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RELAP5 Model for Advanced Neutron Source Reactor Thermal-Hydraulic Transients, Two-Element-Core Design

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November 1995
(Date published: February 1996)

Advanced Neutron Source

MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

ORNL/TM-13075

Engineering Technology Division

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for the
U. S. DEPARTMENT OF ENERGY
under contract DE-AC05-96OR22464

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LIST OF ACRONYMS

ANSR	Advanced Neutron Source Reactor
BOC	beginning-of-cycle
CCFL	counter current flow limit
CHF	critical heat flux
CPBT	core pressure boundary tube
CPU	central processing unit
CR	control rod
CSAR	conceptual safety analysis report
CV	control variable
EHX	emergency heat exchanger
FE	flow excursion
HFIR	High Flux Isotope Reactor
HS	hot spot
HTC	heat transfer coefficient
IB	incipient boiling
INEL	Idaho National Engineering Laboratory
LOSP	loss-of-offsite power
MHX	main heat exchanger
NEPL	nonexceedance probability level
NPSH	net positive suction head
OSV	onset of significant void
PID	Proportional Integral Derivative
PSVAW	primary supply vessel adapter weldment
PVM	Parallel Virtual Machine
RDA	rapid depressurization accident
SF	scaling factor
SZ	Saha-Zuber
TDJ	time dependent junction
TDV	time dependent volume

NOMENCLATURE

Symbol	Definition	Units
A	Cross-sectional area	m^2
C_d	Discharge coefficient	-
dh	Volume hydraulic diameter	m
dZ	Volume elevation rise	m
e	Surface roughness	m^2
f	Friction coefficient	-
g	Coolant gap dimension	m
HAN	Dimensionless homologous pump parameter	-
HVN	Dimensionless homologous pump parameter	-
K_f	Forward loss coefficient	-
K_r	Reverse loss coefficient	-
L	Volume length	m
r	Radial dimension	m
Re	Reynolds number	-
q_{COSTA}	Costa limiting heat flux	MW/m^2
s	Fuel plate span	m
SF	Control variable scaling factor	varies
t_{oxide}	Oxide thickness	m
T_{bulk}	Fluid bulk temperature	K
T_{sat}	Saturation temperature	K
T_w	Wall temperature	K
v	Pump flow ratio	-
v_{fj}	Liquid velocity at a junction	m/s
α	Pump speed ratio	-
α_{fj}	Liquid void fraction at a junction	-
ΔP	Pressure drop	Pa
Δx	Clean fuel plate thickness	m
ρ_{fj}	Liquid density at a junction	kg/m^3

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ABSTRACT

In support of the conceptual safety analysis report (CSAR) for the Advanced Neutron Source Reactor (ANSR), a RELAP5 thermal-hydraulic input model has been developed. The purpose of the model is to quantify the ANS thermal safety margin during a rapid depressurization accident (RDA) and during a loss-of-offsite power (LOSP).

This report contains a detailed description of the input for each RELAP5 component, or a reference where a description for that input may be found. Justification for the assumptions made in developing the RELAP5 model is provided wherever possible. In addition to the RELAP5 component input, the control variables used for various system actions and for auxiliary output are described.

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1. INTRODUCTION

In support of the conceptual safety analysis report (CSAR), a RELAP5/MOD3 Version 8K0 thermal hydraulic input model for the primary cooling system of the Advanced Neutron Source Reactor two-element-core G693 design has been developed. This model has been used for simulating postulated transients (Chap. 15 of the CSAR) involving the primary coolant system. This report describes in detail the RELAP5 input model.

The input model consists of thermal-hydraulic components, heat structures, neutronics model, material property data, and control logic. Thermal hydraulic components are used to define the geometry, connectivity, and boundary conditions of the primary coolant contained within the primary coolant pressure boundary. Heat structures are used to define the geometry and configuration of conducting solids (e.g., piping and fuel plates) important to the thermal behavior of the primary coolant system. The neutronics model is a one-dimensional (point kinetics) model that is used to define the transient behavior of the distributed neutronic heat source in the ANSR. Material property data are supplied to define the thermal conductivity and specific heat for each of the materials comprising the heat structures. The control logic is used to define the dynamic behavior of the reactor control systems (control variables, trips, and general tables), to facilitate post-simulation analysis (minor edit and control variables), and to control directly the numerical simulation (RELAP5 time-step control cards). Appendix A contains a complete listing of the input model.

Special ANSR updates to the RELAP5/MOD3 program are invoked in the core heat structures to use the Petukhovl[1] correlation for heat transfer and Gambill-Weatherhead[2,3] critical heat flux (CHF) correlation and in the fuel channels to use the Griffith[4] drift flux correlation. As part of the post-processing, the following other thermal limits besides CHF are examined:

1. Costa[5] onset of significant void (OSV) correlation, used to predict the point of flow excursion (FE),
2. Bergles/Rohsenow[6] incipient boiling correlation,
3. Saha/Zuber[7] OSV correlation, and
4. A local modification[8] of the Saha/Zuber correlation.

No modifications have been made to the RELAP5 code to examine these other limits.

The nodalization diagram for the RELAP5 model is given in Fig. 1 (core region) and Fig. 2 (loop region).

Some of the assumptions that have been made in developing the model are:

1. The choking option has been disabled at all junctions, unless indicated otherwise. Previous problems have been observed with the choking model giving unrealistic results at internal junctions and causing the code to bomb.

2. The reactor pool temperature is assumed constant at 38 °C (311.15 K).

3. The secondary coolant supply temperature is assumed constant at 29.4 °C (302.55 K).

For all transient simulations, the initial conditions are at a perturbed state from nominal, in the conservative direction, by the amount necessary to account for measurement error and routine control variations:

1. reactor power: +4.2% (ref. 9)

2. primary pressure: -5% (ref. 8)

3. core inlet temperature:+0.6 °C (ref. 8)

4. primary flow: maintained at the nominal flow rate being constrained such that the upper core inlet velocity is 25 m/s inside the fuel channel.

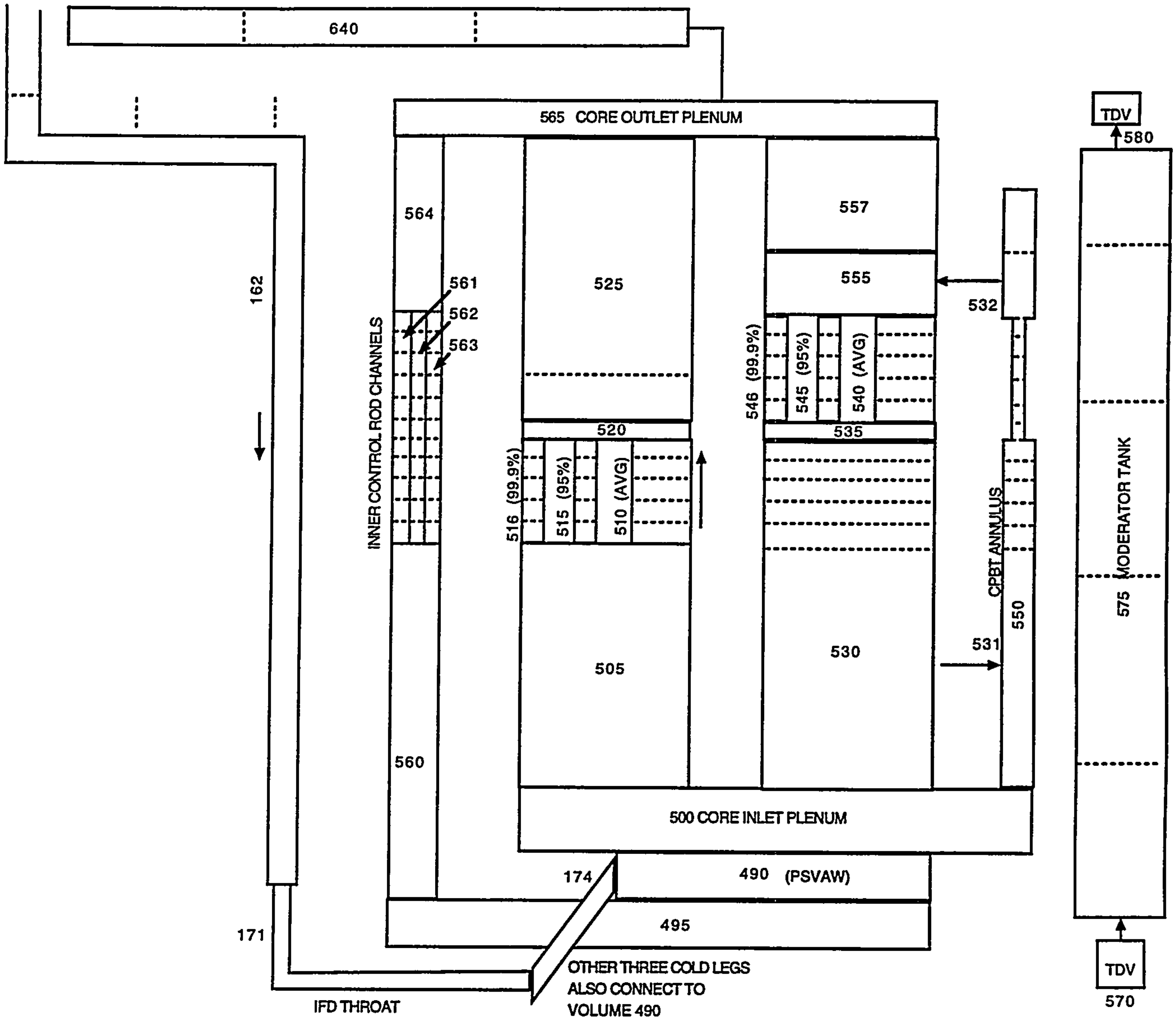

Fig 1. ANS two-element-core RELAP5 nodalization diagram: core region.

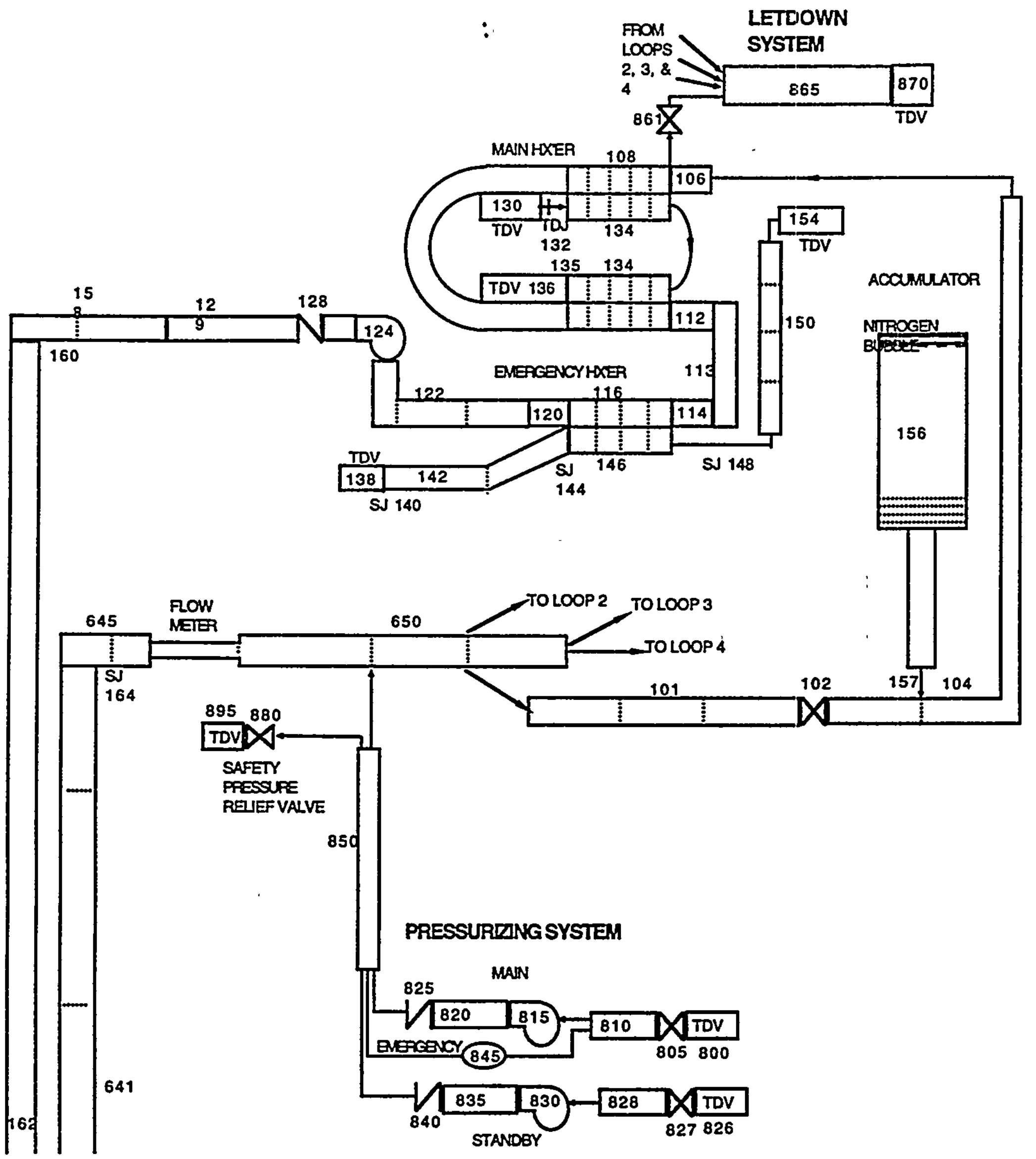

Fig. 2. ANS two-element-core RELAP5 nodalization diagram: loop region.

2. PRELIMINARY INPUT

Card 0000001 - Updates

Updates 8, 10, and 22 (for code version 8K0 only) are invoked.

Update 8 invokes the following functions:

1. limits the time step to the Courant limit (shortest time for fluid to flow through a single control volume) of the most limiting volume in the problem,
2. limits the time step based on void fraction, and
3. makes corrections to the standard CHF calculation.

Update 10 invokes a time-step limit based on the change in pressure within a hydrodynamic volume,

Update 22 invokes an update to improve the RELAP5 use of the Colebrook[10] single-phase pressure correlation. This update should not be used with RELAP5 MOD3.1.1.1 because it serves to *disable* the improvement for that version of the code.

Card 0000100 - Problem Type and Option

The option "new" specifies that this is a new simulation as opposed to a "restart" from a previous simulation. For some transients (e.g., pipe break events) a second input file is used that uses the "restart" option to continue from a run that used the Appendix A input file. This second input file also contains any changes to the normal configuration of the primary system (e.g., the addition of a pipe break junction between the primary system and the pool) that are necessary to represent the transient.

The option "transnt" specifies that a transient simulation is requested. The transient option is always used, even in establishing a new steady-state condition for the primary system.

Card 0000101 - Input Check or Run Option

The option "run" instructs RELAP5 to run the simulation as opposed to simply checking the input for errors.

Card 0000102 - Units Selection

The SI option is selected for both input and output units. This card is not required, but it is included for clarity. Pressures are in Pascals (Pa) and temperatures are in Kelvin (K).

Card 0000105 - CPU Time Remaining

The first two words on this card are central processing unit (CPU) margins that will cause RELAP5 to start wrapping up the job if the CPU time remaining is approaching the value specified in the third word. The allotted CPU time for the job (word 3) is used to smoothly terminate a simulation in case the simulation gets bogged down, and RELAP5 unexpectedly begins using a very small time step. Otherwise, enough CPU time should be allotted to cause the simulation to be terminated based on the time-step control cards (0000201-0000299).

Card 0000110 - Noncondensible gas

The noncondensible gas assumed for the accumulator bubbles is nitrogen. This gas is the only noncondensible used in the ANSR simulations.

Cards 0000120 thru 0000126 - Hydrodynamic Systems

Separate hydrodynamic systems are defined here by specifying one reference volume for each system. Seven systems are identified: the primary heavy-water system and six secondary light-water systems (two for each active loop).

Cards 0000201-0000299 Time-Step Control Cards

These cards are used to request time steps for the simulation. If the requested time step is too high, RELAP5 will halve it until a successful time-step advance can be made with a converged solution. A minimum time step of 0.1 μs is specified. Also, on this card, the frequencies for minor edits, major edits (printed snapshots of the entire system), and restart dumps are specified in integer multiples of the requested time step.

The time-step control cards will nearly always change from simulation to simulation, as the necessary temporal discretization will be a strong function of the simulated transient.

Cards 20800001-20800999 Expanded Edit/Plot Variables

These cards are included to request additional dependent variables to be made available in the restart plot file and in the current run. These variables are not ordinarily provided as such by RELAP5. The heat structure temperatures requested here are internal to the heat structures; whereas RELAP5 normally only provides the heat structure boundary temperatures. The variables with the alpha designator "fwalf" request wall friction terms useful in interpolating pressures at control volume boundaries. The remainder of the extended edit variables request thermal properties (specific heat, thermal conductivity, and dynamic viscosity) in the fuel channels useful in calculating the core thermal limits.

Cards 0000301-0000399 Minor Edit Requests

These variables are requested as output in the RELAP5 standard output file at the frequency specified in the time-step control cards. These cards do not impact the content of the restart/plot file.

3. TRIPS

Trips are logical switches that assume a value of true or false depending on the conditions specified on the trip definition card. For the ANSR thermal-hydraulic model, the trip logic is used for pump, valve, and control variable input. Some trips are dependent upon the state of other trips. The conditions for which each trip is true are given below:

501 - True if cntrlvar 940 (flux-to-flow ratio) exceeds the reactor trip setpoint of 1.2.

502 - True if trip 501 has been true for at least 0.2 s, representing a flow sensor delay.

503 - True if the temperature at the CPBT inlet (volume 500-01) exceeds the high-temperature setpoint of 328.05 K.

504 - True if trip 503 has been true for at least 2 s, representing a temperature sensor delay.

506 - True if cntrlvar 839 (pressure at sensor location, 645-01, with a 0.03 s first-order pressure sensor lag applied) is less than the low-pressure setpoint.

508 - True if time is greater than a predetermined value (normally not used), allowing for a manual reactor trip.

510 - True if trip 603 (reactor scram indicator) has been true for at least 0.03 s, representing the pressure switch unlatch time it takes to start the control rod insertion stroke.

515 - True if time is greater than some predetermined value for loop 1 isolation (normally not used).

516 True if time is greater than some predetermined value for loop 2 isolation (normally not used).

517 - True if time is greater than some predetermined value for loop 3 isolation (normally not used).

525 - True if time is greater than some predetermined value for loop 1 secondary coolant flow coastdown.

526 - True if time is greater than some predetermined value for loop 2 secondary coolant flow coastdown.

527 - True if time is greater than some predetermined value for loop 3 secondary coolant flow coastdown.

528 - True if time is greater than some predetermined value. When the pump cavitation model is being used, this trip determines when to turn off the steady-state pump speed controller and begin holding the speed constant for a forth-coming transient.

536 - True if cntrlvar 65 (loop 1 homologous pump quantity v/α) is greater than 1. Used in determining which portion of the homologous pump curve to reference.

537 - True if cntrlvar 115 (loop 2 homologous pump quantity v/α) is greater than 1. Used in determining which portion of the homologous pump curve to reference.

538 - True if cntrlvar 165 (loop 3 homologous pump quantity v/α) is greater than 1. Used in determining which portion of the homologous pump curve to reference.

540 - True if time is greater than some predetermined value, representing the time at which to trip the main pressurizer pump motor.

541 - True if time is greater than some predetermined value, representing the time at which to trip the standby pressurizer pump motor.

542 - True if time is greater than some predetermined value, representing the time at which to start the emergency pressurizer pump speed table (turn the pump on).

550 - True if time is greater than some predetermined value, representing the time at which to start the standby pressurizer pump speed table (turn the pump on).

551 - True if cntrlvar 804 is greater than a predetermined constant, representing the mass inventory in the make-up tank that leads to a pressurizer pump trip. This constant is currently assumed to be 8358.4 kg.

552 - True if trip 551 has been true for 11 s, resulting in a pressurizer pump trip due to low make-up tank inventory.

555 - True if time is greater than some predetermined value. When this trip turns true, power is disconnected from the primary coolant pump shafts, and the velocity table is not used (i.e., a torque balance based on the pump shaft is used to determine shaft speed). This trip will not override the pump cavitation model, should it be invoked on the pump velocity table cards (1246100, 2246100, 3246100).

560 - True if pressure in 850-01 is greater than a predetermined low-high pressure setpoint for opening the safety valve.

561 - True if pressure in 850-01 is greater than a predetermined high-high pressure setpoint for opening the safety valve.

599 - True if time is greater than a predetermined time to terminate the simulation.

600 - True if trip 599 is true, terminate the simulation.

601 - True if trip 502 or 504 is true, representing the first flag for reactor trip.

602 - True if trip 601 or 506 is true, representing the second flag for reactor trip.

603 - True if trip 602 or 508 is true, representing the third and final flag for reactor trip.

610 - True if trips 560 and 611 are true. This is the first half of the safety valve logic.

611 - True if trips 561 and 610 are true. This is the second half of the safety valve logic.

615 - True if trip 552 is false. This trip is used to isolate the pressurizing system if a low level in the make-up tank occurs.

619 - True if trip 555 is false. This flag is used to disable the pump velocity table, when the user desires to invoke a no-motor primary coolant pump coastdown based on a RELAP5 torque balance.

620 - True if trip 540 is false. This flag is used to disable the pump velocity table for the main pressurizer pump should a trip occur.

621 - True if trip 541 is false. This flag is used to disable the pump velocity table for the standby pressurizer pump should a trip occur.

4. CORE REGION

The core region is very complicated, as shown in Fig. 2. The core model consists of two fuel annuli, core bypass channels, and central control rod region. The core is surrounded by the core pressure boundary tube (CPBT), which separates the high-pressure primary system from the low-pressure moderator tank.

4.1 FUEL ELEMENTS

Three fuel element channels are included for each of the upper and lower fuel elements: an average channel, and two hot channels corresponding to the 95% and 99.9% nonexceedance probability uncertainty levels in the power distribution. In each hot channel, two hot stripes are used to represent both the crtitical heat flux (CHF) and the Costa onset-of-significant-void (OSV), used in the ANSR analysis as a flow excursion (FE) correlation, peaking factors. The G693 power distribution was used with peaking factors and power densities obtained for end-of-cycle (EOC) conditions with the exception of the lower-core hot stripes which were taken at beginning-of-cycle (BOC) conditions. These conditions correspond to the highest (most conservative) heat flux levels. Appendix B contains a listing of the FORTRAN computer program (power.f) that was used to insert the source terms directly into the RELAP5 input file. The source terms that represent heating in the CPBT and control rod region are not modified by power.f. The power densities and peaking factors that were used as input to power.f are supplied in this section. For the power distribution within the fuel plate, uniform heating in the fuel meat and clad is assumed, and a $1/r$ profile in the side plates, control rods, central hole wall, and CPBT walls is used.

4.1.1 Average Fuel Channels

The core contains two fuel annuli. The core geometry is described in ref. 11 The lower fuel annulus consists of 252 fuel plates with thickness of 1.27 mm and span of 87.35 mm. The upper fuel annulus consists of 432 fuel plates with thickness of 1.27 mm and span of 70.29 mm. One average channel is used in the lower fuel region to represent (as a lumped volume) all but two of the fuel channels. The same method is used for the upper fuel region. The two fuel channels excluded from the lumped volume serve as the 95% and 99.9% hot fuel channels where the channel thickness is narrowed to account for uncertainties in the fuel plate manufacture. The fuel plate surface roughness was calibrated such that the pressure drop predicted by the ANSR steady-state code[12] was obtained at an upper-core inlet velocity of 25 m/s.

Pipe 510

Lower core average channel,

L	=	0.1014 m for each of 5 nodes, giving 0.507 m total length
A	=	0.027675 m^2 (total flow area in lower core except two hot channels)
	=	$(250/252) \times [\pi(0.168^2 - 0.102^2) - (252)(1.276 \times 10^{-3})(87.35 \times 10^{-3})]$
dZ	=	0.1014 m, assumes vertical orientation of the core
e	=	1.772×10^{-6} m, calibrated to get correct pressure drop over the core
dh	=	0.002498 m = $4(87.35)(1.2672) / 2(87.35 + 1.2672)$

The ANS rectangular-channel geometry updates are invoked on card 5101001, and the pitch and span are specified to be 0.00127 m and 0.08735 m, respectively, on card 5101501.

Three sets of heat structures are attached to the average channel. The first set represents the average fuel plate. The second set represents the inner side plate, and the third represents the outer side plate. The same method applies for the upper fuel region.

Pipe 540

Upper-core average channel,

L	=	0.1014 m for each of 5 nodes, giving 0.507 m total length
A	=	0.038359 m^2 (total flow area in upper core except two hot channels)
	=	$(430/432) \times [\pi(0.2352 - 0.175^2) - (432)(1.276 \times 10^{-3})(70.25 \times 10^{-3})]$
dZ	=	0.1014 m (elevation)
e	=	1.772×10^{-6} m, calibrated roughness to get correct pressure drop over the core
dh	=	0.002494 m = 4(70.29)(1.269) / 2(70.29 + 1.269)

The ANS rectangular-channel geometry updates are invoked on card 5401001 and the pitch and span are specified to be 0.00127 m and 0.07029 m, respectively, on card 5401501.

4.1.2 Hot Fuel Channels

Two hot channels are used in the lower fuel region to include uncertainties combined to produce the worst-case thermal-hydraulic conditions. Each hot channel is assumed to have a minimum channel gap of 1.14 mm (equal to 90% of nominal 1.27-mm gap).[13] One of the hot channels is used to produce conditions at a 95% nonexceedance probability level (NEPL) for analysis of unlikely events, and the other at 99.9% nonexceedance probability level for analysis of anticipated events. The same method is used for the upper fuel region.

Pipes 515 and 516

Lower core 95% and 99.9% NEPL hot channel,

L	=	0.1014 m for each of 5 nodes, giving 0.507 m total length
A	=	0.000110698 m^2 (flow area for the single channel)
	=	$(1/252) \times [\pi(0.168^2 - 0.102^2) - (252)(1.276 \times 10^{-3})(87.35 \times 10^{-3})]$
dZ	=	0.1014 m (elevation)
e	=	1.772×10^{-6} m, calibrated roughness to get correct pressure drop
dh	=	0.002498 m = $4 \times 1.10698 \times 10^{-4} / [2(87.35 + 1.2672) \times 10^{-3}]$

The ANS rectangular-channel geometry updates are invoked on cards 5151001 and 5161001, and the pitch and span are specified to be 0.0011433 m and 0.08735 m, respectively, on cards 5151501 and 5161501.

Pipe 545 and 546

Upper core 95% and 99.9% NEPL hot channel,

L	=	0.1014 m for each of 5 nodes, giving 0.507 m total length

A = 8.9206×10^{-5} m^2 (flow area for the single channel)
= $(1/432) \times [\pi(0.235^2 - 0.175^2) - (432)(1.276 \times 10^{-3})(70.29 \times 10^{-3})]$
dZ = 0.1014 m (elevation)
e = 1.772×10^{-6} m, calibrated roughness to get correct pressure drop
dh = $0.002493 \text{ m} = 4 \times 8.9206 \times 10^{-5} / [2(70.29 + 1.276) \times 10^{-3}]$

The ANS rectangular-channel geometry updates are invoked on cards 5451001 and 5461001 and the pitch and span are specified to be 0.0011433 m and 0.08735 m, respectively, on cards 5451501 and 5461501.

4.1.3 Unheated Annular Channels

Several control volumes are defined to represent the annular channels upstream and downstream of each fuel element. Volumes 520 and 535 are defined to represent the short (0.05-m) midcore volumes.

Pipe 505

Lower (inner) core inlet annulus

L = 1.545 m (ref. 14)
A = $0.05598 \text{ m}^2 = \pi(0.168^2 - 0.102^2)$
dZ = 1.545 (vertical orientation)
e = 1.52×10^{-6} m
dh = 0.034 m (ERROR IN MODEL, should be $0.132 = 4 \times 0.05598 / [2\pi(0.168 + 0.102)]$)

Pipe 520

Lower (inner) core mid-core volume

L = 0.05 m (ref. 14)
A = $0.055983 \text{ m}^2 = \pi(0.168^2 - 0.102^2)$
dZ = 0.05 m (vertical orientation)
e = 1.52×10^{-6} m
dh = $0.132 \text{ m} = 4 \times 0.05598 / [2\pi(0.168 + 0.102)]$

Pipe 525

Lower (inner)-core exit annulus (upper-core bypass)

Segment 1

L = 0.2028 m, exit of volume aligned with exit of 2nd volume in upper-core fuel channels[14]
A = $0.055983 \text{ m}^2 = \pi(0.168^2 - 0.102^2)$
dZ = 0.2028 m (vertical orientation)
e = 1.52×10^{-6} m
dh = $0.132 \text{ m} = 4 \times 0.05598 / [2\pi(0.168 + 0.102)]$

Segment 2

L = 2.3610 m, entrance of volume aligned with exit of 2nd volume in upper core fuel channels.[14]
A = 0.055983 $m^2 = \pi(0.168^2 - 0.102^2)$
dZ = 0.2028 m (vertical orientation)
e = 1.52×10^{-6} m
dh = 0.132 m = $4 \times 0.05598 / [2\pi(0.168 + 0.102)]$

Pipe 530

Upper (outer)-core inlet annulus

Segment 1

L = 1.545 m, aligned with lower-core inlet annulus[14]
A = 0.07728 $m^2 = \pi(0.235^2 - 0.175^2)$
dZ = 1.545 m (vertical orientation)
e = 1.52×10^{-6} m
dh = 0.044 m (ERROR IN MODEL, should be 0.120 m = $4 \times 0.07728 / [2\pi(0.235 + 0.175)]$)

Segments 2-6

L = 0.1014 m, aligned with lower-core fuel channel volumes
A = 0.07728 $m^2 = \pi(0.235^2 - 0.175^2)$
dZ = 0.1014 m (vertical orientation)
e = 1.52×10^{-6} m
dh = 0.044 m (ERROR IN MODEL, should be 0.120 m = $4 \times 0.07728 / [2\pi(0.235 + 0.175)]$)

Pipe 535

Upper (outer)-core mid-core volume

L = 0.05 m (ref. 14)
A = 0.07728 $m^2 = \pi(0.235^2 - 0.175^2)$
dZ = 0.05 m (vertical orientation)
e = 1.52×10^{-6} m
dh = 0.044 m (ERROR IN MODEL, should be 0.120 m = $4 \times 0.07728 / [2\pi(0.235 + 0.175)]$)

Pipe 555
Upper (outer)-core exit annulus

L = 0.7715 m, aligned to receive cross-flow from CPBT annulus[14]
A = 0.07728 $m^2 = \pi(0.235^2 - 0.175^2)$
dZ = 0.7715 m (vertical orientation)
e = 1.52×10^{-6} m
dh = 0.120 m = $4 \times 0.07728 / [2\pi(0.235 + 0.175)]$

Pipe 557
Upper (outer)-core exit annulus

L	=	1.2853 m (ref. 14)
A	=	$0.07728\ m^2 = \pi(0.235^2 - 0.175^2)$
dZ	=	1.2853 m (vertical orientation)
e	=	1.52×10^{-6} m
dh	=	$0.120\ m = 4 \times 0.07728 / [2\pi(0.235 + 0.175)]$

Core Flow Separation Shroud Heat Structures

Heat Structure 5052 (Separation shroud between core annuli in entrance region)

Number of Heat Structure (NHS) = 1
Number of Mesh Point (NMP) = 4
Left-boundary coordinate = 0.168-m inner radius of core flow separation shroud [14]
Right-boundary coordinate = 0.175-m outer radius of core flow separation shroud[14]
Composition is No. 2 - Al 6061
Left Boundary is Pipe 505
Right Boundary is Pipe 530

Heat Structure 5202 (Separation shroud between core annuli in mid-core region)

Number of Heat Structure (NHS) = 1
Number of Mesh Point (NMP) = 4
Left-boundary coordinate = 0.168-m inner radius of core flow separation shroud[14]
Right-boundary coordinate = 0.175-m outer radius of core flow separation shroud[14]
Composition is No. 2 - Al 6061
Left Boundary is Pipe 520
Right Boundary is Pipe 535

Heat Structure 5551 (Separation shroud between middle and outer cores in core outlet region)

Number of Heat Structure (NHS) = 2
Number of Mesh Point (NMP) = 4
Left-boundary coordinate = 0.168-m inner radius of core flow separation shroud [14]
Right-boundary coordinate = 0.175-m outer radius of core flow separation shroud[14]
Composition is No. 2 - Al 6061
Left-Boundary is Pipe 525
Right-Boundary is Pipe 555

4.1.4 Fuel Channel Interconnecting Junctions

Multiple Junction 507

Junction 1
Connects pipe 500 (core inlet plenum) to pipe 505 (lower-core inlet annulus)
A = 0.05598 m^2 (defaulted to area of 505)
Kf = 0.0
Kr = 0.0
Use abrupt area change model to represent sudden area contraction
dh = 0.132 m (same as the correct dh for 505)

Junction 2
Connects pipe 505 (lower-core inlet annulus) to pipe 510 (lower-core average channel)
A = 0.027675 m^2 (defaulted to area of 510)
Kf = 0.1079 = 0.04 (taken from HFIR value[15]) + 0.0679 (fL/d, for smooth pipe, Re = 1.5 × 10^5, L = 0.010 m unheated length)
Kr = 0.1079
Use smooth area change model
dh = 0.0024831 m, ERROR: should be 0.002498 m, same as the dh for 510

NOTE: The errors on the junction hydraulic diameters are on the CCFL cards and are not used in calculating normal unidirectional flow pressure drops.

Junction 3
Connects pipe 505 (lower-core inlet annulus) to pipe 515 (lower-core 95% NEPL hot channel)
A = 0.000110698 m^2 (defaulted to area of 515)
Kf = 0.1079 = 0.04 (taken from HFIR value[15]) 0.0679 (fL/d, for smooth pipe, Re = 1.5 × 10^5, L = 0.010 m unheated length)
Kr = 0.1079
Use smooth area change model
dh = 0.0024831 m, ERROR: should be 0.002498 m, same as the dh for 515

Junction 4
Connects pipe 505 (lower-core inlet annulus) to pipe 516 (lower-core 99.9% NEPL hot channel)
A = 0.000110698 m^2 (defaulted to area of 516)
Kf = 0.1079 = 0.04 (taken from HFIR value[15]) + 0.0679 (fL/d, for smooth pipe, Re = 1.5 × 10^5, L = 0.01 m unheated length)
Kr = 0.1079
Use smooth area change model
dh = 0.0024831 m, ERROR: should be 0.002498 m, same as the dh for 516

Multiple Junction 522

Junction 1
Connects pipe 510 (lower-core average channel) to pipe 520 (lower-core exit annulus)
A = 0.027675 m^2 (defaulted to area of 510)

Kf = 0.0679 = (fL/d for smooth pipe, Re = 1.5×10^5, L = 0.010 m unheated length)
Kr = 0.1079, ERROR: for reverse flow, 4% loss has inadvertantly been included
Use abrupt area change model to represent sudden expansion at core exit
dh = 0.0024982 m, same as the dh for 510

Junction 2
Connects pipe 515 (lower-core 95% NEPL hot channel) to pipe 520 (lower-core exit annulus)
A = 0.000110698 m^2 (defaulted to area of 515)
Kf = 0.0679 = (fL/d for smooth pipe, Re = 1.5×10^5, L = 0.010 m unheated length)
Kr = 0.1079, ERROR: for reverse flow, 4% loss has inadvertantly been included
Use abrupt area change model to represent sudden expansion at core exit
dh = 0.0024982 m, same as the dh for 515

Junction 3
Connects pipe 520 (lower-core mid-core volume) to pipe 525 (lower-core exit annulus)
A = 0.055983 m^2 (defaulted to area of 520)
Kf = 0.0679, ERROR: unheated length loss coefficient inadvertantly included
Kr = 0.1079, ERROR: core exit loss coefficient inadvertantly included
Abrupt area change model invoked, although no area change exists, so it could be smooth
dh = 0.132 m (same as the correct dh for 520)

Junction 4
Connects pipe 516 (lower-core 99.9% NEPL hot channel) to pipe 520 (lower-core exit annulus)
A = 0.000110698 m^2 (defaulted to area of 516)
Kf = 0.0679 = (fL/d for smooth pipe, Re = 1.5×10^5, L = 0.010 m unheated length)
Kr = 0.1079, ERROR: for reverse flow, 4% loss has inadvertantly been included
Use abrupt area change model to represent sudden expansion at core exit
dh = 0.0024982 m, same as the dh for 515

Single Junction 529

Connects pipe 500 (core inlet plenum) to pipe 530 (lower-core bypass annulus)
A = 0.07728 m^2 (defaulted to area of 530)
Kf = 0.0
Kr = 0.0
Use abrupt area change model to represent sudden area contraction
dh = 0.120 m (same as the correct dh for 530)

Multiple Junction 537

Junction 1
Connects pipe 530 (lower-core bypass annulus) to pipe 535 (upper-core midcore volume)
A = 0.07728 m^2 (defaulted to area of 530)
Kf = 0.0
Kr = 0.0

Use abrupt area change model although there is no area change
dh = 0.120 m (same as the dh for 530)

Junction 2
Connects pipe 535 (upper-core midcore volume) to pipe 540 (upper-core average channel)
A = 0.038359 m^2 (defaulted to area of 540)
Kf = 0.1079 = 0.04 (taken from HFIR value[15]) + 0.0679 (fL/d, for smooth pipe, Re = 1.5 × 10^5, L = 0.010 m unheated length)
Kr = 0.1079
Use smooth area change model
dh = 0.0024787 m, ERROR: should be 0.002494 m, same as the dh for 540

Junction 3
Connects pipe 535 (upper-core midcore volume) to pipe 545 (upper-core 95% NEPL hot channel)
A = 0.000089206 m^2 (defaulted to area of 545)
Kf = 0.1079 = 0.04 (taken from HFIR value[15]) 0.0679 (fL/d, for smooth pipe, Re = 1.5 × 10^5, L = 0.010 m unheated length)
Kr = 0.1079
Use smooth area change model
dh = 0.0024787 m, ERROR: should be 0.002494 m, same as the dh for 515

Junction 4
Connects pipe 535 (upper-core midcore volume) to pipe 546 (upper-core 99.9% NEPL hot channel)
A = 0.000110698 m^2 (defaulted to area of 546)
Kf = 0.1079 = 0.04 (taken from HFIR value[15]) + 0.0679 (fL/d, for smooth pipe, Re = 1.5 × 10^5, L = 0.01 m unheated length)
Kr = 0.1079
Use smooth area change model
dh = 0.0024787 m, ERROR: should be 0.002494 m, same as the dh for 546

<u>Multiple Junction 556</u>

Junction 1
Connects pipe 540 (upper-core average channel) to pipe 555 (upper-core exit annulus)
A = 0.038359 m^2 (defaulted to area of 540)
Kf = 0.0679 = (fL/d for smooth pipe, Re = 1.5 × 10^5, L = 0.010 m unheated length)
Kr = 0.0
Use abrupt area change model to represent sudden expansion at core exit
dh = 0.0024935 m, same as the dh for 540

Junction 2
Connects pipe 545 (upper-core 95% NEPL hot channel) to pipe 555 (upper-core exit annulus)
A = 0.000089206 m^2 (defaulted to area of 545)
Kf = 0.0679 = (fL/d for smooth pipe, Re = 1.5 × 10^5, L = 0.010 m unheated length)
Kr = 0.0
Use abrupt area change model to represent sudden expansion at core exit
dh = 0.0024787 m, ERROR should be 0.002494, same as the dh for 545

Junction 3

Connects pipe 546 (upper-core 99.9% NEPL hot channel) to pipe 555 (upper-core exit annulus)

A = 0.000089206 m^2 (defaulted to area of 545)

Kf = 0.0679 = (fL/d for smooth pipe, Re = 1.5×10^5, L = 0.010 m unheated length)

Kr = 0.0

Use abrupt area change model to represent sudden expansion at core exit

dh = 0.0024787 m, ERROR: should be 0.002494, same as the dh for 545

Junction 4

Connects pipe 555 (upper-core bottom exit annulus) to pipe 557 (upper-core top exit annulus)

A = 0.07728 m^2 (defaulted to area of 555)

Kf = 0.0

Kr = 0.0

Use abrupt area change model (unnecessarily)

dh = 0.0024787 m, ERROR: should be 0.120, same as 557

4.1.5 Average Channel Heat Structures

The fuel plates and side plates are modeled with slab (rectangular geometry) heat structures. Source terms are included within each heat structure based on neutronics calculations for the distribution of thermal power in the core. For illustration, a calculational procedure for the lower-core average fuel plates is here described. The same procedure applies to the upper-core fuel region.

(A) Average Fuel Plates

Fuel plate geometry and response is symmetrical with respect to the plate centerline. Taking advantage of symmetry, the fuel plates are modeled as single-sided plates of half thickness with a convective boundary on one side and an adiabatic (symmetry) boundary on the other side.

The clean fuel plates are 1.27 mm (50 mils) thick with a 0.762 mm (30 mils) thick fuel meat and a 0.254 mm (10 mils) aluminum 6061 clad on each side. During oxide formation, cladding is consumed such that the total plate thickness is increased by only 28.6% of the oxide thickness. For the G693 fuel grading, the maximum oxide thickness was 10.2×10^{-6} m. Therefore, the corroded plates consists of 0.762-mm fuel meat, 0.2468-mm clad on each side, and 0.0102-mm oxide on each side, for a total thickness of 1.276 mm.

Fuel meat thickness (half plate)= 0.381 mm

Clad thickness= 0.2468 mm

Oxide thickness= 0.0102 mm

Heat Structure Group Number 5101

Number of Heat Structure (NHS) = 5

Number of Mesh Point (NMP) = 11

2 intervals from the left boundary through right coordinate (RCOORD) = 1.02×10^{-5} m (oxide)

2 intervals through RCOORD= 2.57×10^{-4} m (cladding)

6 intervals through RCOORD= 6.38×10^{-4} m (fuel meat)

Composition No. 4 (Oxide) through interval 2
Composition No. 2 (Al 6061) through interval 4
Composition No. 5 (Fuel Meat) through interval 10

Power Distribution through the fuel plate thickness

Constant uniform values for heat generation are specified for the fuel meat and cladding. At EOC, the power split between the lower and upper cores is 0.281 - lower, and 0.717 - upper.[16] The constant heat source terms are calculated as follows:

lower-core fuel meat source term = $0.281 \times 0.9106 \times 50.75/(50.75 + 0.3) = 0.25440$,
lower-core fuel clad source term = $0.281 \times 0.9106 \times 0.3/(50.75 + 0.3) = 0.00150$,
upper-core fuel meat source term = $0.717 \times 0.9106 \times 39.74/(39.74 + 0.27) = 0.6485$,
upper-core fuel clad source term = $0.717 \times 0.9106 \times 0.27/(39.74 + 0.27) = 0.00441$,

where 0.9106 is the total power fraction deposited in the fuel meat and cladding,[17] and the fraction of power to fuel meat and cladding is based on the L7 fuel grading.

The heat transfer area to coolant per cell is calculated as follows:

axial heated length per cell × effective span × number of plates × 2 sides,

where the effective span is the total span length less 1.143 mm (45 mils) both ends for the non-fuel regions. Although only half of the average fuel plate is modeled (taking advantage of symmetry), both sides of the fuel plate are included in the area calculation because the total power is used to generate the source term. The following calculations are done for the fuel plate heat structures to determine the total heat transfer area.

HS 5101	$0.507/5 \times (0.08735 - 2 \times 0.001143) \times (252 - 2) \times 2 = 4.31\ m^2$
HS 5151	$0.507/5 \times (0.08735 - 2 \times 0.001143) \times 1 \times 2 = 0.01724\ m^2$
HS 5161	$0.507/5 \times (0.08735 - 2 \times 0.001143) \times 1 \times 2 = 0.01724\ m^2$
HS 5401	$0.507/5 \times (0.07029 - 2 \times 0.001143) \times (432 - 2) \times 2 = 5.93\ m^2$
HS 5451	$0.507/5 \times (0.07029 - 2 \times 0.001143) \times 1 \times 2 = 0.01379\ m^2$
HS 5461	$0.507/5 \times (0.07029 - 2 \times 0.001143) \times 1 \times 2 = 0.01379\ m^2$

A FORTRAN program (Appendix B: power.f) has been written to calculate source terms in heat structures according to RELAP5 input requirements. The procedure to calculate source terms requires the use of power allocation (Table 1), relative power density as derived from neutronic calculations (Tables 2 and 3), and peaking factors (Tables 4 and 5).

Table 1. Distribution of steady-state heat load in the ANSR RELAP5 system model.[a]

Model region		Core power (%)
Fuel meat		89.74
Fuel-plate cladding		0.57
Core coolant		1.74
Fuel side plates		0.71
Central control rods		0.52
CPBT	Inner wall	0.23
	Outer wall	0.36
Moderator tank coolant		5.1
Control rod coolant		0.8
Others (e.g., pool, shielding, neutrinos)		0.26

[a]Normalized to reactor total power.

Table 2. G693 power density in upper core.

Zone[a]	Avg Chan[b]	Hot Chan[c].	CHF HS[d]	FE HS
1	1.157	1.480	1.700	1.671
2	1.315	1.624	1.700	1.544
3	1.287	1.497	1.539	1.428
4	1.238	1.392	1.444	1.315
5	1.151	1.257	1.316	1.246

[a]Axial Zones: Zones 1 and 5 represent entry and exit volumes in any channels, respectively.

[b]Average Channel: Radially and zone averaged over multiple channels using neutronic data, it provides average bulk temperature rise.

[c]Hot Channel: Zone averaged over the single hottest channel for each core, it provides the maximum bulk temperature rise.

[d]Hot Spot: No averaging, used local maximum relative power density as the worst case in each zone.

Table 3. G693 power density in lower core

Zone	Average channel	Hot channel	CHF Hot stripe	FE Hot stripe
1	0.800	1.630	1.709	1.541
2	0.727	1.495	1.573	1.388
3	0.637	1.357	1.428	1.303
4	0.588	1.225	1.305	1.150
5	0.587	1.042	1.146	0.765

Table 4. Peaking factors used for hot channels and hot stripes at 95% nonexceedance probability

Zone	Hot channel	CHF	FE	IB	SZ	SZ (Modified)	T_w=T_{sat}	T_w=T_{sat}
1	1.074	1.631	1.305	1.30	1.521	2.08	1.14	1.16
2	1.074	1.554	1.305	1.30	1.521	2.08	1.14	1.16
3	1.074	1.554	1.305	1.30	1.521	2.08	1.14	1.16
4	1.074	1.554	1.305	1.30	1.521	2.08	1.14	1.16
5	1.074	1.631	1.305	1.30	1.521	2.08	1.14	1.16

Table 5. Peaking factors used for hot channels and hot stripes at 99.9% nonexceedance probability

Zone	Hot Chan	CHF	FE	IB	SZ	$T_w = T_{sat}$	$T_w = T_{sat}$	$T_w = T_{sat}$
1	1.113	1.995	1.592	1.59	2.3	1.23	1.23	1.25
2	1.113	1.899	1.592	1.59	2.3	1.23	1.23	1.25
3	1.113	1.899	1.592	1.59	2.3	1.23	1.23	1.25
4	1.113	1.899	1.592	1.59	2.3	1.23	1.23	1.25
5	1.113	1.995	1.592	1.59	2.3	1.23	1.23	1.25

Sample Calculation: Lower-core average and hot channel fuel plate source terms

1. Determine power fractions

In the lower fuel element, the model contains 250 plates for the average channels, one plate for the 95% hot channel, and one plate for the 99.9% hot channel. The power to the lower core is apportioned to the average and hot channels by applying the conservation of energy.

$$250/252 \times p + \begin{matrix}\text{averaged hot channel} \\ \text{power density/averaged} \\ \text{channel power density}\end{matrix} \times \begin{matrix}\text{(1.252 peaking factor for} \\ \text{the 95\% hot channel +} \\ \text{1/252 peaking factor for the} \\ \text{99.9\% hot channel)}\end{matrix} = 1.$$

The above equation expressed using the FORTRAN variables is:

mavgl + ml95 + ml99 = 1,

where

mavgl = 250 × P/252 = average channel power fraction,

ml95 = 1 × averaged hot channel power desity / averaged channel power density × peaking factor of the 95% hot channel /252 = 95% hot channel power fraction,

ml99 = 1 × averaged hot channel power desity / averaged channel power density × peaking factor of the 99.9% hot channel /252 = 99.9% hot channel power fraction.

2. Derive source terms for average fuel heat structures.

In power.f, the source multiplier (defined as W2) for the averaged fuel heat structure in the first cell of the lower core is expressed by:

W2 = 0.05118 × mavgl × pdlcac(n)/avpdla,

where, in addition:

pdlcac(n) = the *n*th-cell power density, lower core, average channel heat structure

avpdla = average power density in lower core average fuel heat structure

and the leading constant is calculated as follows:

Lower-core power fraction × total fuel meat and clad power fraction / 5 cells

0.28 × 0.9106/5 = 0.05118,

where the lower-core power fraction (0.28), along with the upper-core power fraction, was calculated from neutronic data.[16]

$W3 = 2.56\times10^{-4} \times mavgl \times pdlcac(n)/avpdla$

wherein the leading constant is computed as $0.00128/5 = 2.56\times10^{-4}$ (0.00128 from[17] is the power fraction deposited in the coolant immediately next to the fuel element). Repeat the same procedure for the inner and outer side plates.

3. Load the calculated source terms into the RELAP5 input file.

As the source terms are inserted into the RELAP5 input, a summation of the itemized heat sources is performed as a check on total power conservation. The G693 core output for the lower-core average fuel plates is shown in Table 6. For the lower core average fuel plate (heat structure 5101), the right heat is inputed zero because it is an adiabatic (symmetry) boundary at the fuel plate centerline.

(B) Average Channel Side Plates

Heat Structure 5102 (Lower-Core Average Channel Inner Side Plate)

The lower-core average channel inner side plate is modeled with a two-sided structure that can pass heat from coolant between the average fuel plates (Pipe 510) to coolant in the control rod channel (Pipe 562). RELAP5 does not allow conduction heat transfer between two heat structures. Therefore, fuel plate heat transfer can not be modeled to flow spanwise to the side plates. In the model, heat must pass from the fuel plate to the coolant and then to the side plates. As a result, the side plate temperatures calculated will be low. The same procedure that was used above was used to compute source terms.

Left-boundary radius is 0.095 m
Right-boundary radius is 0.102 m
Composition is No. 2 - Al6061
Heat transfer length = 0.10098 m , ERROR neglected to divide the available heat transfer area by 2, should be $0.5 \times 250/252 \times 0.507/5 = 0.05030$ m

Heat Structure 5103 (Lower-Core Average Channel Outer-Side Plate)

The lower-core average channel outer-side plate is modeled with a two-sided structure that can pass heat from coolant between the average fuel plates (Pipe 510) to coolant in the lower fuel bypass annulus (Pipe 530). The method used for heat structure 5102 was also used here to calculate source terms. The same procedure that was used above was used to compute source terms.

Left-boundary radius is 0.095 m
Right-boundary radius is 0.102 m
Composition is No. 2 - Al6061
Heat transfer length = 0.10098 m, ERROR neglected to divide the available heat transfer area by 2, should be 0.5 × 250/252 × 0.507/5 = 0.05030 m

Heat Structure 5103 (Lower-Core Average Channel Outer-Side Plate)

The lower-core average channel outer-side plate is modeled with a two-sided structure that can pass heat from coolant between the average fuel plates (Pipe 510) to coolant in the lower fuel bypass annulus (Pipe 530). The method used for heat structure 5102 was also used here to calculate source terms. The same procedure that was used above was used to compute source terms.

Left-boundary radius is 0.095 m
Right-boundary radius is 0.102 m
Composition is No. 2 - Al6061
Heat transfer length = 0.10098 m, ERROR neglected to divide the available heat transfer area by 2, should be 0.5 × 250/252 × 0.507/5 = 0.05030 m

Heat Structure 5402 (Upper-Core Average Channel Inner-Side Plate)

The upper-core average channel inner-side plate is modeled with a two-sided structure that can pass heat from coolant between the average fuel plates (Pipe 540) to coolant in the lower-core exit annulus (pipe 525). The same procedure that was used above was used to compute source terms.

Left-boundary radius is 0.168 m
Right-boundary radius is 0.175 m
Composition is No. 2 - Al6061
Heat transfer length = 0.1012 m, ERROR neglected to divide the available heat transfer area by 2, should be 0.5 × 430/432 × 0.507/5 = 0.05047 m

The upper-core outer-side plate is the same as heat structure 5503, corresponding to the inner CPBT wall.

