359.22	678.35	54.06	0.000	0.000	.1354	4.7187	24.2463	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 22
ASSEMBLY 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4847	338.12	610.00	54.62	0.000	0.000	.2859	4.4010	22.8383	.03300
1.0	12.1419	338.94	612.63	54.60	0.000	0.000	.2854	4.4865	22.8229	.03300
2.0	11.8878	339.78	615.37	54.58	0.000	0.000	.2813	4.4197	22.4940	.03300
3.0	12.4158	340.65	618.17	54.56	0.000	0.000	.2411	3.7867	19.2800	.03300
4.0	2.8801	341.61	621.26	54.53	0.000	0.000	0.0000	0.0000	0.0000	.03300
5.0	3.1462	357.21	671.82	54.11	0.000	0.000	-.0768	-1.2069	-6.1821	.03300
6.0	3.9774	352.94	657.96	54.23	0.000	0.000	.0187	.2930	1.5050	.03300
7.0	4.2322	353.42	659.52	54.21	0.000	0.000	.0654	1.0271	5.2625	.03300
8.0	4.1804	354.54	663.13	54.19	0.000	0.000	.1002	1.5736	8.0668	.03300
9.0	4.0275	355.60	666.58	54.16	0.000	0.000	.1254	1.9760	10.1399	.03300
10.0	3.8109	356.63	669.93	54.13	0.000	0.000	.1453	2.2982	11.7936	.03300
11.0	3.5566	357.64	673.21	54.10	0.000	0.000	.1632	2.5637	13.1620	.03300
12.0	3.2770	358.64	676.46	54.08	0.000	0.000	.1775	2.7881	14.3221	.03300
13.0	2.9707	359.62	679.66	54.05	0.000	0.000	.1897	2.9807	15.3191	.03300
14.0	2.6697	360.60	682.83	54.02	0.000	0.000	.2004	3.1482	16.1878	.03300
15.0	2.3504	361.57	685.98	54.00	0.000	0.000	.2098	3.2956	16.9837	.03300
16.0	2.0242	362.52	689.09	53.97	0.000	0.000	.2181	3.4267	17.8366	.03300
17.0	1.6933	363.47	692.18	53.95	0.000	0.000	.2254	3.5448	18.2513	.03300
18.0	1.3604	364.41	695.24	53.92	0.000	0.000	.2324	3.6513	18.8102	.03300
19.0	1.0248	364.33	698.99	53.92	0.000	0.000	.2397	3.7408	19.3160	.03300
20.0	.6863	364.25	698.71	53.93	0.000	0.000	.2446	3.8419	19.7904	.03300
21.0	.3456	364.16	698.42	53.93	0.000	0.000	.2501	3.9287	20.2366	.03300
22.0	0.0000	364.07	698.14	53.93	0.000	0.000	.2553	4.0103	20.6552	.03300

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 23
ASSEMBLY 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4870	338.12	610.00	54.62	0.000	0.000	.2859	4.4010	22.8383	.03300
1.0	12.1214	338.93	612.63	54.60	0.000	0.000	.2864	4.4986	22.8861	.03300
2.0	11.6223	339.77	615.35	54.58	0.000	0.000	.2923	4.5910	23.3679	.03300
3.0	9.7549	340.73	618.43	54.55	0.000	0.000	.3470	5.4504	27.7523	.03300
4.0	3.9166	341.74	621.70	54.53	0.000	0.000	.5002	7.8571	40.0268	.03300
5.0	3.4445	342.26	623.38	54.51	0.000	0.000	.4886	7.6760	39.1141	.03300
6.0	3.9727	342.79	625.10	54.50	0.000	0.000	.4515	7.0034	36.1544	.03300
7.0	4.2002	343.37	626.95	54.48	0.000	0.000	.4234	6.6505	33.9070	.03300
8.0	4.1702	343.98	628.94	54.47	0.000	0.000	.4034	6.3401	32.3342	.03300
9.0	4.0106	344.63	631.04	54.45	0.000	0.000	.3884	6.1018	31.1268	.03300
10.0	3.8053	345.31	633.24	54.43	0.000	0.000	.3760	5.9067	30.1430	.03300
11.0	3.5522	346.02	635.54	54.41	0.000	0.000	.3654	5.7428	29.3169	.03300
12.0	3.2734	346.75	637.91	54.39	0.000	0.000	.3566	5.6018	28.6078	.03300
13.0	2.9766	347.51	640.37	54.37	0.000	0.000	.3488	5.4788	27.9898	.03300
14.0	2.6671	348.29	642.90	54.35	0.000	0.000	.3412	5.3698	27.4437	.03300
15.0	2.3482	349.10	645.50	54.33	0.000	0.000	.3354	5.2720	26.9846	.03300
16.0	2.0222	349.92	648.17	54.31	0.000	0.000	.3299	5.1831	26.5108	.03300
17.0	1.6917	350.77	650.93	54.29	0.000	0.000	.3247	5.1012	26.1024	.03300
18.0	1.3588	351.63	653.70	54.26	0.000	0.000	.3199	5.0246	25.7216	.03300
19.0	1.0233	351.79	656.21	54.26	0.000	0.000	.3153	4.9526	25.3548	.03300
20.0	.6849	351.93	658.69	54.25	0.000	0.000	.3109	4.8846	25.0088	.03300
21.0	.3440	352.08	658.11	54.25	0.000	0.000	.3060	4.8208	24.6835	.03300
22.0	0.0000	352.19	655.52	54.25	0.000	0.000	.3011	4.7610	24.3835	.03300