4.1.6 Hot Channel Heat Structures

(A) Main Fuel Heat Structure

The peaking factors presented in Tables 4 and 5 are used to calculate the 95% and 99.9% non-exceedance probability hot channel power density distributions. Similar to the lower-core average channel, the lower- core hot channel contains heat structures 5151, 5152, 5153, 5161, 5162, and 5163 for the fuel plate, inner side plate, and outer side plate, respectively. The upper-core hot channel heat structures, 5451, 5452, 5461, and 5462 are similar to those for the upper-core average heat structures. The same procedure for calculating source terms applies.

Heat Structures 5151 and 5161 (Lower-Core 95% and 99.9% Hot Channel Main Fuel Plates)

The lower-core hot channel fuel plate has the same dimensions as the average fuel plate. The heat transfer area

The lower-core hot channel fuel plate has the same dimensions as the average fuel plate. The heat transfer area is different because only one fuel plate is modeled.

Left-boundary radius is 0.0 m
Right-boundary radii for each component are same as described for average fuel plate
Composition is the same as described for average channel fuel
Heat transfer area = 0.017102 m = 0.507/5 × (0.08735 − 2 × 0.001143) × 1 × 2 = 0.01724 m^2

Heat Structures 5451 and 5461 (Upper-Core 95% and 99.9% Hot Channel Main Fuel Plates)

The upper-core hot channel fuel plate has the same dimensions as the average fuel plate. The heat transfer area is different because only one fuel plate is modeled.

Left-boundary radius is 0.0 m
Right-boundary radii for each component are same as described for average fuel plate
Composition is the same as described for average channel fuel
Heat transfer area = 0.013711 m = 0.507/5 × (0.07029 − 2 × 0.001143) × 1 × 2 = 0.01379 m^2

(B) Hot Channel Side Plate Heat Structures

Heat Structure 5152 and 5162 (Lower-Core 95% and 99.9% Hot Channel Inner-Side Plate)s

The lower-core hot channel inner-side plate is modeled with a two-sided structure that can pass heat from coolant between the 95% hot channel (Pipes 515 and 516) to coolant in the control rod channel (Pipe 562). The same procedure that was used above was used to compute source terms.

Left-boundary radius is 0.095 m
Right-boundary radius is 0.102 m
Composition is No. 2 - Al6061
Heat transfer length = 0.0004024 m, ERROR neglected to divide the available heat transfer area by 2, should be 0.5 × 1/252 × 0.507/5 = 0.00020119 m

Heat Structures 5153 and 5163 (Lower-Core 95% and 99.9% Hot Channel Outer-Side Plates)

The lower-core hot channel outer-side plate is modeled with a two-sided structure that can pass heat from coolant between the hot fuel channel (Pipes 515 and 516) to coolant in the lower fuel bypass annulus (Pipe 530). The method used for heat structure 5102 was also used here to calculate source terms. The same procedure that was used above was used to compute source terms.

Left-boundary radius is 0.095 m
Right-boundary radius is 0.102 m
Composition is No. 2 - Al6061
Heat transfer length = 0.0004024 m, ERROR neglected to divide the available heat transfer area by 2, should be 0.5 × 1/252 × 0.507/5 = 0.00020119 m

Heat Structure 5452 and 5462 (U-per-Core 95% and 99.9% Hot Channel Inner-Side Plate)s

The upper-core hot channel inner side plate is modeled with a two-sided structure that can pass heat from coolant between the 95% hot channel (Pipes 545 and 546) to coolant in the lower-core exit annulus (Pipe 525). The same procedure that was used above was used to compute source terms.

Left-boundary radius is 0.168 m
Right-boundary radius is 0.175 m
Composition is No. 2 - Al6061
Heat transfer length = 0.000235 m, ERROR neglected to divide the available heat transfer area by 2, should be $0.5 \times 1/432 \times 0.507/5 = 0.00011736$ m

(C) Hot Stripe Heat Structures

Two separate hot spot factors are incorporated in each of the hot channels, one for CHF (heat structures 5154, 5164, 5454 and 5464) and one for Costa OSV (FE) (heat structure 5155, 5165, 5455 and 5465).[1] These hot spots are modeled as extremely small heat structures (heat transfer area is 1/100th of that for the main hot channel fuel plate) at each axial node. The areas of these heat structures are small enough that they do not affect the hot-channel bulk coolant temperature; however, the peaking factors (Tables 4 and 5) are applied to elevate the local heat flux appropriately.

Heat Structures 5154, 5155, 5164, 5165 (Lower-Core 95% and 99.9% CHF and FE Hot Stripes)

The lower-core hot stripes have the same dimensions as the average fuel plate. The heat transfer area is only 1/100th of that for a single fuel plate.

Left-boundary radius is 0.0 m
Right-boundary radii for each component are same as described for average fuel plate
Composition is the same as described for average channel fuel
Heat transfer area = 0.00017102 m^2 = 0.01724/100. m^2

ERROR on card 15155303 for lower-core 95% FE hot stripe, relative source term should be 0.25440 instaed of 0.5075.

Heat Structures 5454, 5455, 5464, 5465 (Upper-Core 95% and 99.9% CHF and FE Hot Stripes)

The upper-core hot stripes have the same dimensions as the average fuel plate. The heat transfer area is only 1/100th of that for a single fuel plate.

Left-boundary radius is 0.0 m

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[1] Additionally, in the postprocessor, three thermal limit heat fluxes are calculated based on the Costa OSV hot spot fluxes for the $T_w = T_{sat}$, the incipient boiling (IB), and the modified Saha-Zuber OSV at the 95% and 99.9% non-exceedance probability levels.

Right-boundary radii for each component are same as described for average fuel plate
Composition is the same as described for average channel fuel
Heat transfer area = 0.00013711 m^2 = 0.01379/100. m^2

Table 6. Source terms in the lower-core average fuel plates (Heat Structure 5101) as coded in the RELAP5 ANSR system input model

Source type	Multiplier (×100)	Left heat (×10^4)	Right heat	Heat structure No.
1000	6.02362	3.01298	0	1
1000	5.47397	2.73805	0	2
1000	4.79631	2.39909	0	3
1000	4.42736	2.21454	0	4
1000	4.41983	2.21078	0	5

4.2 CONTROL ROD CHANNELS

This region is contained within the control rod shroud (IR = 95 mm, OR = 102 mm) (ref. 14). The elevation span is from the flow split elevation to the top of the CPBT. Three control rods are enclosed by the shroud. Each rod consists of an aluminum inner cylinder (IR = 22 mm, OR = 31.25 mm) and a hafnium outer cylinder (IR = 31.5 mm, OR = 35.5 mm) with coolant gaps in between. The control rod channel model incorporates the region of coolant flow surrounding the control rods, the coolant passages between the hafnium and the aluminum carrier, and the central coolant channel within the control rods themselves. All three rods are modeled with a 6-m/s coolant velocity in each coolant channel at steady-state conditions. This is accomplished by outlet orifice loss coefficients at junctions 566-01, 566-02, and 566-03. In the model, pipes 561, 562, and 563 with elevation spanning from the lower-core bottom to the upper-core top represent paths inside rods, paths outside rods, and internal rod gaps, respectively. The remaining branches 560 and 564 represent the inlet and outlet of the channel.

Because of gamma heating, the fraction of core power deposited within structures external to the fueled region (such as the control rods and the CPBT) increases after the reactor scram, although the absolute value decreases. When using the normal RELAP5 reactor point kinetics model for calculating total core power, it is necessary to assume that the distribution of the core power among the various core regions does not vary with time. To improve the simulation of both the control rods and the CPBT after reactor scram, the RELAP5 ANSR model was modified by (a) decoupling the CPBT and control rod heating rates from the reactor point kinetics calculation and (b) implementing realistic functions for CPBT and control rod heating following a reactor trip. The associated heat structures are modeled as a two-sided aluminum wall (heat structure 5611), aluminum-hafnium (heat structure 5621), and hafnium wall (heat structure 5631). In addition, heat structures 5612 and 5622 represent the inside and outside D_2O heating, respectively.

Pipe 560
Control rod inlet

L = 2.419 m (ref. 14)
A = 0.03018 m^2, ERROR IN MODEL, 0.03485 $m^2 = \pi(0.130^2 - 3 \times 0.044^2)$
dZ = 2.419 m (vertical orientation)
e = 1.52×10^{-6} m
dh = 0.0207 m, ERROR IN MODEL, 0.08468 m $= 4 \times 0.03485/2\pi/(3 \times 0.044 + 0.130)$

Pipe 561
Coolant in control rod tube

Segments 1-11, except 6
L = 0.1014 m (ref. 14), corresponds to upper and lower fuel axial regions
A = 0.00456159 $m^2 = 3 \times \pi \times 0.022^2$
dZ = 0.1014 m (vertical orientation)
e = 1.52×10^{-6} m
dh = 0.044 m = 2×0.022

Segment 6
L = 0.050 m (ref. 14), corresponds to midcore volume
A = 0.00456159 $m^2 = 3 \times \pi \times 0.022^2$
dZ = 0.050 m (vertical orientation)
e = 1.52×10^{-6} m
dh = 0.044 m = 2×0.022

Pipe 562
Coolant around control rod tube

Segments 1-11, except 6
L = 0.1014 m (ref. 14), corresponds to upper and lower fuel axial regions
A = 0.0164753 $m^2 = \pi(0.095^2 - 3 \times 0.0355^2)$
dZ = 0.1014 m (vertical orientation)
e = 1.52×10^{-6} m
dh = 0.0520521 m $= 4 \times 0.0164753/2\pi/(0.095 + 3 \times 0.0355)$

Segment 6
L = 0.050 m (ref. 14), corresponds to midcore volume
A = 0.0164753 $m^2 = \pi(0.095^2 - 3 \times 0.0355^2)$
dZ = 0.050 m (vertical orientation)
e = 1.52×10^{-6} m
dh = 0.0520521 m $= 4 \times 0.0164753/2\pi/(0.095 + 3 \times 0.0355)$

Pipe 563
Coolant in control rod gap

Segments 1-11, except 6

L = 0.1014 m (ref. 14), corresponds to upper and lower fuel axial regions
A = 0.0013195 $m^2 = \pi(0.0315^2 - 0.0285^2) \times 8 \times 35°/360° \times 3$
dZ = 0.1014 m (vertical orientation)
e = 1.52×10^{-6} m
dh = 0.006 m = $4 \times 0.0013195 / [2\pi \times 8 \times 35°/360° \times 3(0.0315 + 0.0285)]$

Segment 6
L = 0.050 m (ref. 14), corresponds to midcore volume
A = 0.0013195 $m^2 = \pi(0.0315^2 - 0.0285^2) \times 8 \times 35°/360° \times 3$
dZ = 0.050 m (vertical orientation)
e = 1.52×10^{-6} m
dh = 0.006 m = $4 \times 0.0013195 / [2\pi \times 8 \times 35°/360° \times 3(0.0315 + 0.0285)]$

Pipe 564
Control rod outlet

L = 2.0568 m (ref. 14)
A = 0.03018 m^2, ERROR IN MODEL, 0.03485 $m^2 = \pi(0.130^2 - 3 \times 0.044^2)$
dZ = 2.0568 m (vertical orientation)
e = 1.52×10^{-6} m
dh = 0.0207 m, ERROR IN MODEL, 0.08468 m = $4 \times 0.03485/2\pi/(3 \times 0.044 + 0.130)$

Multiple Junction 559

Junction 1
Connects pipe 560 (control rod inlet plenum) to pipe 561 (control rod tube channel)
A = 0.00456159 m^2 (defaulted to area of 561)
Kf = 0.0
Kr = 0.0
Use smooth area change model
dh = 0.044 m, same as the dh for 540

Junction 2
Connects pipe 560 (control rod inlet plenum) to pipe 562 (control rod tube external channel)
A = 0.0164753 m^2 (defaulted to area of 562)
Kf = 0.0
Kr = 0.0
Use smooth area change model
dh = 0.0520521 m, same as the dh for 562

Junction 3
Connects pipe 560 (control rod inlet plenum) to pipe 563 (control rod gap flow)
A = 0.0013195 m^2 (defaulted to area of 563)
Kf = 0.0
Kr = 0.0
Use smooth area change model

dh = 0.006 m, same as the dh for 563

Multiple Junction 566

Junction 1
Connects pipe 561 (control rod tube channel) to pipe 564 (control rod exit plenum)
A = 0.00456159 m^2 (defaulted to area of 561)
Kf = 55.82 (calibrated to get 6 m/s in control rod channel)
Kr = 55.82
Use smooth area change model
dh = 0.044 m, same as the dh for 540

Junction 2
Connects pipe 562 (control rod tube external channel) to pipe 564 (control rod exit plenum)
A = 0.0164753 m^2 (defaulted to area of 562)
Kf = 55.70 (calibrated to get 6 m/s in control rod channel)
Kr = 55.70
Use smooth area change model
dh = 0.0520521 m, same as the dh for 562

Junction 3
Connects pipe 563 (control rod gap flow) to pipe 564 (control rod exit plenum)
A = 0.0013195 m^2 (defaulted to area of 563)
Kf = 52.13 (calibrated to get 6 m/s in control rod channel)
Kr = 52.13
Use smooth area change model
dh = 0.006 m, same as the dh for 563

Heat Structure 5051 (control rod shroud in the inlet region)

Number of Heat Structure (NHS) = 1
Number of Mesh Point (NMP) = 4
Left-boundary coordinate = 0.095 m ERROR: should be 0.130 m inner radius of control rod shroud[14]
Right-boundary coordinate = 0.102 m ERROR: should be 0.1365 m outer radius of control rod shroud[14]
Composition is No. 2 - Al 6061
Left-Boundary is Pipe 560
Right-Boundary is Pipe 505

Heat Structure 5201 (Control rod shroud in mid-core region)

Number of Heat Structure (NHS) = 1
Number of Mesh Point (NMP) = 4
Left-boundary coordinate = 0.095 m (ref. 14)
Right-boundary coordinate = 0.102 m (ref. 14)
Composition is No. 2 - Al 6061
Left-Boundary is Volume 562-06
Right-Boundary is Volume 520-01

Heat Structure 5251 (Control rod shroud in upper-core region)

Number of Heat Structure (NHS) = 5
Number of Mesh Point (NMP) = 4
Left-boundary coordinate = 0.095 m (ref. 14)
Right-boundary coordinate = 0.102 m (ref. 14)
Composition is No. 2 - Al 6061
Left boundary is Volume 562-07 thru 562-11
Right boundary is Volume 525-01 and 525-02
Heat transfer length = 0.1014 m = 0.507/5

4.3 CORE PRESSURE BOUNDARY TUBE (CPBT)

The CPBT is a double-walled containment for the fuel assemblies. Coolant flows between the inner and outer walls in the CPBT annulus (pipe 550) to keep the exterior of the inner wall pressurized. This is accomplished by sizing the inner wall orifices at the bottom (inlet) and top (outlet) appropriately. The CPBT annulus is modeled as an annular flow channel with a 3-mm gap in the axial region defined by the upper core and a 5-mm gap at all other axial locations. the steady-state design coolant velocity in the 3-mm gap region is 7 m/s. Previous RELAP5 studies have shown that if the outer wall completely disappears, that an inlet orifice diameter of 0.076 m (3 in.) and an outlet orifice diameter of 0.0508 m (2 in.) is an acceptable combination to prevent fuel damage. These orifices are represented by single junctions 531 and 532.

The outer wall has an inside radius of 245 mm and an outside radius of 253 mm. The inner wall has an inside radius of 235 mm and an outside radius of either 240 or 242 mm, depending on the axial location.

4.3.1 CPBT Thermal-Hydraulic Volumes and Junctions

Junction 531

Connects center (via crossflow junction) of 530-01 to center of 550-01
A = 0.00454 m^2 (0.076-m-diam circular orifices)
Kf = 2.79 (orifice with C_D= 0.6)
Kr = 2.79 (orifice with C_D= 0.6)
Use smooth area change model
Invoke crossflow option for both volumes
dh = 0.01 m (assume 1-cm-hole diameters)

Junction 532

Connects center (via crossflow junction) of 530-01 to center of 550-01
A = 0.00204 m^2 (0.051-m-diam circular orifices)
Kf = 2.78 (orifice with C_D= 0.6)
Kr = 2.78 (orifice with C_D= 0.6)
Use smooth area change model
Invoke crossflow option for both volumes

dh = 0.0024787 m

Pipe 550 (CPBT annulus)

Segment 1

L =	1.545 m, aligned with lower-core inlet annulus
A =	$0.007618\ m^2 = \pi(0.245^2 - 0.240^2)$
dZ =	1.545 m
e =	1.52×10^{-6} m
dh =	0.01 m = 2 × gap

Segments 2-6

L =	0.1014 m, aligned with lower-core fuel channel volumes
A =	$0.007618\ m^2 = \pi(0.245^2 - 0.240^2)$
dZ =	0.1014 m
e =	1.52×10^{-6} m
dh =	$0.01\ m = 4 \times 0.007618 / 2\pi(0.245 + 0.240)$

Segment 7

L =	0.05 m, aligned with mid-core volumes
A =	$0.004590\ m^2 = \pi(0.245^2 - 0.242^2)$
dZ =	0.05 m (vertical orientation)
e =	1.52×10^{-6} m
dh =	0.006 m = 2 × gap

Segments 8-12

L =	0.1014 m, aligned with upper-core fuel channel volumes
A =	$0.004590\ m^2 = \pi(0.245^2 - 0.242^2)$
dZ =	0.05 m (vertical orientation)
e =	1.52×10^{-6} m
dh =	0.006 m = 2 × gap

Segments 13-14

L =	0.7715 m, volume 13 aligned with upper-core exit volume for cross-flow[14]
A =	$0.007618\ m^2 = \pi(0.245^2 - 0.240^2)$
dZ =	0.7715 m (vertical orientation)
e =	1.52×10^{-6} m
dh =	0.01 m = 2 × gap

All junctions have default areas with smooth area change option. Only junction 550-12 connecting volumes 550-12 and 550-13 (corresponding to the expanding area change) has a loss coefficient. This value was selected to be 95.40 from trial and error to obtain the correct CPBT flow rate.

4.3.2 CPBT Heat Structures

Heat Structure 5001 (Reactor vessel wall at vessel inlet)

Note: This heat structure is not part of the Al CPBT wall.

Number of Heat Structure (NHS) = 1
Number of Mesh Point (NMP) = 4
Left-boundary coordinate = 0.2265 m (inner radius of pipe leading to CPBT)
Right-boundary coordinate = 0.2465 m (outer radius of pipe leading to CPBT)
Composition is No. 1 - SS304
Left boundary is Pipe 500
Right boundary is natural circulation to pool, htc given by general table 581

Heat Structure 5351 (CPBT inner wall in mid-core region)

Number of Heat Structure (NHS) = 1
Number of Mesh Point (NMP) = 4
Left-boundary coordinate = 0.247 m, IR = 0.235 m
Right-boundary coordinate = 0.2595 m, OR = 0.242 m
Composition is No. 2 - Al 6061
Left boundary is Volume 535-01
Right boundary is Volume 550-01
Heat transfer length = 0.050 m, includes unheated fuel length

Heat Structure 5501 (CPBT outer wall in fueled axial regions)

Number of Heat Structure (NHS) = 10
Number of Mesh Point (NMP) = 4
Left-boundary coordinate = 0.245 m
Right-boundary coordinate = 0.253 m
Composition is No. 2 - Al 6061
Left boundary is Pipe 550 (Volumes 2-6, 8-12)
Right boundary is Pipe 575
Heat transfer length = 0.1014 m = 0.507/5

Heat sources are calculated separate from the point kinetics model and involve a complicated calculation using control variables and general tables.[18]

Heat Structure 5502 (CPBT inner wall in lower core region)

Number of Heat Structure (NHS) = 5
Number of Mesh Point (NMP) = 4
Left-boundary coordinate = 0.235 m (ref. 14)
Right-boundary coordinate = 0.240 m
Composition is No. 2 - Al 6061
Left boundary is Pipe 530 (Volumes 2-6)

Right boundary is Pipe 550
Heat transfer length = 0.1014 m = 0.507/5

Heat Structure 5503 (CPBT inner wall in upper-core region)

Number of Heat Structure (NHS) = 5
Number of Mesh Point (NMP) = 4
Left-boundary coordinate = 0.235 m
Right-boundary coordinate = 0.242 m
Composition is No. 2 - Al 6061
Left boundary is Pipe 540 (Volumes 1-5)
Right boundary is Pipe 550 (Volumes 8-12)
Heat transfer length = 0.1014 m = 0.507/5

Heat Structure 5552 (CPBT inner wall in core outlet region)

Number of Heat Structure (NHS) = 2
Number of Mesh Point (NMP) = 4
Left-boundary coordinate = 0.235 m
Right-boundary coordinate = 0.240 m
Composition is No. Al 6061
Left boundary is Pipe 555
Right boundary is Pipe 550
Heat transfer length = 0.7715 m

5. PRIMARY COOLANT PIPING

The primary coolant piping described in this section extends from the exit of the CPBT through each of the heat exchanger/pump loops, and back to the primary supply vessel adapter weldment (PSVAW). Three complete active loops are modeled, and the fourth inactive loop is included upstream of the isolation valve and downstream of the check valve. Heat structures are also included for each piece of pipe. The description of RELAP5 components in the input model proceeds from the CPBT exit back to the PSVAW. Since some components are the same for all three loops, they are described together. The primary coolant pump and heat exchanger models are not discussed in this section.

Pipe 565 (core outlet plenum)

Exit volume into the hot leg
24-in. pipe, ID = 0.56037 m, A = 0.24663 m^2

ID	=	0.56037 m (ref. 19)
L	=	0.918 m (ref. 19)
A	=	0.24663 m^2
dZ	=	0.54 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.56037 m (default)

Multiple Junction 567

Junction 1
Connects exit of 557-01 to entrance of 565-01

A	=	0.07728 m^2 (default = area of Volume 557-01)
Kf	=	0.
Kr	=	0.

Invoke abrupt area change model

dh	=	0.120 m (= dh of Volume 557-01)

Junction 2
Connects exit of 525-01 to entrance of 565-01

A	=	0.055983 m^2 (default = area of Volume 525-01)
Kf	=	0.
Kr	=	0.

Invoke abrupt area change model

dh	=	0.132 m (= dh of Volume 525-01)

Junction 3
Connects exit of 564-01 to entrance of 565-01

A	=	0.0250354 m^2
Kf	=	22.8
Kr	=	22.8

Invoke smooth area change model

dh	=	0.120 m (= dh of Volume 557-01)

Junction 4
Connects exit of 557-01 to entrance of 565-01

A = $0.07728\ m^2$ (default = area of Volume 557-01)
Kf = 0.
Kr = 0.
Invoke abrupt area change model
dh = 0.120 m (= dh of Volume 557-01)

Pipe 640

24-in. pipe, ID = 0.56037 m, A = $0.24663\ m^2$

L = 1.88 m (ref. 21)
dZ = 0.0 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.56037 m (default)

Pipe 641

24-in. pipe, ID = 0.56037 m, A = $0.24663\ m^2$

L = 7.01 m (ref. 21)
dZ = 7.01 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.56037 m (default)

Pipe 645

24-in. pipe, ID = 0.56037 m, A = $0.24663\ m^2$

L = 8.23 m (ref. 21)
dZ = 0.0 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.56037 m (default)

Junction 647-01

Connects exit of 641 to entrance of 645
A = $0.24663\ m^2$ (default)
Kf = 0.24 [90° bend (ref. 20)]
Kr = 0.24 [90° bend (ref. 20)]
Invoke smooth area change model
dh = 0.56037 m (default)

Junction 647-02

Connects exit of 645 to entrance of 650

A	=	0.24663 m^2 (default)
Kf	=	0.
Kr	=	0.

Invoke smooth area change model

dh	=	0.56037 m (default)

<u>Pipe 650</u>

Segment 1 (Flow.Nozzle)

ID = 0.3362 m, A = 0.08879 m^2

L	=	1.68 m (ref. 21)
dZ	=	0.0 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.3362 m (default)

Segment 2

24-in. pipe, ID = 0.56037 m, A = 0.24663 m^2

L	=	3.51 m (ref. 21)
dZ	=	0.0 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.56037 m (default)

Segment 3

24-in. pipe, ID = 0.56037 m, A = 0.24663 m^2

L	=	1.22 m (ref. 21)
dZ	=	0.0 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.56037 m (default)

Segment 4

24-in. pipe, ID = 0.56037 m, A = 0.24663 m^2

L	=	1.83 m (ref. 21)
dZ	=	0.0 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.56037 m (default)

Junction between Segment 1 and Segment 2

A	=	0.24663 m^2 (default)

Kf = 0. (will change when flow-meter losses are considered)
Kr = 0. (will change when flow-meter losses are considered)
Use smooth area change
dh = default

Junction between Segment 2 and Segment 3

This junction is to facilitate pressurizer flow injection.
A = 0.24663 m^2 (default)
Kf = 0.
Kr = 0.
Use smooth area change
dh = default

Junction between Segment 3 and Segment 4

A = 0.24663 m^2 (default)
Kf = 0.2 [flow thru a main passage of a cross with 2/3 loss (ref. 22)]
Kr = 0.2 [flow thru a main passage of a cross with 2/3 loss (ref. 22)]
Use smooth area change
dh = default

Pipe 101 and Pipe 201

Segment 1

Assume 14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L = 1.07 m (ref. 21)
dZ = 0.0 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.3255 m (default)

Segment 2

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L = 3.66 m (ref. 21)
dZ = 0.0 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.3255 m (default)

Segment 3

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L = 2.21 m (ref. 21)

dZ = 0.0 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.3255 m (default)

Junction between Segment 1 and Segment 2

A = 0.08322 m^2 (default)
Kf = 0.182 (90° bend) (ref. 20)
Kr = 0.182 (90° bend) (ref. 20)
Use smooth area change
dh = default

Junction between Segment 2 and Segment 3

A = 0.08322 m^2 (default)
Kf = 0.182 (90° bend) (ref. 20)
Kr = 0.182 (90° bend) (ref. 20)
Use smooth area change
dh = default

Pipe 301

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L = 3.28 m (ref. 21)
dZ = 0.0 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.3255 m (default)

Pipe 401

Hot leg stub pipe.
14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L = 3.28 m (ref. 21)
dZ = 0.0 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.3255 m (default)

Junction 103, and 203

Connects exit of 650-03 to entrances of 101-01 and 201-01
A = 0.24663 m^2 (area of main pipe)
Kf = 1.2 (based on main pipe area, ref. 22)
Kr = 1.2 (based on main pipe area, ref. 22)
Invoke smooth area change model
dh = 0.56037 m

Junction 303

Connects exit of 650-04 to entrance of 301-01

A	=	0.08322 m^2 (area of main pipe)
Kf	=	0.25 (based on branched area, ref. 22)
Kr	=	0.25 (based on branched area, ref. 22)

Invoke smooth area change model

dh	=	0.3255 m

Junction 102, 202 and 302

Isolation valve (trip valve component).

A	=	0.08322 m^2 (area of 14-in. pipe)
Kf	=	0.104 = $8f_t$, gate valve (ref. 20, p. A-27)
Kr	=	0.104

Invoke smooth area change model

dh	=	0.3255 m

Pipe 104, 204 and 304

Segment 1

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L	=	0.69 m (ref. 21)
dZ	=	0.0 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.3255 m (default)

Segment 2

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L	=	12.95 m (ref. 21)
dZ	=	0.0 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.3255 m (default)

Segment 3

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L	=	2.51 m (ref. 21)
dZ	=	2.44 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.3255 m (default)

Junction between Segment 1 and Segment 2

A	=	0.08322 m^2 (default)
Kf	=	0.0
Kr	=	0.0

Use smooth area change

dh	=	default

Junction between Segment 2 and Segment 3

A	=	0.08322 m^2 (default)
Kf	=	0.182 (90° bend) (ref. 20)
Kr	=	0.182 (90° bend) (ref. 20)

Use smooth area change

dh	=	default

<u>Pipe 113, 213 and 313</u>

Segment 1

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L	=	1.98 m (ref. 21)
dZ	=	0.762 m
theta	=	$-\tan^{-1}(762/1828.8) = -22.6°$
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.3255 m (default)

Segment 2

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L	=	1.23 m (ref. 21)
dZ	=	0.6093 m
theta	=	$-\tan^{-1}(609.6/1067) = -29.7°$
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.3255 m (default)

Segment 3

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L	=	0.6096 m (ref. 21)
dZ	=	0.6096 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.3255 m (default)

Junction between Segment 1 and Segment 2

A	=	0.08322 m^2 (default)
Kf	=	0.182 (90° bend) (ref. 20)
Kr	=	0.182 (90° bend) (ref. 20)

Use smooth area change

dh	=	default

Junction between Segment 2 and Segment 3

A	=	0.08322 m^2 (default)
Kf	=	0.182 (90° bend) (ref. 20)
Kr	=	0.182 (90° bend) (ref. 20)

Use smooth area change

dh	=	default

Pipe 122, 222 and 322

Segment 1

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L	=	2.31 m (ref. 21)
dZ	=	0.305 m
theta	=	$-\tan^{-1}(305/2286) = -7.6°$
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.3255 m (default)

Segment 2

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L	=	2.13 m (ref. 21)
dZ	=	0.0 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.3255 m (default)

Segment 3

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L	=	0.762 m (ref. 21)
dZ	=	0.762 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.3255 m (default)

Junction between Segment 1 and Segment 2

A = 0.08322 m^2 (default)
Kf = 0.182 (90° bend) (ref. 20)
Kr = 0.182 (90° bend) (ref. 20)
Use smooth area change
dh = default

Junction between Segment 2 and Segment 3

A = 0.08322 m^2 (default)
Kf = 0.182 (90° bend) (ref. 20)
Kr = 0.182 (90° bend) (ref. 20)
Use smooth area change
dh = default

<u>Pipe 126, 226 and 326</u>

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L = 0.9146 m (ref. 21)
dZ = 0.0 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.3255 m (default)

<u>Pipe 129, 229, 329 and 429</u>

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L = 6.25 m (ref. 21)
dZ = 0.0 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.3255 m (default)

<u>Single Junction 131, 231, 331, and 431</u>

Junction between pipe x29 and pipe x58 in cold leg

A = 0.08322 m^2 (default)
Kf = 0.182 (90° bend) (ref. 20)
Kr = 0.182 (90° bend) (ref. 20)
Use smooth area change
dh = default

<u>Pipe 158 and 258</u>

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L	=	4.50 m (ref. 21)
dZ	=	0.0 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.3255 m (default)

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Pipe 358 and 458

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L	=	7.24 m (ref. 21)
dZ	=	0.0 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.3255 m (default)

Single Junction 160 and 260

Junctions between pipes 158 and 162 and between pipes 258 and 262

A	=	0.08322 m^2 (default)
Kf	=	0.182 (90° bend) (ref. 20)
Kr	=	0.182 (90° bend) (ref. 20)
Use smooth area change		
dh	=	default

Pipe 162

Cold-leg downcomer up to the inertia flow diode (IFD)

Segment 1

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L	=	1.83 m (ref. 21)
dZ	= -	1.83 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.3255 m (default)

Segment 2

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L	=	1.57 m (ref. 21)
dZ	=	0.0 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.3255 m (default)

Segment 3

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L = 1.45 m (ref. 21)
dZ = 0.0 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.3255 m (default)

Segment 4

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L = 12.6 m − 0.49561 m = 12.10439 m, compromise refs. 21 and 19
dZ = -12.10439 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.3255 m (default)

Junction between Segment 1 and Segment 2

A = 0.08322 m^2 (default)
Kf = 0.182 (90° bend) (ref. 20)
Kr = 0.182 (90° bend) (ref. 20)
Use smooth area change
dh = default

Junction between Segment 2 and Segment 3

A = 0.08322 m^2 (default)
Kf = 0.13 (45° bend) (ref. 20)
Kr = 0.13 (45° bend) (ref. 20)
Use smooth area change
dh = default

Junction between Segment 3 and Segment 4

A = 0.08322 m^2 (default)
Kf = 0.182 (90° bend) (ref. 20)
Kr = 0.182 (90° bend) (ref. 20)
Use smooth area change
dh = default

<u>Single Junction 172, 272, 372, and 472</u>

Junction between pipe x62 and IFD (pipe x71)
Entrance to IFD throat
A = 0.03095 m^2 (default)
Kf = 0.2062 (ref. 20)
Kr = 0.4513 (ref. 20)
Use smooth area change

dh = default

Pipe 171

Inertial Flow Diode
8-in. throat from, ID = 0.1985 m, A = 0.03095 m^2

Segment 1
L = 0.3 m (ref. 19)
dZ = -0.3 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.1985 m (default)

Segment 2
L = 2.0 m (ref. 19)
dZ = 0.0 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.1985 m (default)

Segment 3
L = 2.28 m (ref. 19)
dZ = 0.0 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.1985 m (default)

Junction between Segment 1 and Segment 2

A = 0.03095 m^2 (default)
Kf = 0.196 (90° bend in 8-in. pipe) (ref. 20)
Kr = 0.196 (90° bend in 8-in. pipe) (ref. 20)
Use smooth area change
dh = default

Junction between Segment 2 and Segment 3

A = 0.03095 m^2 (default)
Kf = 0.196 (90° bend in 8-in. pipe) (ref. 20)
Kr = 0.196 (90° bend in 8-in. pipe) (ref. 20)
Use smooth area change
dh = default

Single Junction 173, 273, 373, and 473

Junction between pipes 171 and 174

A = 0.03095 m^2 (default)

Kf = 0.1028 (ref. 20, p. A-26) entering flow with 22.5° half-angle
Kr = 0.04696 (ref. 20, p. A-26) exiting flow with 5.0° half-angle
Use smooth area change
dh = default

Pipe 174, 274, 374, 474

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2
L = 0.50 m (ref. 21)
dZ = 0.50 m (includes some rise in IFD throat)
e = 4.57×10^{-5} m (ref. 20)
dh = 0.3255 m (default)

Pipe 490

CPBT annular volume that receives cold-leg flow
ID = 0.273 m (ref. 19)
OD = 0.573 m (ref. 19)
L = 0.543 m (ref. 19)
A = 0.1993 m^2
dZ = 0.543 m
e = 4.57×10^{-5} m (ref. 20)
dh = $(OD^2 - ID^2)/(OD + ID) = 0.3$ m

Multiple Junction 492-01

Junction 1

Connects exit of pipe 174 to side of 490
A = 0.08322 m^2 (default = area of Volume 174-01)
Kf = 0.
Kr = 0.
Invoke abrupt area change model
Invoke cross-flow junction on volume 490
dh = default

Junction 2

Connects exit of pipe 274 to side of 490
A = 0.08322 m^2 (default = area of Volume 274-01)
Kf = 0.
Kr = 0.
Invoke abrupt area change model
Invoke cross-flow junction on volume 490
dh = default

Junction 3

Connects exit of pipe 374 to side of 490

A	=	0.08322 m^2 (default = area of Volume 374-01)
Kf	=	0.
Kr	=	0.

Invoke abrupt area change model
Invoke cross-flow junction on volume 490

dh	=	default

Junction 4

Connects exit of pipe 490 to entrance of pipe 500

A	=	0.1799 m^2 (default = area of Volume 500-01)
Kf	=	0.
Kr	=	0.

Invoke abrupt area change model

dh	=	default

Junction 5

Connects exit of pipe 495 to entrance of 560

A	=	0.1134115 m^2 (default = area of Volume 560-01)
Kf	=	152. (calibrated to get correct control rod channel flow)
Kr	=	152. (calibrated to get correct control rod channel flow)

Use smooth area change

dh	=	default

Junction 6

Connects entrance of pipe 490 to entrance of 495

A	=	0.1993 m^2 (default = area of Volume 490-01)
Kf	=	0.
Kr	=	0.

Invoke abrupt area change model

dh	=	default

Junction 7

Connects exit of pipe 474 to side of 490

A	=	0.08322 m^2 (default = area of Volume 474-01)
Kf	=	0.
Kr	=	0.

Invoke abrupt area change model
Invoke cross-flow junction on volume 490

dh	=	default

Pipe 495

Bottom CPBT volume that surrounds the three control cylinders

3 cylinders ID		= 0.087 m (ref. 19)
OD	=	0.573 m (ref. 19)
L	=	1.80 m (ref. 19)
A	=	0.2400 m^2
dZ	=	1.80 m
e	=	4.57 × 10^{-5} m (ref. 20)
dh	=	$(OD^2 - 3ID^2)/(OD + 3ID)$ = 0.3664 m (default)

Pipe 500 (core-inlet plenum)

Entry Volume into the inner and outer fuel annuli

OD	=	0.573 m (ref. 19)
L	=	1.80 m (ref. 19)
A	=	0.2400 m^2
dZ	=	1.80 m
e	=	4.57 × 10^{-5} m (ref. 20)
dh	=	$(OD^2 - 3ID^2)/(OD + 3ID)$ = 0.3664 m (default)

Pipe 557

L	=	1.2853 m (ref. 19)
A	=	0.07728 m^2
dZ	=	1.2853 m
e	=	4.57 × 10^{-5} m (ref. 20)
dh	=	0.120 m

Pipe 564

L	=	2.0568 m (ref. 19)
A	=	0.0318 m^2
dZ	=	2.0568 m
e	=	4.57 × 10^{-5} m (ref. 20)
dh	=	0.0207 m

Pipe 262

Cold-leg downcomer up to IFD

Segment 1

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L	=	0.64538 m (ref. 21)
dZ	=	0.00 m

e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.3255 m (default)

Segment 2

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2

L	=	14.7436 m - 0.3 m - 0.49561 m - 0.0136 m (to match RELAP5 elevations) = 13.93439 m (ref. 21 and 19. An elevation drop of 0.3 m is included in the IFD).
dZ	=	-12.10439 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.3255 m (default)

Junction between Segment 1 and Segment 2

A	=	0.08322 m^2 (default)
Kf	=	0.182 (90° bend) (ref. 20)
Kr	=	0.182 (90° bend) (ref. 20)

Use smooth area change

dh	=	default

<u>Pipe 271</u>

Inertial Flow Diode
8-in. throat, ID = 0.1985 m, A = 0.03095 m^2

Segment 1

L	=	0.3 m (ref. 19)
dZ	=	-0.3 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.1985 m (default)

Segment 2

L	=	0.29 m (ref. 19)
dZ	=	0.00 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.1985 m (default)

Segment 3

L	=	0.94 m (ref. 19)
dZ	=	0.0 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.1985 m (default)

Junction between Segment 1 and Segment 2

A	=	0.03095 m^2 (default)
Kf	=	0.196 (90° bend in 8-in. pipe), ref. 20

Kr = 0.196 (90° bend in 8-in. pipe), ref. 20
Use smooth area change
dh = default

Junction between Segment 2 and Segment 3

A = 0.03095 m^2 (default)
Kf = 0.196 (90° bend in 8-in. pipe), ref. 20
Kr = 0.196 (90° bend in 8-in. pipe), ref. 20
Use smooth area change
dh = default

<u>Pipe 362</u>

Cold-leg downcomer up to Inertial Flow Diode
Segment 1

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2
L = 1.2166 m (ref. 21)
dZ = 0.00 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.3255 m (default)

Segment 2

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2
L = 14.7436 m - 0.3 m - 0.49561 m - 0.0136 m (to match RELAP5 elevations) = 13.93439 m (ref. 21 and 19. An elevation drop of 0.3 m is included in the IFD).
dZ = -12.10439 m
e = 4.57×10^{-5} m (ref. 20)
dh = 0.3255 m (default)

Junction between Segment 1 and Segment 2

A = 0.08322 m^2 (default)
Kf = 0.182 (90° bend), ref. 20
Kr = 0.182 (90° bend), ref. 20
Use smooth area change
dh = default

<u>Pipe 371</u>

Inertial Flow Diode
8-in. throat, ID = 0.1985 m, A = 0.03095 m^2

Segment 1
L = 0.3 m (ref. 19)

dZ	=	-0.3 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.1985 m (default)

Segment 2

L	=	0.51 m (ref. 19)
dZ	=	0.0 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.1985 m (default)

Segment 3

L	=	0.98 m (ref. 19)
dZ	=	0.0 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.1985 m (default)

Junction between Segment 1 and Segment 2

A	=	0.03095 m^2 (default)
Kf	=	0.196 (90° bend in 8-in. pipe), (ref. 20)
Kr	=	0.196 (90° bend in 8-in. pipe), (ref. 20)

Use smooth area change

dh	=	default

Junction between Segment 2 and Segment 3

A	=	0.03095 m^2 (default)
Kf	=	0.196 (90° bend in 8-in. pipe), (ref. 20)
Kr	=	0.196 (90° bend in 8-in. pipe), (ref. 20)

Use smooth area change

dh	=	default

6. PIPING HEAT STRUCTURES

Heat structures are attached to the piping control volumes to represent the primary coolant pipe walls. These structures are included to account for heat transfer to the pool and thermal inertia of the piping itself. All of these heat structures are cylindrical type. The length of each heat structure (input as the surface area factor) corresponds exactly to the length of that piping segment specified in the thermal-hydraulic control volume input. The left-boundary condition is the thermal-hydraulic control volume, and the right-boundary condition is the light-water pool with temperature specified in general table 501. The heat transfer coefficient between the pipe wall and the thermal-hydraulic control volume is based on Dittus-Boelter for forced convection (heat transfer package No. 1). The heat transfer coefficient on the right side, to the pool, is a natural convection coefficient that depends on the outside pipe surface temperature, pipe orientation (horizontal or vertical), and outside pipe diameter. Table 7 gives each heat structure number and the corresponding geometry and boundary condition information for each piping heat structure. No neutronic heating is assumed in any of these heat structures.

Table 7. Primary coolant piping heat structure parameters (all dimensions in m)

HS No.	Pipe IR	Pipe OR	Length	T-H Vol	HTC Table	
1011-01	0.1627	0.1778	1.07	101-01	511	* lp1 hot leg
1011-02	0.1627	0.1778	3.66	101-02	511	* lp1 hot leg
1011-03	0.1627	0.1778	3.66	101-03	511	* lp1 hot leg
1041-01	0.1627	0.1778	0.69	104-01	511	* lp1 hot leg
1041-02	0.1627	0.1778	12.96	104-02	511	* lp1 hot leg
1041-03	0.1627	0.1778	2.51	104-03	581	* lp1 hot leg
1221-01	0.1627	0.1778	2.31	122-01	511	* lp1 pump suction
1221-02	0.1627	0.1778	2.13	122-02	511	* lp1 pump suction
1221-03	0.1627	0.1778	0.762	122-03	581	* lp1 pump suction
1261-01	0.1627	0.1778	0.9146	126-03	511	* lp1 pump discharge
1291-01	0.1627	0.1778	4.5	158-01	511	* lp1 cold-leg horizontal
1581-01	0.1627	0.1778	4.50	158-01	511	* lp1 cold-leg horizontal
1581-02	0.1627	0.1778	4.50	158-01	511	* lp1 cold-leg horizontal
1621-01	0.1627	0.1778	1.83	162-01	581	* lp1 cold-leg downcomer
1621-02	0.1627	0.1778	1.57	162-02	511	* lp1 cold-leg downcomer
1621-03	0.1627	0.1778	1.45	162-03	511	* lp1 cold-leg downcomer
1621-04	0.1627	0.1778	12.10439	162-04	581	* lp1 cold-leg downcomer
1711-01	0.09925	0.1016	0.300	171-01	581	* lp1 IFD throat
1711-02	0.09925	0.1016	2.000	171-02	531	* lp1 IFD throat
1711-03	0.09925	0.1016	2.280	171-03	531	* lp1 IFD throat
1741-01	0.1627	0.1778	0.50	174-01	511	* lp1 PSVAW join
2011-01	0.1627	0.1778	1.07	201-01	511	* lp2 hot leg
2011-02	0.1627	0.1778	3.66	201-02	511	* lp2 hot leg
2011-03	0.1627	0.1778	2.21	201-03	511	* lp2 hot leg
2041-01	0.1627	0.1778	6.098	204-01	511	* lp2 hot leg
2041-02	0.1627	0.1778	3.048	204-02	511	* lp2 hot leg
2041-03	0.1627	0.1778	2.51	204-03	581	* lp2 hot leg
2221-01	0.1627	0.1778	2.31	222-01	511	* lp2 pump suction

Table 7. (continued)

HS No.	Pipe IR	Pipe OR	Length	T-H Vol	HTC Table	
2221-02	0.1627	0.1778	2.13	222-02	511	* lp2 pump suction
2221-03	0.1627	0.1778	0.762	222-03	581	* lp2 pump suction
2261-01	0.1627	0.1778	0.9146	226-01	511	* lp2 pump discharge
2291-01	0.1627	0.1778	6.25	229-01	511	* lp2 cold-leg horizontal
2581-01	0.1627	0.1778	4.50	258-01	511	* lp2 cold-leg horizontal
2581-02	0.1627	0.1778	4.50	258-01	511	* lp2 cold-leg horizontal
2621-01	0.1627	0.1778	0.64538	262-01	511	* lp2 cold-leg downcomer
2621-02	0.1627	0.1778	13.93439	262-01	581	* lp2 cold-leg downcomer
2711-01	0.09925	0.1016	0.300	271-01	581	* lp2 IFD throat
2711-02	0.09925	0.1016	0.290	271-02	511	* lp2 IFD throat
2711-03	0.09925	0.1016	0.940	271-03	511	* lp2 IFD throat
2741-01	0.1627	0.1778	0.50	274-01	511	* lp2 PSVAW join
3011-01	0.1627	0.1778	3.28	301-01	511	* lp3 hot leg
3041-01	0.1627	0.1778	0.69	304-01	511	* lp3 hot leg
3041-02	0.1627	0.1778	12.96	304-02	511	* lp3 hot leg
3041-03	0.1627	0.1778	2.51	304-03	581	* lp3 hot leg
3221-01	0.1627	0.1778	2.31	322-01	511	* lp3 pump suction
3221-02	0.1627	0.1778	2.13	322-02	511	* lp3 pump suction
3221-03	0.1627	0.1778	0.762	322-03	581	* lp3 pump suction
3261-01	0.1627	0.1778	0.9146	326-01	511	* lp3 pump discharge
3291-01	0.1627	0.1778	6.25	329-01	511	* lp3 cold-leg horizontal
3581-01	0.1627	0.1778	7.24	358-01	511	* lp3 cold-leg horizontal
3581-02	0.1627	0.1778	7.24	358-02	511	* lp3 cold-leg horizontal
3621-01	0.1627	0.1778	1.2166	362-01	511	* lp3 cold-leg downcomer
3621-02	0.1627	0.1778	13.93439	362-02	581	* lp3 cold-leg downcomer
3711-01	0.09925	0.1016	0.300	371-01	581	* lp3 IFD throat
3711-02	0.09925	0.1016	0.510	371-02	511	* lp3 IFD throat
3711-03	0.09925	0.1016	0.980	371-03	511	* lp3 IFD throat
3741-01	0.1627	0.1778	0.50	374-01	511	* lp3 PSVAW join
4011-01	0.1627	0.1778	3.28	451-01	511	* lp4 hot leg
4291-01	0.1627	0.1778	6.25	429-01	511	* lp4 cold-leg horizontal
4581-01	0.1627	0.1778	7.24	458-01	511	* lp4 cold-leg horizontal
4581-02	0.1627	0.1778	7.24	458-02	511	* lp4 cold-leg horizontal
4621-01	0.1627	0.1778	1.2166	462-01	511	* lp4 cold-leg downcomer
4621-02	0.1627	0.1778	13.93439	462-02	581	* lp4 cold-leg downcomer
4711-01	0.09925	0.1016	0.300	471-01	581	* lp4 IFD throat
4711-02	0.09925	0.1016	0.510	471-02	511	* lp4 IFD throat
4711-03	0.09925	0.1016	0.980	471-03	511	* lp4 IFD throat
4741-01	0.1627	0.1778	0.50	474-01	511	* lp4 PSVAW join
4951-01	0.2865	0.3165	1.800	495-01	581	* bottom voloume of CPBT
5001-01	0.2265	0.2465	0.331	500-01	581	* core inlet plenum
6401-01	0.28019	0.3048	0.91463	640-01	521	* main hot leg
6401-02	0.28019	0.3048	0.91463	640-02	521	* main hot leg

Table 7. (continued)

HS No.	Pipe IR	Pipe OR	Length	T-H Vol	HTC Table	
6401-03	0.28019	0.3048	0.91463	640-03	521	* main hot leg
6401-04	0.28019	0.3048	2.33667	641-01	581	* main hot-leg riser
6401-05	0.28019	0.3048	2.33667	641-02	581	* main hot-leg riser
6401-06	0.28019	0.3048	2.33667	641-03	581	* main hot-leg riser
6451-01	0.28019	0.3048	4.88	645-01	521	* hot-leg distribution header
6451-02	0.28019	0.3048	3.35	645-02	521	* hot-leg distribution header
6501-01	0.28019	0.3048	1.68	650-01	521	* hot-leg distribution header
6501-02	0.28019	0.3048	3.51	650-02	521	* hot-leg distribution header
6501-03	0.28019	0.3048	1.22	650-03	521	* hot-leg distribution header
6501-04	0.28019	0.3048	1.83	650-04	521	* hot-leg distribution header

7. PRIMARY COOLANT PUMPS

Flow through each of the four parallel reactor coolant loops is provided by a centrifugal pump with a rated speed of 188.5 rad/s (1800 rpm), rated flow of 643 L/s (10,200 gpm), and a rated head of 207.3 m (680 ft) (ref. 23). These pumps are modeled with RELAP5 pump components 124, 224, and 324.

In RELAP5, the pump speed is controlled either by specifying torques applied to the pump shaft (and allowing RELAP5 to solve for the speed), or by directly specifying the speed using the 6100 series cards as a function of time or some other parameters. The ANSR input model uses both types of control, however, the torque balance is used only when all motor power (including power supplied by both the main AC motors and the back-up pony motors) is assumed to be lost to the pumps. In all other cases (whenever either the main or pony motors or both are available) the 6100 series cards are used to point to a control variable that directly specifies the pump shaft rotational speed.

In establishing a steady state, the operating pump speed is adjusted until the desired steady-state coolant velocity is achieved. This is accomplished by specifying the pump speed with control variables 86, 136, and 186 for pumps 124, 224, and 324 (see Sect. 15.1). For most transients (when the pump cavitation model is not being used) the control variable used to specify the pump speed is changed to 195 for all three pumps. For all transient cases (even when the pump cavitation model is applied) the pump speed remains equal to the steady-state speed until a trip (either 506 or 540) of the main AC primary pump motors occurs. When control variable 195 is being used, this pump trip causes the pump speed to decline (as prescribed in general table 135) until it reaches 10% of the steady-state value (pony motor speed). The pump cavitation model is rarely used and is explained further in Sect. 15.1.

The specified length, area and volume of the pump control volumes are rather arbitrary, because the final pump specifications are not yet available.

L	=	0.5 m
A	=	defaulted to V/L
V	=	0.7739 m^3
dZ	=	0.0 m
e	=	4.57×10^{-5} m (ref. 20)
dh	=	0.1985 m (default)

Entrance Junction to pump - from pipe 122

A	=	0.08322 m^2 (default)
Kf	=	0.
Kr	=	0.

Use smooth area change

dh	=	default

Exit Junction from pump - strainer junction to pipe 126

Assume a loss coefficient of 2.0 (based on HFIR strainer design)[24]

A	=	0.08322 m^2 (default)
Kf	=	2.0
Kr	=	2.0

Use smooth area change

dh	=	default

The pumps are modeled based on the data shown in Table 8 obtained from Westinghouse. The performance at 18,000 and 24,000 gpm was not included in the data, but is extrapolated. The rated conditions are speed, N_r= 188.5 rad s^{-1}; flow, Q_r= 0.643 m^3/s; head, H_r= 207.3 m; and density, ρ = 1098 kg/m^3.

Table 8. Pump head vs flow at 188.5 rad s^{-1} (1800 rpm). Note that α is the ratio of pump speed to rated pump speed, HAN = h/α^2, and HVN = h/v^2

Flow rate, Q (gpm)	Head, H (ft)	$v = Q/Q_r$	$h = H/H_r$	v/α	α/v	HAN	HVN
0.	766.	0.	1.126	0.		1.126	
2000.	780.	0.196	1.147	0.196		1.147	
4000.	791.	0.392	1.163	0.392		1.163	
6000.	775.	0.588	1.140	0.588		1.140	
8000.	742.	0.784	1.091	0.784		1.091	
10,000.	686.	0.980	1.009	0.980		1.009	
12,000.	605.	1.176	0.890		0.850		0.644
14,000.	502.	1.373	0.738		0.728		0.391
16,000.	400.	1.569	0.588		0.637		0.239
18,000.	300.	1.765	0.441		0.567		0.142
24,000.	0.	2.353	0.		0.425		0.

An additional point was added to the HVN curve to cover the full range of possible values. It was selected so that the transition to the negative flow/speed homologous curve segments would be smooth. The remaining six homologous head curve segments, which are required only for the case of backwards flow or reverse speed, were taken from ref. 25.

The rated torque, shaft friction coefficients, pony motor torque (as a function of speed) and moment of inertia are only important if the pump coastdown is to be calculated by RELAP5 based on a pump shaft torque balance (see discussion above). The assumed moment of inertia is 91.5 kg-m^2 (2171 lbm-ft^2). This inertia is much higher than the HFIR pumps (HFIR pumps are 468 lbm-ft^2) and was selected so that the torque-balance coastdown would be consistent with SDD-61, p. 203, that the pump speed would drop by a factor of 2, 2 s after pump trip. The hydraulic torque, τ_{hy}, imparted to the fluid at rated conditions is

$$\tau_{hy} = \frac{\rho_r g H_r Q_r}{N_r} = \frac{(1098)(9.81)(207.3)(0.643)}{188.5} = 7616.76 \text{ N-m.}$$

In order to specify the motor torque, $\tau = \tau_{hy}/\eta$ to RELAP5, the pump efficiency, η, as a function of speed must be known. Since the efficiency was not known, the torque data for a centrifugal pump[25] were nondimensionalized and used.

The two-phase head multipliers were taken from data for a Semiscale pump supplied in ref. 26.

8. MAIN HEAT EXCHANGER

The main heat exchangers (MHXs) are double-pass counterflow with the primary coolant on the shell side. Design data[27] were used to define the input and calibrate the heat exchanger model. The tube inner and outer diameters are 14.1 and 15.9 mm, respectively. There are 3920 tubes in each main heat exchanger with the tube bank length of 5.55 m. Because each of the 3920 tubes (with total length of 11.1 m) is bent in a U-shape, each cross-section of the exchanger contains 7840 tube cross-sections. The heat exchanger shell has a length of 7.01 m with an inner diameter of 2.03 m and wall thickness of 44.5 mm. The hemispherical cap has a radius of curvature of 0.7315 m (2.4 ft).

The model for the ANS secondary coolant system is limited to the secondary sides of the main heat exchangers. A specified mass flow rate is used as a boundary condition on the main heat exchanger secondary side. Also on each heat exchanger, a secondary mass source and sink (time-dependent volume) is used. The mass flow through the secondary (tube) side of the main heat exchangers is controlled during a steady-state run with a PID controller to reduce the error between the primary coolant core inlet temperature to the target inlet temperature. During a transient, the secondary flow rate is held constant as long as the secondary pumps are assumed to be active. If the secondary pumps are tripped, such as in a loss-of-offsite-power (LOSP) event, then the flow rate is reduced to 3.23% of steady-state flow. This assumed natural convection flow rate is based on the results obtained by E. A. Schneider[28] with a more detailed secondary system model.

Ten nodes were used to represent the coolant in the U-Tubes (secondary, pipe 134), and ten for the coolant on the shell side (primary, pipe 108). An additional control volume (108-06) was included on the primary (shell) side to represent coolant in the MHX hemispherical cap. Heat is lost from the shell (primary) side to the reactor pool from both the MHX cap (assumed to be a vertical surface) and the horizontal cylindrical exterior.

Because the flow pattern on the shell side is multidimensional, the one-dimensional heat transfer and pressure drop correlations in RELAP5 are insufficient. Therefore, the main heat exchanger model was calibrated (using the input shown in Appendix C) to match the supplied performance data. The design shell-side (primary) pressure drop was obtained by adjusting entrance and exit loss coefficients.

<u>Pipes 108, 208 and 308</u>

Segments 1-5 and 7-11

L	=	1.11 m = (5.55 m)/5
A	=	$0.8258\ m^2 = 0.5 \times \pi/4(2.03^2 - 7840 \times 0.0159^2)$
dZ	=	0.0 m
e	=	4.57×10^{-5} m, (ref. 20)
dh	=	$0.636\ m = 4A/P = 4 \times 0.8258/(\pi/2 + 1)/(2.03)$

Segment 6

L	=	2.03 m = inside shell diameter
A	=	$0.841\ m^2 = 0.5 \times \pi \times 0.7315^2$
dZ	=	0.0 m
e	=	4.57×10^{-5} m, (ref. 20)
dh	=	$0.636\ m = 4A/P = 4 \times 0.8258/(\pi/2 + 1)/(2.02)$

Time-Dependent Volume 130

Source boundary condition for secondary coolant

A	=	1.e6 m^2
V	=	1.e6 m^3

Pressure is 0.5 MPa (this value is not used on a source boundary condition)
Temperature is 302.55 K, assumed for secondary coolant supply temperature

Time-Dependent Junction 132, 232, 332

Specified mass flow rate for secondary side based on control variable 586

A	=	0.7122 m^2 (unimportant since mass flow is specified)

The input table for this time-dependent junction is built so that the output value is always equal to the input value for a range of -1.e6 to 1.e6. Hence, the input value (control variable 586) is always taken as the specified mass flow rate for each main heat exchanger secondary.

Pipes 134, 234 and 334

Segments 1-10

L	=	1.314 m = (5.55 m)/5
A	=	0.612 $m^2 = \pi/4(0.01588^2) \times 3920$, the heat exchangers were calibrated using the outside tube diameter instead of the inside diameter on the secondary side. This mistake is not important to the results.
dZ	=	0.0 m
e	=	4.57×10^{-5} m, (ref. 20)
dh	=	0.01588 m (mistake: same comment as above)

Junction 135, 235, 335

Exit junction for primary heat exchanger secondary flow

A	=	0.776 m^2 (defaulted)
Kf	=	0.
Kr	=	0.
dh	=	0.01588 (mistake: see comment for pipe 134)

Time-Dependent Volume 136, 236, 336

Sink boundary condition for secondary coolant

A	=	1.e6 m^2
V	=	1.e6 m^3

Pressure is 0.449 MPa (this assumption is unimportant for simplified secondary system)
Temperature is 319 K, unused for a sink boundary condition

The designed total heat transfer from shell to tube was obtained by adjusting the overall heat transfer area. The calculated total tube length, L_{ht}, is

$$L_{ht} = Nl = 7840 \times 5.55 = 43{,}512 \text{ m},$$

here N is the number of tube cross-sections and l is the tube bank length. This value was approximately doubled to 87,004 m (8700.4 m per heat structure) to transfer the required 100 MW at the design conditions.

Cylindrical heat structures were used to represent the tubes themselves. The heat structure numbers, inner and outer radii, total heat transfer length, and left and right thermal-hydraulic control volume numbers are shown in Table 9. Table 10 shows the heat structure information for the cylindrical heat structures that thermally connect the main heat exchanger primary side to the light-water pool. Table 11 shows the heat structure information for the rectangular (slab) heat structures that thermally connect the main heat exchanger primary side plenum to the light-water pool.

Table 9. Main Heat exchanger tube heat structure information

HS No.	Inner radius (m)	Outer radius (m)	Length (m)	Left volume No.	Right volume No.
1083-01	0.007049	0.007938	8700.4	108-01	134-05
1083-02	0.007049	0.007938	8700.4	108-02	134-04
1083-03	0.007049	0.007938	8700.4	108-03	134-03
1083-04	0.007049	0.007938	8700.4	108-04	134-02
1083-05	0.007049	0.007938	8700.4	108-05	134-01
1083-06	0.007049	0.007938	8700.4	108-07	134-10
1083-07	0.007049	0.007938	8700.4	108-08	134-09
1083-08	0.007049	0.007938	8700.4	108-09	134-08
1083-09	0.007049	0.007938	8700.4	108-10	134-07
1083-10	0.007049	0.007938	8700.4	108-11	134-06
2083-01	0.007049	0.007938	8700.4	208-01	234-05
2083-02	0.007049	0.007938	8700.4	208-02	234-04
2083-03	0.007049	0.007938	8700.4	208-03	234-03
2083-04	0.007049	0.007938	8700.4	208-04	234-02
2083-05	0.007049	0.007938	8700.4	208-05	234-01
2083-06	0.007049	0.007938	8700.4	208-07	234-10
2083-07	0.007049	0.007938	8700.4	208-08	234-09
1083-08	0.007049	0.007938	8700.4	208-09	234-08
2083-09	0.007049	0.007938	8700.4	208-10	234-07
2083-10	0.007049	0.007938	8700.4	208-11	234-06
3083-01	0.007049	0.007938	8700.4	308-01	334-05
3083-02	0.007049	0.007938	8700.4	308-02	334-04
3083-03	0.007049	0.007938	8700.4	308-03	334-03
3083-04	0.007049	0.007938	8700.4	308-04	334-02
3083-05	0.007049	0.007938	8700.4	308-05	334-01
3083-06	0.007049	0.007938	8700.4	308-07	334-10
3083-07	0.007049	0.007938	8700.4	308-08	334-09
3083-08	0.007049	0.007938	8700.4	308-09	334-08
3083-09	0.007049	0.007938	8700.4	308-10	334-07
3083-10	0.007049	0.007938	8700.4	308-11	334-06

Table 10. Cylindrical heat structures joining the shell side of the main heat exchangers to the light-water pool

HS #	Inner radius (m)	Outer radius (m)	Heat transfer length (m)	Left boundary volume No.	General table number for right Boundary HTC	
1081-01	1.009	1.0540	0.555	108-01	599	* Main HX shell-to-pool
1081-02	1.009	1.0540	0.555	108-02	599	* Main HX shell-to-pool
1081-03	1.009	1.0540	0.555	108-03	599	* Main HX shell-to-pool
1081-04	1.009	1.0540	0.555	108-04	599	* Main HX shell-to-pool
1081-05	1.009	1.0540	0.555	108-05	599	* Main HX shell-to-pool
1081-06	1.009	1.0540	0.555	108-07	599	* Main HX shell-to-pool
1081-07	1.009	1.0540	0.555	108-08	599	* Main HX shell-to-pool
1081-08	1.009	1.0540	0.555	108-09	599	* Main HX shell-to-pool
1081-09	1.009	1.0540	0.555	108-10	599	* Main HX shell-to-pool
1081-10	1.009	1.0540	0.555	108-11	599	* Main HX shell-to-pool
2081-01	1.009	1.0540	0.555	208-01	599	* Main HX shell-to-pool
2081-02	1.009	1.0540	0.555	208-02	599	* Main HX shell-to-pool
2081-03	1.009	1.0540	0.555	208-03	599	* Main HX shell-to-pool
2081-04	1.009	1.0540	0.555	208-04	599	* Main HX shell-to-pool
2081-05	1.009	1.0540	0.555	208-05	599	* Main HX shell-to-pool
2081-06	1.009	1.0540	0.555	208-07	599	* Main HX shell-to-pool
2081-07	1.009	1.0540	0.555	208-08	599	* Main HX shell-to-pool
2081-08	1.009	1.0540	0.555	208-09	599	* Main HX shell-to-pool
2081-09	1.009	1.0540	0.555	208-10	599	* Main HX shell-to-pool
2081-10	1.009	1.0540	0.555	208-11	599	* Main HX shell-to-pool
3081-01	1.009	1.0540	0.555	308-01	599	* Main HX shell-to-pool
3081-02	1.009	1.0540	0.555	308-02	599	* Main HX shell-to-pool
3081-03	1.009	1.0540	0.555	308-03	599	* Main HX shell-to-pool
3081-04	1.009	1.0540	0.555	308-04	599	* Main HX shell-to-pool
3081-05	1.009	1.0540	0.555	308-05	599	* Main HX shell-to-pool
3081-06	1.009	1.0540	0.555	308-07	599	* Main HX shell-to-pool
3081-07	1.009	1.0540	0.555	308-08	599	* Main HX shell-to-pool
3081-08	1.009	1.0540	0.555	308-09	599	* Main HX shell-to-pool
3081-09	1.009	1.0540	0.555	308-10	599	* Main HX shell-to-pool
3081-10	1.009	1.0540	0.555	308-11	599	* Main HX shell-to-pool

Table 11. Slab heat structures connecting coolant in main heat exchanger hemispherical plenum to the light-water pool

HS No.	Left coord. (m)	Right Coord. (m)	Heat transfer area (m^2)	Left boundary volume No.	General table number for right Boundary HTC	
1082-01	0.	0.0445	3.49	108-06	581	* Main HX shell-to-pool
2082-01	0.	0.0445	3.49	208-06	581	* Main HX shell-to-pool
3082-01	0.	0.0445	3.49	308-06	581	* Main HX shell-to-pool

9. EMERGENCY HEAT EXCHANGER

The emergency heat exchangers (EHXs) are single-pass counterflow heat exchangers with the primary coolant on the shell side. The secondary tubing (pipe 146 with 4 cells) has an OD of 19.05 mm (0.75 in.) and ID of 17.27 mm (0.68 in.) (ref. 27) and is connected to the pool (TDV 154) with a 3-m chimney (pipe 150) section rising just past the exit from the EHX. The tube bundle length is 6.40 m (21 ft) with 1670 tubes. The heat exchanger shell has an OD of 1.111 m (43.75 in.) and ID of 1.067 m (42.0 in.) and a length, assumed to be equal to the tube bundle length, of 6.4 m (21 ft).

No forced cooling is applied to the EHXs. The pressures in the secondary source and secondary sink time-dependent volumes are specified based on their hydrostatic pressures in the pool. The flow rates are then calculated by RELAP5 for natural circulation conditions. Calibration was performed at design conditions also supplied in ref.27. The hydraulic diameter on the shell side was calibrated to match the design pressure drop (0.048 MPa) at the design (primary) flow rate of 706 kg/s. When the pressure drop was matched, the total heat removed through the tubes was 1.60 MW which is very close to the 1.64 MW specified in the design data. The resulting tube (secondary) flow rate at this calibrated condition was matched (44 kg/s), even though the OD was inadvertently used to define the geometry on the tube-side control volumes instead of the ID. The RELAP5 input file used for the EHX calibration is shown in Appendix D. Table 12 gives the details for the heat structures that represent the tubing of the emergency heat exchangers. Table 13 shows the heat structures connecting the emergency heat exchanger to the light-water pool.

Pipes 116, 216 and 316

Segments 1-4

L	=	1.6 m = (6.4 m)/4
A	=	$0.894\ m^2 = \pi/4(1.067^2)$, incorrect because the tube cross-sectional area was not subtracted, this error was compensated by calibrating dh to design conditions.
dZ	=	0.0 m
e	=	4.57×10^{-5} m, (ref. 20)
dh	=	0.0017 m, calibrated to obtain correct pressure drop and heat transfer

Time-Dependent Volume 138, 238, 338

Source boundary condition for secondary coolant

A	=	1.e6 m^2
V	=	1.e6 m^3

Pressure is 180 kPa (the assumed pool pressure at the EHX secondary intake pipe). Only the pressure *difference* between inlet (these volumes) and outlet (volumes 154, 254, and 354) of tubes is important.
Temperature is 311.15 K, pool temperature

Junction 140, 240, 340

Entrance junction for emergency heat exchanger secondary flow
Abrupt area change model is invoked.

A	=	0.4264 m^2 (defaulted to area of pipe 142)
Kf	=	0.
Kr	=	0.
dh	=	0.4573 m (assume 18.0-in. suction pipe)

Pipes 142, 242 and 342

Entrance pipe leading from pool to secondary side of emergency heat exchanger
Segments 1-2

L	=	0.7622 m = (1.5244 m)/2 (assume total suction pipe length of 5.0 ft)
A	=	0.4264 $m^2 = \pi/4(0.4573^2)$
dZ	=	0.0 m
e	=	4.57×10^{-5} m, (ref. 20)
dh	=	0.4573 m (assum 18.0-in.-diam suction pipe)

Junction 144, 244, 344

Inlet junction for emergency heat exchanger secondary flow (tube entrance)
Abrupt area change model is invoked.

A	=	0.4264 m^2 (defaulted)
Kf	=	0.
Kr	=	0.
dh	=	0.01905 m (same as tubes)

Pipes 146, 246 and 346

Emergency heat exchanger secondary coolant (in tubes).
Segments 1-4

L	=	1.6 m = 6.4 m/4
A	=	0.476 $m^2 = \pi/4(0.01905^2) \times 1670$
dZ	=	0.0 m
e	=	4.57×10^{-5} m, (ref. 20)
dh	=	0.01905 m (incorrect, should have used ID instead of OD)

Junction 148, 248, 348

Exit junction for emergency heat exchanger secondary flow (tube exit)
Abrupt area change is invoked.

A	=	0.4264 m^2 (defaulted)
Kf	=	0.
Kr	=	0.
dh	=	0.01905 m (same as tubes)

Pipes 150, 250 and 350

Emergency heat exchanger secondary coolant in chimney
Segments 1-4

L	=	0.75 m = 3 m / 4
A	=	0.203 m^2 = $(\pi/4)(0.508^2)$
dZ	=	0.75 m
e	=	4.57×10^{-5} m, (ref. 20)
dh	=	0.508 m (assume a 20-in.-diam pipe for chimney)

Junction 152, 252, 352

Exit junction from emergency heat exchanger secondary chimney
Abrupt area change is invoked.

A	=	0.4264 m^2 (defaulted)
Kf	=	0.
Kr	=	0.
dh	=	0.508 m (same as chimney)

Time-Dependent Volume 154, 254, 354

Sink boundary condition for secondary coolant

A	=	1.e6 m^2
V	=	1.e6 m^3

Pressure is 150773.6 Pa = $P_{138} - \rho g h$ = 180 kPa - (993.08 kg/m^3)(9.81 m/s^2)(3 m)
Temperature is 311.15 K, pool temperature

The pressure difference between TDV 138 (238 and 338) and TDV 154 (254 and 354) corresponds to a 3 m (9.8 ft) (ref. 29) difference in elevation within the light-water pool.

Table 12. Heat structure parameters representing emergency heat exchanger tubing

HS No.	Inside radius (m)	Outside radius (m)	Heat transfer area (m^2)	Left boundary volume No.	Right boundary volume No.
1163-01	0.008636	0.009525	2672.	116-01	146-04
1163-02	0.008636	0.009525	2672.	116-02	146-03
1163-03	0.008636	0.009525	2672.	116-03	146-02
1163-04	0.008636	0.009525	2672.	116-04	146-01
2163-01	0.008636	0.009525	2672.	216-01	246-04
2163-02	0.008636	0.009525	2672.	216-02	246-03
2163-03	0.008636	0.009525	2672.	216-03	246-02
2163-04	0.008636	0.009525	2672.	216-04	246-01
3163-01	0.008636	0.009525	2672.	316-01	346-04
3163-02	0.008636	0.009525	2672.	316-02	346-03
3163-03	0.008636	0.009525	2672.	316-03	346-02
3163-04	0.008636	0.009525	2672.	316-04	346-01

Table 13. Heat structures connecting emergency heat exchanger to the light-water pool

HS #	Left coord. (m)	Right Coord. (m)	Heat trans-fer area (m^2)	Left boundary volume No.	General table number for right Boundary HTC	
1161-01	0.5334	0.5556	1.6	116-01	591	* Emergency HX shell-to-pool
1161-02	0.5334	0.5556	1.6	116-02	591	* Emergency HX shell-to-pool
1161-03	0.5334	0.5556	1.6	116-03	591	* Emergency HX shell-to-pool
1161-04	0.5334	0.5556	1.6	116-04	591	* Emergency HX shell-to-pool
1501-01	0.2287	0.2541	0.75	150-01	581	* Emergency HX chimney
1501-02	0.2287	0.2541	0.75	150-02	581	* Emergency HX chimney
1501-03	0.2287	0.2541	0.75	150-03	581	* Emergency HX chimney
1501-04	0.2287	0.2541	0.75	150-04	581	* Emergency HX chimney
2161-01	0.5334	0.5556	1.6	216-01	591	* Emergency HX shell-to-pool
2161-02	0.5334	0.5556	1.6	216-02	591	* Emergency HX shell-to-pool
2161-03	0.5334	0.5556	1.6	216-03	591	* Emergency HX shell-to-pool
2161-04	0.5334	0.5556	1.6	216-04	591	* Emergency HX shell-to-pool
2501-01	0.2287	0.2541	0.75	250-01	581	* Emergency HX chimney
2501-02	0.2287	0.2541	0.75	250-01	581	* Emergency HX chimney
2501-03	0.2287	0.2541	0.75	250-01	581	* Emergency HX chimney
2501-04	0.2287	0.2541	0.75	250-01	581	* Emergency HX chimney
3161-01	0.5334	0.5556	1.6	316-01	591	* Emergency HX shell-to-pool
3161-02	0.5334	0.5556	1.6	316-02	591	* Emergency HX shell-to-pool
3161-03	0.5334	0.5556	1.6	316-03	591	* Emergency HX shell-to-pool
3161-04	0.5334	0.5556	1.6	316-04	591	* Emergency HX shell-to-pool
3501-01	0.2287	0.2541	0.75	350-01	581	* Emergency HX chimney
3501-02	0.2287	0.2541	0.75	350-02	581	* Emergency HX chimney
3501-03	0.2287	0.2541	0.75	350-03	581	* Emergency HX chimney
3501-04	0.2287	0.2541	0.75	350-04	581	* Emergency HX chimney

10. ACCUMULATORS

The accumulators (total of 4) are vertical cylindrical pressure vessels located in the upper portion of each reactor primary coolant system valve limited volume cell. Each accumulator tank (ID = 1.52 m, height = 4.57 m) contains 0.52 m^3 of nitrogen gas, 7.0 m^3 of heavy water and sufficient heat sink material to avoid low gas temperatures on rapid gas expansion.[29]

In the model, the accumulators are modeled with standard RELAP5 control volumes. Pipe components 156, 256, and 356 consisting of six control volumes are defined, the sixth volume of which represents the 0.3556-m (14-in.)-diam standpipe connecting the accumulator to the primary coolant system. The first (uppermost) volume represents 87.2% of the tank volume, and the remaining four volumes are used to discretize the bottom 12.8% of the accumulator tank. The nitrogen bubble (specified through the input noncondensible quality) is completely contained within the first (largest) control volume and remains that way until the system pressure reaches about 1 atm. The accumulators are attached to the hot legs using single junctions 157, 257 and 357. Table 14 shows the heat structures used for representing the tank walls.

The standard RELAP5 accumulator component is inadequate because it does not allow flow back into the accumulator. The present pipe model also has problems with numerical diffusion of the nitrogen gas into the system. RELAP5 assumes the bubbly flow regime in the bubble volume instead of the more physically correct stratified condition. Past experience has shown that when many volumes are used to more clearly define the interface between the bubble and the liquid, problems result during movement of the interface across cell boundaries. Each time nitrogen is convected into a previously liquid filled control volume, it is introduced at the saturation temperature of the control volume instead of the actual temperature of the convected gas.

A new accumulator model has been developed by INEL; however, the new model requires the use of Parallel Virtual Machine (PVM) software which complicates the process of running RELAP5. Hence, unless the rate of expansion of the nitrogen bubble within the accumulator is crucial to a particular transient, it is recommended that the default model be used.

Pipe 156, 256 and 356

Segment 1 (tank)

L	=	4.09 m (total tank height of 4.57, discretization chosen with one big volume)
A	=	(7.52 m^3)/(4.57 m) = 1.65 m^2 (based on L and Volume)
dZ	=	4.09 m
e	=	4.57×10^{-5} m, (ref. 20)
dh	=	sqrt[(1.65 m^2)(4)/3.1459] = 1.449 m

Segments 2-5 (tank)

L	=	0.12 m = (4.57 - 4.09)/4 (remainder of tank height)
A	=	(7.52 m^3)/(4.57 m) = 1.65 m^2 (based on L and Volume)
dZ	=	0.12 m
e	=	4.57×10^{-5} m, (ref. 20)
dh	=	sqrt[(1.65 m^2)(4)/3.1459] = 1.449 m

Segment 6 (surge-pipe)

14-in. pipe, ID = 0.3255 m, A = 0.08322 m^2
L = 4.88 m, (ref. 21)
dZ = 4.88 m
e = 4.57×10^{-5} m, (ref. 20)
dh = 0.3255 m (default)

Junction 157 between surge pipe and hot-leg pipe

A = 0.08322 m^2 (default)
Kf = 0.5, (ref. 20)
Kr = 1.0, (ref. 20)
Use smooth area change
dh = default

Table 14. Heat structure parameters representing accumulator tank wall

HS No.	Inside radius (m)	Outside radius (m)	Heat transfer area (m^2)	Left boundary volume No.	Right boundary Volume No.
1561-01	0.7245	0.7396	4.09	156-01	Insulated
1561-02	0.7245	0.7396	0.12	156-02	Insulated
1561-03	0.7245	0.7396	0.12	156-03	Insulated
1561-04	0.7245	0.7396	0.12	156-04	Insulated
1561-05	0.7245	0.7396	0.12	156-05	Insulated
2561-01	0.7245	0.7396	4.09	256-01	Insulated
2561-02	0.7245	0.7396	0.12	256-02	Insulated
2561-03	0.7245	0.7396	0.12	256-03	Insulated
2561-04	0.7245	0.7396	0.12	256-04	Insulated
2561-05	0.7245	0.7396	0.12	256-05	Insulated
3561-01	0.7245	0.7396	4.09	356-01	Insulated
3561-02	0.7245	0.7396	0.12	356-02	Insulated
3561-03	0.7245	0.7396	0.12	356-03	Insulated
3561-04	0.7245	0.7396	0.12	356-04	Insulated
3561-05	0.7245	0.7396	0.12	356-05	Insulated

11. MODERATOR TANK

A simplified model for the moderator tank was used. In the model, the moderator tank was represented by a single pipe 575 with appropriate boundary conditions imposed. The coolant source and pressure boundary were represented by TDV components 570 and 580, respectively, while the desired mass flow was specified through a TDJ component 571.

The moderator tank, also referred to as the reflector tank, surrounds the core pressure boundary tube (CPBT) and contains 31.0 m^3 of heavy water. The tank has four inlets at the bottom and a single outlet at the top. The nominal pressure at the bottom of the tank is 0.36 MPa. In the present RELAP5 model, a simple, 5-node representation of the reflector tank is used and the reflector tank cooling system is not modeled. Two time dependent volumes are used as source and sink boundary conditions at the inlet (bottom) and outlet (top) of the reflector tank. The reflector tank is inportant only in the event of a rupture of the CPBT, in which case a more detailed model (developed by E. Schneider) can be used.

12. LETDOWN VALVES

The total letdown flow rate is 14.6 kg/s at steady state.[29] The valves are assumed to have a full-open area 0.00028355 m^2 (corresponding to a 0.75-in. diam). This full-open area was obtained by calibration assuming an abrupt area change at the valve, so that when the valve is 50% open, the total flow rate is 14.6 kg/s thru all three valves. The valves are assumed to discharge to atmospheric pressure. Also all of the letdown line losses are lumped into the valve junction, so the actual valve area will be somewhat larger (drawings indicate that the line has a 2-in. diam).

Valves 861, 862, and 863

Connect inlet plenum of main heat exchangers (106, 206, and 306) to letdown lines (865) leading to the letdown head tank.

A	=	0.00028355 m^2 (calibrated for 50% opening to yield total flow of 14.6 kg/s)
Kf	=	0
Kr	=	0
dh	=	default

Invoke the abrupt area change model
Letdown valve area is controlled by control variable 860.

The letdown control system consists of CVs 840, 842, 844, 845, 847, and 860 which define the control action recommended by Jose March-Leuba:[30]

$$d = K(P - P_s)$$
$$dx/dt = (d \; x)/tau,$$

where

d = demanded valve position (normalized),
K = proportional constant = 5/MPa,
P = the measured sensor pressure (the upper-core exit pressure is controlled directly),
P_s = the setpoint pressure,
x = normalized valve position (-1 for fully closed, 1 for fully open, and 0 at normal position),
t = time (s),
tau = the valve time constant = 1 s.

13. PRESSURIZING SYSTEM

The letdown and pressurizing systems are coupled through the cleanup system which is not modeled but may be added later to update the model when the cleanup system design has been defined. The pressurizing system consists of a pressurizing centrifugal pump (component 815), a check valve (component 825), an isolation valve (component 827), and a source tank (time dependent volume 800). The source tank is assumed to be a constant pressure mass source at 300 K (80 F) and 0.165 MPa (24 psia). Heat structures representing the tank walls and the piping in the pressurizing system are not included in the model. The pressurizing line has an ID = 0.1016 m (4-in.) and is connected to the main hot leg header (component 650), located 13.4 m (44 ft) downstream of the hot leg riser. The normal make-up flow rate is 14.6 kg/s and is equal to total letdown flow during steady-state operation. The pump speed is controlled using control variable 815 when establishing an initial steady-state (See Sect. 16.7). The pump is tripped only in the event of a loss-of-offsite power (trip 540), in which case the pump speed is determined using a torque balance on the pump shaft.

ERROR: All piping in the pressurizing system is assumed to be of 0.1016-m (4-in.) diam. However, the drawings indicate that it should be 3-in. piping.

<u>Time-Dependent Volume 800 and 826</u>

Source boundary conditions representing make-up tank. TDV 800 is used for the main pressurizing pump and TDV 826 is used for the standby pressurizing pump.

A	=	1.e6 m^2
V	=	1.e6 m^3

Pressure is 0.165 MPa, assumes atmospheric plus 6 m (18 ft) of head.
Temperature is 300 K.

<u>Trip Valve 805 and 827</u>

Isolation valves if make-up tank drains. Valve 805 is used for the main pressurizing pump and valve 827 is used for the standby pressurizing pump. These valves connect volumes 800-01 or 826-01 (make-up tank) to volume 810-01 or 828-01 (pressurizer pump suction line).

A	=	0.00811 $m^2 = \pi/4 \times (0.1016\ m)^2$
Kf	=	0.48 = 3 × 0.16, three 90° bends, (ref. 31)
Kr	=	0.48

This valve closes if trip 615 turns true.

<u>Branch 810 and 828</u>

L	=	6.096 m (assumption of 20-ft length from tank to pump)
A	=	0.00811 $m^2 = \pi/4 \times (0.1016\ m)^2$
dZ	=	0.0 m
e	=	4.57×10^{-5} m, (ref. 20)
dh	=	0.1016 m (4-in.)

Pumps 815 and 830

Main and Standby Pressurizer Pumps

A	=	$0.00811\ m^2 = \pi/4 \times (0.1016\ m)^2$
V	=	$0.0203\ m^3$ (assumed volume of water in pump)
dZ	=	0.0 m

Suction junction connecting 810-01 or 828-01 to 815-01 or 835-01

Kf	=	0.16, assume 90° bends at inlet and outlet, (ref. 20)
Kr	=	0.16

Discharge junction connecting 815-01 to 820-01

Kf	=	0.16
Kr	=	0.16

Control of the main pressurizer pump is accomplished using both the speed table and the pump motor trip leading to a torque balance on the pump shaft. During an initial steady-state run, the proportional-integral control using control variable 591 is used to achieve the make-up flow of 14.6 kg/s. During a transient, the pump speed is held constant unless a loss-of-offsite power (LOSP) occurs (i.e., trip 540 turns true). As soon as trip 540 (referred to on card 8150301) becomes true, trip 620 (referred to on card 8156100) turns false which de-activates the pump velocity table so that a torque-balance equation is used to perform a coastdown.

The rated flow is specified to be 1.080816 m^3/s, the rated head is 106.39 m, the rated speed is 221.55 rad/s, and the rated torque is 217.82 N-m. The moment of inertia for this pump is assumed to be 2.381 kg -m^2.

Single Volumes 820 and 835

A	=	$0.00811\ m^2 = \pi/4 \times (0.1016\ m)^2$
L	=	30.48 m
e	=	4.57×10^{-5} m, (ref. 20)
dh	=	0.1016 m (4-in.)

Valves 825 and 840

Check valves preventing reverse flow through the pressurizing pumps. Connects volume 820-01 or 835-01 to 850-01 (main supply line to primary).

A	=	$0.00811\ m^2$ (same as line)
Kf	=	$1.28 = 75 f_t = 75 \times 0.017$, (ref. 20, p. A-26, A-27) where f_t is the turbulent friction factor
Kr	=	1.28

Time-Dependent Junction 845

This specified flow condition represents the emergency pressurizing pump, connecting volumes 810-01 to 850-01 (main supply line to primary). If trip 542 turns true, then the flow rate will begin ramping up over a 10-s period from zero to 25 m/s.

A	=	0.001 m^2

Branch 810 and 828

Main supply line to primary.

L	=	12.2 m
A	=	0.00811 $m^2 = \pi/4 \times (0.1016\ m)^2$
dZ	=	0.0 m
e	=	4.57×10^{-5} m, (ref. 20)
dh	=	0.1016 m (4-in.)

14. MATERIAL PROPERTIES

Thermal material properties are supplied to the RELAP5 program through tables as described in this section.

14.1 COMPOSITION No. 1 304L STAINLESS STEEL

The thermal conductivity for stainless steel type 304L (ref. 32) is shown in Table 15. The volumetric heat capacity (product of specific heat and density) is given in Table 16 (ref. 33).

Table 15. Thermal conductivity for 304L stainless steel

T (K)	k (W/m-K)
273.2	14.7
300.	15.2
400.	17.0
500.	18.4
600.	19.8
700.	21.2
800.	22.5
900.	23.9
1000.	25.3
1200.	28.1
1400.	30.9

Table 16. Thermal volumetric heat capacity for 304L stainless steel

T (K)	ρc_p (J/m^3-K)
250.	2.97e6
478.	3.00e6
700.	3.13e6
811.	3.23e6
866.	3.33e6
922.	3.43e6
1033.	3.59e6
1200.	3.76e6
1311.	3.82e6

14.2 COMPOSITION No. 2 ALUMINUM 6061

The thermal conductivity for aluminum type 6061(ref. 34) is shown in Table 17. The volumetric heat capacity (product of specific heat and density) is given in Table 18 (ref. 34).

Table 17. Thermal conductivity for aluminum 6061

T (K)	k (W/m-K)
271.9	155.0
299.7	155.0
349.7	161.9
399.7	165.9
499.7	179.8
549.7	183.9
649.7	180.9
749.7	174.9
799.7	171.9
849.7	167.9
924.7	85.9
999.7	87.9

Table 18. Thermal volumetric heat capacity for aluminum 6061

T (K)	ρc_p (J/m^3-K)
271.9	2.429e6
299.7	2.429e6
399.7	2.542e6
499.7	2.666e6
599.7	2.791e6
699.7	2.915e6
799.7	3.039e6
899.7	3.163e6
924.7	2.826e6
1060.8	2.826e6

14.3 COMPOSITION No. 3 HAFNIUM

The thermal conductivity for hafnium[32] is given in Table 19. The volumetric heat capacity (product of specific heat,[32] and density,[33]) is given in Table 20.

Table 19. Thermal conductivity for hafnium

T (K)	k (W/m-K)
250.	23.6
273.2	23.3
300.	23.0
400.	22.3
600.	21.3
800.	20.8
1200.	20.9
1600.	21.5
2000.	22.6

Table 20. Thermal volumetric heat capacity for hafnium

T (K)	ρc_p (J/m^3-K)
252.9	1.870e6
278.0	1.898e6
315.5	1.924e6
400.	1.975e6
500.	2.031e6
600.	2.087e6
800.	2.199e6
1000.	2.314e6
1350.	2.514e6

14.4 COMPOSITION No. 4 OXIDE

The thermal conductivity of boehmite is assumed constant at 2.25 W/m-K (ref. 35). Also from, the volumetric heat capacity (product of specific heat,[32] and density,[33] is given in Table 21.

Table 21. Thermal volumetric heat capacity for boehmite

T (K)	ρc_p (J/m^3-K)
273.	2.198e6
373.	2.739e6
473.	3.096e6
573.	3.316e6
673.	3.453e6
773.	3.554e6
873.	3.638e6
973.	3.707e6
1073.	3.759e6
1173.	3.803e6

14.5 COMPOSITION No. 5 FUEL MEAT

The properties[36] of the fuel meat are given here. The thermal conductivity fo the fuel meat is given in Table 22. The volumetric heat capacity is given in Table 23.

Table 22. Thermal conductivity for the fuel meat

T (K)	k (W/m-K)
273.	51.86
333.	59.0
1333.	178.0

Table 23. Thermal volumetric heat capacity for the fuel meat

T (K)	ρc_p(J/m^3-K)
273.	2.176e6
373.	2.289e6
473.	2.402e6
673.	2.628e6
873.	2.854e6
1073.	3.080e6
1273.	3.306e6

15. CONTROL VARIABLES

The control variables (CVs) in the RELAP5 input are used for calculating important output values (such as thermal limits or pressure drops), controlling the pump speeds and secondary flow rate, and calculating changes in reactivity due to temperature changes or control rod movement. Because of the extensive use of control variable in the model this section is subdivided to describe each control system separately. A control system is a set of control variables that work together for a single purpose.

15.1 PRIMARY COOLANT PUMP SPEED CONTROL

Initial Steady State

Before reactor transients can be simulated, the initial conditions (temperatures, pressures and mass flows) in the model must be established at an appropriate steady state. Control systems have been developed that can be used during a RELAP5 preliminary run to establish those initial conditions (see Table 24). One of these systems represents a Proportional-Integral-Derivative (PID) controller (CVs 77-83) on the primary pump speed to establish the desired inlet velocity to the upper core. The pump velocity tables (cards 1246100, 2246100, and 3246100 cards) are used with CVs 86, 136, and 186. These control variables are equal to the output from the PID controller.

Table 24. Control variables used to define proportional-integral-derivative pump speed controller during initial steady state

Control variable No.	Variable type	Description
77	TRIPUNIT	Flag indicating if a transient calculation has begun and the pump cavitation model is being used (1 if true, 0 if false).
78	CONSTANT	Specified upper core average channel inlet velocity. This is the setpoint value for the control system.
79	SUM	Error signal supplied to controller. Deviation from setpoint velocity.
80	MULT	Modified error signal (error is zeroed to avoid change in pump speed if the pump cavitation model is being used during a transient simulation).
81	PROP-INT	Proportional Integral control. Control constants have been chosen by trial and error.
82	DIFFREND	Derivative control.
83	SUM	Output from PID controller.

Reactor Transients: Normal Mode

After the steady-state simulation is completed, the results are loaded back into the input deck (using PYGI, a companion program developed for RELAP5 at INEL). The pump velocity table controls (cards 1246100, 2246100, and 3246100) are then normally changed so that CV 195 is used to control the pump speed (see Table 25). This control variable is simply equal to the constant steady-state pump speed, until a pump trip occurs, after which time a specified pump velocity coastdown (general table 135) is applied. General table 135 provides a gradual transition from full speed down to 10% (pony motor speed). Also trip No. 619 is added to the pump velocity control cards as a switch between (1) using the pump velocity table to specify the velocity (trip 619 is true), or (2) using a RELAP5 torque balance calculation on the pump shaft to determine the pump speed (trip 619 is false). The torque balance is normally used only when the pony motors become unavailable, such as when the pony motor batteries expire late in the transient.

Table 25. Control variables used to define proportional-integral-derivative pump speed controller during reactor transients

Control variable No.	Variable type	Description
195	FUNCTION	Extracts function value between zero and 1.0 from general table 135 and multiplies by steady-state pump speed in rad/s.

Reactor Transients: Pump Cavitation Mode

A separate alternative for pump speed control, shown in Table 26, during simulation of a reactor transient has been developed, but is not normally used. To activate the pump cavitation model, the pump velocity table control remains the same as during the steady-state initialization phase. However, trip 528 must also be true. The pump cavitation model (CVs 39-76 for loop 1, 91-126 for loop 2, and 141-176 for loop 3) has largely been borrowed from a RELAP5 model of the High Flux Isotope Reactor.[37] It works by artificially modulating the input pump speed in order to degrade the developed pump head to be consistent with real pump performance when the NPSH is insufficient. The true pump speed is tracked separately by the control system. As long as the pumps have not been tripped (such as during a steady-state run), the pump cavitation model is not used to modulate the pump speed. The output from the cavitation model (CVs 76, 126, and 176) is simply equal to the output of the PID controller, which is the constant steady-state speed if trip 528 is true.

Table 26. Pump cavitation model control variables

Control variable No.	Variable Type	Description
39	TRIPUNIT	Flag indicating primary pumps have been tripped
40	TRIPUNIT	Flag indicating primary pumps have not been tripped
41	FUNCTION	Torque on pump 1 due to friction
42	FUNCTION	Motor torque applied to pump 1 shaft
43	MULT	Hydraulic power developed by primary pump 1
44	DIV	Hydraulic torque applied to shaft of pump 1
45	SUM	Sum of pump 1 torques divided by the pump inertia
46	MULT	Differential adjustment for rate of change of pump speed
47	INTEGRAL	Adjustment for pump speed (rad/s)
48	SUM	Actual (true) pump speed for pump 1
49	MULT	Velocity head at suction of pump 1
50	SUM	Temperature in °C of volume 122−03
51	FUNCTION	Saturation pressure at volume 122−03 based on general table 35
52	SUM	Available NPSH to pump 1 (Pressure in 122-03 + CV 49 − CV 51)
55	SUM	Step 1 for calculation of required NPSH
56	DIV	Step 2 for calculation of required NPSH
57	SUM	Step 3 for calculation of required NPSH

Table 26. (continued)

Control variable No.	Variable Type	Description
58	DIV	Step 4 for calculation of required NPSH
59	MULT	Required NPSH for pump 1
60	DIV	Ratio of available NPSH to critical NPSH
61	FUNCTION	Head degradation factor (less than 1, greater than zero) for pump 1
62	DIV	Flow rate in m^3/s through pump 1
63	MULT	Nondimensional flow ratio for pump 1 (v)
64	MULT	Nondimensional speed ratio for pump 1 (α)
65	DIV	Quantity v/α used to correlate nondimensional pump head
66	DIV	Quantity α/v used to correlate nondimensional pump head
67	FUNCTION	Quantity HVN = (nondimensional pump head)/v^2, based on homologous pump curve in general Table 41
68	TRIPUNIT	Flag to indicate if pump 1 is operating in the second portion (HVN) of the homologous data
69	TRIPUNIT	Flag to indicate if pump 1 is operating in the first portion (HAN) of the homologous data
70	MULT	Quantity HVN for pump 1 after head degradation factor has been applied (if $v/\alpha < 1$)
71	MULT	Square of degraded pump speed (if $v/\alpha > 1$)
72	POWERR	Degraded pump speed (if $v/\alpha > 1$) for pump 1
73	FUNCTION	Quantity α/v for pump 1 based on degraded pump head (CV 70)
74	MULT	Degraded pump speed (if $v/\alpha < 1$)
75	SUM	Degraded pump speed (less than actual pump speed only if pump is cavitating) for pump 1
76	LAG	Degraded pump speed for pump 1 after time lag has been applied
84	MULT	If pump hasn't tripped this value is steady speed, if it has, this value is zero
85	MULT	If pump has tripped, this value is CV76, if not, this value is zero
86	SUM	Sum of pre-trip (CV 84) and post-trip contributions (CV 85). These contributions are mutually exclusive
91-126		Same as 41-76 except applied to pump 2
134-136		Same as 84-86 except applied to pump 2
141-176		Same as 41-76 except applied to pump 3
184-186		Same as 84-86 except applied to pump 3

15.2 COSTA FLOW EXCURSION HEAT FLUX LIMITS

One of the thermal limits of interest in the ANSR safety analysis is the Costa Onset of Significant Void (OSV) correlation. The correlation is being used to represent the heat flux which, if exceeded, will lead to flow excursion (a phenomenon that will result in burnout). The correlation is only a function of the bulk conditions in the coolant:

$$q_{COSTA} = \frac{V^{1/2}(T_{sat} - T_{bulk})}{12.8},$$

where V is the coolant velocity in m/s, $(T_{sat} - T_{bulk})$ is the subcooling in K and q_{COSTA} is the limit in MW/m^2. This limit is calculated using control variables for each control volume in the four hot channels (two each for lower and upper cores corresponding to 95% and 99.9% nonexceedance probability levels). Control variables 200-279 are used to calculate the 20 limits (5 nodes per channel). Each limit calculation requires four CVs:

(1) A POWERR variable is used to calculate the square root of the coolant velocity at the location.
(2) A SUM variable is used to extrapolate the saturation temperature to the exit of the control volume.
(3) A SUM variable is used to calculate the coolant subccoling at the exit of the control volume.
(4) A MULT variable is used to combine the first three variables into the COSTA limit.

This information is used by the postprocessor to determine when and where the Costa limit is violated.

15.3 WALL SUPERHEAT AT CHF HOT SPOTS

Control variables 280–299 are used to calculate the difference between the CHF hot spot fuel surface temperatures and the bulk saturation temperature in the adjacent channel. This information is read by the postprocessor and indicates if T_w exceeds T_{sat} on the CHF hot stripes.

15.4 PECLET NUMBERS FOR HOT CHANNELS

The Peclet number (Re × Pr) is calculated for each control volume in the four hot channels using CVs 300-339 (4 channels × 5 control volumes × 2 variables per Peclet number). The Peclet numbers are used by the postprocessor in determining the level of uncertainty associated with the Saha-Zuber correlation.

15.5 PRANDTL NUMBERS FOR HOT CHANNELS

The Prandtl numbers ($\mu c_p/k$) for the hot channels are calculated using CVs 444–483 (two variables per Prandtl number). Prandtl number is used by the post-processor in calculating Saha-Zuber thermal limits.

15.6 PRIMARY COOLANT SYSTEM TEMPERATURE (MHX SECONDARY FLOW) CONTROL

The primary coolant inlet temperature is controlled by varying the secondary flow through the main heat exchangers. During a preliminary simulation to establish a steady-state with the model, the flow rate at the time-dependent junctions on the main heat exchanger secondary sides is specified to be the output from a PI controller (CV 581 commented out in standard deck). The error signal is the difference between the desired core inlet temperature (control setpoint specified on CV 580) and the current RELAP5-calculated temperature at the core inlet (volume 500-01).

During the simulation of a reactor transient, CV 581 is changed back to the CONSTANT value and assigned that value reached during the preliminary steady-state simulation. Control variable 582 is a trip unit (assumes a value of 1.0 if trip 540 is true, and 0.0 if 540 is false) to indicate whether or not a loss-of-offsite power is indicated. Then, and only then, the secondary flow rate will be ramped down to 3.23% of the steady state value. Control variable 583 calculates the difference between the current time and 10.0 seconds (currently hard-wired as the secondary trip time for a LOSP). This difference is then used a ramp factor starting at 0 and increasing to a maximum of 0.9677 with CV 584. The complement to the ramp factor (1-CV584) is CV585 which then is used to decrement the secondary flow rate by direct multiplication in CV 586. Because CV584 cannot exceed 0.9677, CV 585 cannot be less than 0.0323, and CV 586 does not fall below 3.23% of the steady-state value specified by CV 581.

15.7 PRESSURIZER PUMP SPEED CONTROL

The pressurizer pump speed must also have a controller in order to obtain the correct make-up flow rate while establishing a steady-state in the RELAP5 ANSR model. Control variables 587–591 provide a simple PID controller with constants that have proven to be acceptable. The exact values of these constants are not important since they are used only in establishing a new steady state and not in simulating a reactor transient. The error in make-up flow (CV 588) is calculated as the difference between the current make-up flow and the desired make-up flow (CV 587). This error is then supplied to a PROP-INT control variable (CV 589) and a DIFFREND control variable (CV 590) to produce the output pump speed for the pump (CV 591).

Additional control (CVs 801–807) is specified to simulate the coastdown of the pressurizer pump in the event that the make-up tank empties. This control system has not yet been used for a transient, but is available nonetheless. Control variables 801–804 keep track of the inventory that has left the make-up tank. If that inventory exceeds 8358.4 kg, trip 551 turns true, and CVs 805-807 and 815 are used to decrement the pump speed from full speed to zero over a 1-s time period.

15.8 CONTROL ROD AND CPBT HEATING

The transient heating behavior in the control rods (CRs) and core pressure boundary tube (CPBT) is different from that of the fuel. To prevent underprediction of core power deposited in the CR and CPBT regions it was necessary to model the heating in these regions separately. Control variables 600 to 775 were developed by C. D. Fletcher for this purpose.[38,39] These modifications were performed based on neutronics calculations for the L7 core design and have not been updated to the present G693 design.[40]

15.9 STANDBY PRESSURIZER PUMP SPEED CONTROL

The standby pressurizer pump has not yet been used for transients, but this logic exists so that it is possible to start up a second pressurizer pump in the event of a main pump failure. General table 820 is used to specify a linear ramped start-up from zero speed to full speed over a 5 s time period. In the event of an empty make-up tank, CV 807 is multiplied onto the standby pressurizer pump speed to force a coastdown identical to that of the main pressurizer pump.

15.10 CORE PRESSURE DROP CALCULATION

RELAP5 outputs pressures at the centers of the control volumes. CVs 831–838 are used to calculate the core pressure drop in the upper and lower core. The core pressure drop is the pressure drop through the fuel channels only including entrance and exit losses. The pressures immediately upstream and immediately downstream of the core are calculated by subtracting (or adding) one half of the frictional loss in that volume from the control volume (center) pressure. Consider two control volumes with center locations K and L. The junction between the two control volumes is location J. Then,

$$\Delta P_{K\text{-}L} = \mathrm{FWALFJ} \times \alpha_{fj} \times \rho_{fj} \times \frac{|v_{fj}| v_{fj}}{2} ,$$

where FWALFJ is available in the RELAP5 Major Edit, α_{fj} is the liquid void fraction, ρ_{fj} is the liquid density, and v_{fj} is the liquid velocity at the junction. Although this information is not in the RELAP5 documentation, Cliff Davis of INEL supplied the following relationship:

$$\mathrm{FWALFJ} = \frac{1}{\alpha_{fj}\rho_{fj}|v_{fj}|}(\Delta x_K \frac{A_J}{A_K}\mathrm{FWALF_K} + \Delta x_L \frac{A_J}{A_L}\mathrm{FWALF_L}) ,$$

where Δx_K and Δx_L are the lengths of control volumes K and L, and A_J, A_K, A_L are the areas at junction J, control volume K and control volume L. $\mathrm{FWALF_K}$ and $\mathrm{FWALF_L}$ are control volume quantities only available if requested using the extended minor edits. By substituting this last equation into the expression for ΔP, two contributions to the frictional pressure drop are obtained. Considering the pressure drop only in volume K, (i.e., the frictional pressure drop between locations K and J, excluding concentrated losses at J), we get

$$\Delta P_{K\text{-}J} = \frac{1}{2}\frac{A_J}{A_K}\Delta x_K \mathrm{FWALF_K} v_{fj} ,$$

which is calculated directly by control variables 831, 832, 833 and 834 for the volumes immediately outside both the lower and upper cores. Since the areas and control volume length are constant, they are included in the scaling factor. For CV 831, the frictional pressure drop between the center and exit of control volume 505-01 (lower core inlet) is calculated by multiplying the scaling factor, $\mathrm{SF_{831}}$, times the product of $\mathrm{FWALF_{505\text{-}01}}$ and $v_{507\text{-}02}$ (507-02 is the junction connecting lower core inlet volume to fuel channels), where

$$\mathrm{SF_{831}} = \frac{1}{2}\frac{A_{507\text{-}02}}{A_{505\text{-}01}}\Delta x_{505\text{-}01} = \frac{1}{2}(\frac{0.027675\ \mathrm{m^2}}{0.05598\ \mathrm{m^2}})(1.545\ \mathrm{m}) = 0.381903\mathrm{m} .$$

Similarly at the lower-core exit (CV 831), upper-core inlet (CV 832), and upper-core exit (CV 833), the scaling factors can be calculated as follows:

$$SF_{832} = \frac{1}{2}\frac{A_{522\text{-}01}}{A_{520\text{-}01}}\Delta x_{520\text{-}01} = \frac{1}{2}(\frac{0.027675\ m^2}{0.055983\ m^2})(0.05\ m) = 0.0123587\ m\ ,$$

$$SF_{833} = \frac{1}{2}\frac{A_{537\text{-}02}}{A_{535\text{-}01}}\Delta x_{535\text{-}01} = \frac{1}{2}(\frac{0.038359\ m^2}{0.07728\ m^2})(0.05\ m) = 0.012409\ m\ ,\ \text{and}$$

$$SF_{834} = \frac{1}{2}\frac{A_{556\text{-}01}}{A_{555\text{-}01}}\Delta x_{555\text{-}01} = \frac{1}{2}(\frac{0.038359\ m^2}{0.07728\ m^2})(0.7715\ m) = 0.191472\ m\ .$$

The scaling factor for CV 833 is in error in the input deck, causing the steady-state pressure drop to be too high by only 28.6 Pa.