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 24
ASSEMBLY 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4872	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1229	339.58	614.71	54.58	0.000	0.000	.1292	4.4961	22.8806	.01490
2.0	11.6401	340.99	619.28	54.55	0.000	0.000	.1315	4.5758	23.3020	.01490
3.0	9.8201	342.38	623.77	54.51	0.000	0.000	.1340	5.3596	27.3122	.01490
4.0	3.8435	343.61	627.73	54.48	0.000	0.000	.2254	7.8410	39.9834	.01490
5.0	3.4318	344.28	629.91	54.46	0.000	0.000	.2196	7.6386	38.9620	.01490
6.0	3.9765	344.89	631.87	54.44	0.000	0.000	.2027	7.0517	35.9793	.01490
7.0	4.2036	345.59	634.13	54.42	0.000	0.000	.1900	6.6117	33.7457	.01490
8.0	4.1720	346.37	636.66	54.40	0.000	0.000	.1812	6.3046	32.1908	.01490
9.0	4.0206	347.20	639.37	54.38	0.000	0.000	.1744	6.0687	30.9990	.01490
10.0	3.8060	348.08	642.20	54.36	0.000	0.000	.1689	5.8764	30.0297	.01490
11.0	3.5527	348.99	645.15	54.33	0.000	0.000	.1643	5.7147	29.2163	.01490
12.0	3.2737	349.93	648.19	54.31	0.000	0.000	.1603	5.5759	28.5196	.01490
13.0	2.9769	350.89	651.30	54.28	0.000	0.000	.1568	5.4548	27.9138	.01490
14.0	2.6674	351.87	654.48	54.26	0.000	0.000	.1537	5.3477	27.3787	.01490
15.0	2.3484	352.87	657.74	54.23	0.000	0.000	.1509	5.2518	26.9008	.01490
16.0	2.0224	353.89	661.03	54.20	0.000	0.000	.1484	5.1647	26.4882	.01490
17.0	1.6918	354.92	664.38	54.17	0.000	0.000	.1462	5.0850	26.0732	.01490
18.0	1.3589	355.97	667.79	54.15	0.000	0.000	.1440	5.0115	25.7094	.01490
19.0	1.0234	355.74	667.02	54.15	0.000	0.000	.1421	4.9427	25.3530	.01490
20.0	.6850	355.54	666.39	54.16	0.000	0.000	.1402	4.8780	25.0194	.01490
21.0	.3481	355.38	665.87	54.16	0.000	0.000	.1388	4.8171	24.7050	.01490
22.0	0.0000	355.25	665.44	54.17	0.000	0.000	.1368	4.7608	24.4147	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 25
ASSEMBLY 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4884	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1384	339.62	614.84	54.58	0.000	0.000	.1290	4.4866	22.8326	.01490
2.0	11.8513	341.10	619.64	54.54	0.000	0.000	.1274	4.4386	22.6047	.01490
3.0	12.0608	342.52	624.22	54.51	0.000	0.000	.1124	3.9192	19.9733	.01490
4.0	2.8432	343.44	627.19	54.48	0.000	0.000	0.0000	0.0000	0.0000	.01490
5.0	3.2238	356.09	668.17	54.14	0.000	0.000	.0679	2.3608	12.1120	.01490
6.0	3.9974	352.24	655.68	54.25	0.000	0.000	.0794	2.7261	13.9592	.01490
7.0	4.2337	351.80	654.24	54.26	0.000	0.000	.0844	3.0078	15.3071	.01490
8.0	4.1898	352.51	656.56	54.24	0.000	0.000	.0932	3.2437	16.6121	.01490
9.0	4.0284	353.57	659.99	54.21	0.000	0.000	.0988	3.4258	17.5520	.01490
10.0	3.8113	354.76	663.87	54.18	0.000	0.000	.1026	3.5703	18.3040	.01490
11.0	3.5547	356.02	667.96	54.15	0.000	0.000	.1060	3.6890	18.9273	.01490
12.0	3.2769	357.32	672.16	54.11	0.000	0.000	.1089	3.7897	19.4542	.01490
13.0	2.9795	358.62	676.40	54.08	0.000	0.000	.1114	3.8750	19.9098	.01490
14.0	2.6695	359.94	680.67	54.04	0.000	0.000	.1134	3.9515	20.3114	.01490
15.0	2.3502	361.25	684.93	54.01	0.000	0.000	.1155	4.0190	20.6720	.01490
16.0	2.0240	362.55	689.19	53.97	0.000	0.000	.1173	4.0804	21.0011	.01490
17.0	1.6932	363.85	693.40	53.94	0.000	0.000	.1189	4.1378	21.3068	.01490
18.0	1.3602	365.13	697.58	53.90	0.000	0.000	.1200	4.1900	21.5929	.01490
19.0	1.0246	366.40	696.52	53.91	0.000	0.000	.1219	4.2395	21.8842	.01490
20.0	.6862	364.50	695.53	53.92	0.000	0.000	.1232	4.2852	22.0768	.01490
21.0	.3454	364.22	694.62	53.93	0.000	0.000	.1244	4.3270	22.2886	.01490
22.0	0.0000	363.97	693.73	53.93	0.000	0.000	.1254	4.3631	22.4721	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 26
ASSEMBLY 1

PRESSURE = 130.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (M/LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4879	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1320	339.62	614.86	54.58	0.000	0.000	.1291	4.4904	22.8319	.01490
2.0	11.7666	341.13	619.72	54.54	0.000	0.000	.1290	4.4891	22.8264	.01490
3.0	10.7288	342.63	624.56	54.50	0.000	0.000	.1292	4.4936	22.9020	.01490
4.0	3.2642	343.82	628.40	54.47	0.000	0.000	.1971	6.4581	34.9731	.01490
5.0	3.3309	344.84	631.72	54.44	0.000	0.000	.1900	6.4101	33.7251	.01490
6.0	3.9949	345.85	634.97	54.42	0.000	0.000	.1753	6.0999	31.1377	.01490
7.0	4.2232	346.91	638.41	54.39	0.000	0.000	.1654	5.7684	29.4608	.01490
8.0	4.1815	348.03	642.05	54.36	0.000	0.000	.1598	5.5596	28.4099	.01490
9.0	4.0260	349.20	645.84	54.33	0.000	0.000	.1554	5.4062	27.6419	.01490
10.0	3.8097	350.40	649.73	54.30	0.000	0.000	.1510	5.2851	27.0389	.01490
11.0	3.4554	351.63	653.71	54.26	0.000	0.000	.1491	5.1861	26.5082	.01490
12.0	3.2758	352.88	657.76	54.23	0.000	0.000	.1447	5.1032	26.1397	.01490
13.0	2.9786	354.15	661.88	54.20	0.000	0.000	.1446	5.0325	25.7938	.01490
14.0	2.6687	355.44	666.06	54.16	0.000	0.000	.1420	4.9713	25.4967	.01490
15.0	2.3495	356.74	670.29	54.13	0.000	0.000	.1413	4.9177	25.2380	.01490
16.0	2.0234	358.05	674.53	54.09	0.000	0.000	.1400	4.8701	25.0098	.01490
17.0	1.6927	359.37	678.84	54.06	0.000	0.000	.1387	4.8274	24.8067	.01490
18.0	1.3597	360.70	683.17	54.02	0.000	0.000	.1378	4.7888	24.6248	.01490
19.0	1.0241	360.62	682.91	54.02	0.000	0.000	.1368	4.7531	24.4800	.01490
20.0	.6857	360.54	682.64	54.02	0.000	0.000	.1356	4.7195	24.3664	.01490
21.0	.3448	360.45	682.35	54.03	0.000	0.000	.1347	4.6877	24.1020	.01490
22.0	0.0000	360.36	682.06	54.03	0.000	0.000	.1330	4.6581	23.9483	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 27
ASSEMBLY 1

PRESSURE = 130.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (M/LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4873	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1252	339.62	614.84	54.58	0.000	0.000	.1292	4.4946	22.8732	.01490
2.0	11.6693	341.10	619.64	54.54	0.000	0.000	.1309	4.5530	23.1473	.01490
3.0	9.9552	342.58	624.40	54.50	0.000	0.000	.1483	5.1597	26.2962	.01490
4.0	3.7245	343.86	628.54	54.47	0.000	0.000	.2233	7.7683	39.4155	.01490
5.0	3.4122	344.65	631.11	54.45	0.000	0.000	.2166	7.5350	38.4804	.01490
6.0	3.9815	345.42	633.53	54.43	0.000	0.000	.1904	6.9455	35.4865	.01490
7.0	4.2084	346.24	636.26	54.41	0.000	0.000	.1872	6.9134	33.2546	.01490
8.0	4.1784	347.14	639.16	54.38	0.000	0.000	.1784	6.7152	31.7460	.01490
9.0	4.0220	348.08	642.21	54.36	0.000	0.000	.1721	6.9871	30.5251	.01490
10.0	3.8070	349.06	645.39	54.33	0.000	0.000	.1668	6.8019	29.6631	.01490
11.0	3.5534	350.08	648.69	54.30	0.000	0.000	.1623	6.6467	28.8841	.01490
12.0	3.2743	351.12	652.05	54.28	0.000	0.000	.1585	6.5140	28.2196	.01490
13.0	2.9773	352.19	655.52	54.25	0.000	0.000	.1562	6.3986	27.6435	.01490
14.0	2.6677	353.28	659.03	54.22	0.000	0.000	.1522	6.2968	27.1370	.01490
15.0	2.3487	354.39	662.63	54.19	0.000	0.000	.1494	6.2050	26.6456	.01490
16.0	2.0226	355.51	666.30	54.16	0.000	0.000	.1473	6.1235	26.2781	.01490
17.0	1.6920	356.65	670.01	54.13	0.000	0.000	.1451	6.0483	25.9070	.01490
18.0	1.3591	357.81	673.74	54.10	0.000	0.000	.1431	5.9790	25.5663	.01490
19.0	1.0236	357.63	673.17	54.10	0.000	0.000	.1413	5.9145	25.2325	.01490
20.0	.6852	357.45	672.60	54.11	0.000	0.000	.1395	5.8538	24.9187	.01490
21.0	.3442	357.29	672.04	54.11	0.000	0.000	.1379	5.7968	24.6240	.01490
22.0	0.0000	357.13	671.57	54.12	0.000	0.000	.1364	5.7442	24.3520	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 28
ASSEMBLY 1