The core exit-plane pressures are then calculated (CVs 835 and 837 for the lower and upper cores) by adding these one-half cell frictional losses back onto the exit volume center pressures. Each core pressure drop (including losses at entrance and exit) is then calculated (CVs 836 and 838 for lower and upper cores) by subtracting the one-half cell frictional loss at the entrance volume and the exit-plane pressure from the entrance volume center pressure.

15.11 POINT KINETICS REACTIVITY FEEDBACK

CONTROL VARIABLES 900–905

CVs 900–905 monitor the change in RELAP5-calculated moderator density in the active fuel region. The average channels and 95% NEPL hot channels are monitored to provide feedback to the pointkinetics model via CV 972. Table 27 shows the total fluid volume for the upper and lower core average and 95% hot channels.

ERROR: The fuel channel volume factors applied here are not up to date with the present core design, and the 99.9% hot channels are completely excluded in the feedback calculation.

Table 27. Calculation of volume factors for average and 95% NEPL hot channels

Fuel channel	Cnrtl volumes	Volume per cell (m^3)	Volume factor
Lower average	Pipe 510 cells	$0.027675 \times 0.1014 = 0.002806$	0.0836
Lower 95% hot	Pipe 515 cells	$0.000110698 \times 0.1014 = 1.122 \times 10^{-5}$	0.000334
Upper average	Pipe 540 cells	$0.038359 \times 0.1014 = 0.003890$	0.1158
Upper 95% hot	Pipe 545 cells	$8.9206 \times 10^{-5} \times 0.1014 = 9.045 \times 10^{-6}$	0.000269
Total		$0.006716 \times 5 = 0.0336$	

Control Variable 900

For pipe 510 (lower-core average channel) the correct volume factor for density feedback is 0.0836, as indicated above; however, the input deck incorrectly weights the densities in pipe 510 with the factor 0.0769.

Control Variable 901

For pipe 515 (lower-core 95% hot channel) the correct volume factor for density feedback is 0.000334, as indicated above; however, the input deck incorrectly weights the densities in pipe 510 with the factor 0.000322.

Control Variable 902

For pipe 540 (upper-core average channel) the correct volume factor for density feedback is 0.1158, as indicated above; however, the input deck incorrectly weights the densities in pipe 510 with the factor 0.122.

Control Variable 903

For pipe 545 (upper-core 95% hot channel) the correct volume factor for density feedback is 0.000269, as indicated above; however, the input deck incorrectly weights the densities in pipe 510 with the factor 0.000294.

Control Variable 904

This control variable sums up all of the average and 95% hot channel coolant density contributions to give a weighted average for the coolant density. The initial average density is subtracted out so that this control variable represents the deviation in average density from the initial condition.

The multipliers on control variable 900 and 901 were changed[41] from 1.0 to 0.7600 (0.057/0.075) to account for a change in the assumed lower-core region density feedback coefficient from -0.075 to -0.057. The multiplier on control variable 902 and 903 was changed from 1.0 to 0.2267 (0.017/0.075) to account for a change in the assumed upper core region density feedback coefficient from -0.075 to -0.017 (R. M. Harrington request of April 9, 1992). Whereas the same multiplier was originally applied to both the lower and upper core region density changes in the scaling factor of CV 905, now the lower and upper core regions have different reactivity coefficients of -0.057 and -0.017 respectively. The division by 0.075 is compensated by the multiplication of 0.75 in CV 905. To initialize CV 904 to a zero value, the additive constant, A_0, was changed to -467.766.

Control Variable 905

This control variable calculates the reactivity contribution due to moderator (coolant in the fuel channels) feedback:

$$REACTIVITY = \frac{\Delta\rho}{\rho_{initial}} \times 100 \times reactivity\ coefficient\ ,$$

where the *reactivity coefficient* is 0.075 \$/%change in ρ (ref. 42).

CONTROL VARIABLES 908-913

As the fuel plates change in temperature they will expand or contract leaving less or more room for coolant in the channels. This temperature change produces an apparent change in moderator density which is represented with these control variables. It is assumed that the increase or decrease in coolant volume is produced only to the extent that the fuel plate dimensional change differs from that of the side plates. Hence the temperature difference, ΔT, used in calculating the change in apparent moderator density is defined as

$$\Delta T = (T_{fuel} - T_{sideplate})_{NEW} - (T_{fuel} - T_{sideplate})_{OLD}\ .$$

where T_{fuel} and $T_{sideplate}$ are the average fuel and sideplate temperatures at a given time. The change in fuel plate volume is

$$V - V_0 = (1 + a\Delta T)^3 V_0 - V_0 = (1 + 3a\Delta T + H.O.T.) - V_0 = 3a\Delta T V_0\ .$$

where $H.O.T.$ are terms of order ΔT^2 and higher which are assumed to be very small, and therefore, neglected. Also,

a = coefficient of linear expansion,
V_0 = initial volume of fuel,
V = current volume of fuel.

The change in moderator volume is equal and opposite to the change in metal volume, and for the ANS fuel, the intial moderator volume is equal to the initial fuel volume (plates and gaps have same thickness) so,

$$V_m - V_{m0} = -(V - V_0) = -3a\Delta T ,$$

Rearranging and dividing through by the moderator volume, $V_{m0} = V_0$, gives

$$\frac{V_{m0}}{V_m} = \frac{V_m + 3aV_0\Delta T}{V_m} = 1 + 3a\Delta T\frac{V_{m0}}{V_m} \approx 1 + 3a\Delta T ,$$

The reactivity insertion due to thermal expansion of the fuel plates is proportional to $\Delta\rho/\rho$, where $\Delta\rho$ is the apparent density change of the coolant:

$$\frac{\Delta\rho}{\rho} = \frac{\frac{M}{V_m} - \frac{M}{V_{m0}}}{\frac{M}{V_{m0}}} = \frac{\frac{1}{V_m} - \frac{1}{V_{m0}}}{\frac{1}{V_{m0}}} = \frac{V_{m0}}{V_m} - 1 = 3a\Delta T .$$

The temperature difference between the fuel plate and side plates is calculated by weighting the individual heat structures (using the same volume weighting factors). Again, the 99.9% hot channel is not included and the weighting factors are slightly off (see previous discussion).

Control Variable 908

The calculation for the temperature difference between the lower-core average channel fuel plates and side plates is performed here by summing the differences between each average fuel heat structure temperature and the average (of inner- and outer-) side-plate temperature. This summation is then weighted by the 0.0769 weighting factor, as was done for the liquid densities.

Control Variable 909

The calculation for the temperature difference between the lower-core hot channel fuel plates and side plates is performed here by summing the differences between each average fuel heat structure temperature and the average (of inner- and outer-) side-plate temperature. This summation is then weighted by the 0.000322 weighting factor, as was done for the liquid densities.

Control Variable 910

The calculation for the temperature difference between the upper-core average channel fuel plates and side plates is performed here by summing the differences between each average fuel heat structure temperature and the average (of inner- and outer-) side-plate temperature. This summation is then weighted by the 0.122 weighting factor, as was done for the liquid densities.

Control Variable 911

The calculation for the temperature difference between the upper-core hot channel fuel plates and side plates is performed here by summing the differences between each average fuel heat structure temperature and the average (of inner- and outer-) side-plate temperature. This summation is then weighted by the 0.000292 weighting factor, as was done for the liquid densities.

Control Variable 912

Sum of the contributions to the weighted average temperature difference between the fuel plates and the side plates.

The multiplier on control variables 908 and 909 were changed[41] from 1.0 to 0.7600 (0.057/0.075) to account for a change in the assumed lower-core region density feedback coefficient from -0.075 to -0.057. The multipliers on control variable 910 and 911 were changed from 1.0 to 0.2267 (0.017/0.075) to account for a change in the assumed upper-core region density feedback coefficient from -0.075 to -0.017. Whereas the same multiplier was originally applied to both the lower- and upper-core region density changes in CV 913, now the lower- and upper-core regions have different reactivity coefficients of -0.057 and -0.017, respectively (R. M. Harrington request of April 9, 1992). The division by 0.075 is compensated by the multiplication of 0.75 in CV 913. To initialize CV 912 to a zero value, the additive constant, A_0, was changed to -89.1343.

Control Variable 913

$$CV913 = \frac{\Delta\rho}{\rho_{initial}} \times 100 \times R = -3 \times 27.5 \times 10^{-6}\Delta T \times 100 \times 0.075 = 0.000619\Delta T \, .$$

This control variable calculates the reactivity contribution due to thermal expansion of the fuel channels. where the *reactivity coefficient, R,* is 0.075 \$/%change (from J. M. Ryskamp 12/06/89) in apparent density, and the thermal expansion coefficient is that for aluminum 27.5×10^{-6} K^{-1}.

Control Variable 917

Density feedback for inlet and outlet plenums and bypass gap regions. Table 28 shows the volumes of each cell in the 9/16/94 version of the model. These volumes are different from those that are used in CV 917 because they have been modified since the input for CV 917 was generated. None of the weighting factors is correct in the input model; however, they are close to what they should be and probably within the accuracy of the modeling approximations.

Table 28. Calculation of correct volume factors for plenums and bypass gap regions

Region	Cnrtl volumes	Volume per cell (m^3)	Correct volume factor	Input volume factor
Core Inlet	500-01	$0.1799 \times 0.331 = 0.059546$	0.07144	0.14586
Lower-Core In	505-01	$0.05598 \times 1.545 = 0.08649$	0.10377	0.07207
Upper-Core In	530-01	$0.07728 \times 1.545 = 0.119398$	0.14325	0.12983
Lower-Core Bypass	530-02 thru 530-06	$0.07728 \times 0.1014 = 0.007836$	5 @ 0.0094013	Avg of 0.03863
Upper-Core Out 1	555-01	$0.07728 \times 0.7715 = 0.05962$	0.071529	0.18451
Upper-Core Out 2	557-01	$0.07728 \times 1.2853 = 0.09933$	0.119172	none
Upper-Core Bypass	525-01	$0.055983 \times 0.2028 = 0.01135$	0.013617	0.01550
Lower-Core Out	525-02	$0.055983 \times 2.3610 = 0.13218$	0.158584	0.12177
Core Outlet	565-01	$0.24663 \times 0.918 = 0.22641$	0.271636	0.25263
Total		0.8335	1.00000	1.0

Control Variable 918

Control variable 918 is calculated as

$$CV918 = 0.0333 \ \$/\%density change \times 100 \times \frac{\Delta\rho}{\rho} .$$

The reactivity coefficient assumed for the annular inlet and outlet regions is 0.0333 $/% change in density. This number is specified as the scaling factor for CV 918. The incremental change in density, $\Delta\rho$, is the result from CV 917, and the initial density divided into 100 is included in CV 918 as the multiplier on CV 917.

Control Variable 922

Mid-core density feedback. The two volumes 520-01 and 535-01 are short volumes that are located axially between the fuel elements. Table 29 shows the volume weighting factors.

Table 29. Calculation of volume factors for mid-core annular regions

Region	Control volumes	Volume per cell (m^3)	Correct volume factor	Input volume factor
Lower core annulus	520-01	0.055983 × 0.05 = 0.002799	0.42008	0.34802
Upper core annulus	535-01	0.07728 × 0.05 = 0.003864	0.57992	0.65198
Total		0.006663	1.00000	1.0

Control Variable 923
Control variable 923 is calculated as

$$CV923 = 0.0333\ \$/\%density change \times 100 \times \frac{\Delta\rho}{\rho} .$$

The reactivity coefficient assumed for the annular midcore regions is 0.0333 $/% change in density. This number is specified as the scaling factor for CV 923. The incremental change in density, Δρ, is the result from CV 922, and the initial density divided into 100 is included in CV 923 as the multiplier on CV 922.

Control Variable 928
Control rod region moderator density feedback.

Originally (June 27, 1989, C. D. Fletcher calculation work sheets, p. 182), the model for the control rod region consisted of a single pipe 560. The four volumes in pipe 560 were weighted, as shown in Table 30. Each volume has a cross-sectional area of 0.0229678 m^2, equal to the central hole area (d = 0.095 m) less (originally) four control rod cylinders (d = 0.041402 m). The total length spanned by pipe 560 in the original model is 3.0826 m.

Table 30. Original calculation of volume factors for control rod region

Cnrtl volumes	Volume per cell (m^3)	Volume factor
560-02	0.0229678 × 0.3344 = 0.0076804	0.108465
560-03	0.0229678 × 0.1896 = 0.00435469	0.061499
560-01	0.0229678 × 1.0706 = 0.0245893	0.347259
560-04	0.0229678 × 1.4884 = 0.0341853	0.482777
Total	0.0708097	1.0

Method used by C. D. Fletcher[2] to calculate weighting factors

Since the original calculations were performed, the control rod region has been updated twice. The cross-sectional area has changed, but in the original calculation, the area was constant in the axial direction anyway, so the weighting was based on the lengths. The original weightings are applied to the most recent control rod region discretization by apportioning them to existing volumes based on lengths (and areas, for the three parallel pipes 561, 562, and 563). The pipe lengths of 1.0732 m, 0.2528 m, 0.2028 m, and 1.8472 m for volumes 560-01, -02, -03, and -04 are used to apportion the weighting factors. The old volume length for 560-01 is apportioned 0.769 to volume 560-01, and 0.1014 to each of the first three volumes in pipes 561, 562, and 563. The old volume length for 560-02 of 0.2528 is apportioned 0.1014 to each of cells 4 and 5 and 0.05 to cell 6 of pipes 561, 562, and 563. The old volume length for 560-03 of 0.2028 is apportioned 0.1014 to each of cells 7 and 8 of pipes 561, 562, and 563. Finally, the old volume length of 560-04 of 1.8472 m is apportioned 0.1014 to each of cells 9, 10 and 11 of pipes 561, 562, and 563, and 1.543 to volume 564-01.

Table 31 shows a direct calculation of the weighting factor based on the current input geometry (correct) compared against the input weighting factors based on C. D. Fletcher calculation (including area weighting between the parallel channels).

[2] C. D. Fletcher's calculational sheets for 3-CR Model dated 12-30-91 cite volume length numbers that are not the same as the lengths in the table which were taken from the original calculation work sheets (3-1-89). Since the original worksheets were written, the core length has changed from 0.474 m to 0.507 m. This discrepancy explains the difference in the lengths, but is inconsistent with the use of the weighting factors calculated with the 0.474-m core.

Table 31. Calculation of volume factors for central rod region

Cntrl volumes	Volume per cell (m^3)	Correct volume factor	Input volume factor
560-01	0.03018 × 2.419 = 0.0730054	0.426603	0.24883
561-01	0.00456159 × 0.1014 = 0.000462545	0.00270285	0.00669
561-02	0.00456159 × 0.1014 = 0.000462545	0.00270285	0.00669
561-03	0.00456159 × 0.1014 = 0.000462545	0.00270285	0.00669
562-01	0.0165753 × 0.1014 = 0.0016706	0.00976205	0.02418
562-02	0.0165753 × 0.1014 = 0.0016706	0.00976205	0.02418
562-03	0.0165753 × 0.1014 = 0.0016706	0.00976205	0.02418
563-01	0.0013196 × 0.1014 = 0.000133797	0.000781835	0.001936
563-02	0.24663 × 0.1014 = 0.000133797	0.000781835	0.001936
563-03	0.24663 × 0.1014 = 0.000133797	0.000781835	0.001936
561-04	0.00456159 × 0.1014 = 0.000462545	0.00270285	0.00888
561-05	0.00456159 × 0.1014 = 0.000462545	0.00270285	0.00888
561-06	0.00456159 × 0.05 = 0.00022808	0.00133277	0.00438
562-04	0.0164753 × 0.1014 = 0.0016706	0.00976205	0.03206
562-05	0.0164753 × 0.1014 = 0.0016706	0.00976205	0.03206
562-06	0.0164753 × 0.05 = 0.0008234765	0.00481194	0.01581
563-04	0.24663 × 0.1014 = 0.00013797	0.000781835	0.00257
563-05	0.24663 × 0.1014 = 0.00013797	0.000781835	0.00257
563-06	0.24663 × 0.05 = 0.0123315	0.0720584	0.00127
561-07	0.00456159 ×0.1014 = 0.000462545	0.00270285	0.006274
561-08	0.00456159 ×0.1014 = 0.000462545	0.00270285	0.006274
562-07	0.0164753 × 0.1014 = 0.0016706	0.00976205	0.02266
562-08	0.0164753 × 0.1014 = 0.0016706	0.00976205	0.02266
563-07	0.24663 ×0.1014 = 0.000133797	0.000781835	0.001815
563-08	0.24663 ×0.1014 = 0.000133797	0.000781835	0.001815
561-09	0.00456159 × 0.1014 = 0.000462545	0.00270285	0.005407
561-10	0.00456159 × 0.1014 = 0.000462545	0.00270285	0.005407
561-11	0.00456159 × 0.1014 = 0.000462545	0.00270285	0.005407
562-09	0.0164753 × 0.1014 = 0.0016706	0.00976205	0.01953
562-10	0.0164753 × 0.1014 = 0.0016706	0.00976205	0.01953
562-11	0.0164753 × 0.1014 = 0.0016706	0.00976205	0.01953
563-09	0.24663 × 0.1014 = 0.000133797	0.000781835	0.001564
563-10	0.24663 × 0.1014 = 0.000133797	0.000781835	0.001564
563-11	0.24663 × 0.1014 = 0.000133797	0.000781835	0.001564
564-01	0.03018 × 2.0568 = 0.0620742	0.362727	0.403272
Total	0.171132	1.00000	1.0

Control Variable 929

Control variable 929 is calculated as

$$CV929 = 0.0910\ \$/\%density change \times 100 \times \frac{\Delta\rho}{\rho} \ .$$

The reactivity coefficient assumed for the control rod region is 0.00910 $/% change in density (R. M. Harrington request 4/9/92). This number is specified as the scaling factor for CV 929. The incremental change in density, Δρ, is the result from CV 928, and the initial density divided into 100 is included in CV 929 as the multiplier on CV 928.

Control Variable 934

Control variable 934 calculates the moderator tank feedback:

$$CV934 = -0.0174\ \$/K \times (T_{MT} - T_{MTinitial}) \ .$$

The reactivity coefficient assumed for the moderator tank region is -0.0174 $/K (per R. M. Harrington request, November 29, 1989).

15.12 CONTROL ROD REACTIVITY

The effect of control rod movement on the reactivity of the core is accounted for in the mode (Table 33). The shim speed control, to keep the reactor power constant is represented with control variables 943-961. Then the reactivity of the rods is determined with CVs 965, 967, 969, and 970. The control rods are assumed to move only during normal shim adjustment at a maximum rate[43] of 5.75 in./s or during reactor scram.

Table 33. Control rod reactivity control variables

Control Variable No.	Variable Type	Description
943	SUM	Time step calculation (current time less old time)
944	SUM	Old time (value is updated only after time step is calculated)
945	TRIPUNIT	Equal to 1.0 if a scram (Trip 510) has not yet occurred
946	TRIPUNIT	Equal to 1.0 if a scram (Trip 510) has occurred
949	SUM	Error in reactor power (current power less setpoint) in MW
950	LAG	Lag in reactor power (CV 949) arbitrarily selected to be 0.5 s

16. GENERAL TABLES

General tables are used for specifying tabular functions that are referenced by control systems and some RELAP5 thermal-hydraulic components, such as valves, pumps, heat structures, and time-dependent volumes and junctions. All the tables used in the RELAP5 ANSR input model are shown in Table 33.

Table 33. Summary of general tables used in RELAP5 input model

Table No.	Abcissa	Ordinate	Used by
35	Temperature	Saturation Pressure (Pa)	Pump cavitation model (CVs 51, 101, 151)
39	NPSH ratio	Head degradation factor	Pump cavitation model (CVs 61, 111, 161)
41	v/α	h/v^2	Pump cavitation model (CVs 67, 117, 167)
42	h/v^2	v/α	Pump cavitation model (CVs 73, 123, 173)
43	α	Pump Frictional Torque (N-m)	Pump cavitation model (CVs 41, 91, 141)
44	α	Pony-motor torque (N-m)	Pump cavitation model (CVs 44, 94 144)
135	Time (s)	α	Specified speed primary pump coastdown curve (CV 195)
235	Time (s)	α	Inactive
335	Time (s)	α	Inactive
500	Time (s)	Power (W)	Inactive
501	Time (s)	Temperature (K)	Pool temperature (constant at 311.15 K)
511	Temperature (K)	Heat transfer coefficient (W/m^2-K)	Film coefficient between 356-mm (14-in.)-diam horizontal pipe and pool
521	Temperature (K)	Heat transfer coefficient (W/m^2-K)	Film coefficient between 610-mm (24-in.)-diam horizontal pipe and pool
531	Temperature (K)	Heat transfer coefficient (W/m^2-K)	Film coefficient between 610-mm (24-in.)-diam horizontal pipe and pool
581	Temperature (K)	Heat transfer coefficient (W/m^2-K)	Film coefficient between vertical pipe and pool
591	Temperature (K)	Heat transfer coefficient (W/m^2-K)	Film coefficient between 1111-mm (43.75-in.)-diam horizontal cylinder and pool
599	Temperature (K)	Heat transfer coefficient (W/m^2-K)	Film coefficient between 2108-mm (83-in.)-diam horizontal cylinder and pool

Table 33. (continued)

Table No.	Abcissa	Ordinate	Used by
606	Time (s)	Normlaized fission power	Control Rod and CPBT heating
607	Time (s)	Normalized decay power	Control Rod and CPBT heating
608	Time (s)	A1-28 decay power	Control Rod and CPBT heating
820	Time (s)	Pump speed (rad/s)	Standby pressurizer pump speed (CV 830)
956	Time (s)	Scram rod speed (m/s)	Scram rod insertion rate (CV 956)
970	Rod Position (in.)	Reactivity ($)	Scram rod reactivity (CV 970)

17. POINT KINETICS

The heat generated in the fuel plates and coolant channels caused by neutronic heating is calculated by RELAP5 with a point (space-independent) kinetics model. The heating in the control rods and CPBT is calculated separately by the control system that has already been discussed. One source of information for the point kinetics input is ref. 42. As the design evolved, two key parameters, β (delayed neutron fraction), and λ (neutron generation lifetime), changed periodically. The ans91694in version of the model uses β = 0.0074, and λ = 0.0013 s (ref. 44). The total power for the reactor is 330 MW, and 344 MW with uncertainties included. The reactivity specified as input to the point kinetics model comes from control variable 972, which is a summation of several contributions, including control and safety rod worths and moderator density feedback.

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APPENDIX A: RELAP5 INPUT FOR ANSR MODE (ans91694in)

```
*ANSR relap5 system model - COARSE - ans50994in updated power densities
*
* CHANGES MADE SINCE 2-10-94 VERSION
*
* Areas and Dh's for 560 and 564 assuming annulus w/ 190mm ID & 273mm OD
* Pressurizer line from 4" to 3"
*
*========= PERTURBED CONDITIONS CASE TRANSIENT = FIRST 10 S =========*
*                                                  *
* 1. PRESSURE AT CORE EXIT                              *
*   Control upper core average channel exit pressure so that the   *
*   exit pressure is at 94.9% (95% uncertainty) of the best-estimate *
*   case and the pressure drop is 1.54 MPa (95% uncertainties).    *
*                                                  *
*   Pexit =    1.78 * 0.949 = 1.69 MPa                     *
*                                                  *
* 2. TEMPERATURE AT CORE INLET                              *
*   Hold secondary flow constant based on steady-state run      *
*   primary temp. should be 45.6 deg C (318.75 K).            *
*                                                  *
* 3. VELOCITY AT CORE INLET                              *
*   Primary coolant pump speed is held constant until tripped.   *
*                                                  *
* 4. REACTOR POWER                                      *
*   Set total power in point kinetics model at 1.0424*330 = 344 MW  *
*                                                  *
* 5. LETDOWN VALVE AREA                                   *
*   Calibrate letdown valve area to be 0.5 open at a pressurizing  *
*   flow rate of 14.6 kg/s at nominal pressure.              *
*                                                  *
* 6. PRESSURIZING FLOW                                  *
*   Pressurizer pump speed is held constant until tripped.      *
*                                                  *
* 7. CORE ROUGHNESS                                     *
*   Core roughness is calibrated based on ANS steady-state code   *
*   (assuming 25 m/s) core pressure drop at perturbed (95% uncert) *
*   conditions. This pressure drop is imposed on the upper core   *
*   to get the calibrated nominal core roughness.            *
*                                                  *
*   Delta P = 1.54 MPa >>>>>>>>>> roughness = 1.772E-6 m        *
*                                                  *
* 8. VELOCITY IN CONTROL RODS AND CPBT                       *
*   Loss coefficients on junctions 550-12, 564-01, 564-02, and    *
*   564-03 are calibrated to get velocities in the control rod    *
*   channels to be 6.0 m/s and the entrance velocity in the CPBT   *
*   annulus to be 4.3 m/s.                               *
*                                                  *
* 9. CONTROL ROD POSITION                                  *
*   The control rod position at steady-state is ??????????????    *
*                                                  *
* 10. REACTOR TRIPS                                     *
*   Trips on FFR, high temperature and low pressure are enabled.   *
*                                                  *
* 11. HEAT STRUCTURE HEAT CAPACITIES                         *
*   Heat capacities are set to their true values.            *
*                                                  *
* 12. LOSS-OF-OFFSITE POWER                               *
*   Trips of the pressurizer pump and secondary coolant flow are   *
*   set to occur at 10 s.                                *
*                                                  *
*==================================================================*
*
0000001 8 10 22
*----------------------------------------------------------*
0000100 new    transnt
*----------------------------------------------------------*
0000101 run
*----------------------------------------------------------*
0000102 si     si
*----------------------------------------------------------*
0000105 30. 40. 8.5d4
*----------------------------------------------------------*
0000110 nitrogen
*----------------------------------------------------------*
*
0000120 520010000 0. d2o primary
0000121 130010000 0. h2o mhx1sec
0000122 230010000 0. h2o mhx2sec
0000123 330010000 0. h2o mhx3sec
0000124 138010000 0. h2o ehx1sec
0000125 238010000 0. h2o ehx2sec
0000126 338010000 0. h2o ehx3sec
*
*----------------------------------------------------------*
*   time-step and output frequency information
*----------------------------------------------------------*
0000201 50.00 1.e-7 0.0033 03 303   100000 100000
*0000201 9000.0 1.e-7 0.0033 03 5000 100000 100000
*----------------------------------------------------------*
*   expanded edit/plot variables
*----------------------------------------------------------*
20800001  httemp 550100204 * Max CPBT Temp
20800002  httemp 562100306 * Max CR- Al Temp
20800003  httemp 562100307 * Max CR- Hf Temp
20800004  fwalf 505010000
20800005  fwalf 520010000
20800006  fwalf 535010000
20800007  fwalf 555010000
20800008  fwalf 510010000
* variables for modified saha-zuber correlation
20800011  csubpf 510010000
20800012  csubpf 510020000
20800013  csubpf 510030000
20800014  csubpf 510040000
20800015  csubpf 510050000
20800016  csubpf 515010000
20800017  csubpf 515020000
20800018  csubpf 515030000
20800019  csubpf 515040000
20800020  csubpf 515050000
20800021  csubpf 516010000
20800022  csubpf 516020000
20800023  csubpf 516030000
20800024  csubpf 516040000
20800025  csubpf 516050000
20800026  csubpf 540010000
20800027  csubpf 540020000
20800028  csubpf 540030000
20800029  csubpf 540040000
20800030  csubpf 540050000
20800031  csubpf 545010000
20800032  csubpf 545020000
20800033  csubpf 545030000
20800034  csubpf 545040000
20800035  csubpf 545050000
20800036  csubpf 546010000
20800037  csubpf 546020000
20800038  csubpf 546030000
20800039  csubpf 546040000
20800040  csubpf 546050000
20800041  thconf 510010000
20800042  thconf 510020000
20800043  thconf 510030000
20800044  thconf 510040000
20800045  thconf 510050000
20800046  thconf 515010000
20800047  thconf 515020000
20800048  thconf 515030000
```

```
20800049  thconf 515040000
20800050  thconf 515050000
20800051  thconf 516010000
20800052  thconf 516020000
20800053  thconf 516030000
20800054  thconf 516040000
20800055  thconf 516050000
20800056  thconf 540010000
20800057  thconf 540020000
20800058  thconf 540030000
20800059  thconf 540040000
20800060  thconf 540050000
20800061  thconf 545010000
20800062  thconf 545020000
20800063  thconf 545030000
20800064  thconf 545040000
20800065  thconf 545050000
20800066  thconf 546010000
20800067  thconf 546020000
20800068  thconf 546030000
20800069  thconf 546040000
20800070  thconf 546050000
20800071  viscf  510010000
20800072  viscf  510020000
20800073  viscf  510030000
20800074  viscf  510040000
20800075  viscf  510050000
20800076  viscf  515010000
20800077  viscf  515020000
20800078  viscf  515030000
20800079  viscf  515040000
20800080  viscf  515050000
20800081  viscf  516010000
20800082  viscf  516020000
20800083  viscf  516030000
20800084  viscf  516040000
20800085  viscf  516050000
20800086  viscf  540010000
20800087  viscf  540020000
20800088  viscf  540030000
20800089  viscf  540040000
20800090  viscf  540050000
20800091  viscf  545010000
20800092  viscf  545020000
20800093  viscf  545030000
20800094  viscf  545040000
20800095  viscf  545050000
20800096  viscf  546010000
20800097  viscf  546020000
20800098  viscf  546030000
20800099  viscf  546040000
20800100  viscf  546050000
*-----------------------------------------------------------------*
*    minor edit requests
*-----------------------------------------------------------------*
0000301  mflowj     567010400
0000302  p          505010000
0000303  velfj      507010200
0000304  velfj      537010200
0000305  velfj      550010000
0000306  velfj      550070000
0000308  velfj      559010100
0000309  velfj      559010200
0000310  velfj      559010300
0000311  cntrlvar   835
0000312  cntrlvar   836
0000313  cntrlvar   837
0000314  cntrlvar   838
0000317  rktpow     0
0000318  tempf      490010000
0000321  mflowj     156010000
0000322  mflowj     256010000
0000323  mflowj     356010000
0000327  htmr       515400500
0000328  htchf      515400500
0000336  pmpvel     815
0000338  cntrlvar   840
0000339  mflowj     865010000
0000340  mflowj     825000000
0000341  cntrlvar   860
0000342  tempf      505010000
0000343  cntrlvar   480
0000344  cntrlvar   481
*
*-----------------------------------------------------------------*
*         trip input
*-----------------------------------------------------------------*
* high power-to-flow ratio trips
0000501   cntrlvar 940 gt null 0 1.20 l -1.
0000502   time 0 gt timeof 501 0.200 l -1.
*0000502   time 0 gt null 0 1.e6 l -1.
* high temperature = 1.22*45 deg C = 54.8 deg C
0000503   tempf 500010000 gt null 0 328.05 l -1.
0000504   time 0 gt timeof 503 2.0 l -1. *high temp
*0000504   time 0 gt null 0 1.e6 l -1.
*
* Low-pressure trip is 80% of nominal at sensor location.
* Sensor location is in volume 645-01, 2.44 m downstream of hotleg riser
* Nominal pressure taken from 645-01 in "nomssb0193in" to be 1.674979 MPa.
* Therefore, the setpoint pressure is 1.3399 MPa.
*
0000506 cntrlvar 839 lt null 0 1.3399e6 l -1.
*0000506   time 0 gt null 0 1.e6 l -1.
* reactor trip
0000508   time 0 gt null 0 1.e6 l -1. *manual trip
0000510   time  0 gt timeof 603 0.030 l -1.
0000515   time  0 lt null 0 1.e6 l 0.   *loop1 isolation
0000516   time  0 lt null 0 1.e6 l 0.   *loop2 isolation
0000517   time  0 lt null 0 1.e6 l 0.   *loop3 isolation
* pump cavitation model trips
0000528   time  0 gt null 0 1.d6 l  * begin the transient if true
0000536   cntrlvar  65 gt null 0 1. n * v/alpha range pump pu-1
0000537   cntrlvar 115 gt null 0 1. n * v/alpha range pump pu-2
0000538   cntrlvar 165 gt null 0 1. n * v/alpha range pump pu-3
0000540   time  0 gt null 0 1.d6 l -1. * loss of offsite power
* pressurizer pump trips
0000541   time  0 gt null 0 1.e6 n -1.  *standby przr pump
0000542   time  0 gt null 0 1.e6 n -1.  *emergency przr pump
0000550   time  0 gt null 0 1.e6 l -1.  *standby speed table trip
0000551   cntrlvar  804  gt null 0  8358.4 l -1. *mu tank empty
0000552   time 0  gt  timeof 551  11.0  l -1. *przr sys isolate
* lose power to primary coolant pumps (use torque balance)
0000555   time  0 gt null 0 1.d6 l -1.
*
0000560   p  850010000  ge null 0 4.428e6 n -1. *safety valve
0000561   p  850010000  ge null 0 4.600e6 n -1. *safety valve
*
0000599   time  0 gt null 0 1.e6  l -1.
0000600    599
0000601    502   or   504  l    -1.
0000602    601   or   506  l    -1.
0000603    602   or   508  l    -1.
0000610    560   and  611  n    -1.
0000611    561   or   610  n    -1.
0000615   -552   or  -552  n     0.
0000619   -555 and -555  n  0.
0000620   -540 and -540  n  0.
0000621   -541 and -541  n  0.
```

```
0000635    506   or   540  1     -1.0
*
*==========================================================================*
*                                  *
*  HYDRODYNAMIC COMPONENT INPUT      *
*                                  *
*==========================================================================$
*                                  *
*              CORE REGION                   *
*                                  *
*==========================================================================$
*hydro        component name    component type
4900000         "cvgwye"         pipe
*-----------------------------------------------------------------$
4900001       1
*
*hydro      vol area                        vol
4900101       0.1993                          1
*
*hydro      length                          vol
4900301       0.543                           1
*
*hydro      volume                          vol
4900401       0.0                             1
*
*hydro      vert angle                      vol
4900601       90.                             1
*
*hydro      delta z                         vol
4900701       0.543                           1
*
*hydro      roughness   hyd diam                 vol
4900801     0.0000457    0.2999                    1
*
*hydro         fe                          vol
4901001         00                            1
*
*hydro  ebt pressure    tempe                    vol
4901201  0  3381195.   176629.8 2419499. 0.      0. 1
*
*-----------------------------------------------------------------$
*hydro        component name    component type
4920000         "cvgwye"         mtpljun
*-----------------------------------------------------------------$
*hydro       no. juns        vel/flw
4920001        7               0
*
*hydro   from          to          area    f loss   r loss   vcahs
4920011  174010000   490010003   0.        0.       0.     01101
4920012  1.0  1.0  1.0  0  0  0  1
4920021  274010000   490010003   0.        0.       0.     01101
4920022  1.0  1.0  1.0  0  0  0  2
4920031  374010000   490010003   0.        0.       0.     01101
4920032  1.0  1.0  1.0  0  0  0  3
4920041  490010000   500000000   0.        0.       0.     01100
4920042  1.0  1.0  1.0  0  0  0  4
*
* Kentrance = 35 - constrained by flow through control rod channels
*
4920051  495010000   560000000   0.       35.0     35.0    01000
4920052  1.0  1.0  1.0  0  0  0  5
4920061  490010001   495010002   0.        0.0      0.0    01100
4920062  1.0  1.0  1.0  0  0  0  6
4920071  474010000   490010003   0.        0.       0.     01101
4920072  1.0  1.0  1.0  0  0  0  7
*
4921011  7.11934   7.66841 1 * 651.381
4921021  7.36089   7.9198  2 * 673.39
4921031  7.39046   7.95058 3 * 676.089
4921041  9.37546  9.91641  4 * 1854.196
4921051  4.420535  4.78872  5 * 146.6658
4921061  .669406   .817969  6 * 146.6658
4921071  1.440176-5  1.440423-5  7 * .001320477
*
4922011  0.3255 0.0 1.0 1.0 1
4922021  0.3255 0.0 1.0 1.0 2
4922031  0.3255 0.0 1.0 1.0 3
4922041  0.1799 0.0 1.0 1.0 4
4922051  0.190  0.0 1.0 1.0 5
4922061  0.2999 0.0 1.0 1.0 6
4922071  0.3255 0.0 1.0 1.0 7
*
*-----------------------------------------------------------------$
*hydro        component name    component type
4950000         "cpbtbot"        pipe
*-----------------------------------------------------------------$
4950001       1
*
*hydro      vol area                        vol
4950101       0.2400                          1
*
*hydro      length                          vol
4950301       1.80                            1
*
*hydro      volume                          vol
4950401       0.0                             1
*
*hydro      vert angle                      vol
4950601       90.                             1
*
*hydro      delta z                         vol
4950701       1.80                            1
*
*hydro      roughness   hyd diam                 vol
4950801     0.0000457    0.3664                    1
*
*hydro         fe                          vol
4951001         00                            1
*
*hydro  ebt pressure    tempe                    vol
4951201  0  3392443.   176605.4 2419491. 0.      0. 1
*
*-----------------------------------------------------------------$
*hydro        component name    component type
5000000         "inlet"          pipe
*-----------------------------------------------------------------$
5000001       1
*
*hydro      vol area                        vol
5000101       0.1799                          1
*
*hydro      length                          vol
5000301       0.331                           1
*
*hydro      volume                          vol
5000401       0.                              1
*
*hydro      vert angle                      vol
5000601       90.                             1
*
*hydro      delta z                         vol
5000701       0.331                           1
*
*hydro      roughness   hyd diam                 vol
5000801     0.0000457    0.1799                    1
*
*hydro         fe                          vol
5001001         00                            1
```

```
*
*hydro      vcahs                          jun
*5001101      01100                          1
*
*hydro  ebt pressure    tempe                    vol
5001201  0  3325311.   176630.2 2419540. 0.      0. 1
*
*hydro      f velocity  g velocity  j velocity        jun
*5001300 0
*5001301   7.26805    7.26805 0.                        2
*
*-------------------------------------------------------------$
*hydro         component name     component type
5050000            "lcorein"          pipe
*-------------------------------------------------------------$
5050001        1
*
*hydro        vol area                         vol
5050101          0.05598                          1
*
*hydro         length                          vol
5050301         1.545                            1
*
*hydro          volume                          vol
5050401          0.                             1
*
*hydro        vert angle                        vol
5050601         90.                             1
*
*hydro         delta z                          vol
5050701          1.545                           1
*
*hydro       roughness     hyd diam                     vol
5050801       0.00000152     0.034                        1
*
*hydro           fe                          vol
5051001          00                           1
*
*hydro         vcahs                          jun
*5051101         01100                         1
*
*hydro  ebt pressure    tempe                    vol
5051201  0  3248074.   176675.  2419599. 0.     0. 1
*
*hydro      f velocity  g velocity  j velocity        jun
*5051300 0
*5051301   7.26805    7.26805 0.                        2
*
*-------------------------------------------------------------$
*hydro         component name     component type
5070000            "lcinlt"          mtpljun
*-------------------------------------------------------------$
5070001    4     0
* inlet loss coefficients are:
*  0.04 (from HFIR data) + 0.0679 (10 mm unheated length)
*hydro   from         to          area     f loss   r loss   vcahs
5070011  500010000   505000000  0.         0.        0.    01100
5070012  1.0  1.0  1.0  0   0   0   1
5070021  505010000   510000000  0.        0.1079   0.1079 01000
5070022  1.0  1.0  1.0  0   0   0   2
5070031  505010000   515000000  0.        0.1079   0.1079 01000
5070032  1.0  1.0  1.0  0   0   0   3
5070041  505010000   516000000  0.        0.1079   0.1079 01000
5070042  1.0  1.0  1.0  0   0   0   4
*
*hydro   f velocity     g velocity
5071011  12.32722       12.90393  1 * 758.611
5071021  24.7336        24.7336   2 * 752.454
5071031  25.29286       25.29286  3 * 3.07781
5071041  25.3056        25.3056   4 * 3.07936
*
5072011  0.132       0.0 1.0 1.0 1
5072021  0.0024831   0.0 1.0 1.0 2
5072031  0.0024831   0.0 1.0 1.0 3
5072041  0.0024831   0.0 1.0 1.0 4
*
*-------------------------------------------------------------*
*hydro  component name component type
5100000  "lcavchan"     pipe
*-------------------------------------------------------------$
5100001        5
*
*hydro        vol area                         vol
5100101        0.027675                          5
*
*hydro         length                          vol
5100301'        0.1014                           5
*
*hydro         volume                          vol
5100401          0.                            5
*
*hydro        vert angle                        vol
5100601          90.                            5
*
*hydro         delta z                          vol
5100701          0.1014                          5
*
*hydro       roughness     hyd diam                     vol
5100801       1.7720e-6    0.002498                      5
*
*hydro           fe                          vol
*noans**5101001        00                      5
5101001          200                           5
*
*hydro         vcahs                          jun
5101101          01000                          4
*
*hydro  ebt pressure    tempe                    vol
5101201  0  2791262.    204874.2 2419427. 0.      0. 1
5101202  0  2.519+6     230508.7 2418759. 0.      0. 2
5101203  0  2246044.    252986.  2417343. 0.      0. 3
5101204  0  1972517.    273740.  2415676. 0.      0. 4
5101205  0  1.699+6     294448.  2412997. 0.      0. 5
*
*hydro      f velocity  g velocity  j velocity        jun
5101300 0
5101301   24.8089    32.1852   0. 1 * 752.454
5101302   24.8834    32.33175 0. 2 * 752.454
5101303   24.95473   32.4773   0. 3 * 752.454
5101304   25.02536   32.62555 0. 4 * 752.454
*
*hydro   jun hyd diam                          jun
5101401    0.002498    0.0 1.0 1.0               4
*
*hydro   pitch      span    vol
5101501  1.27e-3    87.35e-3  5
*-------------------------------------------------------------*
*hydro         component name     component type
5150000            "lchotch1"          pipe
*-------------------------------------------------------------$
5150001        5
*
*hydro        vol area                         vol
5150101        0.000110698                       5
*
*hydro         length                          vol
5150301        0.1014                            5
*
```

```
*hydro      volume                          vol
5150401       0.                            5
*
*hydro      vert angle                      vol
5150601       90.                           5
*
*hydro      delta z                         vol
5150701       0.1014                        5
*
*hydro      roughness   hyd diam            vol
5150801       1.7720e-6  0.002498           5
*
*hydro        fe                            vol
*noans**5151001      00                     5
5151001       200                           5
*
*hydro      vcahs                           jun
5151101       01000                         4
*
*hydro  ebt pressure    tempe                      vol
5151201  0  2801631.   238928.3 2419446. 0.     0. 1
5151202  0  2529383.   296007.  2418793. 0.     0. 2
5151203  0  2254116.   347828.  2417388. 0.     0. 3
5151204  0  1975945.   394597.  2415706. 0.     0. 4
5151205  0  1694758.   434306.  2412947. 0.     0. 5
*
*hydro      vel/flw
*
*hydro      f velocity   g velocity   j velocity      jun
5151300 0
5151301  25.4685   33.04053 0. 1 * 3.07781
5151302  25.66407  33.344  0. 2 * 3.07781
5151303  25.8696   33.66467 0. 3 * 3.07781
5151304  26.0773   33.9934  0. 4 * 3.07781
*
*hydro  jun hyd diam                          jun
5151401    0.002498   0.0 1.0 1.0              4
*
*hydro   pitch     span   vol
5151501  1.14330e-3  87.35e-3  5
*
*-----------------------------------------------------------------*
*hydro        component name     component type
5160000         "kchotch2"          pipe
*-----------------------------------------------------------------$
5160001       5
*
*hydro      vol area                        vol
5160101     0.000110698                     5
*
*hydro      length                          vol
5160301       0.1014                        5
*
*hydro      volume                          vol
5160401       0.                            5
*
*hydro      vert angle                      vol
5160601       90.                           5
*
*hydro      delta z                         vol
5160701       0.1014                        5
*
*hydro      roughness   hyd diam            vol
5160801       1.7720e-6  0.002498           5
*
*hydro        fe                            vol
*noans**5161001      00                     5
5161001       200                           5
*
*hydro      vcahs                           jun
5161101       01000                         4
*
*hydro  ebt pressure    tempe                      vol
5161201  0  2801592.   241444.  2419446. 0.     0. 1
5161202  0  2529642.   300827.  2418794. 0.     0. 2
5161203  0  2254448.   354742.  2417389. 0.     0. 3
5161204  0  1976145.   403400.  2415708. 0.     0. 4
5161205  0  1694640.   444698.  2412946. 0.     0. 5
*
*hydro      vel/flw
5161300 0
*
*hydro      f velocity   g velocity   j velocity      jun
5161301  25.4891   33.0672  0. 1 * 3.07936
5161302  25.69474  33.3836  0. 2 * 3.07936
5161303  25.91156  33.7189  0. 3 * 3.07936
5161304  26.13126  34.06326 0. 4 * 3.07936
*
*hydro  jun hyd diam                          jun
5161401    0.002498   0.0 1.0 1.0              4
*
*hydro   pitch     span   vol
5161501  1.14330e-3  87.35e-3  5
*
*-----------------------------------------------------------------$
*hydro        component name     component type
5200000         "kcoutlt"           pipe
*-----------------------------------------------------------------$
5200001       1
*
*hydro      vol area                        vol
5200101       0.055983                      1
*
*hydro      length                          vol
5200301       0.05                          1
*
*hydro      volume                          vol
5200401       0.0                           1
*
*hydro      vert angle                      vol
5200601       90.                           1
*
*hydro      delta z                         vol
5200701       0.05                          1
*
*hydro      roughness    hyd diam           vol
5200801       0.00000152    0.132           1
*
*hydro        fe                            vol
5201001       00                            1
*
*hydro      vcahs                           jun
*5201101      01100                         1
*
*hydro  ebt pressure    tempe                      vol
5201201  0  1708549.   295602.  2413110. 0.     0. 1
*
*hydro      f velocity   g velocity   j velocity      jun
*5201300 0
*5201301   7.52105   7.52105 0.                        2
*
*-----------------------------------------------------------------$
*hydro        component name     component type
5220000         "kcoutl"            mtpljun
*-----------------------------------------------------------------$
5220001    4     0
*
* loss coefficient at fuel channel exit = 0.0679 (10 mm unheated length)
```

```
*hydro   from        to         area     f loss   r loss   vcahs
5220011  510010000   520000000  0.       0.0679   0.     01100
5220012  1.0  1.0  1.0  0  0  0  1
5220021  515010000   520000000  0.       0.0679   0.1079 01100
5220022  1.0  1.0  1.0  0  0  0  2
5220031  520010000   525000000  0.       0.0679   0.1079 01100
5220032  1.0  1.0  1.0  0  0  0  3
5220041  516010000   520000000  0.       0.0679   0.1079 01100
5220042  1.0  1.0  1.0  0  0  0  4
*
*hydro   f velocity   g velocity
5221011  25.10006  32.5845  1 * 752.454
5221021  26.2705   34.0594  2 * 3.07781
5221031  12.51166  13.1206  3 * 758.611
5221041  26.33594  34.14135 4 * 3.07936
*
5222011  0.0024982  0.0 1.0 1.0 1
5222021  0.0024982  0.0 1.0 1.0 2
5222031  0.132      0.0 1.0 1.0 3
5222041  0.0024982  0.0 1.0 1.0 4
*
*---------------------------------------------------------------*
*hydro        component name    component type
5250000        "ucinlet"          pipe
*---------------------------------------------------------------$
5250001       2
*
*hydro       vol area                          vol
5250101       0.055983                            2
*
*hydro       length                            vol
5250301       0.2028                             1
5250302       2.3610                             2
*
*hydro       volume                            vol
5250401       0.                               2
*
*hydro       vert angle                        vol
5250601       90.                              2
*
*hydro       delta z                           vol
5250701       0.2028                             1
5250702       2.3610                             2
*
*hydro       roughness     hyd diam                vol
5250801       0.00000152    0.132                    2
*
*hydro       fe                               vol
5251001       00                               2
*
*hydro       vcahs                            jun
5251101       01000                             1
*
*hydro  ebt pressure    tempe                     vol
5251201  0  1700645.   296652.6 2413017. 0.     0. 1
5251202  0  1678965.   297656.  2412759. 0.     0. 2
*
*hydro       vel/flw
5251300 0
*
*hydro       f velocity   g velocity   j velocity          jun
5251301  12.51358  13.12272 0. 1 * 758.611
*
*hydro  jun hyd diam                             jun
5251401     0.132      0.0 1.0 1.0                 1
*
*---------------------------------------------------------------*
*hydro        component name    component type
5290000        "ucinlet"          sngljun
*---------------------------------------------------------------*
*hydro   from        to         area     f loss   r loss   vcahs
5290101  500010000   530000000  0.       0.       0.     01100
*
*hydro   jun hyd diam
5290110     0.120      0.0 1.0 1.0
*
*hydro   vel/flw     f velocity   g velocity   j velocity
5290201 0  12.89608   13.4712  0. * 1095.585
*
*---------------------------------------------------------------*
*hydro        component name    component type
5300000        "ucinlet"          pipe
*---------------------------------------------------------------$
5300001       6
*
*hydro       vol area                          vol
5300101       0.07728                            6
*
*hydro       length                            vol
5300301       1.545                              1
5300302       0.1014                             6
*
*hydro       volume                            vol
5300401       0.                               6
*
*hydro       vert angle                        vol
5300601       90.                              6
*
*hydro       delta z                           vol
5300701       1.545                              1
5300702       0.1014                             6
*
*hydro       roughness     hyd diam                vol
5300801       0.00000152    0.044                    6
*
*hydro       fe                               vol
5301001       00                               6
*
*hydro       vcahs                            jun
5301101       01000                             5
*
*hydro  ebt pressure    tempe                     vol
5301201  0  3244536.   176665.  2419602. 0.     0. 1
5301202  0  3219632.   178255.4 2419620. 0.     0. 2
5301203  0  3216117.   178311   2419623. 0.     0. 3
5301204  0  3212604.   178364.  2419626. 0.     0. 4
5301205  0  3209088.   178416.3 2419629. 0.     0. 5
5301206  0  3205572.   178468.8 2419631. 0.     0. 6
*
*hydro       vel/flw
5301300 0
*
*hydro       f velocity   g velocity   j velocity          jun
5301301  12.47393  13.0429  0. 1 * 1059.68
5301302  12.47594  13.0453  0. 2 * 1059.68
5301303  12.47603  13.04544 0. 3 * 1059.68
5301304  12.4761   13.04558 0. 4 * 1059.68
5301305  12.4762   13.0457  0. 5 * 1059.68
*
*hydro  jun hyd diam                             jun
5301401     0.120      0.0 1.0 1.0                 5
*
*---------------------------------------------------------------*
*hydro        component name    component type
5310000        "gapinlt"          sngljun
*---------------------------------------------------------------*
*
*hydro   from        to         area     f loss   r loss   vcahs
```

```
5310101  530010003   550010003   0.004540  2.79   2.79   01003
*
*hydro   jun hyd diam
5310110     0.010      0.0 1.0 1.0
*
*hydro   vel/flw    f velocity   g velocity   j velocity
5310201 0  7.1944  7.1944  0. * 35.905
*
*---------------------------------------------------------------$
*hydro          component name     component type
5350000           "ucinlet"           pipe
*---------------------------------------------------------------$
5350001        1
*
*hydro       vol area                              vol
5350101        0.07728                               1
*
*hydro        length                               vol
5350301        0.050                                1
*
*hydro        volume                               vol
5350401        0.0000                               1
*
*hydro       vert angle                            vol
5350601        90.                                 1
*
*hydro       delta z                               vol
5350701        0.050                                1
*
*hydro       roughness     hyd diam                    vol
5350801      0.00000152    0.144                        1
*
*hydro           fe                               vol
5351001          00                                1
*
*hydro          vcahs                              jun
*5351101        01100                                1
*
*hydro  ebt pressure    tempe                          vol
5351201  0  3203393.   178483.6 2419633. 0.        0. 1
*
*hydro       f velocity   g velocity   j velocity          jun
*5351300 0
*5351301    7.52105    7.52105 0.                          2
*
*---------------------------------------------------------------$
*hydro          component name     component type
5370000            "lcinlt"          mtpljun
*---------------------------------------------------------------$
5370001    4     0
* inlet loss coefficients are:
*  0.04 (from HFIR data) + 0.0679 (10 mm unheated length)
*hydro    from           to          area      f loss    r loss    vcahs
5370011  530010000    535000000   0.          0.        0.     01100
5370012  1.0  1.0  1.0  0  0  0  1
5370021  535010000    540000000   0.          0.1079    0.1079 01000
5370022  1.0  1.0  1.0  0  0  0  2
5370031  535010000    545000000   0.          0.1079    0.1079 01000
5370032  1.0  1.0  1.0  0  0  0  3
5370041  535010000    546000000   0.          0.1079    0.1079 01000
5370042  1.0  1.0  1.0  0  0  0  4
*
*hydro              f velocity     g velocity    j velocity
5371011   12.47627   13.04584  1 * 1059.68
5371021   25.01847   25.01847  2 * 1054.75
5371031   25.13356   25.13356  3 * 2.464164
5371041   25.1453    25.1453   4 * 2.465315
*
5372011   0.120      0.0 1.0 1.0 1
```

```
5372021  0.0024787  0.0 1.0 1.0 2
5372031  0.0024787  0.0 1.0 1.0 3
5372044  0.0024787  0.0 1.0 1.0 4
*
*---------------------------------------------------------------*
*hydro          component name     component type
5400000           "ucavchan"          pipe
*---------------------------------------------------------------$
5400001        5
*
*hydro       vol area                              vol
5400101        0.038359                              5
*
*hydro        length                               vol
5400301        0.1014                               5
*
*hydro        volume                               vol
5400401        0.                                  5
*
*hydro       vert angle                            vol
5400601        90.                                 5
*
*hydro       delta z                               vol
5400701        0.1014                               5
*
* Calibration of roughness (SS code has determined that the pressure drop
* across the core is 1.54 MPa excluding the unheated length for perturbed
* LOCA case, and 1.42 MPa for the best-estimate case at 25 m/s).
*
* Unheated fuel losses are included as form loss at the entrance and exit.
*
*  Fuel roughness (m)      Pressure drop (MPa)
*      0.7929e-6              1.42
*      0.8950e-6              1.433
*      1.2000e-6              1.473
*      2.2000e-6              1.586
*      1.7900e-6              1.541752
*      1.7880e-6              1.5417
*      1.7800e-6              1.54077
*      1.7740e-6              1.5403
*
*hydro       roughness     hyd diam                    vol
5400801      1.7720e-6    0.002494                      5
*
*hydro           fe                               vol
*noans**5401001          00                          5
5401001         200                                5
*
*hydro          vcahs                              jun
5401101        01000                                4
*
*hydro  ebt pressure     tempe                          vol
5401201  0  2773144.   218761.5 2419394. 0.       0. 1
5401202  0  2501446.   264473.  2418702. 0.       0. 2
5401203  0  2229980.   309189.  2417253. 0.       0. 3
5401204  0  1957245.   352185.  2415544. 0.       0. 4
5401205  0  1682786.   392150.  2412805. 0.       0. 5
*
*hydro        vel/flw
5401300 0
*
*hydro       f velocity   g velocity   j velocity          jun
5401301   25.12835   32.60395 0. 1 * 1054.75
5401302   25.27187   32.83997 0. 2 * 1054.75
5401303   25.4326    33.1015  0. 3 * 1054.75
5401304   25.60536   33.38306 0. 4 * 1054.75
*
*hydro   jun hyd diam                                jun
5401401     0.002494   0.0 1.0 1.0                     4
```

```
*
*hydro   pitch     span   vol
5401501  1.27e-3   70.29e-3 5
*
*---------------------------------------------------------------*
*hydro        component name     component type
5450000       "uchotch1"         pipe
*---------------------------------------------------------------$
5450001       5
*
*hydro        vol area                        vol
5450101       8.9206d-5                         5
*
*hydro        length                          vol
5450301       0.1014                          5
*
*hydro        volume                          vol
5450401       0.                              5
*
*hydro        vert angle                      vol
5450601       90.                             5
*
*hydro        delta z                         vol
5450701       0.1014                          5
*
*hydro        roughness    hyd diam                vol
5450801       1.7720e-6    0.0024940                 5
*
*hydro        fe                              vol
*noans**5451001       00                        5
5451001       200                             5
*
*hydro        vcahs                           jun
5451101       01000                             4
*
*hydro  ebt pressure    tempe                       vol
5451201  0  2772541.   235177.  2419394. 0.     0. 1
5451202  0  2503655.   297123.  2418709. 0.     0. 2
5451203  0  2232820.   354218.  2417269. 0.     0. 3
5451204  0  1958879.   407314.  2415558. 0.     0. 4
5451205  0  1681802.   455307.  2412793. 0.     0. 5
*
*hydro        vel/flw
5451300 0
*
*hydro      f velocity   g velocity   j velocity          jun
5451301   25.29216   32.8165  0. 1 * 2.464164
5451302   25.5019    33.1375  0. 2 * 2.464164
5451303   25.72854   33.4844  0. 3 * 2.464164
5451304   25.9671    33.852   0. 4 * 2.464164
*
*hydro   jun hyd diam                          jun
5451401     0.0024940   0.0 1.0 1.0                  4
*
*hydro   pitch     span   vol
5451501  1.14300e-3 70.29e-3 5
*
*---------------------------------------------------------------*
*hydro        component name     component type
5460000       "uchotch2"         pipe
*---------------------------------------------------------------$
5460001       5
*
*hydro        vol area                        vol
5460101       8.9206d-5                         5
*
*hydro        length                          vol
5460301       0.1014                          5
*
*hydro        volume                          vol
5460401       0.                              5
*
*hydro        vert angle                      vol
5460601       90.                             5
*
*hydro        delta z                         vol
5460701       0.1014                          5
*
*hydro        roughness    hyd diam                vol
5460801       1.7720e-6    0.0024940                 5
*
*hydro        fe                              vol
*noans**5461001       00                        5
5461001       200                             5
*
*hydro        vcahs                           jun
5461101       01000                             4
*
*hydro  ebt pressure    tempe                       vol
5461201  0  2772531.   237506.8 2419393. 0.     0. 1
5461202  0  2503981.   301960.6 2418710. 0.     0. 2
5461203  0  2233233.   361363.5 2417271. 0.     0. 3
5461204  0  1959149.   416606.  2415560. 0.     0. 4
5461205  0  1681704.   466543.  2412792. 0.     0. 5
*
*hydro        vel/flw
5461300       0
*
*hydro      f velocity   g velocity   j velocity          jun
5461301   25.31105   32.84096 0. 1 * 2.465315
5461302   25.53157   33.17575 0. 2 * 2.465315
5461303   25.7707    33.53885 0. 3 * 2.465315
5461304   26.0232    33.9246  0. 4 * 2.465315
*
*hydro   jun hyd diam                          jun
5461401     0.0024940   0.0 1.0 1.0                  4
*
*hydro   pitch     span   vol
5461501  1.14300e-3 70.29e-3 5
*
*---------------------------------------------------------------*
*hydro        component name     component type
5500000       "ucorebyp"         pipe
*---------------------------------------------------------------$
5500001       14
*
*hydro        vol area                        vol
5500101       0.007618                          6
5500102       0.004590                          12
5500103       0.007618                          14
*
*hydro        jun area                        vol
5500201       0.007618                          6
5500202       0.004590                          11
5500203       0.007618                          13
*
*hydro        length                          vol
5500301       1.545                            1
5500302       0.1014                           6
5500303       0.050                            7
5500304       0.1014                           12
5500305       0.7715                           14
*
*hydro        volume                          vol
5500401       0.                              14
*
*hydro        vert angle                      vol
5500601       90.                             14
```

```
*
*hydro     roughness    hyd diam                 vol
5500801    0.00000152   0.010                    6
5500802    0.00000152   0.006                    12
5500803    0.00000152   0.010                    14
*
5500901    0.    0.  11
*
* Calibrate losses to get 4.3 m/s in CPBT
* K =  85.00  V = 4.46
* K =  86.00  V = 4.4437
* K =  88.00  V = 4.4117
* K =  91.00  V= 4.36
* K =  93.00  V= 4.336
* K =  95.00  V= 4.3059
*
5500902    95.40   95.40   12
5500903    0.    0.    13
*
*hydro       fe                         vol
5501001      00                         14
*
*hydro       vcahs                      jun
5501101      01000                      13
*
*hydro  ebt pressure    tempe                  vol
5501201  0  3165053.   200089.8 2419663. 0.   0. 1
5501202  0  3129494.   204537.  2419690. 0.   0. 2
5501203  0  3126462.   208766.  2419693. 0.   0. 3
5501204  0  3123428.   212461.  2419695. 0.   0. 4
5501205  0  3120390.   215917.4 2419698. 0.   0. 5
5501206  0  3117354.   219280.3 2419700. 0.   0. 6
5501207  0  3095427.   219284.5 2419717. 0.   0. 7
5501208  0  3087670.   222617.  2419723. 0.   0. 8
5501209  0  3077389.   227257.6 2419732. 0.   0. 9
5501210  0  3067180.   232522.  2419740. 0.   0. 10
5501211  0  3057018.   238251.  2419748. 0.   0. 11
5501212  0  3046897.   244388.  2419756. 0.   0. 12
5501213  0  2083108.   252012.7 2416410. 0.   0. 13
5501214  0  2080039.   387090.  2416392. 0.   0. 14
*
*hydro       vel/flw
5501300      0
*
*hydro     f velocity  g velocity   j velocity          jun
5501301  4.29773  4.29773  0. 1 * 35.905
5501302  4.29982  4.29982  0. 2 * 35.905
5501303  4.301785 4.301785 0. 3 * 35.905
5501304  4.30353  4.30353  0. 4 * 35.905
5501305  4.30519  4.30519  0. 5 * 35.90504
5501306 4.30682  4.30682  0. 6 * 35.90505
5501307 7.14808 7.14808 0. 7 * 35.90505
5501308 7.15082 7.15082 0. 8 * 35.90506
5501309 7.15468 7.15468 0. 9 * 35.90506
5501310  7.15914 7.15914 0. 10 * 35.9051
5501311  7.16408 7.16408 0. 11 * 35.9051
5501312  4.31976  4.31976  0. 12 * 35.9051
5501313  -7.11338-6  -7.11349-6  0. 13 * -5.78558-5
*
*hydro   jun hyd diam                        jun
5501401     0.010  0.0 1.0 1.0               5
5501402     0.006  0.0 1.0 1.0               13
*
*-------------------------------------------------------------$
*hydro        component name     component type
5550000          "kcoutlt"          pipe
*-------------------------------------------------------------$
5550001       1
*
```

```
*hydro        vol area                          vol
5550101        0.07728                          1
*
*hydro        length                            vol
5550301        0.7715                           1
*
*hydro        volume                            vol
5550401        0.0                              1
*
*hydro        vert angle                        vol
5550601        90.                              1
*
*hydro        delta z                           vol
5550701        0.7715                           1
*
*hydro       roughness    hyd diam                    vol
5550801      0.00000152    0.120                      1
*
*hydro         fe                               vol
5551001        00                               1
*
*hydro         vcahs                            jun
*5551101        01100                           1
*
*hydro  ebt pressure    tempe                   vol
5551201  0  1687671.   387459.  2412863. 0.    0. 1
*
*hydro       f velocity   g velocity   j velocity          jun
*5551300 0
*5551301    7.52105    7.52105 0.                          2
*
*-------------------------------------------------------------$
*hydro         component name     component type
5560000            "kcoutl"          mtpljun
*-------------------------------------------------------------$
5560001    4  .  0
*
* loss coefficient at fuel channel exit = 0.0679 (10 mm unheated length)
*hydro   from        to         area    f loss   r loss   vcahs
5560011  540010000   555000000  0.       0.0679   0.    01100
5560012  1.0  1.0  1.0  0  0  0  1
5560021  545010000   555000000  0.       0.0679   0.    01100
5560022  1.0  1.0  1.0  0  0  0  2
5560031  546010000   555000000  0.       0.0679   0.    01100
5560032  1.0  1.0  1.0  0  0  0  3
5560041  555010000   557000000  0.       0.0      0.0   01100
5560042  1.0  1.0  1.0  0  0  0  4
*
*hydro             f velocity    g velocity    j velocity
5561011  25.78175  33.60765 1 * 1054.75
5561021  26.20605  34.1519  2 * 2.464164
5561031  26.27665 34.2423   3 * 2.465315
5561041  13.28165 13.28165  4 * 1095.585
*
5562011  0.0024935  0.0 1.0 1.0 1
5562021  0.0024787  0.0 1.0 1.0 2
5562031  0.0024787  0.0 1.0 1.0 3
5562041  0.0024787  0.0 1.0 1.0 4
*
*-------------------------------------------------------------*
*hydro         component name     component type
5320000           "gapoutl"          sngljun
*-------------------------------------------------------------*
*
*hydro   from         to          area      f loss   r loss   vcahs
5320101  550130003   555010003   0.00204   2.78     2.78    01003
*
*hydro   jun hyd diam
5320110     0.0024787    0.0 1.0 1.0
```

```
*
*hydro   vel/flw    f velocity   g velocity   j velocity
5320201 0  16.1534   16.1534  0. * 35.9051
*
*-----------------------------------------------------------------*
*hydro         component name     component type
5570000          "ucoutlt2"         snglvol
*-----------------------------------------------------------------*
*
*hydro       area          length         volume
5570101      0.07728        1.2853          0.
*
*hydro     horz angle     vert angle       delta z
5570102        0.            90.           1.2853
*
*hydro     roughness      hyd diam          fe
5570103    0.00000152      0.120            00
*
*hydro  ebt pressure    tempe
5570200 0  1665063.   387304.  2412592. 0.
*
*-----------------------------------------------------------------$
*hydro         component name     component type
5600000           "crinlet"          pipe
*-----------------------------------------------------------------$
5600001         1
*
*hydro       vol area                             vol
5600101       0.03018                              1
*
*hydro       length                               vol
5600301       2.419                                1
*
*hydro       volume                               vol
5600401       0.                                   1
*
*hydro      vert angle                            vol
5600601       90.                                  1
*
*hydro      delta z                               vol
5600701       2.419                                1
*
*hydro      roughness    hyd diam                     vol
5600801      0.00000152    0.0207                      1
*
*hydro         fe                                 vol
5601001        00                                  1
*
*hydro       vcahs                                jun
*5601101      01100                                1
*
*hydro  ebt pressure    tempe                        vol
5601201  0 2971365.   176620.  2419744. 0.         0. 1
*
*hydro      f velocity   g velocity   j velocity       jun
*5601300 0
*5601301    7.52105    7.52105 0.                      2
*
*-----------------------------------------------------------------$
*hydro         component name     component type
5590000            "crinlt"          mtpljun
*-----------------------------------------------------------------$
5590001    3      0
*hydro   from         to         area    f loss   r loss   vcahs
5590011  560010000   561000000   0.       0.       0.     01000
5590012  1.0  1.0  1.0  0  0  0  1
5590021  560010000   562000000   0.       0.       0.     01000
5590022  1.0  1.0  10  0  0  0  2
5590031  560010000   563000000   0.       0.       0.     01000
5590032  1.0  1.0  1.0  0  0  0  3
*
*hydro             f flowrate    g flowrate    j flowrate
5591011              5.98965       5.98965      1 * 30.0311
5591021              5.95956       5.95956      2 * 107.92
5591031              6.00889       6.00889      3 * 8.7148
*
*hydro   jun hyd diam
5592011  0.044       0.0 1.0 1.0 1
5592021  0.0520521   0.0 1.0 1.0 2
5592031  0.006       0.0 1.0 1.0 3
*
$=========================================================================$
*hydro         component name    component type
5610000          "innercr"        pipe    *flow within control tube
*-----------------------------------------------------------------$
*hydro      no. volumes
5610001        11
*
*hydro      vol area                               vol
5610101     0.00456159                              11
*
*hydro      length                                 vol
5610301      0.1014                                 5
5610302      0.050                                  6
5610303      0.1014                                 11
*
*hydro      volume                                 vol
5610401       0.                                    11
*
*hydro      vert angle                             vol
5610601       90.                                   11
*
*hydro     roughness     hyd diam                     vol
5610801     1.52e-6       0.044                        11
*
*hydro        fe                                  vol
5611001       00                                   11
*
*hydro       vcahs                                 jun
5611101      01000                                  10
*
*hydro  ebt pressure     tempe                           vol
5611201 0  2946293.     178040.8 2419701. 0.          0. 1
5611202 0  2944594.     179812.7 2419698. 0.          0. 2
5611203 0  2942899.     181656.  2419695. 0.          0. 3
5611204 0  2941205.     183511.7 2419692. 0.          0. 4
5611205 0  2939512.     185371.  2419690. 0.          0. 5
5611206 0  2938240.     185427.  2419687. 0.          0. 6
5611207 0  2936953.     185539.3 2419685. 0.          0. 7
5611208 0  2935230.     185651.  2419682. 0.          0. 8
5611209 0  2933507.     185761.6 2419679. 0.          0. 9
5611210 0  2931784.     185871.8 2419676. 0.          0. 10
5611211 0  2930061.     185981.3 2419673. 0.          0. 11
*
*hydro      vel/flw
5611300       0
*
*hydro   f flowrate   g flowrate   j flowrate jun
5611301   5.99052     5.99052    0.    1 * 30.0311
5611302   5.99153     5.99153    0.    2 * 30.0311
5611303   5.9926      5.9926     0.    3 * 30.0311
5611304   5.99368     5.99368    0.    4 * 30.0311
5611305   5.99478     5.99478    0.    5 * 30.0311
5611306   5.99481     5.99481    0.    6 * 30.0311
5611307   5.99488     5.99488    0.    7 * 30.0311
5611308   5.99495     5.99495    0.    8 * 30.0311
5611309   5.99502     5.99502    0.    9 * 30.0311
5611310   5.99509     5.99509    0.   10 * 30.0311
```

```
*
*hydro  jun hyd diam                          jun
5611401    0.044    0.0 1.0 1.0                 10
*
$=====================================================================$
*hydro        component name    component type
5620000          "outercr"    pipe  *flow around control tube
*------------------------------------------------------$
*hydro     no. volumes
5620001        11
*
*hydro        vol area                        vol
5620101        0.0164753                        11
*
*hydro         length                         vol
5620301         0.1014                          5
5620302         0.050                           6
5620303         0.1014                          11
*
*hydro         volume                         vol
5620401          0.                           11
*
*hydro       vert angle                       vol
5620601          90.                          11
*
*hydro       roughness     hyd diam                 vol
5620801        1.52e-6      0.0520521                 11
*
*hydro           fe                           vol
5621001          00                           11
*
*hydro         vcahs                          jun
5621101         01000                           10
*
*hydro  ebt pressure    tempe                       vol
5621201 0  2940828.   182474.  2419692. 0.       0. 1
5621202 0  2939252.   188110.5 2419689. 0.       0. 2
5621203 0  2937680.   193249.6 2419686. 0.       0. 3
5621204 0  2936110.   198102.2 2419684. 0.       0. 4
5621205 0  2934541.   202951.7 2419681. 0.       0. 5
5621206 0  2933357.   203001.4 2419679. 0.       0. 6
5621207 0  2932160.   206275.  2419677. 0.       0. 7
5621208 0  2930549.   210289.6 2419674. 0.       0. 8
5621209 0  2928936.   214414.  2419671. 0.       0. 9
5621210 0  2927324.   218514.  2419668. 0.       0. 10
5621211 0  2925713.   222569.3 2419666. 0.       0. 11
*
*hydro       vel/flw
5621300          0
*
*hydro   f flowrate   g flowrate   j flowrate  jun
5621301   5.96297    5.96297     0.      1 * 107.92
5621302   5.96628    5.96628     0.      2 * 107.92
5621303   5.96937    5.96937     0.      3 * 107.92
5621304   5.97236    5.97236     0.      4 * 107.92
5621305   5.9754     5.9754      0.      5 * 107.92
5621306   5.97544    5.97544     0.      6 * 107.92
5621307   5.97754    5.97754     0.      7 * 107.92
5621308   5.98014    5.98014     0.      8 * 107.92
5621309   5.98286    5.98286     0.      9 * 107.92
5621310   5.98561    5.98561     0.     10 * 107.92
*
*hydro  jun hyd diam                          jun
5621401    0.0520521  0.0 1.0 1.0               10
*
$=====================================================================$
*hydro        component name    component type
5630000           "gap"            pipe
*------------------------------------------------------$
*hydro     no. volumes
5630001        11
*
*hydro        vol area                        vol
5630101       0.0013195                         11
*
*hydro         length                         vol
5630301         0.1014                          5
5630302         0.050                           6
5630303         0.1014                          11
*
*hydro         volume                         vol
5630401          0.                           11
*
*hydro       vert angle                       vol
5630601          90.                          11
*
*hydro       roughness     hyd diam                 vol
5630801        1.52e-6      0.00600                  11
*
*hydro           fe                           vol
5631001         00000                           11
*
*hydro         vcahs                          jun
5631101         01000                           10
*
*hydro  ebt pressure    tempe                       vol
5631201 0  2944727.    186291.4  2419698. 0.     0. 1
5631202 0  2937027.    198163.   2419685. 0.     0. 2
5631203 0  2929392.    210293.   2419672. 0.     0. 3
5631204 0  2921785.    222267.6  2419658. 0.     0. 4
5631205 0  2914196.    234027.5  2419645. 0.     0. 5
5631206 0  2908419.    233767.5  2419635. 0.     0. 6
5631207 0  2902450.    233264.   2419625. 0.     0. 7
5631208 0  2894454.    232787.   2419611. 0.     0. 8
5631209 0  2886458.    232338.   2419597. 0.     0. 9
5631210 0  2878461.    231915.   2419583. 0.     0. 10
5631211 0  2870464.    231519.   2419568. 0.     0. 11
*
*hydro       vel/flw
5631300          0
*
*hydro   f flowrate   g flowrate j flowrate jun
5631301   6.01457  6.01457   0.     1 * 8.7148
5631302   6.02183  6.02183   0.     2 * 8.7148
5631303   6.02965  6.02965   0.     3 * 8.7148
5631304   6.03774  6.03774   0.     4 * 8.7148
5631305   6.04606  6.04606   0.     5 * 8.7148
5631306   6.04589  6.04589   0.     6 * 8.7148
5631307   6.04554  6.04554   0.     7 * 8.7148
5631308   6.04522  6.04522   0.     8 * 8.7148
5631309   6.04492  6.04492   0.     9 * 8.7148
5631310   6.04464  6.04464   0.    10 * 8.7148
*
*hydro  jun hyd diam                          jun
5631401    0.006    0.0 1.0 1.0                 10
*
*------------------------------------------------------$
*hydro        component name    component type
5640000          "croutlt"         pipe
*------------------------------------------------------$
5640001        1
*
*hydro        vol area                        vol
5640101        0.03018                          1
*
*hydro         length                         vol
5640301        2.0568                           1
*
```

```
*hydro      volume                         vol
5640401       0.                           1
*
*hydro      vert angle                     vol
5640601       90.                          1
*
*hydro      delta z                        vol
5640701       2.0568                       1
*
*hydro      roughness     hyd diam                 vol
5640801       0.00000152    0.0207                 1
*
*hydro        fe                           vol
5641001       00                           1
*
*hydro      vcahs                          jun
*5641101      01100                        1
*
*hydro  ebt pressure    tempe                      vol
5641201  0  1821830.   215620.4 2414334. 0.        0. 1
*
*hydro      f velocity  g velocity  j velocity        jun
*5641300 0
*5641301    7.52105    7.52105 0.                     2
*
*-----------------------------------------------------------$
*hydro          component name    component type
5660000           "crinlt"          mtpljun
*-----------------------------------------------------------$
5660001   3     0
*
* calibrated exit losses to get velocity to 6 m/s in CR channels
*
*  55.82/55.70/52.13 ======>    5.97139  5.99083  6.01318
*
*hydro   from         to          area    f loss   r loss   vcahs
5660011  561010000   564000000   0.       55.82    55.82   01000
5660012  1.0  1.0  1.0  0  0  0  1
5660021  562010000   564000000   0.       55.70    55.70   01000
5660022  1.0  1.0  1.0  0  0  0  2
5660031  563010000   564000000   0.       52.13    52.13   01000
5660032  1.0  1.0  1.0  0  0  0  3
*
*hydro           f flowrate     g flowrate    j flowrate
5661011            5.99516        5.99516      1 * 30.0311
5661021            5.98837        5.98837      2 * 107.92
5661031            6.04437        6.04437      3 * 8.7148
*
*hydro   jun hyd diam
5662011  0.044       0.0 1.0 1.0 1
5662021  0.0520521   0.0 1.0 1.0 2
5662031  0.006       0.0 1.0 1.0 3
*
*-----------------------------------------------------------$
*hydro          component name    component type
5650000           "cpbtex"          pipe
*-----------------------------------------------------------$
5650001        1
*
*hydro      vol area                       vol
5650101       0.24663                      1
*
*hydro      length                         vol
5650301       0.918                        1
*
*hydro      volume                         vol
5650401       0.                           1
*
*hydro      vert angle                     vol
5650601       90.                          1
*
*hydro      delta z                        vol
5650701       0.540                        1
*
*hydro      roughness     hyd diam                 vol
5650801       0.0000457     0.56037                1
*
*hydro        fe                           vol
5651001       00                           1
*
*hydro      vcahs                          jun
*5651101      01100                        1
*
*hydro  ebt pressure    tempe                      vol
5651201  0  1696541.   340731.  2412968. 0.        0. 1
*
*hydro      f velocity  g velocity  j velocity        jun
*5651300 0
*5651301    7.52105    7.52105 0.                     2
*
*-----------------------------------------------------------$
*hydro          component name    component type
5670000           "cpbtex"          mtpljun
*-----------------------------------------------------------$
5670001   4     0
*hydro   from         to          area       f loss   r loss   vcahs
5670011  557010000   565000000   0.          0.       0.      01100
5670012  1.0  1.0  1.0  0  0  0  1
5670021  525010000   565000000   0.          0.       0.      01100
5670022  1.0  1.0  1.0  0  0  0  2
*
* Kexit = 0.15*Kentrance =  22.80
*
5670031  564010000   565000000   0.0250354   5.25     5.25    01000
5670032  1.0  1.0  1.0  0  0  0  3
5670041  565010000   640000000   0.          0.24     0.24    01100
5670042  1.0  1.0  1.0  0  0  0  4
*
*hydro          f velocity    g velocity    j velocity
5671011  13.28143   13.8851   1 * 1095.585
5671021  12.5155    13.12035 2 * 758.611
5671031  5.35405    5.77968  3 * 146.6658
5671041  7.54176    8.22472  4 * 2000.86
*
*hydro   jun hyd diam
5672011  0.120  0.0 1.0 1.0 1
5672021  0.132  0.0 1.0 1.0 2
5672031  0.190  0.0 1.0 1.0 3
5672041  0.5604 0.0 1.0 1.0 4
*
*===============================================================$
*
*               MODERATOR TANK
*
*===============================================================$
*
*-----------------------------------------------------------*
*hydro          component name    component type
1670000           "connect"         sngljun
*-----------------------------------------------------------*
*hydro   from        to          area        f loss  r loss fvcahs disch
1670101  530010003  575020003  0.0000001    1.e6    1.e6   031000  1.0
*
1670110     0.3255     0.0 1.0 1.0
*
*hydro     vel/flw    f massrate    g massrate    j massrate
1670201 0  .0704636 .0704636 0. * 7.74585-6
*
```

```
*-----------------------------------------------------------*
*hydro       component name    component type
5700000        "modcool"         tmdpvol
*-----------------------------------------------------------*
*hydro     area    length    volume
5700101    1.e6     .0      1.0e+06
*
*hydro   horz angle  vert angle   delta z
5700102     .0         .0          .0
*
*hydro    roughness  hyd diam     fe
5700103     .0         .0         10
*
*hydro  ebt      trip no.    alpha vrc    numeric vrc
5700200 003
*
*hydro  time    pressure    tempe
5700201  0.      1.e5        300.
*
*-----------------------------------------------------------*
*hydro       component name    component type
5710000        "tankcool"        tmdpjun
*-----------------------------------------------------------*
*hydro   from        to          area
5710101  570000000   575000000   0.0286
*
*hydro   vel/flw    trip no.    alpha vrc    numeric vrc
5710200    1
*
*hydro   time      f flow     g flow     j flow
5710201  0.         316.4      0.          0
5710202  1.e6       316.4      0.          0
*
*-----------------------------------------------------------*
*hydro       component name    component type
5750000        "modtank"         pipe
*-----------------------------------------------------------$
5750001       4
*
*hydro      vol area                         vol
5750101      2.7539                           4
*
*hydro      length                           vol
5750301      1.2675                           1
5750302      1.545                            2
5750303      1.064                            3
5750304      0.7715                           4
*
*hydro      volume                           vol
5750401      0.                              4
*
*hydro      vert angle                       vol
5750601      90.                             4
*
*hydro      delta z                          vol
5750701      1.2675                           1
5750702      1.545                            2
5750703      1.064                            3
5750704      0.7715                           4
*
*hydro      roughness    hyd diam                 vol
5750801      0.0000457    0.532                    4
*
*hydro      fe                              vol
5751001      00                              4
*
*hydro      vcahs                           jun
5751101      01000                           3
*

*hydro ebt pressure    tempe                            vol
5751201  0  143458.7 98151.5 2339196. 0. 0. 1
5751202  0  128232.3 98151.4 2335630. 0. 0. 2
5751203  0  114107.7 98151.4 2331943. 0. 0. 3
5751204  0  104170.7 98151.4 2329100. 0. 0. 4
5751301  .1040595 .1242055 0. 1 * 316.4
5751302  .1040603 .1242064 0. 2 * 316.4
5751303  .104061  .1242073 0. 3 * 316.4
*
*-----------------------------------------------------------*
*hydro       component name    component type
5760000        "tankout"         sngljun
*-----------------------------------------------------------*
*hydro   from        to          area      f loss   r loss   vcahs
5760101  575010000   580000000   0.028603  0.       0.       01000
*
*hydro   vel/flw    f velocity   g velocity   j velocity
5760201 0   10.01905   10.66442 0. * 316.4
*
*-----------------------------------------------------------*
*hydro       component name    component type
5800000        "modtankp"        tmdpvol
*-----------------------------------------------------------*
*hydro     area    length    volume
5800101    1.e6     .0      1.0e+06
*
*hydro   horz angle  vert angle   delta z
5800102     .0         .0          .0
*
*hydro    roughness  hyd diam     fe
5800103     .0         .0         10
*
*hydro  ebt      trip no.    alpha vrc    numeric vrc
5800200 003
*
*hydro  time    pressure    tempe
5800201  0.      1.e5        300.
5800202  1.e6    1.e5        300.
*
*===========================================================$
*
*              HOT LEG MAIN HEADER
*
*===========================================================$
*
*-----------------------------------------------------------*
*hydro       component name    component type
6400000        "coreout"         pipe
*-----------------------------------------------------------*
6400001       3
*
*hydro      vol area                         vol
6400101      0.24663                          3
*
*hydro      length                           vol
6400301      0.6267                           3
*
*hydro      volume                           vol
6400401      0.                              3
*
*hydro      volume                           vol
6400501      0.                              3
*
*hydro      vert angle                       vol
6400601      0.                              3
*
*hydro      vert length                      vol
6400701      0.00                            3
*
```

```
*hydro     roughness    hyd diam                 vol
6400801     0.0000457    0.56037                   3
*
*hydro      f loss     r loss               jun
6400901      0.00      0.00                   2
*
*hydro       fe                         vol
6401001       00                           3
*
*hydro       vcahs                        jun
6401101       01000                          2
*
*hydro  ebt pressure     tempe                    vol
6401201  0  1685793.   340717.  2412840. 0.      0. 1
6401202  0  1685391.   340703.  2412836. 0.      0. 2
6401203  0  1684989.   340689.  2412831. 0.      0. 3
*
*hydro      vel/flw
6401300       0
*
*hydro      f flowrate   g flowrate   j flowrate          jun
6401301  7.54178    7.54178 0. 1 * 2000.86
6401302  7.54176    7.54176 0. 2 * 2000.86
*
*-----------------------------------------------------------*
*hydro          component name     component type
1640000            "riserin"            sngljun
*-----------------------------------------------------------$
*hydro   from         to          area    f loss   r loss   vcahs
1640101 640010000  641000000       0.      0.4      0.4   01000
*
*hydro   hyd diam
1640110 0.56037 0.  1. 1.
*
*hydro   vel/flw      f velocity     g velocity    j velocity
1640201     0          7.54175        7.54175       0. * 2000.862
*
*-----------------------------------------------------------*
*hydro          component name     component type
6410000            "hlriser"           pipe
*-----------------------------------------------------------*
6410001        3
*
*hydro       vol area                       vol
6410101        0.24663                        3
*
*hydro       length                        vol
6410301        2.33667                        3
*
*hydro        volume                        vol
6410401          0.                        3
*
*hydro        volume                        vol
6410501          0.                        3
*
*hydro       vert angle                      vol
6410601        90.                           3
*
*hydro       vert length                     vol
6410701        2.33667                        3
*
*hydro      roughness    hyd diam                 vol
6410801     0.0000457     0.56037                   3
*
*hydro      f loss      r loss               jun
6410901       0.          0.                  2
*
*hydro       fe                         vol
6411001       00                           3
*
*hydro       vcahs                                 jun
6411101       01000                                  2
*
*hydro  ebt pressure     tempe                       vol
6411201  0  1659459.   340654.  2412525. 0.      0. 1