PRESSURE = 130.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (M/LB-HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4883	338.12	610.00	54.62	0.000	0.000	.2850	4.4910	22.8383	.03300
1.0	12.1384	338.91	612.56	54.60	0.000	0.000	.2857	4.4883	22.8335	.03300
2.0	11.8516	339.73	615.19	54.58	0.000	0.000	.2862	4.4822	22.8080	.03300
3.0	12.1192	340.57	617.92	54.56	0.000	0.000	.2867	4.4776	20.0478	.03300
4.0	2.8229	341.53	621.01	54.53	0.000	0.000	0.0000	0.0000	0.0000	.03300
5.0	3.2376	342.14	661.84	54.20	0.000	0.000	.1257	1.9740	10.1225	.03300
6.0	3.9981	350.37	649.62	54.30	0.000	0.000	.1483	2.3303	11.9215	.03300
7.0	4.2329	349.50	646.80	54.32	0.000	0.000	.1679	2.6375	13.4872	.03300
8.0	4.1854	349.69	647.43	54.31	0.000	0.000	.1851	2.9079	14.8718	.03300
9.0	4.0281	350.25	640.24	54.30	0.000	0.000	.1987	3.1211	15.9665	.03300
10.0	3.8112	350.98	651.58	54.28	0.000	0.000	.2097	3.2943	16.8584	.03300
11.0	3.5566	351.79	654.21	54.26	0.000	0.000	.2180	3.4390	17.6058	.03300
12.0	3.2768	352.65	657.02	54.24	0.000	0.000	.2248	3.5624	18.2453	.03300
13.0	2.9793	353.55	659.94	54.21	0.000	0.000	.2336	3.6694	18.8018	.03300
14.0	2.6695	354.48	662.94	54.19	0.000	0.000	.2396	3.7636	19.2931	.03300
15.0	2.3502	355.42	665.99	54.16	0.000	0.000	.2440	3.8475	19.7327	.03300
16.0	2.0240	356.37	669.09	54.14	0.000	0.000	.2497	3.9233	20.1308	.03300
17.0	1.6933	357.33	672.21	54.11	0.000	0.000	.2541	3.9922	20.4942	.03300
18.0	1.3602	358.30	675.36	54.08	0.000	0.000	.2581	4.0553	20.8280	.03300
19.0	1.0246	358.39	675.65	54.08	0.000	0.000	.2619	4.1138	21.1292	.03300
20.0	.6861	358.47	675.92	54.08	0.000	0.000	.2653	4.1684	21.4106	.03300
21.0	.3454	358.55	676.16	54.08	0.000	0.000	.2686	4.2194	21.6736	.03300
22.0	0.0000	358.62	676.39	54.08	0.000	0.000	.2714	4.2661	21.9138	.03300

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 29
ASSEMBLY 1

PRESSURE = 130.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (M/LB-HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4872	338.12	610.00	54.62	0.000	0.000	.2859	4.4910	22.8383	.03300
1.0	12.1234	338.91	612.56	54.60	0.000	0.000	.2863	4.4870	22.8798	.03300
2.0	11.6466	339.73	615.22	54.58	0.000	0.000	.2911	4.5736	23.2770	.03300
3.0	9.8502	340.66	618.22	54.56	0.000	0.000	.3384	5.3156	27.0651	.03300
4.0	3.8167	341.67	621.47	54.53	0.000	0.000	.4972	7.8103	39.7871	.03300
5.0	3.4305	342.18	623.12	54.52	0.000	0.000	.4937	7.5085	38.7170	.03300
6.0	3.9767	342.71	624.82	54.50	0.000	0.000	.4062	7.0102	35.7290	.03300
7.0	4.2039	343.28	626.66	54.49	0.000	0.000	.4182	6.5703	33.4063	.03300
8.0	4.1721	343.89	628.65	54.47	0.000	0.000	.3988	6.2605	31.9471	.03300
9.0	4.0207	344.54	630.75	54.45	0.000	0.000	.3839	6.0304	30.7628	.03300
10.0	3.8060	345.22	632.96	54.43	0.000	0.000	.3718	5.8401	29.8022	.03300
11.0	3.5527	345.94	635.26	54.41	0.000	0.000	.3616	5.6805	28.9980	.03300
12.0	3.2737	346.67	637.65	54.40	0.000	0.000	.3529	5.5430	28.3100	.03300
13.0	2.9769	347.44	640.13	54.37	0.000	0.000	.3453	5.4251	27.7145	.03300
14.0	2.6674	348.23	642.68	54.35	0.000	0.000	.3387	5.3203	27.1895	.03300
15.0	2.3484	349.04	645.30	54.33	0.000	0.000	.3327	5.2266	26.7213	.03300
16.0	2.0224	349.87	648.00	54.31	0.000	0.000	.3273	5.1417	26.2982	.03300
17.0	1.6919	350.72	650.76	54.29	0.000	0.000	.3220	5.0638	25.9108	.03300
18.0	1.3590	351.59	653.53	54.26	0.000	0.000	.3177	4.9910	25.5513	.03300
19.0	1.0234	351.77	656.15	54.26	0.000	0.000	.3130	4.9237	25.2065	.03300
20.0	.6850	351.94	658.69	54.25	0.000	0.000	.3094	4.8601	24.8831	.03300
21.0	.3441	352.09	655.19	54.25	0.000	0.000	.3056	4.8007	24.5808	.03300
22.0	0.0000	352.23	655.66	54.25	0.000	0.000	.3021	4.7462	24.3038	.03300