6411202  0  1633306.   340618.4 2412208. 0.      0. 2
6411203  0  1607152.   340583.  2411886. 0.      0. 3
*
*hydro       vel/flw
6411300        0
*
*hydro      f flowrate   g flowrate   j flowrate            jun
6411301  7.54179    8.22555 0. 1 * 2000.863
6411302  7.54184    8.22617 0. 2 * 2000.864
*
*-----------------------------------------------------------$
*hydro          component name      component type
6450000            "coreout"           pipe
*-----------------------------------------------------------$
6450001        2
*
*hydro       vol area                          vol
6450101        0.24663                           2
*
*hydro       length                            vol
6450301        4.88                              1
6450302        3.35                              2
*
*hydro        volume                           vol
6450401         0.0                            2
*
*hydro       vert angle                        vol
6450601         0.                             2
*
*hydro       delta z                           vol
6450701         0.                             2
*
*hydro      roughness    hyd diam                  vol
6450801     0.0000457     0.56037                    2
*
*hydro        fe                             vol
6451001        00                              2
*
*hydro        vcahs                          jun
6451101        01000                           1
*
*hydro  ebt pressure     tempe                       vol
6451201  0  1585148.   340509.  2411613. 0.      0. 1
6451202  0  1582491.   340458.5 2411580. 0.      0. 2
*
*hydro      f velocity   g velocity   j velocity          jun
6451300 0
6451301   7.54188    7.54188 0.                        1 *
+ * 2000.868
+ * 2000.792
+ * 1974.102
+ * 2001.035
+ * 2001.057
*
*-----------------------------------------------------------$
*hydro          component name      component type
6470000            "creout"            mtpljun
*-----------------------------------------------------------$
6470001    2     0
*hydro   from          to           area     f loss   r loss   vcahs
6470011  641010000   645000000   0.        0.24     0.24   01000
6470012  1.0  1.0  1.0  0  0  0  1
6470021  645010000   650000000   0.        0.       0.     01000
```

```
6470022  1.0  1.0  1.0  0  0  0  2
*
6471011  7.54189   8.2268  1 * 2000.865
6471021  20.9488   20.9488  2 * 2000.87
*
6472011  0.56037 0.0 1.0 1.0 1
6472021  0.56037 0.0 1.0 1.0 2
*
*-------------------------------------------------------$
*hydro        component name    component type
6500000         "hothead"          pipe
*-------------------------------------------------------$
6500001       4
*
*hydro      vol area                               vol
6500101       0.08879                                1
6500102       0.24663                                4
*
*hydro       length                               vol
6500301       1.68                                  1
6500302       3.51                                  2
6500303       1.22                                  3
6500304       1.83                                  4
*
*hydro       volume                                vol
6500401        0.                                  4
*
*hydro      vert angle                             vol
6500601        0.                                  4
*
*hydro      elev. change                           vol
6500701        0.                                  4
*
*hydro      roughness     hyd diam                     vol
6500801      0.0000457     0.33622                        1
6500802      0.0000457     0.56037                        4
*
*hydro       f loss      r loss                    jun
6500901       0.00        0.00                        2
6500902       0.20        0.20                        3
*
*hydro         fe                                vol
6501001        00                                  4
*
*hydro        vcahs                              jun
6501101        01000                                3
*
*hydro  ebt pressure    tempe                          vol
6501201  0  1368415.   340445.5 2408383. 0.     0. 1
6501202  0  1565159.   340392.5 2411362. 0.     0. 2
6501203  0  1563230.   338636.  2411337. 0.     0. 3
6501204  0  1589808.   338555.3 2411671. 0.     0. 4
*
*hydro       vel/flw
6501300        0
*
*hydro       f flowrate  g flowrate   j flowrate              jun
6501301  20.9507     20.9507  0. 1 * 2000.87
6501302  7.54182     7.54182 0. 2 * 2000.87
6501303  2.5661      2.5661   0. 3 * 680.984
*
*=====================================================================$
*
*          PRESSURIZING SYSTEM
*
*=====================================================================$
*
*-------------------------------------------------------$
*hydro         component name     component type

8000000          "mutank"           tmdpvol
*-------------------------------------------------------$
*hydro       area      length      volume
8000101       1.e6       .0       1.0e+06
*
*hydro     horz angle  vert angle   delta z
8000102        .0          .0          .0
*
*hydro      roughness   hyd diam      fe
8000103        .0         .0          10
*
*hydro  ebt        trip no.       alpha vrc      numeric vrc
8000200 003
*
*hydro   time     pressure     tempe
8000201  0.      0.165e6      300.
*
*-------------------------------------------------------$
* trip valve to isolate the pressurizing system following
* draining of the makeup tank
*-------------------------------------------------------$
*
8050000    isolate      valve
8050101    800000000    810000000 0.00811  0.48 0.48 01000
8050201 0   1.632018    1.632018   0. * 14.61378
8050300   trpvlv
8050301    615
*
*-------------------------------------------------------$
*hydro          component name     component type
8100000           "suction"             branch
*-------------------------------------------------------$
*hydro         no. juns          vel/flw
8100001           0                 0
*
*hydro         area             length            volume
8100101       0.00811             6.096              0.
*
*hydro       horz angle          vert angle          delta z
8100102          0.                  0.                0.
*
*hydro        roughness          hyd diam            fe
8100103       0.0000457           0.1016              00
*
*hydro  ebt pressure     tempe
8100200 0  161997.    97873.7 2343094. 0.
*
*-------------------------------------------------------
*hydro       component name    component type
8150000     mainprz    pump
*-------------------------------------------------------
*hydro        area          length         volume
8150101     0.00811          0.            .0203
*
8150102         0.              0.              0.
*
*hydro        equil flag
8150103          00
*
*hydro     from      jun area    f loss     r loss     vcahs
8150108     810010000  0.00811      0.16       0.16      01000
*
*hydro      to       jun area    f loss     r loss     vcahs
8150109     820000000  0.00811      0.16       0.16      01000
*
*hydro  ebt pressure      tempe
8150200 0  883766.     100661.  2396979. 0.
*
*hydro   vel/flw    f velocity     g velocity    j velocity
```

```
8150201 0  1.63202   1.63202   0. * 14.61378
*
*hydro   vel/flw   f velocity    g velocity   j velocity
8150202 0  1.631706  1.631706  0. * 14.61377
*
*hydro    ptdi  2fazi  diff i  tork i  pvel i  trip no.  rvrs i
8150301    0     -1     -3      -1      0       540       0
*
*hydro   rated pump vel.  init/rated vel.  rated flow   rated head
8150302       221.55        1.080816         0.01366      106.39
*
*hydro   rated torque    mom of inertia   rated dens   mtr torque
8150303      217.82           2.381          1098.         .0
*
*hydro   coeff. tf2      coeff. tf0     coeff. tf1   coeff. tf3
8150304     2.1782          2.1782          0.           0.
*
*-------------------------------------------------------------------$
* single phase homologous curves
*-------------------------------------------------------------------$
* han homologous data
8151100 1 1 0.000 1.228  0.050 1.226  0.100 1.225
8151101 0.150 1.224  0.200 1.223  0.250 1.223
8151102 0.300 1.222  0.350 1.220  0.400 1.218
8151103 0.450 1.214  0.500 1.209  0.550 1.202
8151104 0.600 1.192  0.650 1.180  0.700 1.165
8151105 0.750 1.147  0.800 1.126  0.850 1.101
8151106 0.900 1.072  0.950 1.038  1.000 1.000
* hvn homologous data
8151200 1 2 0.513 -.270  0.526 -.233  0.541 -.195
8151201 0.556 -.155  0.571 -.113  0.588 -.069
8151202 0.606 -.023  0.625 0.025  0.645 0.076
8151203 0.667 0.130  0.690 0.187  0.714 0.249
8151204 0.741 0.316  0.769 0.388  0.800 0.466
8151205 0.833 0.551  0.870 0.646  0.909 0.751
8151206 0.952 0.868  1.000 1.000
* had homologous data taken from bingham pump in relap
8151300 1 3 -1. 2.5 -.9 2.28  -.63 2.  -.55 1.74
8151301 -.5 1.68  -.42 1.6  -.15 1.4  0. 1.228
* hvd homologous data taken from bingham pump in relap
8151400 1 4 -1. 2.5 -.9 2.28  -.63 2.  -.55 1.74
8151401 -.5 1.68  -.42 1.6  -.15 1.4  0. 1.228
* ban homologous data
8151500 2 1 0.000 0.470  0.050 0.500  0.100 0.529
8151501 0.150 0.559  0.200 0.589  0.250 0.618
8151502 0.300 0.648  0.350 0 677  0.400 0.706
8151503 0.450 0.734  0.500 0.762  0.550 0.789
8151504 0.600 0.816  0.650 0.842  0.700 0.867
8151505 0.750 0.892  0.800 0.915  0.850 0.938
8151506 0.900 0.960  0.950 0.980  1.000 1.000
* bvn homologous data
8151600 2 2 0.513 0.283  0.526 0.302  0.541 0.321
8151601 0.556 0.342  0.571 0.364  0.588 0.388
8151602 0.606 0.413  0.625 0.439  0.645 0.468
8151603 0.667 0.498  0.690 0.531  0.714 0.566
8151604 0.741 0.604  0.769 0.645  0.800 0.691
8151605 0.833 0.740  0.870 0.795  0.909 0.856
8151606 0.952 0.924  1.000 1.000
* bad homologous data taken from bingham pump in relap
8151700 2 3 -1. 2.5  -.8 2.  -.6 1.45  -.46 1.15
8151701 -.3 .95  -.13 .8  0. .8
* bvd homologous data taken from bingham pump in relap
8151800 2 4 -1. 2.5  -.65 2.15  -.4 1.79  -.30 1.61
8151801 -.13 1.5  0. 1.44
* pump trip
8156100  620  cntrlvar 815
*8156100  0  cntrlvar 591
8156101 -1.e6 -1.e6
8156102 1.e6 1.e6
```

```
*
*-------------------------------------------------------------------$
*hydro        component name     component type
8200000          "maindisc"          snglvol
*-------------------------------------------------------------------$
*hydro          area          length          volume
8200101        0.00811          30.48            0.
*
*hydro       horz angle       vert angle        delta z
8200102          0.               0.              0.
*
*hydro        roughness        hyd diam          fe
8200103       0.0000457         0.1016           00
*
*hydro  ebt pressure    tempe
8200200 0  1602253.   100669.  2411826. 0.
*
*-------------------------------------------------------------------$
*hydro        component name     component type
8250000          "mainpump"          valve
*-------------------------------------------------------------------$
*hydro    from          to          area     f loss   r loss   vcahs
8250101   820010000    850000000   0.00811   1.28     1.28     01000
*
*hydro    vel/flw     f velocity    g velocity    j velocity
8250201 0   1.631146   1.631146  0. * 14.6136
*
*hydro            valve type
8250300              chkvlv
*
*hydro   chkvlv type  init. posn  back press  leak ratio
8250301      0           0           0.          0.
*
*-------------------------------------------------------------------$
*hydro        component name     component type
8260000          "mutank"            tmdpvol
*-------------------------------------------------------------------$
*hydro      area      length      volume
8260101      1.e6       .0        1.0e+06
*
*hydro    horz angle  vert angle   delta z
8260102       .0          .0          .0
*
*hydro     roughness   hyd diam      fe
8260103        .0          .0         10
*
*hydro  ebt       trip no.     alpha vrc      numeric vrc
8260200 003
*
*hydro  time     pressure     tempe
8260201  0.      0.165e6      300.
*
*-------------------------------------------------------------------$
* trip valve to shut off time dependent volume from przing system
* following draining of the makeup tank
*-------------------------------------------------------------------$
*
8270000  isolate valve
8270101 826000000 828000000 0.00811 0.48 0.48 01000
8270201 0   3.082857-44  -2.44452-21  0. * 2.76056-43
8270300 trpvlv
8270301  615
*
*-------------------------------------------------------------------$
*hydro        component name     component type
8280000          "suction"           branch
*-------------------------------------------------------------------$
*hydro        no. juns        vel/flw
8280001          0               0
```

```
*
*hydro      area        length      volume
8280101     0.00811     6.096       0.
*
*hydro      horz angle  vert angle  delta z
8280102     0.          0.          0.
*
*hydro      roughness   hyd diam    fe
8280103     0.0000457   0.1016      00
*
*hydro ebt pressure  uf     ug      voidg
8280200 0 1.65+5   83097. 2343686. 0.
*
*----------------------------------------------------------------$
*hydro      component name   component type
8300000     "standby"        pump
*----------------------------------------------------------------$
*hydro      area        length      volume
8300101     0.00811     0.          0.0232
*
*hydro      horz angle  vert angle  delta z
8300102     0.          0.          0.
*
*hydro      equil flag
8300103     00
*
*hydro   from       jun area  f loss   r loss   vcahs
8300108  828010000  0.00811   0.16     0.16     01000
*
*hydro   to         jun area  f loss   r loss   vcahs
8300109  835000000  0.00811   0.16     0.16     01000
*
*hydro ebt pressure   tempe
8300200 0 1.65+5   83054.7 2343686. 0.
*
*hydro   vel/flw   f velocity    g velocity    j velocity
8300201 0  2.382207-44  1.60856-21  0. * 2.186026-43
*
*hydro   vel/flw   f velocity    g velocity    j velocity
8300202 0  2.242078-44  -4.32082-22 0. * 2.003857-43
*
*hydro   ptdi  2fazi  diff i  tork i  pvel i  trip no.  rvrs i
8300301  815   -1     -3      -1      0       541       0
*
*hydro   rated pump vel.  init/rated vel.  rated flow  rated head
8300302  221.55           0.               0.01366     106.39
*
*hydro   rated torque   mom of inertia   rated dens   mtr torque
8300303  217.82         2.381            1098.        .0
*
*hydro   coeff. tf2   coeff. tf0   coeff. tf1   coeff. tf3
8300304  2.1782       2.1782       0.           0.
*
*hydro   trip no.   alpha vrc   numeric vrc
8306100  621        cntrlvar    830
*
*hydro   search arg   pump vel.
8306101  -1.e6        -1.e6
8306102  1.e6         1.e6
*
*----------------------------------------------------------------$
*hydro      component name   component type
8350000     "sbdisc"         snglvol
*----------------------------------------------------------------$
*hydro      area        length      volume
8350101     0.00811     30.48       0.
*
*hydro      horz angle  vert angle  delta z
8350102     0.          0.          0.
*
*hydro      roughness   hyd diam    fe
8350103     0.0000457   0.1016      00
*
*hydro ebt pressure   tempe
8350200 0 1.65+5   83054.7 2343686. 0.
*
*----------------------------------------------------------------$
*hydro      component name   component type
8400000     "sbpump"         valve
*----------------------------------------------------------------$
*hydro   from       to         area     f loss  r loss  vcahs
8400101  835010000  850000000  0.00811  1.28    1.28    01000
*
*hydro   vel/flw   f velocity   g velocity   j velocity
8400201 0  0.      0. 0. * 0.
*
*hydro        valve type
8400300       chkvlv
*
*hydro   chkvlv type  init. posn  back press  leak ratio
8400301  0            1           0.          0.
*
*----------------------------------------------------------------$
*hydro      component name   component type
8450000     "emerpump"       tmdpjun
*----------------------------------------------------------------$
*hydro   from       to         area
8450101  810010000  850000000  0.001
*
*hydro   vel/flw   trip no.   alpha vrc   numeric vrc
8450200  0         542
*
*hydro   time     f velocity   g velocity   j velocity
8450201 -1.       0.           0.           00
8450202  0.       0.           0.           00
8450203  10.      25.          0.           00
8450204  1.e6     25.          0.           00
*
*----------------------------------------------------------------$
*hydro      component name   component type
8500000     "przrout"        branch
*----------------------------------------------------------------$
*hydro      no. juns    vel/flw
8500001     1           0
*
*hydro      area        length      volume
8500101     0.00811     12.20       0.
*
*hydro      horz angle  vert angle  delta z
8500102     0.          0.          0.
*
*hydro      roughness   hyd diam    fe
8500103     0.0000457   0.1016      00
*
*hydro ebt pressure   tempe
8500200 0 1594564.  100671.9 2411730. 0.
*
*hydro   from       to         area     f loss  r loss  vcahs
8501101  850010002  650030001  0.00811  0.      0.      01100
*
*hydro             f velocity   g velocity   j velocity
8501201  1.631208  1.631208  0. * 14.6141
*
*================================================================$
$
$            LETDOWN SYSTEM
$
*================================================================$
```

```
*
*-----------------------------------------------------------------$
*hydro       component name    component type
8610000        "letdown"          valve
*-----------------------------------------------------------------$
*hydro  from        to        area     f loss   r loss   vcahs
8610101  106010000   865000000  0.00028355 0.     0.     00100
*
*hydro  vel/flw    f flowrate    g flowrate   j flowrate
8610201   0        .0543178      .0543178     0. * 4.86447
*
*hydro             valve type
8610300              srvvlv
*
*hydro    cntrlvar  table no.
8610301     860       0
*
$=====================================================================$
*hydro       component name    component type
8620000        "letdown"          valve
*-----------------------------------------------------------------$
*hydro  from        to        area     f loss   r loss   vcahs
8620101  206010000   865000000  0.00028355 0.     0.     00100
*
*hydro  vel/flw    f flowrate    g flowrate   j flowrate
8620201   0        .0542849      .0542849     0. * 4.86137
*
*hydro             valve type
8620300              srvvlv
*
*hydro    cntrlvar  table no.
8620301     860       0
*
$=====================================================================$
*hydro       component name    component type
8630000        "letdown"          valve
*-----------------------------------------------------------------$
*hydro  from        to        area     f loss   r loss   vcahs
8630101  306010000   865000000  0.00028355 0.     0.     00100
*
*hydro  vel/flw    f flowrate    g flowrate   j flowrate
8630201   0        .0546334      .0546334     0. * 4.8927
*
*hydro             valve type
8630300              srvvlv
*
*hydro    cntrlvar  table no.
8630301     860       0
*
$=====================================================================$
*hydro       component name    component type
8650000        "ldoutlet"         branch
*-----------------------------------------------------------------$
*hydro        no. juns        vel/flw
8650001         1               0
*
*hydro        area          length         volume
8650101       0.3333          1.             0.
*
*hydro      horz angle      vert angle      delta z
8650102        0.              0.             0.
*
*hydro      roughness       hyd diam        fe
8650103     0.0000457          0.            00
*
*hydro  ebt pressure    tempe
8650200 0  99999.2    337891.  2327831. 0.
*
*hydro   from       to        area    f loss   r loss   vcahs
8651101  865010000   870000000  0.3333    0.      0.     01000
*
*hydro           f flowrate    g flowrate   j flowrate
8651201            .0407829      .0407829    0. * 14.61853
*
$=====================================================================$
*hydro       component name    component type
8700000        "ldsink"          tmdpvol
*-----------------------------------------------------------------$
*hydro       area     length     volume
8700101      1.e6       .0       1.0e+06
*
*hydro    horz angle  vert angle   delta z
8700102      .0          .0          .0
*
*hydro    roughness  hyd diam     fe
8700103      .0          .0        10
*
*hydro  ebt      trip no.     alpha vrc     numeric vrc
8700200 003
*
*hydro  time    pressure    tempe
8700201  0.     0.1e6       356.5
*
*=====================================================================$
* primary coolant system safety pressure relief valve
*-----------------------------------------------------------------$
*hydro       component name    component type
8800000         "relief"          valve
*-----------------------------------------------------------------$
*hydro  from        to        area     f loss   r loss   vcahs
8800101  850010000   895000000  2.456e-4   0.     0.     01100
*
*hydro  vel/flw    f flowrate    g flowrate   j flowrate
8800201 0  0.      0. 0. * 0.
*
*hydro             valve type
8800300              trpvlv
*
*hydro              trip no.
8800301               611
*
*=====================================================================$
*hydro       component name    component type
8950000        "vlvsink"         tmdpvol
*-----------------------------------------------------------------$
*hydro       area     length     volume
8950101      1.e6       .0       1.0e+06
*
*hydro    horz angle  vert angle   delta z
8950102      .0          .0          .0
*
*hydro    roughness  hyd diam     fe
8950103      .0          .0        10
*
*hydro  ebt      trip no.     alpha vrc     numeric vrc
8950200 002
*
*hydro  time    pressure    quale
8950201  0.     0.1e6       1.
*
*=====================================================================$
*                                $
*  >>>>>>> INDIVIDUAL HEAT EXCHANGER/PUMP LOOPS   <<<<<<<      $
*                                $
*=====================================================================$
*
*-----------------------------------------------------------------$
*
```

```
*     components 1xx - heat exchanger coolant loop 1
*
*------------------------------------------------------------$
*hydro      component name    component type
1010000       "hlsplit1"         pipe
*------------------------------------------------------------$
1010001     3
*
*hydro      vol area                          vol
1010101      0.08322                            3
*
*hydro      length                            vol
1010301      1.07                               1
1010302      3.66                               2
1010303      2.21                               3
*
*hydro      volume                            vol
1010401      0.0                               3
*
*hydro      vert angle                        vol
1010601      0.                                3
*
*hydro      delta z                           vol
1010701      0.                                3
*
*hydro      roughness    hyd diam                 vol
1010801      0.0000457    0.3255                    3
*
*hydro      kf     kr                         jun
1010901      0.182  0.182                         2
*
*hydro      fe                                vol
1011001      00                                 3
*
*hydro      vcahs                             jun
1011101      01100                              2
*
*hydro ebt pressure   tempe                       vol
1011201 0 1560632.  338597. 2411304. 0.     0. 1
1011202 0 1552628.  338464. 2411203. 0.     0. 2
1011203 0 1543972.  338384. 2411093. 0.     0. 3
*
*hydro      vel/flw
1011300      0
*
*hydro     f velocity  g velocity  j velocity       jun
1011301   7.3286    7.3286 0.                   1 * 656.248
1011302   7.32847   7.32847 0.                   2 * 656.248
*
*------------------------------------------------------------$
*hydro      component name    component type
1030000       "hlsp1j"          mtpljun
*------------------------------------------------------------$
1030001   1    0
*hydro   from        to        area    f loss   r loss   vcahs
1030011  650030002   101010001  0.24663   1.20     1.20   01000
1030012  1.0  1.0  1.0  0  0  0  1
*
1031011  2.47289  2.47289  1 * 656.248
*
1032011  0.56037 0.0 1.0 1.0 1
*
*------------------------------------------------------------$
*hydro      component name    component type
1020000       "isolate"         valve
*------------------------------------------------------------$
*hydro   from        to         area     f loss  r loss   vcahs
1020101  101010000   104000000  0.08322  0.104   0.104   01100
*
```

```
*hydro   vel/flw    f flowrate   g flowrate   j flowrate
1020201 0  7.3284    7.3284 0. * 656.248
*
*hydro          valve type
1020300           trpvlv
*
*hydro          trip no.
1020301            515
*
*------------------------------------------------------------$
*hydro      component name    component type
1040000       "hotleg"          pipe
*------------------------------------------------------------$
1040001     3
*
*hydro     vol area                            vol
1040101     0.08322                              3
*
*hydro     length                              vol
1040301     0.69                                 1
1040302     12.95                                2
1040303     2.51                                 3
*
*hydro     volume                              vol
1040401     0.                                 3
*
*hydro     volume                              vol
1040501     0.                                 3
*
*hydro     vert angle                          vol
1040601     0.                                 2
1040602     90.                                3
*
*hydro     delta z                             vol
1040701     0.                                 2
1040702     2.44                               3
*
*hydro     roughness    hyd diam                   vol
1040801    0.0000457    0.3255                       3
*
*hydro     f loss     r loss                   jun
1040901     0.0       0.0                        1
1040902     0.24      0.24                       2
*
*hydro     fe                                  vol
1041001     00                                   3
*
*hydro     vcahs                               jun
1041101     01000                                2
*
*hydro ebt pressure   tempe                          vol
1041201 0 1539289.  338358.6 2411033. 0.      0. 1
1041202 0 1531421.  337886.6 2410932. 0.      0. 2
1041203 0 1502711.  337796.5 2410561. 0.      0. 3
*
*hydro     vel/flw
1041300     0
*
*hydro     f flowrate  g flowrate  j flowrate          jun
1041301  7.32839   7.32839 0. 1 * 656.247
1041302  7.3276    7.3276 0. 2 * 656.223
*
*================================================================$
*
*          MAIN HEAT EXCHANGER - LOOP 1
*
*================================================================$
*
*------------------------------------------------------------$
```

```
*hydro        component name    component type
1060000         "hxplin1"         branch
*---------------------------------------------------------------$
*hydro       no. juns        vel/flw
1060001        2               0
*
*hydro       area          length         volume
1060101      0.08322         1.0            0.
*
*hydro       horz angle     vert angle      delta z
1060102        0.             0.             0.
*
*hydro       roughness      hyd diam         fe
1060103      0.0000457       0.3255           0
*
*hydro ebt pressure    tempe
1060200 0 1516144.   337797.6 2410735. 0.
*
*hydro  from        to         area    f loss   r loss   vcahs
1061101 106000000  108000000    0.      0.15     0.15  01000
1062101 104010000  106000000    0.      0.       0.    01000
*
*hydro  hyd diam
1061110 0.3255  0.0 1.0 1.0
1062110 0.3255  0.0 1.0 1.0
*
*hydro            f velocity   g velocity   j velocity
1061201  7.27322   7.27322 0. * 651.358
1062201  7.32758   7.91376 0. * 656.223
*
*---------------------------------------------------------------*
*hydro        component name    component type
1080000         "mhx-prim"        pipe
*---------------------------------------------------------------$
1080001      11
*
*hydro      vol area                          vol
1080101      0.8258                            5
1080102      0.841                             6
1080103      0.8258                            11
*
*hydro      length                           vol
1080301       1.11                            5
1080302       2.03                            6
1080303       1.11                            11
*
*hydro      volume                           vol
1080401       0.                              11
*
*hydro      vert angle                       vol
1080601       0.                              11
*
*hydro      delta z                          vol
1080701       0.0                             11
*
*hydro      roughness    hyd diam                vol
1080801     0.0000457    0.636                    5
1080802     0.0000457    0.894                    6
1080803     0.0000457    0.636                    11
*
*hydro        fe                            vol
1081001       00                            11
*
*hydro      vcahs                           jun
1081101     01000                           10
*
*hydro  ebt pressure   tempe                     vol
1081201 0 1510449.  301206. 2410662. 0.        0. 1
1081202 0 1510445.  270294. 2410662. 0.        0. 2
1081203 0 1510442.  2.44+5  2410661. 0.        0. 3
1081204 0 1510437.  221489.7 2410661. 0.       0. 4
1081205 0 1510432.  202106.4 2410661. 0.       0. 5
1081206 0 1510437.  202090.  2410661. 0.       0. 6
1081207 0 1510420.  195799.4 2410661. 0.       0. 7
1081208 0 1510414.  190280.2 2410661. 0.       0. 8
1081209 0 1510408.  185430.2 2410661. 0.       0. 9
1081210 0 1510403.  181161.5 2410661. 0.       0. 10
1081211 0 1510397.  177399.  2410661. 0.       0. 11
*
*hydro      f velocity  g velocity  j velocity          jun
1081300 0
1081301  .728927   .728927 0. 1 * 651.359
1081302  .725807   .725807 0. 2 * 651.36
1081303  .723367   .723367 0. 3 * 651.361
1081304  .721442   .721442 0. 4 * 651.363
1081305  .71991    .71991  0. 5 * 651.364
1081306  .719912   .719912 0. 6 * 651.367
1081307  .719442   .719442 0. 7 * 651.368
1081308  .71904    .71904  0. 8 * 651.37
1081309  .718696   .718696 0. 9 * 651.371
1081310  .7184     .7184   0. 10 * 651.372
*
*hydro  jun hyd diam                                  jun
1081401   0.100     0.0 1.0 1.0                        10
*
*---------------------------------------------------------------$
*hydro        component name    component type
1120000         "hxplout1"        branch
*---------------------------------------------------------------$
*hydro       no. juns        vel/flw
1120001        2               0
*
*hydro       area          length         volume
1120101      0.08322         1.0            0.
*
*hydro       horz angle     vert angle      delta z
1120102        0.             0.             0.
*
*hydro       roughness      hyd diam         fe
1120103      0.0000457       0.3255           0
*
*hydro  ebt pressure    tempe
1120200 0 1478037.   177400. 2410178. 0.
*
*hydro  from        to         area      f loss   r loss   vcahs
1121101 108010000  112000000    0.        0.15     0.15  01000
1122101 112010000  113000000    0.08322   0.       0.    01000
*
*hydro  hyd diam
1121110 0.3255  0.0 1.0 1.0
1122110 0.3255 0.0 1.0 1.0
*
*hydro            f velocity   g velocity   j velocity
1121201  7.12622   7.12622 0. * 651.374
1122201  7.12632   7.12632 0. * 651.374
*
*---------------------------------------------------------------$
*hydro        component name    component type
1130000         "joinhx"          pipe
*---------------------------------------------------------------$
1130001      3
*
*hydro      vol area                          vol
1130101      0.08322                           3
*
*hydro      length                           vol
1130301      1.981                            1
1130302      1.23                             2
```

```
1130303     0.6096                      3
*
*hydro      volume                      vol
1130401     0.                          3
*
*hydro      vert angle                  vol
1130601     -22.6                       1
1130602     -29.7                       2
1130603     -90.                        3
*
*hydro      elev. change                vol
1130701     -0.762                      1
1130702     -0.6093                     2
1130703     -0.6096                     3
*
*hydro      roughness   hyd diam        vol
1130801     0.0000457   0.3255          3
*
*hydro      f loss    r loss            jun
1130901     0.182     0.182             2
*
*hydro      fe                          vol
1131001     00                          3
*
*hydro      vcahs                       jun
1131101     01000                       2
*
*hydro  ebt pressure   tempe                   vol
1131201 0  1480465.   177401.7 2410217. 0.     0. 1
1131202 0  1480963.   177403.  2410225. 0.     0. 2
1131203 0  1481410.   177403.5 2410232. 0.     0. 3
*
*hydro      vel/flw
1131300     0
*
*hydro      f flowrate  g flowrate  j flowrate       jun
1131301  7.12632   7.12632 0. 1 * 651.374
1131302  7.12632   7.12632 0. 2 * 651.375
*
*-----------------------------------------------------$
*    main heat exchanger secondary flow system (tube side)    $
*-----------------------------------------------------$
*
*-----------------------------------------------------*
*hydro        component name     component type
1300000         "secsrel"          tmdpvol
*-----------------------------------------------------*
*hydro      area     length     volume
1300101     1.e6     .0         1.0e+06
*
*hydro      horz angle  vert angle   delta z
1300102     .0          .0           .0
*
*hydro      roughness   hyd diam     fe
1300103     .0          .0           10
*
*hydro ebt      trip no.     alpha vrc     numeric vrc
1300200 003
*
*hydro  time    pressure     tempe
1300201 0.      5.000e5      302.55
*
*-----------------------------------------------------*
*hydro        component name     component type
1320000         "sectdj1"          tmdpjun
*-----------------------------------------------------*
*hydro  from        to          area
1320101 130000000   134000000   0.7122
*
*hydro     vel/flw    trip no.    alpha vrc    numeric vrc
1320200    1          0           cntrlvar     586
*
*hydro  time       f flow     g flow     j flow
1320201 -1.e6      -1.e6      0.         0
1320202 1.e6       1.e6       0.         0
*
*-----------------------------------------------------*
*hydro        component name     component type
1340000         "mhx-sec"          pipe
*-----------------------------------------------------$
1340001     10
*
*hydro      vol area                    vol
1340101     0.776                       10
*
*hydro      length                      vol
1340301     1.314                       10
*
*hydro      volume                      vol
1340401     0.                          10
*
*hydro      vert angle                  vol
1340601     0.                          10
*
*hydro      delta z                     vol
1340701     0.0                         10
*
*hydro      roughness    hyd diam              vol
1340801     0.0000457    0.01588               10
*
*hydro      fe                          vol
1341001     00                          10
*
*hydro      vcahs                       jun
1341101     01000                       9
*
*hydro  ebt pressure   tempe                      vol
1341201 0  504256.    130221.5 2560196. 0.     0. 1
1341202 0  498131.    138486.  2559808. 0.     0. 2
1341203 0  492028.    148137.7 2559418. 0.     0. 3
1341204 0  485951.    159482.8 2559025. 0.     0. 4
1341205 0  479900.    172910.  2558630. 0.     0. 5
1341206 0  473823.    174294.3 2558230. 0.     0. 6
1341207 0  467715.    175864.  2557823. 0.     0. 7
1341208 0  461610.    177646.5 2557412. 0.     0. 8
1341209 0  455508.    179674.3 2556997. 0.     0. 9
1341210 0  449411.    181985.  2556578. 0.     0. 10
*
*hydro      f velocity   g velocity   j velocity          jun
1341300 0
1341301  2.2963    2.2963    0. 1 * 1774.07
1341302  2.29778   2.29778   0. 2 * 1774.07
1341303  2.299604  2.299604  0. 3 * 1774.07
1341304  2.30188   2.30188   0. 4 * 1774.07
1341305  2.30475   2.30475   0. 5 * 1774.07
1341306  2.30506   2.30506   0. 6 * 1774.07
1341307  2.305416  2.305416  0. 7 * 1774.07
1341308  2.30582   2.30582   0. 8 * 1774.07
1341309  2.306286  2.306286  0. 9 * 1774.07
*
*hydro  jun hyd diam                    jun
1341401     0.01588    0.0 1.0 1.0      9
*
*-----------------------------------------------------*
*hydro        component name     component type
1350000         "tubeout"          sngljun
*-----------------------------------------------------*
*hydro   from       to       area    f loss   r loss   vcahs
```

```
1350101 134010000   136000000  0.0     0.     0.    01000
*
*hydro  hyd diam
1350110  0.01588    0.0    1.0    1.0
*
*hydro   vel/flw     f velocity   g velocity   j velocity
1350201    0          2.30682       2.30682      0. * 1774.07
*
*-----------------------------------------------------------*
*hydro         component name    component type
1360000          "secsnk1"          tmdpvol
*-----------------------------------------------------------*
*hydro      area     length     volume
1360101     1.e6       .0       1.0e+06
*
*hydro     horz angle  vert angle   delta z
1360102       .0          .0          .0
*
*hydro     roughness   hyd diam      fe
1360103       .0          .0          10
*
*hydro ebt      trip no.      alpha vrc      numeric vrc
1360200 003
*
*hydro  time     pressure     tempe
1360201  0.      4.490e5      319.
*
*==================================================================$
*
*    EMERGENCY HEAT EXCHANGER - LOOP 1
*
*==================================================================$
*
*-----------------------------------------------------------$
*hydro          component name    component type
1140000            hxplin1            branch
*-----------------------------------------------------------$
*hydro          no. juns          vel/flw
1140001            2                 0
*
*hydro           area            length            volume
1140101        0.08322             1.0               0.
*
*hydro       horz angle       vert angle        delta z
1140102           0.               0.              0.
*
*hydro        roughness        hyd diam           fe
1140103       0.0000457          0.3255            0
*
*hydro  ebt pressure     tempe
1140200 0  1511130.   177404.4 2410670. 0.
*
*hydro   from        to          area     f loss   r loss   vcahs
1141101 114000000  116000000     0.        0.15     0.15   01000
1142101 113010000  114000000     0.        0.       0.     01000
*
*hydro   hyd diam
1141110 0.3255  0.0 1.0 1.0
1142110 0.3255  0.0 1.0 1.0
*
*hydro             f velocity    g velocity    j velocity
1141201   7.12623 7.12623 0. * 651.375
1142201   7.12632 7.70491 0. * 651.375
*
*-----------------------------------------------------------*
*hydro          component name     component type
1160000            "ehx-prim"           pipe
*-----------------------------------------------------------$
1160001        4
*
*hydro        vol area                              vol
1160101         0.894                                4
*
*hydro         length                               vol
1160301          1.6                                4
*
*hydro         volume                               vol
1160401          0.                                 4
*
*hydro        vert angle                            vol
1160601          0.                                 4
*
*hydro         delta z                              vol
1160701          0.0                                4
*
* Calibrated hydraulic diameter to match pressure drop
*
*hydro        roughness      hyd diam                       vol
*1160801        0.0000457     0.0346                         4
1160801       0.0000457     0.00170                        4
*
*hydro          f loss       r loss                    jun
1160901          0.0          0.0                        3
*
*hydro            fe                                  vol
1161001           00                                   4
*
*hydro           vcahs                                jun
1161101          01000                                 3
*
*hydro  ebt pressure      tempe                              vol
1161201  0  1501448.   177188.5 2410544. 0.        0. 1
1161202  0  1493160.   176866.6 2410418. 0.        0. 2
1161203  0  1484856.   176386.  2410286. 0.        0. 3
1161204  0  1476526.   175669.  2410154. 0.        0. 4
*
*hydro       f velocity   g velocity    j velocity              jun
1161300 0
1161301   .663351 .663351 0. 1 * 651.376
1161302   .663335 .663335 0. 2 * 651.377
1161303   .663308 .663308 0. 3 * 651.378
*
*hydro   jun hyd diam                                       jun
1161401     0.00170     0.0 1.0 1.0                          3
*
*-----------------------------------------------------------$
*hydro          component name     component type
1200000             hxplout1            branch
*-----------------------------------------------------------$
*hydro          no. juns         vel/flw
1200001            2                0
*
*hydro           area           length            volume
1200101        0.08322            1.0               0.
*
*hydro       horz angle       vert angle         delta z
1200102          0.               0.               0.
*
*hydro        roughness        hyd diam            fe
1200103       0.0000457         0.3255             0
*
*hydro  ebt pressure     tempe
1200200 0  1439958.   175670.  2409567. 0.
*
*hydro   from         to          area      f loss   r loss    vcahs
1201101 116010000   120000000     0.         0.15     0.15    01000
1202101 120010000   122000000     0.08322    0.       0.      01000
*
```

```
*hydro  hyd diam
1201110 0.3255  0.0 1.0 1.0
1202110 0.3255 0.0 1.0 1.0
*
*hydro            f velocity   g velocity   j velocity
1201201   7.12522 7.12522 0. * 651.379
1202201   7.12534 7.12534 0. * 651.38
*
*-----------------------------------------------------------$
*     emergency heat exchanger secondary flow system (tube side)        $
*-----------------------------------------------------------$
*
*-----------------------------------------------------------*
*hydro         component name     component type
1380000          "secsrc1"           tmdpvol
*-----------------------------------------------------------*
*hydro      area      length      volume
1380101     1.e6       .0        1.0e+06
*
*hydro     horz angle  vert angle   delta z
1380102       .0          .0          .0
*
*hydro     roughness   hyd diam      fe
1380103       .0          .0         10
*
*hydro  ebt       trip no.      alpha vrc      numeric vrc
1380200 003
*
*hydro  time     pressure     tempe
1380201  0.      1.800e5      311.15
*
*-----------------------------------------------------------*
*hydro         component name     component type
1400000          "tubein"            sngljun
*-----------------------------------------------------------*
*hydro   from         to          area     f loss   r loss   vcahs
1400101  138000000    142000000   0.0       0.       0.      01100
*
*hydro   hyd diam
1400110  0.4573     0.0     1.0     1.0
*
*hydro   vel/flw     f velocity    g velocity    j velocity
1400201     0        .0977954      .0977954      0. * 41.41146
*
*-----------------------------------------------------------*
*hydro         component name     component type
1420000          "ehx-sec"           pipe
*-----------------------------------------------------------$
1420001       2
*
*hydro       vol area                           vol
1420101       0.4264                             2
*
*hydro       length                             vol
1420301       0.7622                             2
*
*hydro       volume                             vol
1420401       0.                                 2
*
*hydro       vert angle                         vol
1420601       0.                                 2
*
*hydro       delta z                            vol
1420701       0.0                                2
*
*hydro       roughness    hyd diam                     vol
1420801       0.0000457    0.4573                       2
*
*hydro       fe                                 vol
1421001       00                                2
*
*hydro       vcahs                              jun
1421101       01000                              1
*
*hydro  ebt pressure     tempe                             vol
1421201  0   179993.2   159067.4 2525552. 0.        0. 1
1421202  0   179993.    159067.4 2525552. 0.        0. 2
*
*hydro       f velocity   g velocity   j velocity          jun
1421300 0
1421301   .0977954 .0977954   0. 1 * 41.41146
*
*hydro   jun hyd diam                                 jun
1421401      0.4573      0.0 1.0 1.0                   1
*
*-----------------------------------------------------------*
*hydro         component name     component type
1440000          "tubein"            sngljun
*-----------------------------------------------------------*
*hydro   from         to          area     f loss   r loss   vcahs
1440101  142010000    146000000   0.0       0.       0.      01100
*
*hydro   hyd diam
1440110  0.01905     0.0     1.0     1.0
*
*hydro   vel/flw     f velocity    g velocity    j velocity
1440201     0        .0977954      .0977954      0. * 41.41146
*
*-----------------------------------------------------------*
*hydro         component name     component type
1460000          "ehx-sec"           pipe
*-----------------------------------------------------------$
1460001       4
*
*hydro       vol area                           vol
1460101       0.476                              4
*
*hydro       length                             vol
1460301       1.6                                4
*
*hydro       volume                             vol
1460401       0.                                 4
*
*hydro       vert angle                         vol
1460601       0.                                 4
*
*hydro       delta z                            vol
1460701       0.0                                4
*
*hydro       roughness     hyd diam                    vol
1460801       0.0000457     0.01905                     4
*
*hydro       fe                                 vol
1461001       00                                 4
*
*hydro       vcahs                              jun
1461101       01000                              3
*
*hydro  ebt pressure     tempe                             vol
1461201  0   179988.    170167.  2525552. 0.       0. 1
1461202  0   179975.5   177542.  2525549. 0.       0. 2
1461203  0   179962.7   182415.7 2525547. 0.       0. 3
1461204  0   179949.6   185630.5 2525544. 0.       0. 4
*
*hydro       f velocity   g velocity   j velocity          jun
1461300 0
1461301   .0876943  .0876943  0. 1 * 41.4115
1461302   .0877563  .0877563  0. 2 * 41.41145
```

```
1461303  .0877983 .0877983 0.3 * 41.4114
*
*hydro  jun hyd diam                                  jun
1461401    0.01905    0.0 1.0 1.0                       3
*
*-------------------------------------------------------------*
*hydro         component name    component type
1480000          "tubeout"          sngljun
*-------------------------------------------------------------*
*hydro  from        to         area    f loss   r loss   vcahs
1480101  146010000  150000000  0.0      0.       0.      01100
*
*hydro  hyd diam
1480110  0.01905    0.0    1.0    1.0
*
*hydro  vel/flw    f velocity   g velocity   j velocity
1480201  0         .2059376     .2059376     0. * 41.41125
*
*-------------------------------------------------------------$
*hydro         component name    component type
1500000          "chimney"          pipe
*-------------------------------------------------------------$
1500001       4
*
*hydro       vol area                             vol
1500101       0.203                                4
*
*hydro       length                               vol
1500301       0.75                                 4
*
*hydro       volume                               vol
1500401       0.                                  4
*
*hydro       vert angle                           vol
1500601       90.                                 4
*
*hydro       elev. change                         vol
1500701       0.75                                 4
*
*hydro       roughness    hyd diam                   vol
1500801      0.0000457    0.508                       4
*
*hydro       f loss      r loss                   jun
1500901       0.          0.                       3
*
*hydro       fe                                 vol
1501001       00                                 4
*
*hydro       vcahs                                jun
1501101       01000                                3
*
*hydro  ebt pressure     tempe                        vol
1501201  0  176276.3   185602.  2524838. 0.       0. 1
1501202  0  168990.    185576.  2523401. 0.       0. 2
1501203  0  161704.    185553.  2521913. 0.       0. 3
1501204  0  154417.8   185533.5 2520368. 0.       0. 4
*
*hydro       vel/flw
1501300       0
*
*hydro       f flowrate   g flowrate   j flowrate          jun
1501301  .205937   .2523523 0. 1 * 41.4112
1501302  .205937   .252352  0. 2 * 41.4112
1501303  .205937   .252352  0. 3 * 41.4111
*
*-------------------------------------------------------------
*hydro         component name    component type
1520000          "tubeout"          sngljun
*-------------------------------------------------------------
*hydro  from        to         area    f loss   r loss  vcahs
1520101  150010000  154000000  0.0      0.       0.     01100
*
*hydro  hyd diam
1520110  0.508      0.0    1.0    1.0
*
*hydro  vel/flw     f velocity   g velocity   j velocity
1520201   0         .205937      .214594      0. * 41.41104
*
*-------------------------------------------------------------*
*hydro         component name    component type
1540000          "secsnk1"          tmdpvol
*-------------------------------------------------------------*
*hydro       area     length     volume
1540101       1.e6     .0        1.0e+06
*
*hydro     horz angle  vert angle   delta z
1540102       .0          .0          .0
*
*hydro     roughness   hyd diam     fe
1540103       .0          .0         10
*
*hydro  ebt       trip no.      alpha vrc      numeric vrc
1540200 003
*
*hydro  time     pressure     tempe
1540201  0.      150773.66    311.15
*
*=============================================================$
*
*  ACCUMULATOR AND SURGE LINE - LOOP 1
*    assembled from normal relap5 components.
*    a tank wall heat structure (#1561) has been defined
*
*=============================================================$
*
*hydro         component name    component type
1560000          "accum1"          pipe
*-------------------------------------------------------------$
*hydro       no. volumes
1560001        6
*
*hydro       vol area                              vol
1560101       1.65                                  5
1560102       0.08322                                 6
*
*hydro       length                                vol
1560301       4.09                                  1
1560302       0.12                                  5
1560303       4.88                                  6
*
*hydro       volume                                vol
1560401       0.                                   6
*
*hydro       vert angle                            vol
1560601       -90.                                 6
*
*hydro       roughness     hyd diam                    vol
1560801      0.0000457     1.449                        5
1560802      0.0000457     0.3255                        6
*
*hydro       f loss       r loss                   jun
1560901       0.           0.                       4
1560902       0.5          1.0                       5
*
*hydro       fe                                 vol
1561001       00000                                6
*
*hydro       vcahs                                jun
```

```
1561101     00000                    5
*
*hydro  ebt                          vol
* try for quala of 0.077054  for 0.52 m^3
1561201 6  1482314.  106539.8 373161. .0770037 .998317 1
1561202 0  1503427.  111229.2 2410570. 0. 0.  2
1561203 0  1504726.  119898.7 2410587. 0. 0.  3
1561204 0  1506024.  136726.5 2410604. 0. 0.  4
1561205 0  1507319.  169782.  2410621. 0. 0.  5
1561206 0  1534116.  232090.7 2410967. 0. 0.  6
*
*hydro     vel/flw
1561300      0
*
*hydro    f velocity  g velocity  j velocity        jun
1561301      -1.171195-5 -.554059   0.          1 * -.0213344
1561302      -1.172064-5 -1.172205-5 0.         2 * -.02133886
1561303      -1.17303-5  -1.17317-5  0.         3 * -.02133163
1561304      -1.174258-5 -1.1744-5   0.         4 * -.02129592
1561305      -2.332057-4 -2.33757-4  0.         5 * -.02119257
$=================================================================$
*hydro       component name    component type
1570000        "accumout"        sngljun
*-----------------------------------------------------------------$
*hydro   from        to        area     f loss   r loss   vcahs
1570101 156060002  104020001 0.08322    0.      0.       01000
*
*hydro   vel/flw    f velocity   g velocity   j velocity
1570201    0      -2.384177-4 -2.384177-4   0. * -.0213515
*
$=================================================================$
*hydro       component name    component type
1220000        "coldleg"          pipe
*-----------------------------------------------------------------$
1220001      3
*
*hydro      vol area                         vol
1220101      0.08322                           3
*
*hydro      length                           vol
1220301      2.31                              1
1220302      2.13                              2
1220303      0.762                             3
*
*hydro       volume                          vol
1220401       0.                               3
*
*hydro       volume                          vol
1220501       0.                               3
*
*hydro      vert angle                       vol
1220601      -7.6                              1
1220602       0.                               2
1220603       90.                              3
*
*hydro      delta z                          vol
1220701      -0.305                            1
1220702       0.                               2
1220703       0.762                            3
*
*hydro     roughness    hyd diam                   vol
1220801    0.0000457    0.3255                       3
*
*hydro      f loss     r loss                jun
1220901      0.182      0.182                  2
*
*hydro       fe                              vol
1221001      00                                3
*
*hydro       vcahs                                      jun
1221101       01000                                       2
*
*hydro  ebt pressure    tempe                           vol
1221201  0  1439733.   175661.6 2409563. 0.           0. 1
1221202  0  1433788.   175654.  2409466. 0.           0. 2
1221203  0  1422969.   175651.2 2409290. 0.           0. 3
*
*hydro      vel/flw
1221300       0
*
*hydro      f flowrate   g flowrate   j flowrate          jun
1221301   7.12534    7.12534 0. 1 * 651.38
1221302   7.12535    7.12535 0. 2 * 651.38
*
*=================================================================$
*
*   PRIMARY COOLANT PUMP - LOOP 1
*
*=================================================================$
*
*-----------------------------------------------------------------$
*hydro        component name     component type
1240000         "rcpump1"           pump
*-----------------------------------------------------------------$
*hydro        area          length          volume
1240101        0.            0.500           0.7739
*
*hydro      horz angle      vert angle        delta z
1240102        0.              0.             0.000
*
*hydro       equil flag
1240103        00
*
*hydro      from       jun area    f loss    r loss    vcahs
1240108   122010000    0.          0.0       0.0      01000
*
* Assume k=2.0 for strainer loss coefficient
*
*hydro       to        jun area    f loss    r loss    vcahs
1240109   126000000    0.          2.0       2.0      01000
*
*hydro  ebt pressure     tempe
1240200 0  2516015.   175700.  2418750. 0.
*
*hydro   vel/flw    f flowrate     g flowrate    j flowrate
1240201 0   7.12538    7.70508 0. * 651.38
*
*hydro   vel/flw    f flowrate     g flowrate    j flowrate
1240202 0   7.122      7.122   0. * 651.38
*
*hydro     ptdi   2fazi   diff i   tork i   pvel i   trip no.  rvrs i
1240301     0       0       0       -1        0        555       0
*
*hydro  rated pump vel.  init/rated vel.  rated flow   rated head
1240302      188.5          .968583        0.643        207.3
*
*hydro   rated torque    mom of inertia   rated dens   mtr torque
1240303      7616.8          91.50          1098.         .0
*
*hydro    coeff. tf2     coeff. tf0     coeff. tf1    coeff. tf3
1240304      10.0          150.0           0.            0.
*
*hydro      curve type        regime
1241100        1                1
*
*hydro        v/a          head        $normal     (+q,+n)
1241101        0.           1.126
1241102        .196         1.147
```

```
1241103     .392        1.163
1241104     .588        1.140
1241105     .784        1.091
1241106     0.98        1.009
1241107     1.00        1.000
*
*hydro      curve type  regime
1241200     1           2
*
*hydro      a/v         head      $normal     (+q,+n)
1241201     0.          -.35
1241204     .425        0.
1241205     .567        0.142
1241206     .637        0.239
1241207     0.728       0.391
1241208     0.850       0.644
1241209     1.000       1.
*
*hydro      curve type  regime
1241300     1           3
*
*hydro      v/a         head      $energy     (-q,+n)
1241301     -1.0        1.5
1241304     0.          1.126
*
*hydro      curve type  regime
1241400     1           4
*
*hydro      v/a         head      $energy     (-q,+n)
1241401     -1.0        1.5
1241404     0.          0.7
*
*hydro      curve type  regime
1241900     2           1
*
*hydro      v/a         torque    $normal     (+q,+n)
1241901     0.          .4
1241902     .2          .46
1241903     .4          .62
1241904     .6          .76
1241905     .79         .88
1241906     1.          1.
*
*hydro      curve type  regime
1242000     2           2
*
*hydro      a/v         torque    $normal     (+q,+n)
1242001     0.          -.32
1242002     .2          -.1
1242003     .4          .15
1242004     .6          .4
1242005     .8          .7
1242006     1.          1.
*
*hydro      curve type  regime
1242100     2           3
*
*hydro      v/a         torque    $energy     (-q,+n)
1242101     -1.0        0.8
1242104     0.          0.4
*
*hydro      curve type  regime
1242200     2           4
*
*hydro      v/a         torque    $energy     (-q,+n)
1242201     -1.0        0.8
1242204     0.          0.3
*
*
*hydro      extrap ind  void fraction   head
1243000     0           0.00            0.00
1243001                 0.83e-4         0.00
1243002                 7.16e-3         0.98
1243003                 0.60            0.97
1243004                 0.80            0.90
1243005                 0.90            0.80
1243006                 0.96            0.50
1243007                 1.00            0.0
*
*hydro      extrap ind  void fraction   torque
1243100     0           0.0             0.0
1243101                 1.0             0.0
*
*hydro      curve type  regime
1244100     1           1
*
*hydro      v/a         head      $normal     (+q,+n)
1244101     0.00        0.00
1244102     0.10        0.83
1244103     0.20        1.09
1244104     0.50        1.02
1244105     0.70        1.01
1244106     0.90        0.94
1244107     1.00        1.00
*
*hydro      curve type  regime
1244200     1           2
*
*hydro      a/v         head      $normal     (+q,+n)
1244201     0.00        0.00
1244202     0.10        -0.04
1244203     0.20        0.0
1244204     0.30        0.10
1244205     0.40        0.21
1244206     0.80        0.67
1244207     0.90        0.80
1244208     1.00        1.00
*
*hydro      curve type  regime
1244300     1           3
*
*hydro      v/a         head      $dissipation (-q,+n)
1244301     -1.00       -1.16
1244302     -0.90       -1.24
1244303     -0.80       -1.77
1244304     -0.70       -2.36
1244305     -0.60       -2.79
1244306     -0.50       -2.91
1244307     -0.40       -2.67
1244308     -0.25       -1.69
1244309     -0.10       -0.50
1244310     0.00        0.00
*
*hydro      curve type  regime
1244400     1           4
*
*hydro      a/v         head      $dissipation (-q,+n)
1244401     -1.0        -1.16
1244402     -0.90       -0.78
1244403     -0.80       -0.50
1244404     -0.70       -0.31
1244405     -0.60       -0.17
1244406     -0.50       -0.08
1244407     -0.35       0.00
1244408     -0.20       0.05
1244409     -0.10       0.08
1244410     0.00        0.11
*
```

```
*hydro    curve type    regime
1244500      1          5
*
*hydro    v/a       head      $turbine   (-q,-n)
1244501   0.00      0.00
1244502   0.20      -0.34
1244503   0.40      -0.65
1244504   0.60      -0.95
1244505   0.80      -1.19
1244506   1.00      -1.47
*
*hydro    curve type    regime
1244600      1          6
*
*hydro    a/v       head      $turbine   (-q,-n)
1244601   0.00      0.11
1244602   0.10      0.13
1244603   0.25      0.15
1244604   0.40      0.13
1244605   0.50      0.07
1244606   0.60      -0.04
1244607   0.70      -0.23
1244608   0.80      -0.51
1244609   0.90      -0.91
1244610   1.00      -1.47
*
*hydro    curve type    regime
1244700      1          7
*
*hydro    v/a       head      $reverse   (+q,-n)
1244701   -1.00     0.00
1244702   0.00      0.00
*
*hydro    curve type    regime
1244800      1          8
*
*hydro    a/v       head      $reverse   (+q,-n)
1244801   -1.00     0.00
1244802   0.00      0.00
*
*hydro    curve type    regime
1244900      2          1
*
*hydro    v/a       head      $normal    (+q,+n)
1244901   0.00      0.00
1244907   1.00      0.00
*
*hydro    curve type    regime
1245000      2          2
*
*hydro    a/v       head      $normal    (+q,+n)
1245001   0.00      0.00
1245008   1.00      0.00
*
*hydro    curve type    regime
1245100      2          3
*
*hydro    v/a       head      $dissipation (-q,+n)
1245101   -1.00     0.00
1245110   0.00      0.00
*
*hydro    curve type    regime
1245200      2          4
*
*hydro    a/v       head      $dissipation (-q,+n)
1245201   -1.0      0.00
1245210   0.00      0.00
*
*hydro    curve type    regime
1245300      2          5
*
*hydro    v/a       head      $turbine   (-q,-n)
1245301   0.00      0.00
1245306   1.00      0.00
*
*hydro    curve type    regime
1245400      2          6
*
*hydro    a/v       head      $turbine   (-q,-n)
1245401   0.00      0.00
1245410   1.00      0.00
*
*hydro    curve type    regime
1245500      2          7
*
*hydro    v/a       head      $reverse   (+q,-n)
1245501   -1.00     0.00
1245502   0.00      0.00
*
*hydro    curve type    regime
1245600      2          8
*
*hydro    a/v       head      $reverse   (+q,-n)
1245601   -1.00     0.00
1245602   0.00      0.00
*-------------------------------------------------------------*
*   pump speed table
*1246100   0   cntrlvar 86
1246100   619   cntrlvar 195
1246101   -1.e6  -1.e6
1246102   1.e6   1.e6
*-------------------------------------------------------------$
*hydro       component name     component type
1260000        "pmpdisc"            pipe
*-------------------------------------------------------------$
1260001      1
*
*hydro       vol area                          vol
1260101      0.08322                            1
*
*hydro       length                            vol
1260301      0.9146                             1
*
*hydro       volume                            vol
1260401      0.                                 1
*
*hydro       volume                            vol
1260501      0.                                 1
*
*hydro       vert angle                        vol
1260601      0.0                                1
*
*hydro       delta z                           vol
1260701      0.0                                1
*
*hydro       roughness    hyd diam             vol
1260801      0.0000457    0.3255                1
*
*hydro       f loss     r loss                 jun
*1260901     0.0        0.0                     1
*
*hydro       fe                                vol
1261001      00                                 1
*
*hydro       vcahs                             jun
*1261101     01000                              2
*
*hydro  ebt pressure    tempe                  vol
```

```
1261201 0 3501653.  175698. 2419412. 0.       0. 1
*
*hydro       vel/flw
*1261300        0
*
*hydro       f flowrate  g flowrate  j flowrate            jun
*1261301  7.21537   7.79558 0. 2 * 659.73
*--------------------------------------------------------------$
*hydro          component name    component type
1280000           "check"            valve
*--------------------------------------------------------------$
*hydro   from        to          area     f loss   r loss   vcahs
1280101  126010000   129000000  0.08322   0.98     0.98    01100
*
*hydro   vel/flw     f flowrate    g flowrate    j flowrate
1280201 0  7.11892   7.11892 0. * 651.38
*
*hydro             valve type
1280300               chkvlv
*
*hydro   chkvlv type  init. posn  back press  leak ratio
1280301      0          0           0.          0.
*
*--------------------------------------------------------------$
*hydro          component name    component type
1290000           "cljoin"           pipe
*--------------------------------------------------------------$
1290001        1
*
*hydro       vol area                             vol
1290101       0.08322                              1
*
*hydro       length                               vol
1290301        6.25                                1
*
*hydro       volume                               vol
1290401        0.                                 1
*
*hydro       volume                               vol
1290501        0.                                 1
*
*hydro       vert angle                           vol
1290601        0.0                                1
*
*hydro       delta z                              vol
1290701       0.0                                 1
*
*hydro       roughness     hyd diam                      vol
1290801       0.0000457     0.3255                        1
*
*hydro       f loss     r loss                    jun
*1290901       0.0       0.0                       1
*
*hydro        fe                                  vol
1291001       00                                   1
*
*hydro       vcahs                                jun
*1291101     01000                                 2
*
*hydro  ebt pressure     tempe                           vol
1291201  0  3470288.   175675.2 2419434. 0.        0. 1
*
*hydro       vel/flw
*1291300        0
*
*hydro       f flowrate  g flowrate  j flowrate            jun
*1291301  7.21537   7.79558 0. 2 * 659.73
*
*--------------------------------------------------------------*
```

```
*hydro         component name    component type
1310000          "elbow1"           sngljun
*--------------------------------------------------------------*
*hydro   from        to          area      f loss   r loss   vcahs
1310101  129010000   158000000  0.083220   0.182    0.182   01000
*
*hydro   vel/flw     f velocity    g velocity    j velocity
1310201 0  7.11901   7.11901 0. * 651.38
*
*--------------------------------------------------------------$
*hydro         component name    component type
1580000          "coldleg"          pipe
1580001        2
*
*hydro       vol area                             vol
1580101       0.08322                               2
*
*hydro       length                               vol
1580301        4.50                                2
*
*hydro       volume                               vol
1580401        0.                                 2
*
*hydro       horz angle                           vol
1580501        0.                                 2
*
*hydro       vert angle                           vol
1580601        0.                                 2
*
*hydro       delta z                              vol
1580701        0.                                 2
*
*hydro       roughness     hyd diam                     vol
1580801       0.0000457     0.3255                       2
*
*hydro       kf          kr                       jun
1580901       0.0         0.0                       1
*hydro        fe                                  vol
1581001       00                                   2
*
*hydro       vcahs                                jun
1581101       01000                                 1
*
*hydro  ebt pressure     tempe                           vol
1581201  0  3459148.   175637.7 2419442. 0.        0. 1
1581202  0  3454074.   175642.7 2419446. 0.        0. 2
*
*hydro       vel/flw
1581300        0
*
*hydro   vel/flw     f velocity    g velocity    j velocity
1581301  7.11902   7.11902 0. 1 * 651.381
*