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 30
ASSFMRLV 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (M/R/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4883	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1373	339.54	614.60	54.59	0.000	0.000	.1290	4.4875	22.8364	.01490
2.0	11.8442	340.92	619.04	54.55	0.000	0.000	.1278	4.4870	22.8302	.01490
3.0	12.0257	342.15	623.03	54.52	0.000	0.000	.1151	4.0034	20.3999	.01490
4.0	2.8258	342.82	625.19	54.50	0.000	0.000	0.0000	0.0000	0.0000	.01490
5.0	3.2585	350.62	650.42	54.29	0.000	0.000	.0788	2.7411	14.0251	.01490
6.0	3.9980	349.11	645.52	54.33	0.000	0.000	.0903	3.1431	16.0699	.01490
7.0	4.2313	349.34	646.29	54.32	0.000	0.000	.0972	3.3834	17.3003	.01490
8.0	4.1848	350.19	649.03	54.30	0.000	0.000	.1027	3.5744	18.2848	.01490
9.0	4.0278	351.23	652.40	54.27	0.000	0.000	.1068	3.7171	19.0243	.01490
10.0	3.8109	352.34	656.01	54.24	0.000	0.000	.1100	3.8281	19.6034	.01490
11.0	3.5563	353.49	659.74	54.21	0.000	0.000	.1124	3.9178	20.0745	.01490
12.0	3.2766	354.66	663.53	54.18	0.000	0.000	.1148	3.9924	20.4699	.01490
13.0	2.9703	355.84	667.35	54.15	0.000	0.000	.1164	4.0561	20.8070	.01490
14.0	2.6603	357.02	671.18	54.12	0.000	0.000	.1182	4.1113	21.1024	.01490
15.0	2.3500	358.19	675.01	54.09	0.000	0.000	.1196	4.1601	21.3652	.01490
16.0	2.0238	359.37	678.84	54.06	0.000	0.000	.1208	4.2030	21.6027	.01490
17.0	1.6931	360.55	682.64	54.02	0.000	0.000	.1220	4.2430	21.8210	.01490
18.0	1.3601	361.71	686.46	53.99	0.000	0.000	.1230	4.2810	22.0246	.01490
19.0	1.0245	361.39	685.39	54.00	0.000	0.000	.1240	4.3155	22.1084	.01490
20.0	.6860	361.11	684.50	54.01	0.000	0.000	.1250	4.3475	22.3597	.01490
21.0	.3453	360.88	683.74	54.02	0.000	0.000	.1258	4.3768	22.5081	.01490
22.0	0.0000	360.68	683.10	54.02	0.000	0.000	.1265	4.4024	22.6371	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 31
ASSFMRLV 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (M/R/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4878	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1313	339.58	614.74	54.58	0.000	0.000	.1291	4.4908	22.8544	.01490
2.0	11.7585	341.04	619.43	54.55	0.000	0.000	.1293	4.4973	22.9030	.01490
3.0	10.6842	342.43	623.94	54.51	0.000	0.000	.1323	4.6017	23.4507	.01490
4.0	3.2952	343.38	627.01	54.48	0.000	0.000	.2020	7.0277	35.8302	.01490
5.0	3.3526	344.36	630.14	54.46	0.000	0.000	.1941	6.7534	34.4482	.01490
6.0	3.9958	345.25	633.04	54.43	0.000	0.000	.1792	6.2338	31.8116	.01490
7.0	4.2218	346.21	636.15	54.41	0.000	0.000	.1691	5.8844	30.0427	.01490
8.0	4.1809	347.24	639.49	54.38	0.000	0.000	.1624	5.6587	28.9040	.01490
9.0	4.0257	348.32	642.98	54.35	0.000	0.000	.1578	5.4010	28.0633	.01490
10.0	3.8095	349.43	646.59	54.32	0.000	0.000	.1540	5.3578	27.3978	.01490
11.0	3.5562	350.57	650.27	54.29	0.000	0.000	.1500	5.2885	26.8534	.01490
12.0	3.2747	351.73	654.04	54.26	0.000	0.000	.1482	5.1567	26.3091	.01490
13.0	2.9745	352.91	657.86	54.23	0.000	0.000	.1460	5.0784	26.0133	.01490
14.0	2.6686	354.10	661.72	54.20	0.000	0.000	.1440	5.0107	25.6815	.01490
15.0	2.3495	355.31	665.63	54.16	0.000	0.000	.1423	4.9514	25.3927	.01490
16.0	2.0233	356.52	669.59	54.13	0.000	0.000	.1408	4.8988	25.1382	.01490
17.0	1.6926	357.74	673.55	54.10	0.000	0.000	.1395	4.8518	24.9123	.01490
18.0	1.3506	358.97	677.54	54.07	0.000	0.000	.1382	4.8094	24.7102	.01490
19.0	1.0241	359.83	677.07	54.07	0.000	0.000	.1371	4.7707	24.5088	.01490
20.0	.6856	358.70	676.65	54.07	0.000	0.000	.1361	4.7344	24.3207	.01490
21.0	.3448	358.57	676.23	54.08	0.000	0.000	.1351	4.7003	24.1437	.01490
22.0	0.0000	358.45	675.84	54.08	0.000	0.000	.1342	4.6686	23.9795	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 32
ASSEMBLY 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4873	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1250	339.54	614.60	54.59	0.000	0.000	.1292	4.4949	22.8741	.01490
2.0	11.6671	340.93	619.07	54.55	0.000	0.000	.1310	4.5576	23.2086	.01490
3.0	9.9476	342.26	623.39	54.51	0.000	0.000	.1502	5.2246	26.4227	.01490
4.0	3.7305	343.39	627.02	54.48	0.000	0.000	.2246	7.8108	39.8432	.01490
5.0	3.4172	344.11	629.34	54.46	0.000	0.000	.2177	7.5733	38.6256	.01490
6.0	3.9910	344.74	631.40	54.45	0.000	0.000	.2005	6.9775	35.5970	.01490
7.0	4.2077	345.47	633.77	54.43	0.000	0.000	.1879	6.5384	33.3697	.01490
8.0	4.1740	346.29	636.40	54.41	0.000	0.000	.1792	6.2345	31.8314	.01490
9.0	4.0218	347.16	639.22	54.38	0.000	0.000	.1725	6.0018	30.6566	.01490
10.0	3.8068	348.07	642.17	54.36	0.000	0.000	.1671	5.8129	29.7050	.01490
11.0	3.5533	349.01	645.23	54.33	0.000	0.000	.1625	5.6547	28.9098	.01490
12.0	3.2742	349.99	648.39	54.31	0.000	0.000	.1586	5.5194	28.2317	.01490
13.0	2.9773	350.98	651.61	54.28	0.000	0.000	.1553	5.4019	27.6443	.01490
14.0	2.6676	352.00	654.91	54.25	0.000	0.000	.1523	5.2984	27.1281	.01490
15.0	2.3486	353.04	658.24	54.23	0.000	0.000	.1496	5.2060	26.6686	.01490
16.0	2.0226	354.09	661.67	54.20	0.000	0.000	.1472	5.1224	26.2541	.01490
17.0	1.6920	355.15	665.13	54.17	0.000	0.000	.1450	5.0461	25.8767	.01490
18.0	1.3591	356.23	668.63	54.14	0.000	0.000	.1430	4.9759	25.5301	.01490
19.0	1.0236	356.03	667.99	54.15	0.000	0.000	.1411	4.9100	25.1917	.01490
20.0	.6852	355.87	667.45	54.15	0.000	0.000	.1394	4.8490	24.8744	.01490
21.0	.3442	355.73	667.00	54.15	0.000	0.000	.1377	4.7914	24.5776	.01490
22.0	0.0000	355.61	666.61	54.16	0.000	0.000	.1362	4.7387	24.3055	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 33
ASSEMBLY 1