*--------------------------------------------------------------*
*hydro         component name    component type
1600000          "elbow1"           sngljun
*--------------------------------------------------------------*
*hydro   from        to          area      f loss   r loss   vcahs
1600101  158010000   162000000  0.083220   0.182    0.182   01000
*
*hydro   vel/flw     f velocity    g velocity    j velocity
1600201 0  7.11904   7.11904 0. * 651.381
*
*--------------------------------------------------------------*
*hydro         component name    component type
1620000          "14incdlg"         pipe
1620001        4
*
*hydro       vol area                             vol
```

```
1620101     0.08322                     4
*
*hydro      length                      vol
1620301     1.83                        1
1620302     1.57                        2
1620303     1.45                        3
1620304     12.10439                    4
*
*hydro      volume                      vol
1620401     0.                          4
*
*hydro      horz angle                  vol
1620501     0.                          4
*
*hydro      vert angle                  vol
1620601     -90.                        1
1620602     0.                          3
1620603     -90.                        4
*
*hydro      delta z                     vol
1620701     -1.83                       1
1620702     0.                          3
1620703     -12.10439                   4
*
*hydro      roughness   hyd diam        vol
1620801     0.0000457   0.3255          4
*
*hydro      kf          kr              jun
1620901     0.182       0.182           1
1620902     0.13        0.13            2
1620903     0.182       0.182           3
*
*hydro      fe                          vol
1621001     00                          4
*
*hydro      vcahs                       jun
1621101     01000                       3
*
*hydro  ebt pressure   tempe                      vol
1621201 0  3455294.  175636.3 2419445. 0.    0. 1
1621202 0  3458164.  175630.6 2419443. 0.    0. 2
1621203 0  3452834.  175625.4 2419447. 0.    0. 3
1621204 0  3505372.  175583.6 2419409. 0.    0. 4
*
*hydro      vel/flw
1621300     0
*
*hydro     f velocity  g velocity  j velocity      jun
1621301  7.11903   7.6668   0. 1 * 651.381
1621302  7.11902   7.11902  0. 2 * 651.381
1621303  7.11903   7.11903  0. 3 * 651.381
*
*-----------------------------------------------------------*
*hydro        component name    component type
1720000         "inlet"           sngljun
*-----------------------------------------------------------*
*hydro   from        to          area     f loss   r loss   vcahs
1720101  162010000   171000000   0.03095  0.2062   0.4513   01000
*
*hydro   jun hyd diam
1720110    0.1985      0.0 1.0 1.0
*
*hydro   vel/flw   f velocity   g velocity   j velocity
1720201 0  19.14153   19.9515  0. * 651.381
*
*-----------------------------------------------------------*
*hydro        component name    component type
1710000         "ifdthrot"        pipe
*-----------------------------------------------------------$
```

```
1710001     3
*
*hydro      vol area                    vol
1710101     0.03095                     3
*
*hydro      length                      vol
1710301     0.30                        1
1710302     2.00                        2
1710303     2.28                        3
*
*hydro      volume                      vol
1710401     0.                          3
*
*hydro      volume                      vol
1710501     0.                          3
*
*hydro      vert angle                  vol
1710601     -90.0                       1
1710602     0.0                         2
1710603     0.0                         3
*
*hydro      delta z                     vol
1710701     -0.3                        1
1710702     0.0                         2
1710703     0.0                         3
*
*hydro      roughness   hyd diam        vol
1710801     0.0000457   0.1985          3
*
*hydro      f loss      r loss          jun
1710901     0.196       0.196           2
*
*hydro      fe                          vol
1711001     00                          3
*
*hydro      vcahs                       jun
1711101     01000                       2
*
*hydro  ebt pressure   tempe                      vol
1711201 0  3348128.  175586.2 2419524. 0.    0. 1
1711202 0  3293533.  175604.2 2419564. 0.    0. 2
1711203 0  3222966.  175624.8 2419618. 0.    0. 3
*
*hydro      vel/flw
1711300     0
*
*hydro     f flowrate  g flowrate  j flowrate      jun
1711301  19.14285  19.9559  0. 1 * 651.381
1711302  19.14334  19.14334 0. 2 * 651.381
*
*-----------------------------------------------------------*
*hydro        component name    component type
1730000         "ifdexit"         sngljun
*-----------------------------------------------------------*
*hydro   from        to          area     f loss   r loss   vcahs
1730101  171010000   174000000   0.03095  0.1028   0.04696  01000
*
*hydro   jun hyd diam
1730110    0.1985      0.0 1.0 1.0
*
*hydro   vel/flw   f velocity   g velocity   j velocity
1730201 0  19.14397 19.14397 0. * 651.381
*
*-----------------------------------------------------------$
*hydro        component name    component type
1740000         "psvaw-1"         pipe
*-----------------------------------------------------------$
1740001     1
*
```

```
*hydro      vol area                      vol
1740101      0.08322                        1
*
*hydro      length                        vol
1740301      0.50                           1
*
*hydro      volume                        vol
1740401      0.                             1
*
*hydro      volume                        vol
1740501      0.                             1
*
*hydro      vert angle                    vol
1740601      45.0                           1
*
*hydro      delta z                       vol
1740701      0.50                           1
*
*hydro      roughness     hyd diam              vol
1740801      0.0000457     0.3255                 1
*
*hydro      f loss     r loss             jun
*1740901     0.0        0.0                 1
*
*hydro      fe                            vol
1741001      00                             1
*
*hydro      vcahs                         jun
*1741101     01000                          2
*
*hydro  ebt pressure    tempe                      vol
1741201  0  3356308.   175623.2 2419518. 0.        0. 1
*
*hydro      vel/flw
*
*hydro      f flowrate   g flowrate   j flowrate          jun
*1741300 0
*1741301   7.21537   7.79558 0. 2 * 659.73
*
*------------------------------------------------------------$
*
*     components 2xx - heat exchanger coolant loop 2
*
*------------------------------------------------------------$
*hydro        component name    component type
2010000         "hlsplit2"        pipe
*------------------------------------------------------------$
2010001       3
*
*hydro      vol area                      vol
2010101      0.08322                        3
*
*hydro      length                        vol
2010301      1.07                           1
2010302      3.66                           2
2010303      2.21                           3
*
*hydro      volume                        vol
2010401      0.0                            3
*
*hydro      vert angle                    vol
2010601      0.                             3
*
*hydro      delta z                       vol
2010701      0.                             3
*
*hydro      roughness     hyd diam              vol
2010801      0.0000457     0.3255                 3
*
*hydro      kf     kr                       jun
2010901      0.182  0.182                     2
*
*hydro      fe                             vol
2011001      00                               3
*
*hydro      vcahs                          jun
2011101      01100                            2
*
*hydro  ebt pressure    tempe                       vol
2011201  0  1558346.   338598.3 2411276. 0.       0. 1
2011202  0  1549799.   338470.  2411167. 0.       0. 2
2011203  0  1540555.   338392.4 2411049. 0.       0. 3
*
*hydro      vel/flw
2011300      0
*
*hydro      f velocity   g velocity   j velocity         jun
2011301   7.57437   7.57437 0.                     1 * 678.254
2011302   7.57424   7.57424 0.                     2 * 678.254
*
*------------------------------------------------------------$
*hydro        component name    component type
2030000         "hlsp1j"          mtpljun
*------------------------------------------------------------$
2030001    1     0
*hydro   from         to          area      f loss   r loss   vcahs
2030011  650030002   201010001   0.24663    1.20     1.20     01000
2030012  1.0  1.0  1.0  0  0  0  1
*
2031011   2.555817  2.555817 1 * 678.254
*
2032011   0.56037 0.0 1.0 1.0 1
*
*------------------------------------------------------------$
*hydro        component name    component type
2020000         "isolate"         valve
*------------------------------------------------------------$
*hydro   from        to          area      f loss  r loss   vcahs
2020101  201010000   204000000   0.08322   0.104   0.104    01100
*
*hydro   vel/flw     f flowrate   g flowrate   j flowrate
2020201 0   7.57417    7.57417 0. * 678.254
*
*hydro          valve type
2020300           trpvlv
*
*hydro          trip no.
2020301           515
*
*------------------------------------------------------------$
*hydro        component name    component type
2040000         "hotleg"          pipe
2040001       3
*------------------------------------------------------------$
*
*hydro      vol area                      vol
2040101      0.08322                        3
*
*hydro      length                        vol
2040301      0.69                           1
2040302      12.95                          2
2040303      2.51                           3
*
*hydro      volume                        vol
2040401      0.                             3
*
*hydro      volume                        vol
2040501      0.                             3
```

```
*
*hydro      vert angle                    vol
2040601       0.                           2
2040602       90.                          3
*
*hydro      delta z                       vol
2040701       0.                           2
2040702       2.44                         3
*
*hydro      roughness    hyd diam              vol
2040801       0.0000457    0.3255               3
*
*hydro      f loss    r loss                jun
2040901       0.0       0.0                  1
2040902       0.182     0.182                  2
*
*hydro      fe                            vol
2041001       00                           3
*
*hydro      vcahs                         jun
2041101       01000                         2
*
*hydro  ebt pressure    tempe                   vol
2041201  0  1535554.   338172.  2410985. 0.    0. 1
2041202  0  1527154.   338075.  2410877. 0.    0. 2
2041203  0  1499156.   337988.  2410512. 0.    0. 3
*
*hydro      vel/flw
2041300       0
*
*hydro      f flowrate   g flowrate   j flowrate          jun
2041301  7.57393   7.57393 0. 1 * 678.254
2041302  7.57355   7.57355 0. 2 * 678.228
*
*===============================================================$
*
*           MAIN HEAT EXCHANGER - LOOP 2
*
*===============================================================$
*
*--------------------------------------------------------$
*hydro        component name     component type
2060000         "hxplin2"            branch
*--------------------------------------------------------$
*hydro        no. juns        vel/flw
2060001          2               0
*
*hydro        area          length          volume
2060101       0.08322          1.0             0.
*
*hydro        horz angle       vert angle        delta z
2060102          0.               0.               0.
*
*hydro        roughness          hyd diam          fe
2060103       0.0000457            0.3255            0
*
*hydro  ebt pressure    tempe
2060200 0  1514385.   337989.  2410712. 0.
*
*hydro   from        to         area    f loss   r loss   vcahs
2061101 206000000  208000000    0.      0.15     0.15   01000
2062101 204010000  206000000    0.      0.       0.     01000
*
*hydro   hyd diam
2061110 0.3255   0.0 1.0 1.0
2062110 0.3255   0.0 1.0 1.0
*
*hydro              f velocity    g velocity    j velocity
2061201   7.5192     7.5192  0. * 673.367
2062201   7.57354    8.17014 0. * 678.228
*
*--------------------------------------------------------*
*hydro        component name     component type
2080000         "mhx-prim"           pipe
*--------------------------------------------------------$
2080001       11
*
*hydro      vol area                      vol
2080101       0.8258                       5
2080102       0.841                        6
2080103       0.8258                       11
*
*hydro      length                        vol
2080301       1.11                         5
2080302       2.03                         6
2080303       1.11                         11
*
*hydro      volume                        vol
2080401       0.                           11
*
*hydro      vert angle                    vol
2080601       0.                           11
*
*hydro      delta z                       vol
2080701       0.0                          11
*
*hydro      roughness     hyd diam              vol
2080801       0.0000457     0.636                5
2080802       0.0000457     0.894                6
2080803       0.0000457     0.636                11
*
*hydro      fe                            vol
2081001       00                           11
*
*hydro      vcahs                         jun
2081101       01000                        10
*
*hydro  ebt pressure    tempe                    vol
2081201  0  1508299.   301969.5 2410634. 0.    0. 1
2081202  0  1508295.   271398.6 2410634. 0.    0. 2
2081203  0  1508291.   245282.  2410634. 0.    0. 3
2081204  0  1508286.   222832.  2410633. 0.    0. 4
2081205  0  1508281.   203426.2 2410633. 0.    0. 5
2081206  0  1508286.   203410.2 2410633. 0.    0. 6
2081207  0  1508268.   197205.3 2410633. 0.    0. 7
2081208  0  1508262.   191741.  2410633. 0.    0. 8
2081209  0  1508255.   186921.2 2410633. 0.    0. 9
2081210  0  1508249.   182664.  2410633. 0.    0. 10
2081211  0  1508242.   178898.  2410633. 0.    0. 11
*
*hydro      f velocity   g velocity   j velocity         jun
2081300 0
2081301  .75364    .75364   0. 1  * 673.368
2081302  .750442   .750442  0. 2  * 673.369
2081303  .747927   .747927  0. 3  * 673.37
2081304  .745933   .745933  0. 4  * 673.371
2081305  .74434    .74434   0. 5  * 673.373
2081306  .744341   .744341  0. 6  * 673.375
2081307  .74386    .74386   0. 7  * 673.377
2081308  .743446   .743446  0. 8  * 673.379
2081309  .74309    .74309   0. 9  * 673.38
2081310  .742782   .742782  0. 10 * 673.382
*
*hydro   jun hyd diam                        jun
2081401     0.100     0.0 1.0 1.0             10
*
*--------------------------------------------------------$
*hydro        component name     component type
```

```
2120000        "hxplout1"        branch
*--------------------------------------------------------------$
*hydro      no. juns      vel/flw
2120001        2            0
*
*hydro      area        length       volume
2120101     0.08322        1.0          0.
*
*hydro      horz angle    vert angle      delta z
2120102       0.            0.             0.
*
*hydro      roughness     hyd diam        fe
2120103     0.0000457      0.3255          0
*
*hydro ebt pressure   tempe
2120200 0 1473655.  178899. 2410108. 0.
*
*hydro  from        to         area      f loss   r loss   vcahs
2121101 208010000  212000000   0.        0.15     0.15   01000
2122101 212010000  213000000   0.08322   0.       0.     01000
*
*hydro  hyd diam
2121110 0.3255  0.0 1.0 1.0
2122110 0.3255 0.0 1.0 1.0
*
*hydro          f velocity    g velocity    j velocity
2121201  7.36806   7.36806 0. * 673.383
2122201  7.36817   7.36817 0. * 673.384
*
*--------------------------------------------------------------$
*hydro       component name    component type
2130000        "joinhx"          pipe
*--------------------------------------------------------------$
2130001       3
*
*hydro      vol area                           vol
2130101      0.08322                            3
*
*hydro      length                             vol
2130301      1.981                              1
2130302      1.23                               2
2130303      0.6096                             3
*
*hydro      volume                             vol
2130401      0.                                 3
*
*hydro      vert angle                         vol
2130601       -22.6                             1
2130602       -29.7                             2
2130603       -90.                              3
*
*hydro      elev. change                       vol
2130701       -0.762                            1
2130702       -0.6093                           2
2130703       -0.6096                           3
*
*hydro      roughness    hyd diam                  vol
2130801     0.0000457    0.3255                     3
*
*hydro      f loss     r loss                  jun
2130901      0.182      0.182                   2
*
*hydro      fe                                vol
2131001      00                                 3
*
*hydro      vcahs                             jun
2131101      01000                              2
*
*hydro  ebt pressure    tempe                      vol
2131201  0  1475968.   178901.  2410146. 0.      0. 1
2131202  0  1475993.   178902.3 2410146. 0.      0. 2
2131203  0  1476019.   178903.  2410146. 0.      0. 3
*
*hydro      vel/flw
2131300       0
*
*hydro      f flowrate   g flowrate   j flowrate          jun
2131301   7.36817    7.36817 0. 1 * 673.384
2131302   7.36817    7.36817 0. 2 * 673.384
*
*--------------------------------------------------------------$
*    main heat exchanger secondary flow system (tube side)     $
*--------------------------------------------------------------$
*
*--------------------------------------------------------------*
*hydro         component name     component type
2300000          "secsrc2"          tmdpvol
*--------------------------------------------------------------*
*hydro      area     length     volume
2300101      1.e6      .0        1.0e+06
*
*hydro     horz angle  vert angle   delta z
2300102       .0          .0          .0
*
*hydro     roughness   hyd diam     fe
2300103       .0          .0        10
*
*hydro  ebt       trip no.      alpha vrc      numeric vrc
2300200 003
*
*hydro  time     pressure     tempe
2300201  0.      5.000e5      302.55
*
*--------------------------------------------------------------*
*hydro         component name     component type
2320000          "sectdj1"          tmdpjun
*--------------------------------------------------------------*
*hydro   from          to          area
2320101  230000000   234000000    0.7122
*
*hydro   vel/flw     trip no.     alpha vrc     numeric vrc
2320200     1           0         cntrlvar        586
*
*hydro   time        f flow       g flow       j flow
2320201  -1.e6       -1.e6         0.            0
2320202   1.e6        1.e6         0.            0
*
*--------------------------------------------------------------*
*hydro         component name     component type
2340000          "mhx-sec"           pipe
*--------------------------------------------------------------$
2340001       10
*
*hydro      vol area                           vol
2340101      0.776                              10
*
*hydro      length                             vol
2340301      1.314                              10
*
*hydro      volume                             vol
2340401      0.                                 10
*
*hydro      vert angle                         vol
2340601      0.                                 10
*
*hydro      delta z                            vol
2340701      0.0                                10
*
```

```
*hydro      roughness    hyd diam                vol
2340801      0.0000457    0.01588                 10
*
*hydro       fe                           vol
2341001      00                           10
*
*hydro       vcahs                        jun
2341101      01000                          9
*
*hydro  ebt pressure    tempe                  vol
2341201  0  504234.   130470.4 2560195. 0.    0. 1
2341202  0  498111.   138991.  2559807. 0.    0. 2
2341203  0  492011.   148901.6 2559417. 0.    0. 3
2341204  0  485937.   160500.5 2559024. 0.    0. 4
2341205  0  479889.   174164.6 2558630. 0.    0. 5
2341206  0  473814.   175596.6 2558229. 0.    0. 6
2341207  0  467707.   177214.6 2557822. 0.    0. 7
2341208  0  461604.   179045.7 2557412. 0.    0. 8
2341209  0  455505.   181121.  2556997. 0.    0. 9
2341210  0  449410.   183477.  2556578. 0.    0. 10
*
*hydro      f velocity   g velocity   j velocity        jun
2341300 0
2341301  2.29634   2.29634   0. 1 * 1774.07
2341302  2.29787   2.29787   0. 2 * 1774.07
2341303  2.299752  2.299752  0. 3 * 1774.07
2341304  2.30209   2.30209   0. 4 * 1774.07
2341305  2.305026  2.305026  0. 5 * 1774.07
2341306  2.30535   2.30535   0. 6 * 1774.07
2341307  2.30572   2.30572   0. 7 * 1774.07
2341308  2.306137  2.306137  0. 8 * 1774.07
2341309  2.306616  2.306616  0. 9 * 1774.07
*
*hydro   jun hyd diam                           jun
2341401     0.01588     0.0 1.0 1.0               9
*
*-------------------------------------------------------------*
*hydro        component name     component type
2350000         "tubeout"          sngljun
*-------------------------------------------------------------*
*hydro    from        to         area    f loss   r loss    vcahs
2350101   234010000   236000000   0.0      0.       0.      01000
*
*hydro   hyd diam
2350110  0.01588     0.0    1.0     1.0
*
*hydro   vel/flw     f velocity    g velocity    j velocity
2350201    0          2.307163      2.307163      0. * 1774.07
*
*-------------------------------------------------------------*
*hydro        component name     component type
2360000         "secsnk1"          tmdpvol
*-------------------------------------------------------------*
*hydro      area     length    volume
2360101     1.e6      .0       1.0e+06
*
*hydro    horz angle  vert angle   delta z
2360102      .0          .0          .0
*
*hydro    roughness   hyd diam     fe
2360103      .0          .0        10
*
*hydro  ebt      trip no.     alpha vrc      numeric vrc
2360200 003
*
*hydro  time     pressure     tempe
2360201  0.      4.490e5      319.
*
*=================================================================$
```

```
*
*    EMERGENCY HEAT EXCHANGER - LOOP 2
*
*=================================================================$
*
*----------------------------------------------------$
*hydro        component name     component type
2140000          hxplin1            branch
*----------------------------------------------------$
*hydro        no. juns        vel/flw
2140001          2              0
*
*hydro         area          length           volume
2140101        0.08322         1.0               0.
*
*hydro       horz angle      vert angle        delta z
2140102          0.              0.              0.
*
*hydro       roughness       hyd diam           fe
2140103       0.0000457        0.3255            0
*
*hydro  ebt pressure     tempe
2140200 0  1507560.    178904.  2410624. 0.
*
*hydro   from        to          area    f loss   r loss   vcahs
2141101 214000000   216000000     0.      0.15     0.15    01000
2142101 213010000   214000000     0.      0.       0.      01000
*
*hydro   hyd diam
2141110 0.3255   0.0 1.0 1.0
2142110 0.3255   0.0 1.0 1.0
*
*hydro           f velocity    g velocity    j velocity
2141201   7.36807 7.36807 0. * 673.384
2142201   7.36817 7.9572  0. * 673.384
*
*-------------------------------------------------------------*
*hydro        component name     component type
2160000         "ehx-prim"          pipe
*-------------------------------------------------------------$
2160001       4
*
*hydro        vol area                              vol
2160101        0.894                                 4
*
*hydro        length                                vol
2160301         1.6                                  4
*
*hydro        volume                                vol
2160401         0.                                   4
*
*hydro       vert angle                             vol
2160601         0.                                   4
*
*hydro        delta z                               vol
2160701        0.0                                   4
*
* Calibrated hydraulic diameter to match pressure drop
*
*hydro      roughness      hyd diam                       vol
*2160801     0.0000457      0.0346                         4
2160801      0.0000457      0.00170                        4
*
*hydro       f loss      r loss                     jun
2160901       0.0         0.0                        3
*
*hydro        fe                                  vol
2161001       00                                   4
*
```

```
*hydro        vcahs                              jun
2161101        01000                               3
*
*hydro  ebt pressure    tempe                          vol
2161201  0  1497384.   178674.6 2410484. 0.     0. 1
2161202  0  1488870.   178345.  2410350. 0.     0. 2
2161203  0  1480338.   177857.  2410215. 0.     0. 3
2161204  0  1471782.   177128.5 2410079. 0.     0. 4
*
*hydro       f velocity   g velocity   j velocity          jun
2161300 0
2161301   .685863 .685863 0. 1 * 673.385
2161302   .685845 .685845 0. 2 * 673.387
2161303   .685818 .685818 0. 3 * 673.388
*
*hydro   jun hyd diam                              jun
2161401     0.00170    0.0 1.0 1.0                    3
*
*-----------------------------------------------------------$
*hydro           component name     component type
2200000            hxplout1            branch
*-----------------------------------------------------------$
*hydro          no. juns          vel/flw
2200001            2                0
*
*hydro          area           length          volume
2200101         0.08322          1.0             0.
*
*hydro       horz angle        vert angle         delta z
2200102          0.               0.               0.
*
*hydro       roughness         hyd diam            fe
2200103       0.0000457          0.3255             0
*
*hydro  ebt pressure     tempe
2200200 0  1432869.    177129.6 2409452. 0.
*
*hydro   from         to          area     f loss   r loss    vcahs
2201101 216010000   220000000     0.        0.15      0.15   01000
2202101 220010000   222000000     0.08322   0.        0.     01000
*
*hydro   hyd diam
2201110 0.3255  0.0 1.0 1.0
2202110 0.3255 0.0 1.0 1.0
*
*hydro              f velocity    g velocity     j velocity
2201201   7.367    7.367    0. * 673.389
2202201   7.36713 7.36713 0. * 673.389
*
*-----------------------------------------------------------$
*       emergency heat exchanger secondary flow system (tube side)        $
*-----------------------------------------------------------$
*
*-----------------------------------------------------------*
*hydro           component name     component type
2380000            "secsrc1"          tmdpvol
*-----------------------------------------------------------*
*hydro        area       length       volume
2380101        1.e6         .0         1.0e+06
*
*hydro      horz angle   vert angle    delta z
2380102         .0            .0            .0
*
*hydro       roughness    hyd diam        fe
2380103         .0            .0            10
*
*hydro  ebt          trip no.        alpha vrc        numeric vrc
2380200 003
*
*hydro   time     pressure     tempe
2380201  0.       1.800e5      311.15
*
*-----------------------------------------------------------*
*hydro           component name     component type
2400000             "tubein"           sngljun
*-----------------------------------------------------------*
*hydro    from          to          area     f loss   r loss    vcahs
2400101  238000000    242000000    0.0       0.        0.      01100
*
*hydro   hyd diam
2400110  0.4573      0.0     1.0     1.0
*
*hydro    vel/flw      f velocity    g velocity    j velocity
2400201     0          .0980432      .0980432      0. * 41.5164
*
*-----------------------------------------------------------*
*hydro          component name     component type
2420000            "ehx-sec"           pipe
*-----------------------------------------------------------$
2420001        2
*
*hydro         vol area                                  vol
2420101          0.4264                                   2
*
*hydro         length                                    vol
2420301          0.7622                                   2
*
*hydro         volume                                    vol
2420401          0.                                      2
*
*hydro        vert angle                                 vol
2420601          0.                                      2
*
*hydro         delta z                                   vol
2420701          0.0                                      2
*
*hydro        roughness     hyd diam                          vol
2420801         0.0000457     0.4573                            2
*
*hydro          fe                                     vol
2421001          00                                     2
*
*hydro          vcahs                                  jun
2421101          01000                                   1
*
*hydro  ebt pressure     tempe                            vol
2421201  0   179993.    159067.4 2525552. 0.        0. 1
2421202  0   179993.    159067.4 2525552. 0.        0. 2
*
*hydro       f velocity   g velocity   j velocity          jun
2421300 0
2421301   .0980432 .0980432  0. 1 * 41.5164
*
*hydro   jun hyd diam                                 jun
2421401     0.4573      0.0 1.0 1.0                      1
*
*-----------------------------------------------------------*
*hydro           component name     component type
2440000             "tubein"           sngljun
*-----------------------------------------------------------*
*hydro    from          to          area     f loss   r loss    vcahs
2440101  242010000    246000000    0.0       0.        0.      01100
*
*hydro   hyd diam
2440110  0.01905     0.0     1.0     1.0
*
*hydro    vel/flw      f velocity    g velocity    j velocity
2440201     0          .0980432      .0980432      0. * 41.5164
```

```
*
*------------------------------------------------------------*
*hydro        component name    component type
2460000         "chx-sec"        pipe
*------------------------------------------------------------$
2460001      4
*
*hydro      vol area                       vol
2460101       0.476                          4
*
*hydro       length                        vol
2460301       1.6                           4
*
*hydro       volume                        vol
2460401       0.                            4
*
*hydro      vert angle                     vol
2460601       0.                            4
*
*hydro       delta z                       vol
2460701       0.0                           4
*
*hydro      roughness    hyd diam                 vol
2460801      0.0000457    0.01905                  4
*
*hydro        fe                         vol
2461001       00                           4
*
*hydro        vcahs                        jun
2461101       01000                          3
*
*hydro  ebt pressure     tempe                vol
2461201  0   179987.6  170764.7 2525551. 0.     0. 1
2461202  0   179975.   178511.3 2525549. 0.     0. 2
2461203  0   179962.   183521.  2525546. 0.     0. 3
2461204  0   179948.4  186651.7 2525544. 0.     0. 4
*
*hydro     f velocity   g velocity   j velocity        jun
2461300 0
2461301  .0879209  .0879209  0. 1 * 41.51614
2461302  .087986   .087986   0. 2 * 41.5159
2461303  .0880303  .0880303  0. 3 * 41.51625
*
*hydro  jun hyd diam                             jun
2461401    0.01905    0.0 1.0 1.0                  3
*
*------------------------------------------------------------*
*hydro         component name    component type
2480000           "tubeout"        sngljun
*------------------------------------------------------------*
*hydro   from       to        area     f loss   r loss   vcahs
2480101  246010000  250000000  0.0       0.       0.     01100
*
*hydro   hyd diam
2480110  0.01905    0.0    1.0    1.0
*
*hydro   vel/flw    f velocity   g velocity   j velocity
2480201    0         .206488      .206488     0. * 41.5176
*
*------------------------------------------------------------$
*hydro         component name    component type
2500000           "chimney"        pipe
*------------------------------------------------------------$
2500001       4
*
*hydro      vol area                       vol
2500101       0.203                          4
*
*hydro       length                        vol
2500301       0.75                          4
*
*hydro       volume                        vol
2500401       0.                            4
*
*hydro      vert angle                     vol
2500601       90.                           4
*
*hydro      elev. change                   vol
2500701       0.75                          4
*
*hydro      roughness    hyd diam                 vol
2500801      0.0000457    0.508                    4
*
*hydro       f loss     r loss               jun
2500901       0.         0.                    3
*
*hydro        fe                         vol
2501001       00                           4
*
*hydro        vcahs                        jun
2501101       01000                          3
*
*hydro  ebt pressure     tempe                vol
2501201  0  176275.    186513.  2524838. 0.     0. 1
2501202  0  168989.5   186343.2 2523401. 0.     0. 2
2501203  0  161703.7   186134.6 2521912. 0.     0. 3
2501204  0  154417.7   185878.3 2520368. 0.     0. 4
*
*hydro       vel/flw
2501300        0
*
*hydro      f flowrate   g flowrate   j flowrate          jun
2501301  .2064873   .25305   0. 1 * 41.518
2501302  .206487    .253049  0. 2 * 41.5185
2501303  .2064864   .2530486 0. 3 * 41.5192
*
*------------------------------------------------------------
*hydro          component name    component type
2520000            "tubeout"        sngljun
*------------------------------------------------------------
*hydro   from        to         area     f loss   r loss  vcahs
2520101  250010000   254000000  0.0       0.       0.    01100
*
*hydro   hyd diam
2520110  0.508      0.0     1.0     1.0
*
*hydro   vel/flw    f velocity    g velocity    j velocity
2520201    0          .206486       .2152023      0. * 41.52
*
*------------------------------------------------------------*
*hydro          component name    component type
2540000            "secsnk1"        tmdpvol
*------------------------------------------------------------*
*hydro      area     length     volume
2540101      1.e6      .0        1.0e+06
*
*hydro    horz angle  vert angle   delta z
2540102      .0         .0          .0
*
*hydro    roughness   hyd diam     fe
2540103      .0          .0         10
*
*hydro  ebt      trip no.     alpha vrc      numeric vrc
2540200 003
*
*hydro  time    pressure    tempe
2540201  0.     150773.66   306.
*
```

```
*=====================================================================$
*
*   ACCUMULATOR AND SURGE LINE - LOOP 2
*     assembled from normal relap5 components.
*     a tank wall heat structure (#2561) has been defined
*
*=====================================================================$
*
*hydro       component name    component type
2560000         "accum2"          pipe
*-----------------------------------------------------------$
*hydro     no. volumes
2560001       6
*
*hydro     vol area                          vol
2560101 ·   1.65                              5
2560102    0.08322                             6
*
*hydro     length                            vol
*
*hydro     length                            vol
2560301     4.09                              1
2560302     0.12                              5
2560303     4.88                              6
*
*hydro     volume                            vol
2560401      0.                               6
*
*hydro     vert angle                        vol
2560601     -90.                              6
*
*hydro     roughness    hyd diam                  vol
2560801    0.0000457    1.449                      5
2560802    0.0000457    0.3255                     6
*
*hydro     f loss    r loss                  jun
2560901     0.        0.                      4
2560902     0.5       1.0                      5
*
*hydro      fe                               vol
2561001     00000                              6
*
*hydro     vcahs                             jun
2561101     00000                             5
*
*hydro  ebt                                  vol
2561201 6  1479975.  106484.6 373154.  .0770027  .998316 1
2561202 0  1501088.  110921.4 2410540. 0. 0.  2
2561203 0  1502387.  119419.  2410556. 0. 0.  3
2561204 0  1503684.  136328.7 2410574. 0. 0.  4
2561205 0  1504980.  168508.6 2410590. 0. 0.  5
2561206 0  1531798.  225321.  2410937. 0. 0.  6
*
*hydro     vel/flw
2561300       0
*
*hydro     f velocity   g velocity   j velocity        jun
2561301   -1.161025-5  -.554085     0.            1 * -.02114952
2561302   -1.161987-5  -1.162126-5  0.            2 * -.021156
2561303   -1.163051-5  -1.16319-5   0.            3 * -.0211508
2561304   -1.164364-5  -1.164503-5  0.            4 * -.0211189
2561305   -2.3123-4    -2.317714-4  0.            5 * -.02102965
*
$=====================================================================$
*hydro       component name    component type
2570000        "accumout"        sngljun
*-----------------------------------------------------------$
*hydro   from        to          area     f loss  r loss   vcahs
2570101  256060002  204020001  0.08322  0.      0.       01000
*
*hydro   vel/flw     f velocity   g velocity   j velocity
2570201    0          -2.37475-4   -2.37475-4    0. * -.0212664
*
$=====================================================================$
*hydro       component name    component type
2220000         "coldleg"         pipe
*-----------------------------------------------------------$
2220001       3
*
*hydro      vol area                          vol
2220101      0.08322                            3
*
*hydro      length                            vol
2220301      2.31                              1
2220302      2.13                              2
2220303      0.762                             3
*
*hydro      volume                            vol
2220401       0.                               3
*
*hydro      volume                            vol
2220501       0.                               3
*
*hydro      vert angle                        vol
2220601      -7.6                              1
2220602       0.                               2
2220603      90.                               3
*
*hydro      delta z                           vol
2220701      -0.305                            1
2220702       0.                               2
2220703       0.762                            3
*
*hydro      roughness    hyd diam                 vol
2220801     0.0000457    0.3255                    3
*
*hydro      f loss     r loss                jun
2220901      0.182      0.182                  2
*
*hydro       fe                              vol
2221001       00                               3
*
*hydro      vcahs                            jun
2221101      01000                             2
*
*hydro  ebt pressure    tempe                      vol
2221201  0  1432517.   177121.  2409446. 0.    0. 1
2221202  0  1426052.   177113.2 2409340. 0.    0. 2
2221203  0  1414773.   177110.5 2409156. 0.    0. 3
*
*hydro      vel/flw
2221300       0
*
*hydro      f flowrate  g flowrate  j flowrate          jun
2221301   7.36713    7.36713 0. 1 * 673.389
2221302   7.36715    7.36715 0. 2 * 673.389
*
*=====================================================================$
*
*   PRIMARY COOLANT PUMP - LOOP 2
*
*=====================================================================$
*
*-----------------------------------------------------------$
*hydro       component name    component type
2240000         "rcpump2"         pump
*-----------------------------------------------------------$
*hydro        area        length        volume
```

```
2240101       0.          0.500          0.7739
*
*hydro     horz angle     vert angle       delta z
2240102       0.           0.             0.
*
*hydro     equil flag
2240103       00
*
*hydro    from      jun area   f loss    r loss    vcahs
2240108   222010000   0.        0.00      0.00     01000
*
* Assume k=2.0 for strainer loss coefficient
*
*hydro      to       jun area   f loss    r loss    vcahs
2240109   226000000   0.        2.0       2.0      01000
*
*hydro  ebt pressure    tempe
2240200 0  2495248.   177155.  2418673. 0.
*hydro   vel/flw    f flowrate     g flowrate    j flowrate
2240201 0   7.36718    7.9574  0. * 673.389
*hydro   vel/flw    f flowrate     g flowrate    j flowrate
2240202 0   7.36372    7.36372 0. * 673.39
*
*hydro    ptdi  2fazi  diff i  tork i  pvel i  trip no.  rvrs i
2240301    124    124    124     -1      0      555      0
*
*hydro   rated pump vel.  init/rated vel.  rated flow   rated head
2240302       188.5         .968583          0.643        207.3
*
*hydro    rated torque     mom of inertia    rated dens   mtr torque
2240303      7616.8          91.50            1098.         .0
*
*hydro    coeff. tf2       coeff. tf0      coeff. tf1    coeff. tf3
2240304     10.0            150.0            0.            0.
*     pump speed table
*2246100  0  cntrlvar 136
2246100  619  cntrlvar 195
2246101    -1.e6   -1.e6
2246102     1.e6    1.e6
*---------------------------------------------------------------$
*hydro          component name     component type
2260000           "pmpdisc"            pipe
*---------------------------------------------------------------$
2260001         1
*
*hydro       vol area                              vol
2260101       0.08322                               1
*
*hydro        length                               vol
2260301        0.9146                               1
*
*hydro        volume                               vol
2260401        0.                                  1
*
*hydro        volume                               vol
2260501        0.                                  1
*
*hydro      vert angle                             vol
2260601       0.0                                  1
*
*hydro       delta z                               vol
2260701       0.0                                  1
*
*hydro      roughness     hyd diam                     vol
2260801     0.0000457      0.3255                        1
*
*hydro        f loss      r loss                   jun
*2260901       0.0         0.0                       1
*
*hydro         fe                                      vol
2261001         00                                       1
*
*hydro        vcahs                                     jun
*2261101       01000                                      2
*
*hydro  ebt pressure     tempe                              vol
2261201  0  3460638.   177153.  2419441. 0.          0. 1
*
*hydro        vel/flw
*
*hydro        f flowrate   g flowrate    j flowrate              jun
*2261300 0
*2261301   7.21537    7.79558 0. 2 * 659.73
*---------------------------------------------------------------$
*hydro          component name      component type
2280000            "check"               valve
*---------------------------------------------------------------$
*hydro    from          to           area       f loss    r loss   vcahs
2280101   226010000    229000000    0.08317    0.98      0.98     01100
*
*hydro   vel/flw      f flowrate     g flowrate     j flowrate
2280201 0   7.3606      7.3606  0. * 673.39
*
*hydro             valve type
2280300               chkvlv
*
*hydro    chkvlv type  init. posn  back press  leak ratio
2280301       0           0           0.          0.
*---------------------------------------------------------------$
*hydro          component name      component type
2290000            "cljoin"              pipe
*---------------------------------------------------------------$
2290001          1
*
*hydro        vol area                             vol
2290101        0.08322                               1
*
*hydro         length                              vol
2290301         6.25                                1
*
*hydro         volume                               vol
2290401          0.                                 1
*
*hydro         volume                               vol
2290501          0.                                 1
*
*hydro       vert angle                             vol
2290601         0.0                                 1
*
*hydro        delta z                              vol
2290701         0.0                                 1
*
*hydro       roughness      hyd diam                    vol
2290801      0.0000457       0.3255                       1
*
*hydro         f loss      r loss                   jun
*2290901        0.0         0.0                       1
*
*hydro          fe                                  vol
2291001          00                                   1
*
*hydro         vcahs                                 jun
*2291101        01000                                  2
*
*hydro  ebt pressure     tempe                          vol
2291201  0  3427118.    177129.8 2419466. 0.       0. 1
*
*hydro        vel/flw
```

```
*
*hydro     f flowrate  g flowrate  j flowrate          jun
*2291300 0
*2291301  7.21537  7.79558 0. 2 * 659.73
*
*------------------------------------------------------------*
*hydro         component name    component type
2310000         "elbow1"          sngljun
*------------------------------------------------------------*
*hydro  from       to        area     f loss   r loss   vcahs
2310101  229010000  258000000  0.083220  0.182  0.182  01000
*
*hydro  vel/flw    f velocity   g velocity   j velocity
2310201 0  7.3607   7.3607  0. * 673.39
*
*------------------------------------------------------------$
*hydro         component name    component type
2580000         "coldleg"         pipe
*------------------------------------------------------------$
2580001      2
*
*hydro      vol area                          vol
*
2580101      0.08322                           2
*
*hydro      length                            vol
2580301      4.50                              2
*
*hydro      volume                            vol
2580401      0.                                2
*
*hydro      horz angle                        vol
2580501      0.                                2
*
*hydro      vert angle                        vol
2580601      0.                                2
*
*hydro      delta z                           vol
2580701      0.                                2
*
*hydro      roughness    hyd diam                  vol
2580801      0.0000457    0.3255                    2
*
*hydro      kf         kr                     jun
2580901      0.0        0.0                    1
*hydro       fe                               vol
2581001      00                               2
*
*hydro      vcahs                             jun
2581101      01000                             1
*
*hydro  ebt pressure    tempe                       vol
2581201  0  3415218.   177091.5 2419474. 0.      0. 1
2581202  0  3409801.   177096.5 2419478. 0.      0. 2
*
2581300 0
2581301  7.36071   7.36071 0. 1 * 673.39
*
*------------------------------------------------------------*
*hydro         component name    component type
2600000         "elbow2"          sngljun
*------------------------------------------------------------*
*hydro  from       to        area     f loss   r loss   vcahs
2600101  258010000  262000000  0.083220  0.182   0.182  01000
*
*hydro  vel/flw    f velocity   g velocity   j velocity
2600201 0  7.36073   7.36073 0. * 673.39
*
*------------------------------------------------------------*
```

```
*hydro         component name    component type
2620000         "14incdlg"        pipe
*------------------------------------------------------------*
2620001      2
*
*hydro      vol area                          vol
2620101      0.08322                           2
*
*hydro      length                            vol
2620301      0.64538                           1
2620302      13.93439                          2
*
*hydro      volume                            vol
2620401      0.                                2
*
*hydro      horz angle                        vol
2620501      0.                                2
*
*hydro      vert angle                        vol
2620601      0.                                1
2620602      -90.                              2
*
*hydro      delta z                           vol
2620701      0.0                               1
2620702      -13.93439                         2
*
*hydro      roughness    hyd diam                  vol
2620801      0.0000457    0.3255                    2
*
*hydro      kf         kr                     jun
2620901      0.182      0.182                  1
*
*hydro      fe                                vol
2621001      00                                2
*
*hydro      vcahs                             jun
2621101      01000                             1
*
*hydro  ebt pressure    tempe                       vol
2621201  0  3401278.   177094.  2419484. 0.      0. 1
2621202  0  3462186.   177044.6 2419440. 0.      0. 2
*
*hydro      f velocity  g velocity  j velocity          jun
2621300 0
2621301  7.36076   7.36076  0. 1 * 673.39
*
*------------------------------------------------------------*
*hydro         component name    component type
2720000         "inlet"           sngljun
*------------------------------------------------------------*
*hydro  from       to        area     f loss   r loss   vcahs
2720101  262010000  271000000  0.03095  0.2062  0.4513  01000
*
*hydro  jun hyd diam
2720110    0.1985    0.0 1.0 1.0
*
*hydro  vel/flw    f velocity   g velocity   j velocity
2720201 0  19.7914   20.61653 0. * 673.39
*
*------------------------------------------------------------*
*hydro         component name    component type
2710000         "ifdthrot"        pipe
*------------------------------------------------------------$
2710001      3
*
*hydro      vol area                          vol
2710101      0.03095                           3
*
*hydro      length                            vol
```

```
2710301     0.30                        1
2710302     0.29                        2
2710303     0.94                        3
*
*hydro      volume                      vol
2710401     0.                          3
*
*hydro      volume                      vol
2710501     0.                          3
*
*hydro      vert angle                  vol
2710601     -90.0                       1
2710602     0.0                         2
2710603     0.0                         3
*
*hydro      delta z                     vol
2710701     -0.3                        1
2710702     0.0                         2
2710703     0.0                         3
*
*hydro      roughness   hyd diam              vol
2710801     0.0000457   0.1985                3
*
*hydro      f loss   r loss             jun
2710901     0.196    0.196                2
*
*hydro      fe                          vol
2711001     00                          3
*
*hydro      vcahs                       jun
2711101     01000                         2
*
*hydro ebt pressure   tempe                   vol
2711201 0 3298269.   177047.4 2419561. 0.    0. 1
2711202 0 3253064.   177050.2 2419595. 0.    0. 2
2711203 0 3201296.   177059.4 2419635. 0.    0. 3
*
*hydro      vel/flw
*
*hydro      f flowrate  g flowrate  j flowrate       jun
2711300 0
2711301  19.7928   20.62123 0. 1 * 673.39
2711302  19.7932   19.7932  0. 2 * 673.39
*
*-----------------------------------------------------------*
*hydro       component name    component type
2730000      "ifdexit"         sngljun
*-----------------------------------------------------------*
*hydro  from        to          area      f loss   r loss   vcahs
2730101  271010000  274000000   0.03095   0.1028   0.04696  01000
*
*hydro  jun hyd diam
2730110   0.1985   0.0 1.0 1.0
*
*hydro  vel/flw   f velocity   g velocity   j velocity
2730201 0  19.79367 19.79367 0. * 673.39
*
*-----------------------------------------------------------$
*hydro       component name    component type
2740000      "psvaw-2"         pipe
*-----------------------------------------------------------$
2740001      1
*
*hydro      vol area                    vol
2740101     0.08322                       1
*
*hydro      length                      vol
2740301     0.50                        1
*
*hydro      volume                      vol
2740401     0.                          1
*
*hydro      volume                      vol
2740501     0.                          1
*
*hydro      vert angle                  vol
2740601     45.0                        1
*
*hydro      delta z                     vol
2740701     0.50                        1
*
*hydro      roughness   hyd diam              vol
2740801     0.0000457   0.3255                1
*
*hydro      f loss   r loss             jun
*2740901    0.0      0.0                  1
*
*hydro      fe                          vol
2741001     00                          1
*
*hydro      vcahs                       jun
*2741101    01000                         2
*
*hydro ebt pressure   tempe                   vol
2741201 0 3354407.   177057.8 2419519. 0.    0. 1
*
*hydro      vel/flw
*
*hydro      f flowrate  g flowrate  j flowrate       jun
*2741300 0
*2741301  7.21537   7.79558 0. 2 * 659.73
*
*-----------------------------------------------------------$
*
*    components 3xx - heat exchanger coolant loop 3
*
*-----------------------------------------------------------$
*hydro       component name    component type
3010000      "hlsplit3"        pipe
*-----------------------------------------------------------$
3010001      1
*
*hydro      vol area                    vol
3010101     0.08322                       1
*
*hydro      length                      vol
3010301     3.28                        1
*
*hydro      volume                      vol
3010401     0.0                         1
*
*hydro      vert angle                  vol
3010601     0.                          1
*
*hydro      delta z                     vol
3010701     0.                          1
*
*hydro      roughness   hyd diam              vol
3010801     0.0000457   0.3255                1
*
*hydro      fe                          vol
3011001     00                          1
*
*hydro      vcahs                       jun
*3011101    01100                         1
*
*hydro      f velocity  g velocity  j velocity       jun
*3011300 0
```

```
*3011301   7.44853   7.44853 0.                    2
*
*hydro  ebt pressure    tempe                         vol
3011201 0  1559498.   338441.  2411290. 0.      0. 1
*
*-----------------------------------------------------------$
*hydro          component name    component type
3030000           "hlsp1j"          mtpljun
*-----------------------------------------------------------$
3030001   1      0
*hydro   from         to         area     f loss   r loss   vcahs
3030011  650010000   301000000  0.24663   0.17     0.17   01000
3030012  1.0  1.0  1.0  0  0  0  1
*
3031011  2.56604  2.56604  1 * 680.984
*
3032011  0.3255 0.0 1.0 1.0 1
*
*-----------------------------------------------------------$
*hydro          component name    component type
3020000           "isolate"         valve
*-----------------------------------------------------------$
*hydro   from         to         area     f loss   r loss   vcahs
3020101  301010000   304000000  0.08322  0.104    0.104   01100
*
*hydro   vel/flw    f flowrate   g flowrate    j flowrate
3020201 0   7.60466   7.60466 0. * 680.984
*
*hydro              valve type
3020300               trpvlv
*
*hydro              trip no.
3020301               515
*
*-----------------------------------------------------------$
*hydro          component name    component type
3040000           "hotleg"          pipe
*-----------------------------------------------------------$
3040001         3
*
*hydro       vol area                                  vol
3040101       0.08322                                   3
*
*hydro       length                                    vol
3040301       0.69                                      1
3040302       12.96                                     2
3040303       2.51                                      3
*
*hydro       volume                                    vol
3040401       0.                                        3
*
*hydro       volume                                    vol
3040501       0.                                        3
*
*hydro       vert angle                                vol
3040601       0.                                        2
3040602       90.                                       3
*
*hydro       delta z                                   vol
3040701       0.                                        2
3040702       2.44                                      3
*
*hydro       roughness    hyd diam                         vol
3040801       0.0000457    0.3255                           3
*
*hydro       f loss     r loss                         jun
3040901       0.0        0.0                            1
3040902       0.182      0.182                            2
*

*hydro          fe                                   vol
3041001          00                                   3
*
*hydro          vcahs                                jun
3041101          01000                                  2
*
*hydro  ebt pressure    tempe                              vol
3041201  0  1553794.   338416.6 2411218. 0.          0. 1
3041202  0  1545327.   337962.7 2411110. 0.          0. 2
3041203  0  1517198.   337876.  2410749. 0.          0. 3
*
*hydro          vel/flw
*
*hydro      f flowrate   g flowrate   j flowrate            jun
3041300 0
3041301   7.60465    7.60465 0. 1 * 680.984
3041302   7.60385    7.60385 0. 2 * 680.958
*
*=================================================================$
*
*          MAIN HEAT EXCHANGER - LOOP 3
*
*=================================================================$
*
*-----------------------------------------------------------$
*hydro          component name    component type
3060000           "hxplin3"          branch
*-----------------------------------------------------------$
*hydro          no. juns        vel/flw
3060001            2              0
*
*hydro          area           length          volume
3060101          0.08322          1.0             0.
*
*hydro        horz angle       vert angle        delta z
3060102          0.               0.              0.
*
*hydro        roughness        hyd diam           fe
3060103        0.0000457         0.3255            0
*
*hydro  ebt pressure     tempe
3060200 0  1532651.   337877.  2410948. 0.
*
*hydro   from          to          area    f loss   r loss    vcahs
3061101 306000000   308000000     0.       0.15      0.15  01000
3062101 304010000   306000000     0.       0.        0.     01000
*
*hydro   hyd diam
3061110 0.3255   0.0 1.0 1.0
3062110 0.3255   0.0 1.0 1.0
*
*hydro               f velocity    g velocity    j velocity
3061201   7.54915    7.54915 0. * 676.066
3062201   7.60384    8.20134 0. * 680.958
*
*-----------------------------------------------------------*
*hydro          component name    component type
3080000           "mhx-prim"          pipe
*-----------------------------------------------------------$
3080001         11
*
*hydro       vol area                                  vol
3080101       0.8258                                    5
3080102       0.841                                     6
3080103       0.8258                                    11
*
*hydro       length                                    vol
3080301       1.11                                      5
3080302       2.03                                      6
```

```
3080303      1.11                        11
*
*hydro       volume                      vol
3080401        0.                        11
*
*hydro       vert angle                  vol
3080601        0.                        11
*
*hydro       delta z                     vol
3080701        0.0                       11
*
*hydro       roughness    hyd diam             vol
3080801        0.0000457   0.636                 5
3080802        0.0000457   0.894                 6
3080803        0.0000457   0.636                11
*
*hydro       fe                          vol
3081001        00                        11
*
*hydro       vcahs                       jun
3081101        01000                      10
*
*hydro  ebt pressure     tempe                    vol
3081201  0  1526516.   301950.3 2410869. 0.      0. 1
3081202  0  1526512.   271440.  2410869. 0.      0. 2
3081203  0  1526507.   245361.  2410869. 0.      0. 3
3081204  0  1526502.   222932.  2410869. 0.      0. 4
3081205  0  1526497.   203535.  2410869. 0.      0. 5
3081206  0  1526502.   203519.  2410869. 0.      0. 6
3081207  0  1526484.   197327.3 2410869. 0.      0. 7
3081208  0  1526478.   191872.  2410868. 0.      0. 8
3081209  0  1526471.   187058.  2410868. 0.      0. 9
3081210  0  1526465.   182804.  2410868. 0.      0. 10
3081211  0  1526458.   179039.3 2410868. 0.      0. 11
*
*hydro     f velocity   g velocity   j velocity         jun
3081300 0
3081301  .756653   .756653  0. 1  * 676.067
3081302  .753448   .753448  0. 2  * 676.068
3081303  .750926   .750926  0. 3  * 676.069
3081304  .748926   .748926  0. 4  * 676.07
3081305  .747325   .747325  0. 5  * 676.071
3081306  .747327   .747327  0. 6  * 676.074
3081307  .746844   .746844  0. 7  * 676.075
3081308  .746429   .746429  0. 8  * 676.077
3081309  .746072   .746072  0. 9  * 676.078
3081310  .745763   .745763  0. 10 * 676.08
*
*hydro   jun hyd diam                          jun
3081401     0.100      0.0 1.0 1.0              10
*
*-----------------------------------------------------------$
*hydro          component name      component type
3120000           "hxplout3"          branch
*-----------------------------------------------------------$
*hydro         no. juns        vel/flw
3120001          2               0
*
*hydro         area           length          volume
3120101        0.08322           1.0             0.
*
*hydro        horz angle      vert angle        delta z
3120102          0.              0.              0.
*
*hydro        roughness        hyd diam          fe
3120103        0.0000457         0.3255            0
*
*hydro  ebt pressure     tempe
3120200 0  1491593.   179040.3 2410393. 0.
*
*hydro   from        to          area     f loss   r loss   vcahs
3121101 308010000  312000000    0.        0.15      0.15  01000
3122101 312010000  313000000    0.08322   0.        0.    01000
*
*hydro   hyd diam
3121110 0.3255  0.0 1.0 1.0
3122110 0.3255 0.0 1.0 1.0
*
*hydro              f velocity   g velocity   j velocity
3121201   7.39762    7.39762 0. * 676.081
3122201   7.39773    7.39773 0. * 676.081
*
*-----------------------------------------------------------$
*hydro           component name      component type
3130000            "joinhx"            pipe
*-----------------------------------------------------------$
3130001         3
*
*hydro          vol area                          vol
3130101           0.08322                           3
*
*hydro          length                            vol
3130301           1.981                             1
3130302           1.23                              2
3130303           0.6096                            3
*
*hydro          volume                            vol
3130401           0.                                3
*
*hydro          vert angle                        vol
3130601           -22.6                             1
3130602           -29.7                             2
3130603           -90.                              3
*
*hydro          elev. change                      vol
3130701           -0.762                            1
3130702           -0.6093                           2
3130703           -0.6096                           3
*
*hydro          roughness      hyd diam                 vol
3130801           0.0000457      0.3255                   3
*
*hydro          f loss      r loss                jun
3130901           0.182       0.182                 2
*
*hydro          fe                                vol
3131001           00                                3
*
*hydro          vcahs                             jun
3131101           01000                             2
*
*hydro  ebt pressure      tempe                       vol
3131201  0  1493892.    179042.3 2410429. 0.        0. 1
3131202  0  1493858.    179043.6 2410429. 0.        0. 2
3131203  0  1493832.    179044.2 2410428. 0.        0. 3
*
*hydro          vel/flw
3131300    .      0
*
*hydro       f flowrate   g flowrate   j flowrate            jun
3131301   7.39773    7.39773 0. 1 * 676.082
3131302   7.39773    7.39773 0. 2 * 676.082
*
*-----------------------------------------------------------$
*     main heat exchanger secondary flow system (tube side)       $
*-----------------------------------------------------------$
*
*-----------------------------------------------------------*
```

```
*hydro        component name    component type
3300000         "secsrc3"          tmdpvol
*-----------------------------------------------------------------*
*hydro      area      length     volume
3300101      1.e6        .0      1.0e+06
*
*hydro    horz angle  vert angle   delta z
3300102       .0          .0          .0
*
*hydro    roughness   hyd diam      fe
3300103       .0         .0         10
*
*hydro ebt      trip no.     alpha vrc     numeric vrc
3300200 003
*
*hydro  time    pressure     tempe
3300201  0.     5.000e5      302.55
*
*-----------------------------------------------------------------*
*hydro        component name    component type
3320000         "sectdj1"          tmdpjun
*-----------------------------------------------------------------*
*hydro   from          to           area
3320101  330000000   334000000     0.7122
*
*hydro   vel/flw     trip no.     alpha vrc     numeric vrc
3320200     1            0         cntrlvar        586
*
*hydro  time          f flow       g flow       j flow
3320201  -1.e6        -1.e6          0.            0
3320202   1.e6         1.e6          0.            0
*
*-----------------------------------------------------------------*
*hydro        component name    component type
3340000         "mhx-sec"           pipe
*-----------------------------------------------------------------$
3340001       10
*
*hydro       vol area                             vol
3340101       0.776                                10
*
*hydro       length                               vol
3340301        1.314                               10
*
*hydro       volume                               vol
3340401       0.                                  10
*
*hydro       vert angle                           vol
3340601       0.                                  10
*
*hydro       delta z                              vol
3340701       0.0                                 10
*
*hydro       roughness     hyd diam                       vol
3340801       0.0000457    0.01588                        10
*
*hydro       fe                                   vol
3341001       00                                   10
*
*hydro       vcahs                                jun
3341101       01000                                 9
*
*hydro ebt pressure      tempe                           vol
3341201 0  504232.    130496.6 2560195. 0.             0. 1
3341202 0  498109.    139043.4 2559807. 0.             0. 2
3341203 0  492010.    148979.4 2559417. 0.             0. 3
3341204 0  485936.    160601.6 2559024. 0.             0. 4
3341205 0  479888.    174285.2 2558630. 0.             0. 5
3341206 0  473813.    175722.4 2558229. 0.             0. 6
3341207 0  467707.    177345.7 2557822. 0.             0. 7
3341208 0  461604.    179182.  2557412. 0.             0. 8
3341209 0  455505.    181262.  2556997. 0.             0. 9
3341210 0  449410.    183622.3 2556578. 0.             0. 10
*
*hydro      f velocity  g velocity   j velocity            jun
3341300 0
3341301  2.296346 2.296346 0. 1 * 1774.07
3341302  2.29788  2.29788  0. 2 * 1774.07
3341303  2.29977  2.29977  0. 3 * 1774.07
3341304  2.30211  2.30211  0. 4 * 1774.07
3341305  2.305053 2.305053 0. 5 * 1774.07
3341306  2.30538  2.30538  0. 6 * 1774.07
3341307  2.30575  2.30575  0. 7 * 1774.07
3341308  2.30617  2.30617  0. 8 * 1774.07
3341309  2.30665  2.30665  0. 9 * 1774.07
*
*hydro  jun hyd diam                                   jun
3341401    0.01588    0.0 1.0 1.0                        9
*
*-----------------------------------------------------------------*
*hydro        component name    component type
3350000         "tubeout"          sngljun
*-----------------------------------------------------------------*
*hydro   from        to          area    f loss   r loss   vcahs
3350101  334010000   336000000   0.0       0.       0.     01000
*
*hydro   hyd diam
3350110  0.01588     0.0     1.0     1.0
*