PRESSURE = 130.0 Psia

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLUX (LB/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4880	338.12	610.00	54.62	0.000	0.000	.1291	4.4910	22.8383	.01490
1.0	12.1342	339.52	614.54	54.59	0.000	0.000	.1290	4.4893	22.8454	.01490
2.0	11.7989	340.89	618.94	54.55	0.000	0.000	.1285	4.4714	22.7706	.01490
3.0	11.2524	342.21	623.22	54.51	0.000	0.000	.1224	4.2576	21.6940	.01490
4.0	3.0028	343.04	625.84	54.49	0.000	0.000	.1395	4.8518	24.7324	.01490
5.0	3.3191	344.41	630.32	54.46	0.000	0.000	.1459	5.0761	25.8931	.01490
6.0	4.0019	345.43	633.62	54.43	0.000	0.000	.1405	4.8870	24.9458	.01490
7.0	4.2283	346.47	636.99	54.40	0.000	0.000	.1372	4.7710	24.3661	.01490
8.0	4.1839	347.57	640.53	54.37	0.000	0.000	.1357	4.7107	24.1125	.01490
9.0	4.0273	348.68	644.15	54.34	0.000	0.000	.1347	4.6857	23.9520	.01490
10.0	3.8105	349.81	647.82	54.31	0.000	0.000	.1330	4.6601	23.8343	.01490
11.0	3.5560	350.96	651.52	54.28	0.000	0.000	.1334	4.6399	23.7437	.01490
12.0	3.2763	352.10	655.24	54.25	0.000	0.000	.1329	4.6233	23.6727	.01490
13.0	2.9790	353.26	658.98	54.22	0.000	0.000	.1325	4.6098	23.6167	.01490
14.0	2.6690	354.41	662.73	54.19	0.000	0.000	.1322	4.5986	23.5730	.01490
15.0	2.3498	355.57	666.50	54.16	0.000	0.000	.1319	4.5893	23.5391	.01490
16.0	2.0236	356.73	670.27	54.13	0.000	0.000	.1317	4.5817	23.5134	.01490
17.0	1.6929	357.90	674.04	54.10	0.000	0.000	.1315	4.5754	23.4952	.01490
18.0	1.3599	359.06	677.81	54.06	0.000	0.000	.1314	4.5706	23.4836	.01490
19.0	1.0243	358.84	677.17	54.07	0.000	0.000	.1313	4.5660	23.4595	.01490
20.0	.6859	358.65	676.50	54.08	0.000	0.000	.1311	4.5625	23.4370	.01490
21.0	.3450	358.50	676.00	54.08	0.000	0.000	.1310	4.5584	23.4140	.01490
22.0	0.0000	358.37	675.58	54.08	0.000	0.000	.1309	4.5545	23.3975	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 34
ASSEMBLY 1

PRESSURE = 130.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (LBS/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4875	338.12	610.00	54.62	0.000	0.000	.1201	4.4910	22.8387	.01490
1.0	12.1277	339.52	614.54	54.59	0.000	0.000	.1201	4.4932	22.8650	.01490
2.0	11.7049	340.90	618.97	54.55	0.000	0.000	.1302	4.5300	23.0697	.01490
3.0	10.1922	342.27	623.39	54.51	0.000	0.000	.1422	4.9463	25.2044	.01490
4.0	3.5538	343.37	626.97	54.48	0.000	0.000	.2191	7.6225	38.8626	.01490
5.0	3.3941	344.09	629.29	54.46	0.000	0.000	.2112	7.3478	37.4751	.01490
6.0	3.9878	344.81	631.61	54.45	0.000	0.000	.1944	6.7630	34.5045	.01490
7.0	4.2138	345.60	634.17	54.42	0.000	0.000	.1824	6.3452	32.3857	.01490
8.0	4.1770	346.45	636.93	54.40	0.000	0.000	.1742	6.0618	30.9521	.01490
9.0	4.0235	347.35	639.85	54.38	0.000	0.000	.1681	5.8469	29.8680	.01490
10.0	3.8080	348.29	642.89	54.35	0.000	0.000	.1631	5.6737	28.9068	.01490
11.0	3.5541	349.26	646.03	54.33	0.000	0.000	.1589	5.5296	28.2736	.01490
12.0	3.2748	350.26	649.25	54.30	0.000	0.000	.1554	5.4071	27.6606	.01490
13.0	2.9778	351.27	652.54	54.27	0.000	0.000	.1524	5.3012	27.1728	.01490
14.0	2.6681	352.31	655.89	54.24	0.000	0.000	.1497	5.2085	26.6717	.01490
15.0	2.3490	353.36	659.30	54.22	0.000	0.000	.1472	5.1261	26.2635	.01490
16.0	2.0229	354.42	662.74	54.19	0.000	0.000	.1452	5.0520	25.8975	.01490
17.0	1.6923	355.50	666.27	54.16	0.000	0.000	.1433	4.9847	25.5663	.01490
18.0	1.3593	356.59	669.81	54.13	0.000	0.000	.1415	4.9231	25.2639	.01490
19.0	1.0238	356.61	669.22	54.13	0.000	0.000	.1399	4.8660	24.9883	.01490
20.0	.6854	356.26	668.74	54.14	0.000	0.000	.1383	4.8124	24.6917	.01490
21.0	.3445	356.13	668.29	54.14	0.000	0.000	.1369	4.7623	24.4330	.01490
22.0	0.0000	356.02	667.94	54.15	0.000	0.000	.1356	4.7164	24.1959	.01490

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS
CHANNEL 35
ASSEMBLY 1

PRESSURE = 130.0 PSIA

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (LBS/HR-FT ²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4880	338.12	610.00	54.62	0.000	0.000	.2859	4.4910	22.8387	.03300
1.0	12.1337	338.90	612.52	54.60	0.000	0.000	.2859	4.4911	22.8477	.03300
2.0	11.7932	339.70	615.11	54.58	0.000	0.000	.2851	4.4787	22.7934	.03300
3.0	11.1706	340.57	617.91	54.56	0.000	0.000	.2780	4.3677	22.2377	.03300
4.0	3.0754	341.62	621.32	54.53	0.000	0.000	.3856	6.0574	30.4566	.03300
5.0	3.3205	342.48	624.10	54.51	0.000	0.000	.3688	5.7901	29.5075	.03300
6.0	3.9980	343.20	626.40	54.49	0.000	0.000	.3387	5.3204	27.1233	.03300
7.0	4.2257	343.94	628.62	54.47	0.000	0.000	.3212	5.0459	25.7331	.03300
8.0	4.1825	344.74	631.40	54.45	0.000	0.000	.3118	4.8988	24.9908	.03300
9.0	4.0266	345.57	634.09	54.42	0.000	0.000	.3058	4.8034	24.5162	.03300
10.0	3.8100	346.43	636.86	54.40	0.000	0.000	.3015	4.7369	24.1866	.03300
11.0	3.5557	347.31	639.71	54.38	0.000	0.000	.2988	4.6883	23.9489	.03300
12.0	3.2761	348.21	642.61	54.35	0.000	0.000	.2961	4.6519	23.7737	.03300
13.0	2.9788	349.12	645.58	54.33	0.000	0.000	.2944	4.6243	23.6432	.03300
14.0	2.6689	350.05	648.59	54.31	0.000	0.000	.2930	4.6031	23.5455	.03300
15.0	2.3497	351.00	651.65	54.28	0.000	0.000	.2920	4.5867	23.4726	.03300
16.0	2.0235	351.95	654.74	54.25	0.000	0.000	.2912	4.5740	23.4187	.03300
17.0	1.6928	352.92	657.89	54.23	0.000	0.000	.2905	4.5640	23.3786	.03300
18.0	1.3598	353.89	661.04	54.20	0.000	0.000	.2900	4.5550	23.3481	.03300
19.0	1.0242	354.11	661.73	54.20	0.000	0.000	.2896	4.5493	23.3168	.03300
20.0	.6858	354.31	662.33	54.19	0.000	0.000	.2893	4.5440	23.2917	.03300
21.0	.3450	354.49	662.99	54.19	0.000	0.000	.2890	4.5396	23.2713	.03300
22.0	0.0000	354.67	663.56	54.18	0.000	0.000	.2887	4.5360	23.2548	.03300

CALCULATED FLUID CONDITIONS AT TIME = 0.0000 SECONDS

PRESSURE = 130.0 PSIA

CHANNEL 36
ASSEMBLY 1

DISTANCE (IN.)	DELTA-P (PSI)	ENTHALPY (BTU/LB)	TEMPERATURE (DEG-F)	DENSITY (LB/CU-FT)	EQUIL. QUALITY	VOID FRACTION	FLOW (LB/SEC)	MASS FLOW (LB/HR-FT²)	VELOCITY (FT/SEC)	AREA (SQ-IN)
0.0	12.4873	338.12	610.00	54.62	0.000	0.000	.2859	4.4910	22.8383	.03300
1.0	12.1275	338.90	612.52	54.60	0.000	0.000	.2861	4.4949	22.8669	.03300
2.0	11.7034	339.70	615.11	54.58	0.000	0.000	.2864	4.5343	23.0759	.03300
3.0	10.1911	340.54	617.83	54.56	0.000	0.000	.3142	4.9357	25.1294	.03300
4.0	3.5576	341.49	620.90	54.53	0.000	0.000	.4759	7.4756	38.0789	.03300
5.0	3.3953	342.04	622.67	54.52	0.000	0.000	.4587	7.2053	36.7117	.03300
6.0	3.9868	342.61	624.52	54.50	0.000	0.000	.4214	6.6197	33.7373	.03300
7.0	4.2130	343.24	626.53	54.49	0.000	0.000	.3950	6.2045	31.6309	.03300
8.0	4.1767	343.90	628.68	54.47	0.000	0.000	.3773	5.9268	30.2252	.03300
9.0	4.0233	344.60	630.94	54.45	0.000	0.000	.3641	5.7192	29.1761	.03300
10.0	3.8079	345.33	633.30	54.43	0.000	0.000	.3536	5.5540	28.3436	.03300
11.0	3.5541	346.09	635.74	54.41	0.000	0.000	.3449	5.4181	27.6603	.03300
12.0	3.2748	346.88	638.30	54.39	0.000	0.000	.3376	5.3038	27.0875	.03300
13.0	2.9778	347.69	640.93	54.37	0.000	0.000	.3314	5.2062	26.5993	.03300
14.0	2.6680	348.52	643.62	54.35	0.000	0.000	.3260	5.1214	26.1770	.03300
15.0	2.3490	349.37	646.39	54.32	0.000	0.000	.3213	5.0468	25.8067	.03300
16.0	2.0229	350.23	649.22	54.30	0.000	0.000	.3170	4.9804	25.4778	.03300
17.0	1.6923	351.14	652.11	54.28	0.000	0.000	.3132	4.9203	25.1816	.03300
18.0	1.3593	352.05	655.03	54.25	0.000	0.000	.3097	4.8653	24.9109	.03300
19.0	1.0238	352.25	655.71	54.25	0.000	0.000	.3065	4.8145	24.6537	.03300
20.0	.6854	352.44	656.33	54.24	0.000	0.000	.3035	4.7677	24.4161	.03300
21.0	.3444	352.62	656.91	54.24	0.000	0.000	.3008	4.7245	24.1971	.03300
22.0	0.0000	352.79	657.45	54.23	0.000	0.000	.2983	4.6856	23.9997	.03300

CROSSFLOW BETWEEN ADJACENT CHANNELS AT TIME = 0.0000 SECONDS

ASSEMBLY NUMBER	1	1	1	1	1	1	1	1	1	1
AXIAL ZONE	W(11, 17)	W(11, 14)	W(6, 11)	W(17, 21)	W(12, 17)	W(21, 24)	W(21, 27)	W(20, 26)	W(24, 31)	W(14, 20)
0.0 - 1.0	.00559	-.00420	.00078	.00133	-.00402	-.00431	.00518	.00553	.00143	.00127
1.0 - 2.0	.07267	-.05321	.01414	.01719	-.04930	-.05694	.06484	.07051	.01399	.01559
2.0 - 3.0	.72583	-.51941	.16365	.17672	-.07639	-.56195	.42186	.70199	.13849	.15756
3.0 - 4.0	3.29875	-2.75424	1.30992	.69770	-1.67850	-2.32622	2.08268	3.62072	.87897	.82155
4.0 - 5.0	-.15473	-.15037	-.39251	.00798	.06526	.24810	-.14442	-.10778	.25587	.27998
5.0 - 6.0	-.71913	.56870	-.31405	-.13555	.38625	.57249	-.40498	-.77729	-.02886	-.17332
6.0 - 7.0	-.53022	.43617	-.19465	-.10086	.29430	.42132	-.38110	-.57273	-.03707	-.14663
7.0 - 8.0	-.36048	.29121	-.13041	-.06688	.20414	.29227	-.26391	-.38488	-.02009	-.09807
8.0 - 9.0	-.27350	.22109	-.09692	-.04928	.15702	.22461	-.20133	-.28022	-.01270	-.07524
9.0 - 10.0	-.22060	.17871	-.07679	-.03862	.12819	.18299	-.16318	-.23330	-.00856	-.06124
10.0 - 11.0	-.18363	.14886	-.06314	-.03119	.10795	.15378	-.13627	-.19358	-.00564	-.05121
11.0 - 12.0	-.13604	.12642	-.05320	-.02566	.09278	.13190	-.11611	-.16395	-.00344	-.04359
12.0 - 13.0	-.13474	.10901	-.04568	-.02141	.08102	.11494	-.10049	-.14110	-.00178	-.03764
13.0 - 14.0	-.11803	.09328	-.03977	-.01811	.07176	.10153	-.08818	-.12318	-.00056	-.03295
14.0 - 15.0	-.10481	.08440	-.03512	-.01555	.06440	.09082	-.07839	-.10903	-.00027	-.02924
15.0 - 16.0	-.09434	.07576	-.03144	-.01359	.05851	.08217	-.07056	-.09784	-.00076	-.02632
16.0 - 17.0	-.08594	.06881	-.02843	-.01211	.05378	.07506	-.06427	-.08890	-.00090	-.02404
17.0 - 18.0	-.07818	.06322	-.02599	-.01102	.04995	.06914	-.05920	-.08174	-.00072	-.02228
18.0 - 19.0	-.07374	.05876	-.02414	-.01022	.04670	.06421	-.05493	-.07607	-.00045	-.02091
19.0 - 20.0	-.06908	.05501	-.02272	-.00960	.04374	.05983	-.05110	-.07127	-.00013	-.01978
20.0 - 21.0	-.06459	.05144	-.02147	-.00901	.04079	.05554	-.04733	-.06671	-.00021	-.01871
21.0 - 22.0	-.05914	.04712	-.01997	-.00822	.03728	.05054	-.04291	-.06118	-.00040	-.01740

CROSSFLOW BETWEEN ADJACENT CHANNELS AT TIME = 0.0000 SECONDS

ASSEMBLY NUMBER	1	1	1	1	1	1	1	1	1	1	1
AXIAL ZONE	W(20, 25)	W(10, 14)	W(7, 6)	W(3, 5)	W(1, 3)	W(4, 6)	W(0, 7)	W(2, 4)	W(7, 12)	W(7, 9)	
0.0 - 1.0	-.00322	.00425	.00434	-.00329	-.00034	-.00430	.00453	.00013	.00157	.00236	
1.0 - 2.0	-.00412	.05392	.05859	-.04032	.00279	-.05144	.06004	.00911	.02496	.02405	
2.0 - 3.0	-.43549	.54468	.49845	-.38515	.03785	-.52658	.41869	.11128	.25774	.23299	
3.0 - 4.0	-3.15548	3.68804	4.14245	-2.15600	.42977	-2.69128	2.70827	.81543	1.00680	.77468	
4.0 - 5.0	.42336	.37388	-.43979	-.54668	-.18632	.24372	-.23124	-.08219	-.18526	.03669	
5.0 - 6.0	.69004	-.79141	-1.00752	.85133	-.01594	.64516	-.08777	-.11940	-.25910	-.12204	
6.0 - 7.0	.46591	-.58207	-.68329	.56240	-.02840	.46136	-.02883	-.08129	-.18790	-.09429	
7.0 - 8.0	.30169	-.37242	-.45205	.34790	-.03081	.31172	-.29247	-.05405	-.13364	-.06189	
8.0 - 9.0	.22417	-.27998	-.33917	.25551	-.02907	.23592	-.22254	-.04088	-.10416	-.04559	
9.0 - 10.0	.17855	-.22864	-.27176	.20239	-.02697	.18999	-.18017	-.03239	-.08585	-.03605	
10.0 - 11.0	.14724	-.18767	-.22533	.16629	-.02488	.15811	-.15060	-.02642	-.07297	-.02951	
11.0 - 12.0	.12408	-.15912	-.19104	.13984	-.02288	.13446	-.12057	-.02284	-.06327	-.02469	
12.0 - 13.0	.10628	-.13687	-.16471	.11966	-.02101	.11631	-.11160	-.01944	-.05572	-.02102	
13.0 - 14.0	.09229	-.11924	-.14403	.10389	-.01927	.10209	-.09829	-.01692	-.04971	-.01821	
14.0 - 15.0	.08120	-.10517	-.12760	.09140	-.01773	.09082	-.08779	-.01497	-.04487	-.01609	
15.0 - 16.0	.07239	-.09399	-.11445	.08143	-.01635	.08181	-.07848	-.01350	-.04096	-.01453	
16.0 - 17.0	.06528	-.08501	-.10375	.07339	-.01503	.07458	-.07286	-.01232	-.03770	-.01353	
17.0 - 18.0	.05957	-.07789	-.09503	.06692	-.01379	.06869	-.06758	-.01140	-.03493	-.01301	
18.0 - 19.0	.05523	-.07255	-.08812	.06178	-.01299	.06377	-.06338	-.01100	-.03270	-.01263	
19.0 - 20.0	.05182	-.06843	-.08242	.05754	-.01253	.05943	-.05883	-.01097	-.03078	-.01231	
20.0 - 21.0	.04877	-.06478	-.07723	.05369	-.01231	.05524	-.05445	-.01110	-.02891	-.01200	
21.0 - 22.0	.04510	-.06045	-.07133	.04954	-.01222	.05039	-.04931	-.01105	-.02872	-.01147	

CROSSFLOW BETWEEN ADJACENT CHANNELS AT TIME = 0.0000 SECONDS

ASSEMBLY NUMBER	1	1	1	1	1	1	1	1	1	1	1
AXIAL ZONE	W(12, 18)	W(18, 24)	W(16, 18)	W(24, 27)	W(24, 24)	W(27, 32)	W(32, 34)	W(29, 32)	W(31, 34)	W(34, 36)	
0.0 - 1.0	.00474	.00109	-.00206	-.00334	-.00267	.00061	-.00053	-.00279	.00515	.00085	
1.0 - 2.0	.05928	.01447	-.02005	-.04100	-.02800	.00364	-.00491	-.02998	.06419	.00347	
2.0 - 3.0	.55958	.13736	-.17570	-.37662	-.24364	.03597	-.07260	-.27851	.44230	.02623	
3.0 - 4.0	1.75203	.40774	-.46902	-1.08674	-.63847	.09622	-1.62119	-.82403	.57280	.02857	
4.0 - 5.0	-.13891	-.05599	.00773	.10030	.08653	.03657	.15742	.03757	-.26291	-.01075	
5.0 - 6.0	-.44083	-.12431	.11055	.28743	.21133	-.01624	.34464	.17737	-.59417	-.02782	
6.0 - 7.0	-.33524	-.09700	.08671	.22118	.16640	-.01088	.27027	.12971	-.43146	-.01710	
7.0 - 8.0	-.23699	-.07107	.06062	.15860	.12378	-.00246	.18685	.08418	-.29281	-.00822	
8.0 - 9.0	-.18411	-.05671	.04670	.12495	.10029	.00209	.14275	.08082	-.22050	-.00363	
9.0 - 10.0	-.15150	-.04765	.03822	.10427	.08560	.00496	.11595	.04583	-.17661	-.00093	
10.0 - 11.0	-.12855	-.04119	.03229	.08974	.07515	.00699	.09730	.03573	-.14619	.00083	
11.0 - 12.0	-.11130	-.03628	.02783	.07883	.06722	.00851	.08741	.02825	-.12363	.00203	
12.0 - 13.0	-.09787	-.03241	.02441	.07034	.06098	.00965	.07269	.02251	-.10834	.00286	
13.0 - 14.0	-.08724	-.02930	.02170	.06360	.05597	.01052	.06028	.01804	-.09283	.00344	
14.0 - 15.0	-.07873	-.02677	.01956	.05820	.05188	.01118	.05763	.01458	-.08221	.00384	
15.0 - 16.0	-.07188	-.02468	.01786	.05383	.04849	.01167	.05238	.01188	-.07382	.00411	
16.0 - 17.0	-.06634	-.02294	.01660	.05028	.04574	.01195	.04818	.00992	-.06721	.00418	
17.0 - 18.0	-.06184	-.02147	.01572	.04737	.04347	.01205	.04484	.00856	-.06202	.00407	
18.0 - 19.0	-.05798	-.02016	.01485	.04482	.04128	.01216	.04218	.00744	-.05779	.00411	
19.0 - 20.0	-.05445	-.01874	.01395	.04244	.03804	.01227	.03993	.00646	-.05415	.00424	
20.0 - 21.0	-.05090	-.01768	.01300	.04000	.03667	.01232	.03774	.00558	-.05066	.00437	
21.0 - 22.0	-.04671	-.01624	.01185	.03711	.03393	.01234	.03506	.00451	-.04844	.00447	

CROSSFLOW BETWEEN ADJACENT CHANNELS AT TIME = 0.0000 SECONDS

ASSEMBLY NUMBER	1	1	1	1	1	1	1	1	1	1
AXIAL ZONE	W(3, 3)	W(30, 33)	W(33, 35)	W(25, 30)	W(28, 30)	W(19, 25)	W(14, 19)	W(19, 22)	W(10, 13)	W(13, 15)
0.0 - 1.0	-.00370	.00480	.00128	.00208	.00111	.00377	.00098	-.00077	-.00245	-.00130
1.0 - 2.0	-.05239	.05558	.00928	.02128	.02065	.01884	.01138	-.01540	-.03283	-.02134
2.0 - 3.0	-.53982	.57026	.10425	.20646	.21056	.46281	.10423	-.10415	-.30008	-.18821
3.0 - 4.0	-2.93056	3.94538	.80990	1.02097	1.54354	2.82466	.80791	-.90610	-1.70129	-1.00131
4.0 - 5.0	.58339	-.67816	-.17213	.35795	-.09067	.74886	.24095	-.25419	-.45626	-.42562
5.0 - 6.0	.74652	-.99474	-.18332	-.41119	-.04490	-.97526	-.17035	.10507	.44496	.05867
6.0 - 7.0	.51490	-.67442	-.11950	-.29747	-.29409	-.66630	-.26777	.22304	.43770	.38920
7.0 - 8.0	.35058	-.44451	-.07592	-.18774	-.19088	-.40797	-.12017	.18246	.28843	.18195
8.0 - 9.0	.26562	-.33140	-.05405	-.13894	-.14325	-.30043	-.08707	.10727	.18568	.13137
9.0 - 10.0	.21398	-.26396	-.04114	-.11031	-.11534	-.23891	-.06382	.04713	.15009	.10522
10.0 - 11.0	.17827	-.21783	-.03256	-.09069	-.09618	-.19685	-.05115	.07342	.12508	.08706
11.0 - 12.0	.15185	-.18403	-.02648	-.07629	-.08198	-.16578	-.04205	.06284	.10411	.07330
12.0 - 13.0	.13157	-.15827	-.02203	-.06535	-.07100	-.14188	-.03522	.05086	.09120	.06242
13.0 - 14.0	.11563	-.13818	-.01869	-.05684	-.06230	-.12305	-.02094	.00764	.07922	.05360
14.0 - 15.0	.10293	-.12227	-.01616	-.05014	-.05531	-.10805	-.02592	.04202	.06952	.04636
15.0 - 16.0	.09271	-.10957	-.01422	-.04482	-.04965	-.09605	-.02261	.03715	.06166	.04038
16.0 - 17.0	.08431	-.09929	-.01284	-.04059	-.04490	-.08633	-.02010	.03332	.05521	.03532
17.0 - 18.0	.07733	-.09093	-.01191	-.03722	-.04091	-.07852	-.01817	.02989	.05000	.03110
18.0 - 19.0	.07165	-.08413	-.01104	-.03435	-.03788	-.07253	-.01671	.02717	.04613	.02805
19.0 - 20.0	.06690	-.07836	-.01019	-.03178	-.03555	-.06781	-.01555	.02559	.04327	.02598
20.0 - 21.0	.06223	-.07304	-.00939	-.02933	-.03358	-.06371	-.01431	.02430	.04097	.02456
21.0 - 22.0	.05697	-.06711	-.00847	-.02673	-.03158	-.05935	-.01338	.02335	.03870	.02370

CROSSFLOW BETWEEN ADJACENT CHANNELS AT TIME = 0.0000 SECONDS

ASSEMBLY NUMBER	1	1	1	1	1	1	1	1	1	1
AXIAL ZONE	W(5, 10)	W(5, 8)	W(1, 2)	W(1, 8)	W(2, 9)	W(9, 16)	W(18, 23)	W(23, 29)	W(29, 36)	W(35, 36)
0.0 - 1.0	-.00004	-.00145	.00598	-.00371	.00513	.00439	.00124	-.00190	-.00401	.00615
1.0 - 2.0	.00336	-.02383	.07626	-.04495	.06799	.05895	.01658	-.02632	-.05157	.08113
2.0 - 3.0	.04367	-.22796	.77746	-.42911	.69252	.57254	.16125	-.25126	-.53049	.81993
3.0 - 4.0	.66028	-1.48982	4.92594	-2.54732	3.05056	1.88611	.07269	-.72732	-1.80900	3.72067
4.0 - 5.0	-.00153	-.50283	-.65108	-.90023	-.04016	-.19827	-.05154	.00028	.12048	-.32023
5.0 - 6.0	.01704	.35886	-1.23461	1.02702	-.78983	-.46478	-.12709	.10664	.17872	-.79827
6.0 - 7.0	.03717	.32745	-.43866	.66751	-.56757	-.34453	-.09523	.07664	.28296	-.58302
7.0 - 8.0	.00406	.17424	-.54623	.39531	-.29227	-.24052	-.06719	.04614	.19523	-.39910
8.0 - 9.0	-.00197	.14561	-.40364	.28816	-.29957	-.18439	-.05184	.03019	.14864	-.30361
9.0 - 10.0	-.00417	.11822	-.31952	.22851	-.24257	-.14989	-.04238	.02078	.12029	-.24559
10.0 - 11.0	-.00490	.09902	-.26233	.18826	-.20277	-.12578	-.03576	.01434	.10050	-.20513
11.0 - 12.0	-.00509	.08440	-.22056	.15880	-.17311	-.10777	-.03083	.00940	.08570	-.17499
12.0 - 13.0	-.00483	.07282	-.18883	.13628	-.15022	-.09384	-.02702	.00599	.07425	-.15172
13.0 - 14.0	-.00440	.06346	-.16417	.11864	-.13210	-.08287	-.02402	.00324	.06526	-.13344
14.0 - 15.0	-.00391	.05581	-.14474	.10463	-.11781	-.07417	-.02165	.00116	.05817	-.11896
15.0 - 16.0	-.00347	.04955	-.12932	.09345	-.10623	-.06725	-.01677	-.00035	.05259	-.10746
16.0 - 17.0	-.00308	.04431	-.11695	.08446	-.09678	-.06170	-.01426	-.00139	.04818	-.09824
17.0 - 18.0	-.00282	.04000	-.10700	.07729	-.08896	-.05724	-.01706	-.00204	.04472	-.09084
18.0 - 19.0	-.00289	.03688	-.09900	.07167	-.08241	-.05352	-.01606	-.00231	.04202	-.08488
19.0 - 20.0	-.00329	.03472	-.09231	.06718	-.07661	-.05042	-.01517	-.00231	.03979	-.07981
20.0 - 21.0	-.00391	.03315	-.08613	.06326	-.07098	-.04731	-.01426	-.00217	.03764	-.07498
21.0 - 22.0	-.00453	.03185	-.07906	.05921	-.06446	-.04357	-.01317	-.00212	.03694	-.06915

CROSSFLOW BETWEEN ADJACENT CHANNELS AT TIME = 0.0000 SECONDS

ASSEMBLY NUMBER	1	1	1	1
AXIAL ZONE	W(2A, 35)	W(22, 28)	W(15, 22)	W(8, 15)
0.0 - 1.0	.00497	.00403	.00110	-.00171
1.0 - 2.0	.06234	.04780	.01262	-.02005
2.0 - 3.0	.63086	.45591	.11651	-.18365
3.0 - 4.0	4.20152	2.73720	.75069	-1.13212
4.0 - 5.0	-.35224	1.06571	.39798	-.49526
5.0 - 6.0	-.07374	-1.14721	-.10633	.14920
6.0 - 7.0	-.67323	-.73267	-.39555	.47582
7.0 - 8.0	-.03583	-.42010	-.14513	.14309
8.0 - 9.0	-.32211	-.30250	-.10166	.13105
9.0 - 10.0	-.25520	-.23835	-.08028	.10564
10.0 - 11.0	-.20970	-.19546	-.06593	.08823
11.0 - 12.0	-.17627	-.16398	-.05541	.07521
12.0 - 13.0	-.15070	-.14003	-.04735	.06506
13.0 - 14.0	-.13094	-.12131	-.04099	.05698
14.0 - 15.0	-.11531	-.10648	-.03593	.05046
15.0 - 16.0	-.10293	-.09469	-.03188	.04518
16.0 - 17.0	-.09304	-.08529	-.02866	.04088
17.0 - 18.0	-.08515	-.07786	-.02614	.03743
18.0 - 19.0	-.07888	-.07210	-.02423	.03480
19.0 - 20.0	-.07370	-.06792	-.02276	.03280
20.0 - 21.0	-.06895	-.06353	-.02153	.03120
21.0 - 22.0	-.06343	-.05940	-.02043	.02992

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