*hydro   vel/flw     f velocity    g velocity    j velocity
3350201     0         2.307196      2.307196     0. * 1774.07
*
*-----------------------------------------------------------------*
*hydro        component name    component type
3360000         "secsnk1"          tmdpvol
*-----------------------------------------------------------------*
*hydro      area      length     volume
3360101      1.e6        .0      1.0e+06
*
*hydro    horz angle  vert angle   delta z
3360102       .0          .0          .0
*
*hydro    roughness   hyd diam      fe
3360103       .0         .0         10
*
*hydro ebt      trip no.     alpha vrc     numeric vrc
3360200 003
*
*hydro  time    pressure     tempe
3360201  0.     4.490e5      319.
*
*=================================================================$
*
*     EMERGENCY HEAT EXCHANGER - LOOP 3
*
*=================================================================$
*
*-----------------------------------------------------------------$
*hydro        component name    component type
3140000          hxplin1           branch
*-----------------------------------------------------------------$
*hydro        no. juns       vel/flw
3140001          2              0
*
*hydro        area          length          volume
3140101       0.08322         1.0             0.
*
*hydro      horz angle      vert angle        delta z
```

```
3140102      0.        0.        0.
*
*hydro    roughness    hyd diam     fe
3140103    0.0000457    0.3255       0
*
*hydro ebt pressure   tempe
3140200 0 1525599.  179045.2 2410857. 0.
*
*hydro  from       to        area   f loss  r loss  vcahs
3141101 314000000  316000000  0.     0.15    0.15  01000
3142101 313010000  314000000  0.     0.      0.    01000
*
*hydro  hyd diam
3141110 0.3255  0.0 1.0 1.0
3142110 0.3255  0.0 1.0 1.0
*
*hydro         f velocity  g velocity  j velocity
3141201  7.39763 7.39763 0. * 676.082
3142201  7.39773 7.98767 0. * 676.082
*
*-------------------------------------------------------------*
*hydro     component name   component type
3160000     "ehx-prim"       pipe
*-------------------------------------------------------------$
3160001    4
*
*hydro     vol area                     vol
3160101     0.894                        4
*
*hydro     length                       vol
3160301     1.6                          4
*
*hydro     volume                       vol
3160401     0.                           4
*
*hydro     vert angle                   vol
3160601     0.                           4
*
*hydro     delta z                      vol
3160701     0.0                          4
*
* Calibrated hydraulic diameter to match pressure drop
*
*hydro     roughness   hyd diam                vol
*3160801    0.0000457   0.0346                  4
3160801     0.0000457   0.00170                 4
*
*hydro     f loss    r loss                jun
3160901     0.0       0.0                   3
*
*hydro     fe                              vol
3161001     00                              4
*
*hydro     vcahs                           jun
3161101     01000                           3
*
*hydro ebt pressure   tempe                       vol
3161201  0  1515362.  178822.3 2410725. 0.        0. 1
3161202  0  1506819.  178491.  2410614. 0.        0. 2
3161203  0  1498259.  177996.8 2410498. 0.        0. 3
3161204  0  1489673.  177259.6 2410363. 0.        0. 4
*
*hydro    f velocity  g velocity  j velocity         jun
3161300 0
3161301  .688615 .688615 0. 1 * 676.083
3161302  .688597 .688597 0. 2 * 676.084
3161303  .688569 .688569 0. 3 * 676.086
*
*hydro  jun hyd diam                                 jun
3161401    0.00170    0.0 1.0 1.0                    3
*
*-------------------------------------------------------------$
*hydro      component name    component type
3200000      hxplout1          branch
*-------------------------------------------------------------$
*hydro      no. juns       vel/flw
3200001      2              0
*
*hydro      area           length        volume
3200101      0.08322        1.0           0.
*
*hydro      horz angle     vert angle      delta z
3200102      0.             0.              0.
*
*hydro      roughness      hyd diam        fe
3200103      0.0000457      0.3255          0
*
*hydro ebt pressure   tempe
3200200 0  1450468.   177260.7 2409737. 0.
*
*hydro  from       to         area    f loss   r loss   vcahs
3201101 316010000  320000000  0.      0.15     0.15  01000
3202101 320010000  322000000  0.08322 0.       0.    01000
*
*hydro  hyd diam
3201110 0.3255  0.0 1.0 1.0
3202110 0.3255 0.0 1.0 1.0
*
*hydro         f velocity  g velocity   j velocity
3201201  7.39655 7.39655 0. * 676.087
3202201  7.39668 7.39668 0. * 676.087
*
*-------------------------------------------------------------$
*   emergency heat exchanger secondary flow system (tube side)      $
*-------------------------------------------------------------$
*
*-------------------------------------------------------------*
*hydro        component name    component type
3380000        "secsrc1"         tmdpvol
*-------------------------------------------------------------*
*hydro       area     length     volume
3380101       1.e6     .0         1.0e+06
*
*hydro       horz angle  vert angle   delta z
3380102       .0          .0           .0
*
*hydro       roughness   hyd diam     fe
3380103       .0          .0           10
*
*hydro ebt      trip no.     alpha vrc      numeric vrc
3380200 003
*
*hydro  time    pressure    tempe
3380201  0.     1.800e5     311.15
*
*-------------------------------------------------------------*
*hydro        component name    component type
3400000        "tubein"          sngljun
*-------------------------------------------------------------*
*hydro  from       to         area    f loss  r loss  vcahs
3400101 338000000  342000000  0.0     0.      0.    01100
*
*hydro  hyd diam
3400110  0.4573     0.0    1.0    1.0
*
*hydro  vel/flw    f velocity    g velocity    j velocity
3400201  0         .099223       .099223       0. * 42.016
*
```

```
*-----------------------------------------------------------------------*
*hydro      component name     component type
3420000       "ehx-sec"        pipe
*-----------------------------------------------------------------------$
3420001     2
*
*hydro      vol area                           vol
3420101      0.4264                              2
*
*hydro      length                             vol
3420301      0.7622                              2
*
*hydro      volume                             vol
3420401      0.                                 2
*
*hydro      vert angle                         vol
3420601      0.                                 2
*
*hydro      delta z                            vol
3420701      0.0                                2
*
*hydro      roughness    hyd diam                      vol
3420801      0.0000457   0.4573                          2
*
*hydro      fe                                 vol
3421001      00                                  2
*
*hydro      vcahs                              jun
3421101      01000                               1
*
*hydro  ebt pressure    tempe                          vol
3421201  0  179993.   159067.4 2525552. 0.      0. 1
3421202  0  179993.   159067.4 2525552. 0.      0. 2
*
*hydro      f velocity  g velocity  j velocity         jun
3421300 0
3421301  .099223  .099223   0. 1 * 42.016
*
*hydro   jun hyd diam                          jun
3421401   0.4573    0.0 1.0 1.0                   1
*
*-----------------------------------------------------------------------*
*hydro      component name    component type
3440000       "tubein"        sngljun
*-----------------------------------------------------------------------*
*hydro   from        to         area    f loss  r loss   vcahs
3440101  342010000   346000000  0.0     0.      0.       01100
*
*hydro   hyd diam
3440110  0.01905    0.0    1.0    1.0
*
*hydro   vel/flw    f velocity    g velocity    j velocity
3440201   0          .099223       .099223       0. * 42.016
*
*-----------------------------------------------------------------------*
*hydro      component name    component type
3460000       "ehx-sec"       pipe
*-----------------------------------------------------------------------$
3460001     4
*
*hydro      vol area                           vol
3460101      0.476                              4
*
*hydro      length                             vol
3460301      1.6                                4
*
*hydro      volume                             vol
3460401      0.                                 4
*
*hydro      vert angle                         vol
3460601      0.                                 4
*
*hydro      delta z                            vol
3460701      0.0                                4
*
*hydro      roughness    hyd diam                      vol
3460801      0.0000457   0.01905                         4
*
*hydro      fe                                 vol
3461001      00                                 4
*
*hydro      vcahs                              jun
3461101      01000                               3
*
*hydro  ebt pressure    tempe                          vol
3461201  0  179987.3  170744.4 2525551. 0.      0. 1
3461202  0  179974.3  178496.  2525549. 0.      0. 2
3461203  0  179961.   183604.  2525546. 0.      0. 3
3461204  0  179947.   186953.7 2525544. 0.      0. 4
*
*hydro      f velocity  g velocity   j velocity        jun
3461300 0
3461301  .0889793  .0889793  0. 1 * 42.016
3461302  .0890457  .0890457  0. 2 * 42.016
3461303  .0890908  .0890908  0. 3 * 42.016
*
*hydro   jun hyd diam                          jun
3461401   0.01905   0.0 1.0 1.0                   3
*
*-----------------------------------------------------------------------*
*hydro      component name    component type
3480000       "tubeout"       sngljun
*-----------------------------------------------------------------------*
*hydro   from        to         area    f loss  r loss   vcahs
3480101  346010000   350000000  0.0     0.      0.       01100
*
*hydro   hyd diam
3480110  0.01905    0.0    1.0    1.0
*
*hydro   vel/flw    f velocity    g velocity    j velocity
3480201   0          .2089733      .2089733      0. * 42.0161
*
*-----------------------------------------------------------------------$
*hydro      component name    component type
3500000       "chimney"       pipe
*-----------------------------------------------------------------------$
3500001     4
*
*hydro      vol area                           vol
3500101      0.203                              4
*
*hydro      length                             vol
3500301      0.75                               4
*
*hydro      volume                             vol
3500401      0.                                 4
*
*hydro      vert angle                         vol
3500601      90.                                4
*
*hydro      elev. change                       vol
3500701      0.75                               4
*
*hydro      roughness    hyd diam                      vol
3500801      0.0000457   0.508                           4
*
*hydro      f loss    r loss                   jun
3500901      0.        0.                       3
```

```
*
*hydro      fe                        vol
3501001     00                        4
*
*hydro      vcahs                     jun
3501101     01000                     3
*
*hydro ebt pressure   tempe                  vol
3501201 0 176273.   186911. 2524838. 0.    0. 1
3501202 0 168988.   186867.5 2523401. 0.   0. 2
3501203 0 161702.6  186823. 2521912. 0.    0. 3
3501204 0 154417.3  186777. 2520368. 0.    0. 4
*
*hydro      vel/flw
3501300     0
*
*hydro     f flowrate  g flowrate  j flowrate          jun
3501301  .208973   .2562017 0. 1 * 42.0161
3501302  .2089726  .2562014 0. 2 * 42.0161
3501303  .2089724  .256201  0. 3 * 42.0161
*
*---------------------------------------------------------------
*hydro        component name    component type
3520000         "tubeout"          sngljun
*---------------------------------------------------------------
*hydro  from        to         area    f loss   r loss  vcahs
3520101  350010000  354000000  0.0      0.      0.   01100
*
*hydro  hyd diam
3520110  0.508     0.0    1.0    1.0
*
*hydro  vel/flw    f velocity   g velocity   j velocity
3520201    0        .2089722     .21796      0. * 42.0161
*
*--------------------------------------------------------------*
*hydro        component name    component type
3540000         "secsnk1"          tmdpvol
*--------------------------------------------------------------*
*hydro      area     length    volume
3540101     1.e6      .0       1.0e+06
*
*hydro    horz angle  vert angle   delta z
3540102      .0         .0          .0
*
*hydro    roughness  hyd diam    fe
3540103      .0        .0        10
*
*hydro ebt      trip no.     alpha vrc      numeric vrc
3540200 003
*
*hydro  time    pressure    tempe
3540201  0.     150773.66   306.
*
*===============================================================$
*
*  ACCUMULATOR AND SURGE LINE - LOOP 3
*    assembled from normal relap5 components.
*    a tank wall heat structure (#3561) has been defined
*
*===============================================================$
*
*hydro        component name    component type
3560000         "accum3"            pipe
*--------------------------------------------------------------$
*hydro      no. volumes
3560001       6
*
*hydro      vol area                      vol
3560101      1.65                         5
3560102      0.08322                      6
*
*hydro      length                        vol
*
*hydro      length                        vol
3560301      4.09                         1
3560302      0.12                         5
3560303      4.88                         6
*
*hydro      volume                        vol
3560401      0.                           6
*
*hydro      vert angle                    vol
3560601      -90.                         6
*
*hydro     roughness     hyd diam               vol
3560801    0.0000457      1.52                  5
3560802    0.0000457      0.3255                6
*
*hydro      f loss     r loss             jun
3560901      0.         0.                4
3560902      0.5        1.0               5
*
*hydro      fe                            vol
3561001      00000                        6
*
*hydro      vcahs                         jun
3561101      00000                        5
*
*hydro ebt                                       vol
3561201 6  1498454.   106623.2 373147.  .0770827  .998333 1
3561202 0  1519565.   113130.  2410780. 0. 0.  2
3561203 0  1520864.   124112.5 2410796. 0. 0.  3
3561204 0  1522161.   144141.7 2410813. 0. 0.  4
3561205 0  1523455.   179238.  2410830. 0. 0.  5
3561206 0  1550244.   235538.  2411172. 0. 0.  6
*
*hydro      vel/flw
3561300      0
*
*hydro      f velocity   g velocity   j velocity          jun
3561301      -1.228429-5  -.554139      0.       1 * -.0223746
3561302      -1.229335-5  -1.22949-5    0.       2 * -.02237553
3561303      -1.23036-5   -1.230515-5   0.       3 * -.0223618
3561304      -1.231656-5  -1.23181-5    0.       4 * -.0223174
3561305      -2.44555-4   -2.451576-4   0.       5 * -.022215
*
$==============================================================$
*hydro        component name    component type
3570000         "accumout"         sngljun
*--------------------------------------------------------------$
*hydro  from        to          area     f loss  r loss   vcahs
3570101  356060002  304020001 0.08322  0.      0.     01000
*
*hydro  vel/flw     f velocity    g velocity    j velocity
3570201   0         -2.497053-4   -2.497053-4   0. * -.02236223
*
$==============================================================$
*hydro   .    component name    component type
3220000         "coldleg"          pipe
*--------------------------------------------------------------$
3220001       3
*
*hydro      vol area                      vol
3220101      0.08322                      3
*
*hydro      length                        vol
3220301      2.31                         1
3220302      2.13                         2
```

```
3220303     0.762                 3
*
*hydro      volume               vol
3220401     0.                    3
*
*hydro      volume               vol
3220501     0.                    3
*
*hydro      vert angle           vol
3220601     -7.6                  1
3220602     0.                    2
3220603     90.                   3
*
*hydro      delta z              vol
3220701     -0.305                1
3220702     0.                    2
3220703     0.762                 3
*
*hydro      roughness   hyd diam        vol
3220801     0.0000457   0.3255           3
*
*hydro      f loss      r loss          jun
3220901     0.182       0.182            2
*
*hydro      fe                   vol
3221001     00                    3
*
*hydro      vcahs                jun
3221101     01000                 2
*
*hydro  ebt pressure   tempe                          vol
3221201  0  1450100.   177252.3 2409731. 0.          0. 1
3221202  0  1443570.   177244.5 2409625. 0.          0. 2
3221203  0  1432234.   177242.  2409441. 0.          0. 3
*
*hydro      f flowrate  g flowrate  j flowrate        jun
3221300 0
3221301  7.39668   7.39668 0. 1 * 676.087
3221302  7.3967    7.3967  0. 2 * 676.087
*
*=====================================================================$
*
*   PRIMARY COOLANT PUMP - LOOP 3
*
*=====================================================================$
*
*---------------------------------------------------------$
*hydro        component name    component type
3240000       "rcpump3"         pump
*---------------------------------------------------------$
*hydro      area        length       volume
3240101     0.          0.500        0.7739
*
*hydro      horz angle    vert angle     delta z
3240102     0.            0.             0.
*
*hydro      equil flag
3240103     00
*
*hydro      from       jun area   f loss   r loss   vcahs
3240108     322010000  0.         0.00     0.00     01000
*
* Assume k=2.0 for strainer loss coefficient
*
*hydro      to         jun area   f loss   r loss   vcahs
3240109     326000000  0.         2.0      2.0      01000
*
*hydro  ebt pressure   tempe
3240200 0 2511077.   177286.5 2418733. 0.
*
*hydro   vel/flw   f flowrate    g flowrate    j flowrate
3240201 0  7.39673   7.98785 0. * 676.087
*
*hydro   vel/flw   f flowrate    g flowrate    j flowrate
3240202 0  7.39326   7.39326 0. * 676.088
*
*hydro     ptdi   2fazi   diff i   tork i   pvel i   trip no.   rvrs i
3240301    124    124     124      -1       0        555        0
*
*hydro   rated pump vel.   init/rated vel.   rated flow   rated head
3240302      188.5             .968583          0.643        207.3
*
*hydro   rated torque    mom of inertia    rated dens    mtr torque
3240303     7616.8          91.50            1098.          .0
*
*hydro    coeff. tf2    coeff. tf0    coeff. tf1    coeff. tf3
3240304     10.0          150.0         0.            0.
*    pump speed table
*3246100    0 cntrlvar 186
3246100    619 cntrlvar 195
3246101    -1.e6  -1.e6
3246102    1.e6   1.e6
*
*---------------------------------------------------------$
*hydro        component name    component type
3260000       "pmpdisc"         pipe
*---------------------------------------------------------$
3260001      1
*
*hydro      vol area             vol
3260101     0.08322               1
*
*hydro      length               vol
3260301     0.9146                1
*
*hydro      volume               vol
3260401     0.                    1
*
*hydro      volume               vol
3260501     0.                    1
*
*hydro      vert angle           vol
3260601     0.0                   1
*
*hydro      delta z              vol
3260701     0.0                   1
*
*hydro      roughness   hyd diam        vol
3260801     0.0000457   0.3255           1
*
*hydro      f loss      r loss          jun
*3260901    0.0         0.0              1
*
*hydro      fe                   vol
3261001     00                    1
*
*hydro      vcahs                jun
*3261101    01000                 2
*
*hydro  ebt pressure   tempe                          vol
3261201  0  3473876.   177284.5 2419432. 0.          0. 1
*
*hydro      vel/flw
*
*hydro      f flowrate  g flowrate  j flowrate        jun
*3261300 0
*3261301  7.21537   7.79558 0. 2 * 659.73
*
```

```
*----------------------------------------------------------------$
*hydro        component name    component type
3280000          "check"            valve
*----------------------------------------------------------------$
*hydro   from        to        area    f loss   r loss   vcahs
3280101  326010000   329000000  0.08317  0.98    0.98    01100
*
*hydro   vel/flw    f flowrate   g flowrate   j flowrate
3280201 0  7.39014   7.39014 0. * 676.088
*
*hydro          valve type
3280300            chkvlv
*
*hydro   chkvlv type  init. posn  back press  leak ratio
3280301     0          0           0.          0.
*
*----------------------------------------------------------------$
*hydro        component name    component type
3290000          "cljoin"           pipe
*----------------------------------------------------------------$
3290001        1
*
*hydro       vol area                          vol
3290101      0.08322                             1
*
*hydro       length                            vol
3290301      6.25                               1
*
*hydro       volume                            vol
3290401      0.                                1
*
*hydro       volume                            vol
3290501      0.                                1
*
*hydro       vert angle                        vol
3290601      0.0                               1
*
*hydro       delta z                           vol
3290701      0.0                               1
*
*hydro       roughness    hyd diam                  vol
3290801      0.0000457    0.3255                     1
*
*hydro       f loss     r loss                 jun
*3290901     0.0        0.0                     1
*
*hydro       fe                                vol
3291001      00                                1
*
*hydro       vcahs                             jun
*3291101     01000                              2
*
*hydro  ebt pressure    tempe                        vol
3291201  0  3440088.   177261.7 2419456. 0.        0. 1
*
*hydro       vel/flw
*
*hydro     f flowrate   g flowrate   j flowrate           jun
*3291300 0
*3291301   7.21537    7.79558 0. 2 * 659.73
*
*----------------------------------------------------------------*
*hydro        component name    component type
3310000          "elbow1"           sngljun
*----------------------------------------------------------------*
*hydro   from        to        area      f loss   r loss   vcahs
3310101  329010000   358000000  0.083220  0.182    0.182    01000
*
*hydro   vel/flw    f velocity   g velocity   j velocity
3310201 0  7.39024   7.39024 0. * 676.088
*
*----------------------------------------------------------------$
*hydro        component name    component type
3580000          "coldleg"          pipe
3580001      2
*----------------------------------------------------------------$
*
*hydro       vol area                          vol
3580101      0.08322                             2
*
*hydro       length                            vol
3580301      7.24                              2
*
*hydro       volume                            vol
3580401      0.                                2
*
*hydro       horz angle                        vol
3580501      0.                                2
*
*hydro       vert angle                        vol
3580601      0.                                2
*
*hydro       delta z                           vol
3580701      0.                                2
*
*hydro       roughness    hyd diam                  vol
3580801      0.0000457    0.3255                     2
*
*hydro       kf          kr                    jun
3580901      0.0         0.0                    1
*
*hydro       fe                                vol
3581001      00                                2
*
*hydro       vcahs                             jun
3581101      01000                              1
*
*hydro  ebt pressure    tempe                        vol
3581201  0  3426428.   177200.7 2419466. 0.        0. 1
3581202  0  3417642.   177209.  2419472. 0.        0. 2
*
3581300 0
3581301   7.39025    7.39025 0. 1 * 676.088
*
*----------------------------------------------------------------*
*hydro        component name    component type
3600000          "elbow3"           sngljun
*----------------------------------------------------------------*
*hydro   from        to        area      f loss   r loss   vcahs
3600101  358010000   362000000  0.083220  0.182    0.182    01000
*
*hydro   vel/flw    f velocity   g velocity   j velocity
3600201 0  7.39028   7.39028 0. * 676.089
*
*----------------------------------------------------------------*
*hydro        component name    component type
3620000          "14incdlg"         pipe
*----------------------------------------------------------------*
3620001        2
*
*hydro       vol area                          vol
3620101      0.08322                             2
*
*hydro       length                            vol
3620301      1.2166                             1
3620302      13.93439                            2
*
*hydro       volume                            vol
```

```
3620401     0.                  2
*
*hydro      horz angle          vol
3620501     0.                  2
*
*hydro      vert angle          vol
3620601     0.                  1
3620602     -90.                2
*
*hydro      delta z             vol
3620701     0.0                 1
3620702     -13.93439           2
*
*hydro      roughness   hyd diam        vol
3620801     0.0000457   0.3255          2
*
*hydro      kf      kr          jun
3620901     0.182   0.182       1
*
*hydro      fe                  vol
3621001     00                  2
*
*hydro      vcahs               jun
3621101     01000               1
*
*hydro  ebt pressure    tempe           vol
3621201 0 3407042.  177204.7 2419480. 0.    0. 1
3621202 0 3467488.  177156.3 2419436. 0.    0. 2
*
*hydro      f velocity  g velocity  j velocity      jun
3621300 0
3621301  7.39032   7.39032 0. 1 * 676.089
*
*-----------------------------------------------------------------*
*hydro      component name      component type
3720000     "inlet"             sngljun
*-----------------------------------------------------------------*
*hydro  from        to          area    f loss  r loss  vcahs
3720101 362010000  371000000  0.03095  0.2062  0.4513   01000
*
*hydro  jun hyd diam
3720110   0.1985    0.0 1.0 1.0
*
*hydro  vel/flw   f velocity   g velocity   j velocity
3720201 0 19.87086  20.69764 0. * 676.089
*
*-----------------------------------------------------------------*
*hydro      component name      component type
3710000     "ifdthrot"          pipe
*-----------------------------------------------------------------$
3710001     3
*
*hydro      vol area            vol
3710101     0.03095             3
*
*hydro      length              vol
3710301     0.30                1
3710302     0.51                2
3710303     0.98                3
*
*hydro      volume              vol
3710401     0.                  3
*
*hydro      volume              vol
3710501     0.                  3
*
*hydro      vert angle          vol
3710601     -90.0               1
3710602     0.0                 2
3710603     0.0                 3
*
*hydro      delta z             vol
3710701     -0.3                1
3710702     0.0                 2
3710703     0.0                 3
*
*hydro      roughness   hyd diam        vol
3710801     0.0000457   0.1985          3
*
*hydro      f loss    r loss            jun
3710901     0.196     0.196             2
*
*hydro      fe                  vol
3711001     00                  3
*
*hydro      vcahs               jun
3711101     01000               2
*
*hydro  ebt pressure    tempe           vol
3711201 0 3301636.  177159.2 2419558. 0.    0. 1
3711202 0 3254335.  177164.2 2419594. 0.    0. 2
3711203 0 3200119.  177174.  2419636. 0.    0. 3
*
*hydro      vel/flw
*
*hydro      f flowrate  g flowrate  j flowrate      jun
3711300 0
3711301  19.8723    20.7024 0. 1 * 676.089
3711302  19.87272   19.87272 0. 2 * 676.089
*
*-----------------------------------------------------------------*
*hydro      component name      component type
3730000     "ifdexit"           sngljun
*-----------------------------------------------------------------*
*hydro  from        to          area    f loss  r loss  vcahs
3730101 371010000  374000000  0.03095  0.1028  0.04696  01000
*
*hydro  jun hyd diam
3730110   0.1985    0.0 1.0 1.0
*
*hydro  vel/flw   f velocity   g velocity   j velocity
3730201 0 19.8732  19.8732 0. * 676.089
*
*-----------------------------------------------------------------$
*hydro      component name      component type
3740000     "psvaw-3"           pipe
*-----------------------------------------------------------------$
3740001     1
*
*hydro      vol area            vol
3740101     0.08322             1
*
*hydro      length              vol
3740301     0.50                1
*
*hydro      volume              vol
3740401     0.                  1
*
*hydro      volume              vol
3740501     0.                  1
*
*hydro      vert angle          vol
3740601     45.0                1
*
*hydro      delta z             vol
3740701     0.50                1
*
*hydro      roughness   hyd diam        vol
```

```
3740801     0.0000457    0.3255                    1
*
*hydro       f loss      r loss                jun
*3740901       0.0         0.0                   1
*
*hydro        fe                             vol
3741001        00                              1
*
*hydro       vcahs                           jun
*3741101      01000                            2
*
*hydro  ebt pressure    tempe                    vol
3741201  0  3354170.   177172.4 2419519. 0.     0. 1
*
*hydro       vel/flw
*
*hydro      f flowrate   g flowrate   j flowrate        jun
*3741300 0
*3741301   7.21537    7.79558 0. 2 * 659.73
*
*===================================================================$
*
*    components 4xx - inactive heat exchanger/pump loop
*
*===================================================================$
*
*hydro         component name     component type
4510000           "hlsplit4"          pipe
*-----------------------------------------------------$
4510001        1
*
*hydro       vol area                        vol
4510101       0.08322                          1
*
*hydro        length                         vol
4510301        3.28                            1
*
*hydro        volume                         vol
4510401        0.0                             1
*
*hydro       vert angle                      vol
4510601        0.                              1
*
*hydro       delta z                         vol
4510701        0.                              1
*
*hydro       roughness     hyd diam                  vol
4510801      0.0000457     0.3255                      1
*
*hydro        fe                             vol
4511001        00                              1
*
*hydro       vcahs                           jun
*4511101      01100                            1
*
*hydro      f velocity   g velocity   j velocity        jun
*4511300 0
*4511301   0.      0.     0.                      2
*
*hydro  ebt pressure    tempe                    vol
4511201  0  1593319.   154261.6 2411714. 0.     0. 1
*
*-----------------------------------------------------$
*hydro         component name     component type
4530000           "hlsp1j"          mtpljun
*-----------------------------------------------------$
4530001    1     0
*hydro   from        to          area     f loss   r loss   vcahs
4530011  650010000   451000000   0.24663   0.00    0.00   01000
*
4530012  1.0  1.0  1.0  0   0   0   1
*
4531011  -5.6919-7  -5.69192-7  1 * -1.545093-4
*
4532011  0.3255 0.0 1.0 1.0 1
*
*-----------------------------------------------------$
*hydro         component name     component type
4290000           "cljoin"            pipe
*-----------------------------------------------------$
4290001        1
*
*hydro       vol area                        vol
4290101       0.08322                          1
*
*hydro        length                         vol
4290301        6.25                            1
*
*hydro        volume                         vol
4290401        0.                              1
*
*hydro        volume                         vol
4290501        0.                              1
*
*hydro       vert angle                      vol
4290601        0.0                             1
*
*hydro       delta z                         vol
4290701        0.0                             1
*
*hydro       roughness     hyd diam                  vol
4290801      0.0000457     0.3255                      1
*
*hydro       f loss      r loss                jun
*4290901       0.0         0.0                   1
*
*hydro        fe                             vol
4291001        00                              1
*
*hydro       vcahs                           jun
*4291101      01000                            2
*
*hydro  ebt pressure    tempe                    vol
4291201  0  3232759.   1.5+5   2419610. 0.     0. 1
*
*hydro       vel/flw
*
*hydro      f flowrate   g flowrate   j flowrate        jun
*4291300 0
*4291301   7.21537    7.79558 0. 2 * 659.73
*
*-----------------------------------------------------*
*hydro         component name     component type
4310000           "elbow1"          sngljun
*-----------------------------------------------------*
*hydro   from        to          area     f loss   r loss   vcahs
4310101  429010000   458000000   0.083220   0.182   0.182   01000
*
*hydro   vel/flw    f velocity   g velocity   j velocity
4310201 0  4.54971-6  4.54971-6  0. * 4.171875-4
*
*-----------------------------------------------------$
*hydro         component name     component type
4580000           "coldleg"           pipe
4580001        2
*-----------------------------------------------------$
*
*hydro       vol area                        vol
```

```
4580101     0.08322                    2
*
*hydro      length                     vol
4580301     7.24                       2
*
*hydro      volume                     vol
4580401     0.                         2
*
*hydro      horz angle                 vol
4580501     0.                         2
*
*hydro      vert angle                 vol
4580601     0.                         2
*
*hydro      delta z                    vol
4580701     0.                         2
*
*hydro      roughness    hyd diam            vol
4580801     0.0000457    0.3255              2
*
*hydro      kf        kr               jun
4580901     0.0       0.0              1
*
*hydro      fe                         vol
4581001     00                         2
*
*hydro      vcahs                      jun
4581101     01000                      1
*
*hydro  ebt pressure    tempe                    vol
4581201  0  3232760.   146227.6 2419610. 0.      0. 1
4581202  0  3232763.   173850.4 2419610. 0.      0. 2
*
4581300 0
4581301   9.83857-6   9.83857-6   0. 1 * 9.02424-4
*
*-----------------------------------------------------------*
*hydro        component name    component type
4600000       "elbow3"          sngljun
*-----------------------------------------------------------*
*hydro   from        to         area      f loss   r loss   vcahs
4600101  458010000   462000000  0.083220  0.182    0.182    01000
*
*hydro   vel/flw   f velocity   g velocity   j velocity
4600201 0   1.413168-5  1.413168-5  0. * .001293117
*
*-----------------------------------------------------------*
*hydro        component name    component type
4620000       "14incdlg"        pipe
*-----------------------------------------------------------*
4620001     2
*
*hydro      vol area                   vol
4620101     0.08322                    2
*
*hydro      length                     vol
4620301     1.2166                     1
4620302     13.93439                   2
*
*hydro      volume                     vol
4620401     0.                         2
*
*hydro      horz angle                 vol
4620501     0.                         2
*
*hydro      vert angle                 vol
4620601     0.                         1
4620602     -90.                       2
*
*hydro      delta z                    vol
4620701     0.0                        1
4620702     -13.93439                  2
*
*hydro      roughness    hyd diam            vol
4620801     0.0000457    0.3255              2
*
*hydro      kf        kr               jun
4620901     0.182     0.182            1
*
*hydro      fe                         vol
4621001     00                         2
*
*hydro      vcahs                      jun
4621101     01000                      1
*
*hydro  ebt pressure    tempe                    vol
4621201  0  3232766.   150422.2 2419610. 0.      0. 1
4621202  0  3308056.   150056.4 2419554. 0.      0. 2
*
*hydro      f velocity   g velocity   j velocity        jun
4621300 0
4621301   1.44641-5   1.44641-5   0. 1 * .001326246
*
*-----------------------------------------------------------*
*hydro        component name    component type
4720000       "inlet"           sngljun
*-----------------------------------------------------------*
*hydro   from        to         area      f loss   r loss   vcahs
4720101  462010000   471000000  0.03095   0.2062   0.4513   01000
*
*hydro   jun hyd diam
4720110     0.1985     0.0 1.0 1.0
*
*hydro   vel/flw   f velocity   g velocity   j velocity
4720201 0  3.88559-5   3.88742-5   0. * .001325103
*
*-----------------------------------------------------------*
*hydro        component name    component type
4710000       "ifdthrot"        pipe
*-----------------------------------------------------------$
4710001     3
*
*hydro      vol area                   vol
4710101     0.03095                    3
*
*hydro      length                     vol
4710301     0.30                       1
4710302     0.51                       2
4710303     0.98                       3
*
*hydro      volume                     vol
4710401     0.                         3
*
*hydro      volume                     vol
4710501     0.                         3
*
*hydro      vert angle                 vol
4710601     -90.0                      1
4710602     0.0                        2
4710603     0.0                        3
*
*hydro      delta z                    vol
4710701     -0.3                       1
4710702     0.0                        2
4710703     0.0                        3
*
*hydro      roughness    hyd diam            vol
4710801     0.0000457    0.1985              3
```

```
*
*hydro      f loss    r loss                jun
4710901     0.196     0.196                   2
*
*hydro      fe                             vol
4711001     00                               3
*
*hydro      vcahs                          jun
4711101     01000                            2
*
*hydro ebt pressure   tempe                        vol
4711201 0 3384970.  146967.4 2419496. 0.   0. 1
4711202 0 3386593.  146294.5 2419495. 0.   0. 2
4711203 0 3386595.  146686. 2419495. 0.    0. 3
*
*hydro     f flowrate  g flowrate  j flowrate        jun
4711300 0
4711301  3.88531-5  3.88531-5  0. 1 * .001325382
4711302  3.88666-5  3.88666-5  0. 2 * .001325915
*
*-----------------------------------------------------------*
*hydro        component name    component type
4730000         "ifdexit"         sngljun
*-----------------------------------------------------------*
*hydro   from       to         area    f loss   r loss   vcahs
4730101  471010000  474000000  0.03095  0.1028  0.04696  01000
*
*hydro   jun hyd diam
4730110    0.1985    0.0 1.0 1.0
*
*hydro   vel/flw    f velocity   g velocity   j velocity
4730201 0 3.886865-5 3.88687-5  0. * .001325943
*
*-----------------------------------------------------------$
*hydro        component name    component type
4740000         "psvaw-4"          pipe
*-----------------------------------------------------------$
4740001       1
*
*hydro      vol area                        vol
4740101     0.08322                           1
*
*hydro      length                          vol
4740301     0.50                              1
*
*hydro      volume                          vol
4740401     0.                                1
*
*hydro      volume                          vol
4740501     0.                                1
*
*hydro      vert angle                      vol
4740601     45.0                              1
*
*hydro      delta z                         vol
4740701     0.50                              1
*
*hydro      roughness     hyd diam               vol
4740801     0.0000457     0.3255                   1
*
*hydro      f loss    r loss                jun
*4740901      0.0       0.0                   1
*
*hydro      fe                              vol
4741001     00                                1
*
*hydro      vcahs                           jun
*4741101    01000                             2
*
*hydro ebt pressure    tempe                          vol
4741201 0 3383896.   151712.6 2419497. 0.       0. 1
*
*hydro      f flowrate  g flowrate  j flowrate          jun
*4741300 0
*4741301  0. 0. 0. 2
*
*=================================================================$
*                              *
*     M A T E R I A L   P R O P E R T I E S            *
*                              *
*---------------------------------------------------------$
*                              *
*        composition 1  stainless 3041             *
*        composition 2  6061 aluminum               *
*        composition 3  hafnium                    *
*        composition 4  boehmite (oxide)            *
*        composition 5  u3si2-al fuel meat          *
*                              *
*---------------------------------------------------------$
*  thermal properties of composition  1  -  ss3041          $
*---------------------------------------------------------$
*compxn      composition   th.con flg    ht.cap flg    material
20100100      tbl/fctn       1              1         $ss3041
*
*compxn      temperature        th. cond.
20100101       273.2             14.7
20100102       300.              15.2
20100103       400.              17.0
20100104       500.              18.4
20100105       600.              19.8
20100106       700.              21.2
20100107       800.              22.5
20100108       900.              23.9
20100109       1000.             25.3
20100110       1200.             28.1
20100111       1400.             30.9
20100112       20000.            30.9
*
*compxn      temperature        vol ht cap
*steady20100151      273.2             10.0
*steady20100152      20000.            10.0
20100151       250.              2.97e6
20100152       478.              3.00e6
20100153       700.              3.13e6
20100154       811.              3.23e6
20100155       866.              3.33e6
20100156       922.              3.43e6
20100157       1033.             3.59e6
20100158       1200.             3.76e6
20100159       1311.             3.82e6
20100160       1400.             3.82e6
20100161       20000.            3.82e6
*=================================================================$
*  thermal properties of composition  2  -  al6061          $
*---------------------------------------------------------$
*compxn      composition   th.con flg    ht.cap flg    material
20100200      tbl/fctn       1              1         $al6061
*
*compxn      temperature        th. cond.
20100201       271.9             155.0
20100202       299.7             155.0
20100203       349.7             161.9
20100204       399.7             165.9
20100205       499.7             179.8
20100206       549.7             183.9
20100207       649.7             180.9
20100208       749.7             174.9
20100209       799.7             171.9
```

```
20100210   849.7      167.9
20100211   924.7      85.9
20100212   999.7      87.9
20100213   20000.     87.9
*
*compxn    temperature   vol ht cap
20100251   271.9      2.429e6
20100252   299.7      2.429e6
20100253   399.7      2.542e6
20100254   499.7      2.666e6
20100255   599.7      2.791e6
20100256   699.7      2.915e6
20100257   799.7      3.039e6
20100258   899.7      3.163e6
20100259   924.7      2.826e6
20100260   1060.8     2.826e6
20100261   1100.      2.826e6
20100262   20000.     2.826e6
*==================================================================$
*  thermal properties of composition  3 - hafnium       $
*---------------------------------------------------------$
*compxn    composition  th.con flg   ht.cap flg   material
20100300   tbl/fctn     1            1            $hafnium
*
*compxn    temperature   th. cond.
20100301   250.       23.6
20100302   273.2      23.3
20100303   300.       23.0
20100304   400.       22.3
20100305   600.       21.3
20100306   800.       20.8
20100307   1200.      20.9
20100308   1600.      21.5
20100309   2000.      22.6
20100310   20000.     22.6
*
*compxn    temperature   vol ht cap
20100351   252.9      1.870e6
20100352   278.       1.898e6
20100353   315.5      1.924e6
20100354   400.       1.975e6
20100355   500.       2.031e6
20100356   600.       2.087e6
20100357   800.       2.199e6
20100358   1000.      2.314e6
20100359   1350.      2.514e6
20100360   1400.      2.514e6
20100361   20000.     2.514e6
*==================================================================$
*  thermal properties of composition  4 - boehmite      $
*---------------------------------------------------------$
*compxn    composition  th.con flg   ht.cap flg   material
20100400   tbl/fctn     1            1            $boehmite
*
*compxn                 th. cond.
20100401                2.25
*
*
*compxn    temperature   vol ht cap
20100451   273.       2.198e6
20100452   373.       2.739e6
20100453   473.       3.096e6
20100454   573.       3.316e6
20100455   673.       3.453e6
20100456   773.       3.554e6
20100457   873.       3.638e6
20100458   973.       3.707e6
20100459   1073.      3.759e6
20100460   1173.      3.803e6
20100461   1200.      3.803e6
20100462   20000.     3.803e6
*==================================================================$
*  thermal properties of composition  5 - u3si2-al      $
*---------------------------------------------------------$
*compxn    composition  th.con flg   ht.cap flg   material
20100500   tbl/fctn     1            1            $u3si2-al
*
*compxn    temperature   th. cond.
20100501   273.       51.86
20100502   333.       59.0
20100503   1333.      178.0
20100504   20000.     178.0
*
*compxn    temperature   vol ht cap
20100551   273.       2.176e6
20100552   373.       2.289e6
20100553   473.       2.402e6
20100554   673.       2.628e6
20100555   873.       2.854e6
20100556   1073.      3.080e6
20100557   1273.      3.306e6
20100558   1300.      3.306e6
20100559   20000.     3.306e6
$==================================================================$
$  thermal properties of composition  6 - heavy water   $
*---------------------------------------------------------$
*compxn    composition  th.con flg   ht.cap flg   material
20100600   tbl/fctn     1            1            $heavy water
*
*compxn                 th. cond.
20100601                0.627
*
*
*compxn                 vol ht cap
20100651                4.56e6
*
*==================================================================*
*                                                  *
*      HEAT  STRUCTURE  INPUT                                  *
*                                                  *
*==================================================================*
*
*loop1*loop1*loop1*loop1*loop1*loop1*loop1*loop1*loop1*loop1*loop1*loop1
*
$==================================================================
$          ht str no. 1081       hx shell
*---------------------------------------------------------
*htstr   ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
11081000   10      4      2     1     1.009    0     0      0
*
*htstr     mesh locn   mesh fmt
11081100     0           1
*
*htstr     intervals   rt. coord
11081101     3           1.054
*
*htstr     compxn no.  interval
11081201     1           3
*
*htstr     source      interval
11081301     0.          3
*
*htstr              temp flg
11081400              0
*
*htstr     temp        mesh pt.
11081401   302.          4
*
```

```
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
11081501  108010000  10000  1    1    0.555    5
11081502  108070000  10000  1    1    0.555    10
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
11081601  -501    0    4599   1    0.555    10
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
11081701    0     0     0     0     10
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
11081801  0. 10. 10. 0. 0. 0. 0. 1.  10
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
11081901  0. 10. 10. 0. 0. 0. 0. 1.  10
*
$===================================================================
$          ht str no. 1082       hx shell
*------------------------------------------------------------------
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
11082000   1    4    1    1    0.00 0  0     0
*
*htstr     mesh locn     mesh fmt
11082100      0          1
*
*htstr     intervals     rt. coord
11082101      3          0.0445
*
*htstr     compxn no.    interval
11082201      1          3
*
*htstr     source        interval
11082301      0.         3
*
*htstr                  temp flg
11082400                   0
*
*htstr     temp          mesh pt.
11082401    302.           4

*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
11082501  108060000  00000  1    1    3.49     1
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
11082601  -501    0    4581   1    3.49     1
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
11082701    0     0     0     0     1
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
11082801  0. 10. 10. 0. 0. 0. 0. 1.  1
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
11082901  0. 10. 10. 0. 0. 0. 0. 1.  1
*
$==================================================================$
$          ht str no. 1083       hx tube          $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
11083000   10   4    2    1   7.049e-3   0  0     0
*
*htstr     mesh locn     mesh fmt
11083100      0          1
*
*htstr     intervals     rt. coord
11083101      3          7.938e-3
*
*htstr     compxn no.    interval
11083201      1          3
*
*htstr     source        interval
11083301      0.         3
*
*htstr                  temp flg
11083400                   0
*
*htstr     temp          mesh pt.
11083401    302.           4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
11083501  108010000  10000  1    1    8700.4    5
11083502  108070000  10000  1    1    8700.4    10
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
11083601  134050000  -10000  1    1    8700.4    5
11083602  134100000  -10000  1    1    8700.4    10
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
11083701    0     0     0     0     10
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
11083801  0. 10. 10. 0. 0. 0. 0. 1.  10
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
11083901  0. 10. 10. 0. 0. 0. 0. 1.  10
*
* tube and shell heat structures for emergency heat exchanger
*
$===================================================================
$          ht str no. 1161       hx shell
*------------------------------------------------------------------
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
11161000   4    4    2    1    0.5334 0  0     0
*
*htstr     mesh locn     mesh fmt
11161100      0          1
*
*htstr     intervals     rt. coord
11161101      3          0.5556
*
*htstr     compxn no.    interval
11161201      1          3
*
*htstr     source        interval
11161301      0.         3
*
*htstr                  temp flg
11161400                   0
*
*htstr     temp          mesh pt.
11161401    302.           4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
11161501  116010000  10000  1    1    1.6      4
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
11161601  -501    0    4591   1    1.6      4
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
11161701    0     0     0     0     4
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
11161801  0. 10. 10. 0. 0. 0. 0. 1.  4
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
11161901  0. 10. 10. 0. 0. 0. 0. 1.  4
*
*
```

```
$==================================================================$
$          ht str no. 1163       hx tube              $
*---------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
11163000   4   4   2   1   8.636e-3   0  0    0
*
*htstr     mesh locn     mesh fmt
11163100      0          1
*
*htstr     intervals     rt. coord
11163101      3          9.525e-3
*
*htstr     compxn no.    interval
11163201      1          3
*
*htstr     source        interval
11163301      0.         3
*
*htstr                temp flg
11163400                 0
*
*htstr     temp          mesh pt.
11163401    302.         4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
11163501  116010000  10000  1    1     2672.     4
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
11163601  146040000  -10000  1   1     2672.     4
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
11163701    0        0         0          0          4
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
11163801  0. 10. 10. 0. 0. 0. 0. 1.  4
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
11163901  0. 10. 10. 0. 0. 0. 0. 1.  4
*
$==================================================================$
$          ht str no. 1501       chimney              $
*---------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
11501000   4   4   2   1   0.2287   0  0    0
*
*htstr     mesh locn     mesh fmt
11501100      0          1
*
*htstr     intervals     rt. coord
11501101      3          0.2541
*
*htstr     compxn no.    interval
11501201      1          3
*
*htstr     source        interval
11501301      0.         3
*
*htstr                temp flg
11501400                 0
*
*htstr     temp          mesh pt.
11501401    302.         4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
11501501  150010000  10000  1    1     0.75      4
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
11501601  -501        0   4581   1     0.75      4
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
11501701    0        0         0          0          4
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
11501801  0. 10. 10. 0. 0. 0. 0. 1.  4
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
11501901  0. 10. 10. 0. 0. 0. 0. 1.  4
*
* accumulator heat structure - loop 1
*
$==================================================================$
$          ht str no. 1561       tankwall             $
*---------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
11561000   5   4   2   1   0.7245   0  0    0
*
*htstr     mesh locn     mesh fmt
11561100      0          1
*
*htstr     intervals     rt. coord
11561101      3          0.7396
*
*htstr     compxn no.    interval
11561201      1          3
*
*htstr     source        interval
11561301      0.         3
*
*htstr                temp flg
11561400                 0
*
*htstr     temp          mesh pt.
11561401    302.         4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
11561501  156010000  10000  1 1     4.09       1
11561502  156020000  10000  1 1     0.12       5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
11561601  0       0     0 1     4.09       1
11561602  0       0     0 1     0.12       5
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
11561701    0        0    0     0          5
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
11561801  0. 10. 10. 0. 0. 0. 0. 1. 5
*
*loop2*loop2*loop2*loop2*loop2*loop2*loop2*loop2*loop2*loop2*loop2*loop2
$==================================================================
$          ht str no. 2081       hx shell
*---------------------------------------------------------------
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
12081000  10   4   2   1   1.009  0  0    0
*
*htstr     mesh locn     mesh fmt
12081100      0          1
*
*htstr     intervals     rt. coord
12081101      3          1.054
*
*htstr     compxn no.    interval
12081201      1          3
*
*htstr     source        interval
12081301      0.         3
*
*htstr                temp flg
```

```
12081400              0
*
*htstr     temp       mesh pt.
12081401   302.         4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
12081501  208010000  10000  1     1     0.555       5
12081502  208070000  10000  1     1     0.555       10
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
12081601  -501      0     4599  1     0.555       10
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
12081701    0         0         0          0          10
*
*htstr   chf flag   hyd diam   equiv diam  ch. len   ht str no.
12081801  0. 10. 10. 0. 0. 0. 0. 1.  10
*
*htstr   chf flag   hyd diam   equiv diam  ch. len   ht str no.
12081901  0. 10. 10. 0. 0. 0. 0. 1.  10
*
$=================================================================
$          ht str no. 2082        hx shell
*-----------------------------------------------------------------
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
12082000   1     4     1     1     0.00 0  0      0
*
*htstr     mesh locn     mesh fmt
12082100      0            1
*
*htstr     intervals     rt. coord
12082101      3            0.0445
*
*htstr     compxn no.    interval
12082201      1            3
*
*htstr     source        interval
12082301      0.           3
*
*htstr                   temp flg
12082400                   0
*
*htstr     temp       mesh pt.
12082401   302.         4

*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
12082501  208060000  00000  1     1     3.49        1
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
12082601  -501      0     4581  1     3.49        1
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
12082701    0         0         0          0          1
*
*htstr   chf flag   hyd diam   equiv diam  ch. len   ht str no.
12082801  0. 10. 10. 0. 0. 0. 0. 1.  1
*
*htstr   chf flag   hyd diam   equiv diam  ch. len   ht str no.
12082901  0. 10. 10. 0. 0. 0. 0. 1.  1
*
$=================================================================$
$          ht str no. 2083        hx tube          $
*----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
12083000  10     4     2     1     7.049e-3  0  0      0
*
*htstr     mesh locn     mesh fmt
12083100      0            1
*
*htstr     intervals     rt. coord
12083101      3            7.938e-3
*
*htstr     compxn no.    interval
12083201      1            3
*
*htstr     source        interval
12083301      0.           3
*
*htstr                   temp flg
12083400                   0
*
*htstr     temp       mesh pt.
12083401   302.         4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
12083501  208010000  10000  1     1     8700.4      5
12083502  208070000  10000  1     1     8700.4      10
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
12083601  234050000  -10000  1    1     8700.4      5
12083602  234100000  -10000  1    1     8700.4      10
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
12083701    0         0         0          0          10
*
*htstr   chf flag   hyd diam   equiv diam  ch. len   ht str no.
12083801  0. 10. 10. 0. 0. 0. 0. 1.  10
*
*htstr   chf flag   hyd diam   equiv diam  ch. len   ht str no.
12083901  0. 10. 10. 0. 0. 0. 0. 1.  10
*
* tube and shell heat structures for emergency heat exchanger
*
$=================================================================
$          ht str no. 2161        hx shell
*-----------------------------------------------------------------
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
12161000   4     4     2     1     0.5334 0  0      0
*
*htstr     mesh locn     mesh fmt
12161100      0            1
*
*htstr     intervals     rt. coord
12161101      3            0.5556
*
*htstr     compxn no.    interval
12161201      1            3
*
*htstr     source        interval
12161301      0.           3
*
*htstr                   temp flg
12161400                   0
*
*htstr     temp       mesh pt.
12161401   302.         4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
12161501  216010000  10000  1     1     1.6         4
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
12161601  -501      0     4591  1     1.6         4
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
12161701    0         0         0          0          4
*
*htstr   chf flag   hyd diam   equiv diam  ch. len   ht str no.
12161801  0. 10. 10. 0. 0. 0. 0. 1.  4
```

```
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
12161901  0. 10. 10. 0. 0. 0. 0. 1.  4
*
*
$==============================================================$
$            ht str no. 2163        hx tube              $
*-------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
12163000    4     4    2    1   8.636e-3   0  0      0
*
*htstr       mesh locn       mesh fmt
12163100         0              1
*
*htstr       intervals       rt. coord
12163101         3            9.525e-3
*
*htstr       compxn no.      interval
12163201         1              3
*
*htstr       source          interval
12163301         0.             3
*
*htstr                   temp flg
12163400                     0
*
*htstr       temp            mesh pt.
12163401     302.               4
*
*htstr   left vol   incr   b.cond  sa code  area/factor  ht str no.
12163501  216010000  10000  1       1        2672.         4
*
*htstr   right vol   incr   b.cond  sa code  area/factor  ht str no.
12163601  246040000  -10000  1      1        2672.         4
*
*htstr   s. type    s. mult    left heat  right heat   ht str no.
12163701    0          0          0          0            4
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
12163801  0. 10. 10. 0. 0. 0. 0. 1.  4
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
12163901  0. 10. 10. 0. 0. 0. 0. 1.  4
*
$==============================================================$
$            ht str no. 2501        chimney              $
*-------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
12501000    4     4    2    1   0.2287     0  0      0
*
*htstr       mesh locn       mesh fmt
12501100         0              1
*
*htstr       intervals       rt. coord
12501101         3            0.2541
*
*htstr       compxn no.      interval
12501201         1              3
*
*htstr       source          interval
12501301         0.             3
*
*htstr                   temp flg
12501400                     0
*
*htstr       temp            mesh pt.
12501401     302.               4
*
*htstr   left vol   incr   b.cond  sa code  area/factor  ht str no.
12501501  250010000  10000  1       1        0.75          4
*
*htstr   right vol   incr   b.cond  sa code  area/factor  ht str no.
12501601  -501        0     4581    1        0.75          4
*
*htstr   s. type    s. mult    left heat  right heat   ht str no.
12501701    0          0          0          0            4
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
12501801  0. 10. 10. 0. 0. 0. 0. 1.  4
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
12501901  0. 10. 10. 0. 0. 0. 0. 1.  4
*
* accumulator heat structure - loop2
*
$==============================================================$
$            ht str no. 2561        tankwall             $
*-------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
12561000    5     4  2  1   0.7245    0    0      0
*
*htstr       mesh locn       mesh fmt
12561100         0              1
*
*htstr       intervals       rt. coord
12561101         3            0.7396
*
*htstr       compxn no.      interval
12561201         1              3
*
*htstr       source          interval
12561301         0.             3
*
*htstr                   temp flg
12561400                     0
*
*htstr       temp            mesh pt.
12561401     302.               4
*
*htstr   left vol   incr   b.cond  sa code  area/factor  ht str no.
12561501  256010000  10000  1  1     4.09          1
12561502  256020000  10000  1  1     0.12          5
*htstr   right vol  incr   b.cond  sa code  area/factor  ht str no.
12561601  0   0   0   1   4.09     1
12561602  0   0   0   1   0.12     5
*
*htstr   s. type    s. mult    left heat  right heat   ht str no.
12561701  0     0         0        0          5
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
12561801  0. 10. 10. 0. 0. 0. 0. 1.  5
*
*loop3*loop3*loop3*loop3*loop3*loop3*loop3*loop3*loop3*loop3*loop3*loop3
*
$==============================================================
$            ht str no. 3081        hx shell
*-------------------------------------------------------------
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
13081000   10    4    2    1   1.009  0  0      0
*
*htstr       mesh locn       mesh fmt
13081100         0              1
*
*htstr       intervals       rt. coord
13081101         3            1.054
*
*htstr       compxn no.      interval
13081201         1              3
```

```
*
*htstr     source      interval
13081301     0.          3
*
*htstr                 temp flg
13081400                   0
*
*htstr     temp        mesh pt.
13081401    302.           4
*
*htstr   left vol   incr  b.cond  sa code  area/factor   ht str no.
13081501  308010000  10000  1     1     0.555        5
13081502  308070000  10000  1     1     0.555       10
*
*htstr   right vol  incr  b.cond  sa code  area/factor   ht str no.
13081601  -501     0    4599   1    0.555       10
*
*htstr    s. type    s. mult   left heat  right heat   ht str no.
13081701    0          0          0         0           10
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
13081801  0. 10. 10. 0. 0. 0. 0. 1.  10
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
13081901  0. 10. 10. 0. 0. 0. 0. 1.  10
*
$==========================================================================
$            ht str no. 3082        hx shell
*-----------------------------------------------------------------
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
13082000   1     4    1    1    0.00 0  0      0
*
*htstr     mesh locn     mesh fmt
13082100      0             1
*
*htstr     intervals     rt. coord
13082101       3          0.0445
*
*htstr     compxn no.    interval
13082201       1            3
*
*htstr     source      interval
13082301     0.          3
*
*htstr                 temp flg
13082400                   0
*
*htstr     temp        mesh pt.
13082401    302.           4

*htstr   left vol   incr  b.cond  sa code  area/factor   ht str no.
13082501  308060000  00000  1     1     3.49        1
*
*htstr   right vol  incr  b.cond  sa code  area/factor   ht str no.
13082601  -501     0    4581   1    3.49        1
*
*htstr    s. type    s. mult   left heat  right heat   ht str no.
13082701    0          0          0         0           1
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
13082801  0. 10. 10. 0. 0. 0. 0. 1.  1
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
13082901  0. 10. 10. 0. 0. 0. 0. 1.  1
*
$==========================================================================$
$            ht str no. 3083        hx tube              $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
13083000   10    4    2    1   7.049e-3  0  0     0
*
*htstr     mesh locn     mesh fmt
13083100      0             1
*
*htstr     intervals     rt. coord
13083101       3          7.938e-3
*
*htstr     compxn no.    interval
13083201       1            3
*
*htstr     source      interval
13083301     0.          3
*
*htstr                 temp flg
13083400                   0
*
*htstr     temp        mesh pt.
13083401    302.           4
*
*htstr   left vol   incr  b.cond  sa code  area/factor   ht str no.
13083501  308010000  10000  1     1     8700.4       5
13083502  308070000  10000  1     1     8700.4      10
*
*htstr   right vol  incr  b.cond  sa code  area/factor   ht str no.
13083601  334050000  -10000  1    1     8700.4       5
13083602  334100000  -10000  1    1     8700.4      10
*
*htstr    s. type    s. mult   left heat  right heat   ht str no.
13083701    0          0          0         0           10
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
13083801  0. 10. 10. 0. 0. 0. 0. 1.  10
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
13083901  0. 10. 10. 0. 0. 0. 0. 1.  10
*
* tube and shell heat structures for emergency heat exchanger
*
$==========================================================================
$            ht str no. 3161        hx shell
*-----------------------------------------------------------------
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
13161000   4     4    2    1    0.5334 0  0     0
*
*htstr     mesh locn     mesh fmt
13161100      0             1
*
*htstr     intervals     rt. coord
13161101       3          0.5556
*
*htstr     compxn no.    interval
13161201       1            3
*
*htstr     source      interval
13161301     0.          3
*
*htstr                 temp flg
13161400                   0
*
*htstr     temp        mesh pt.
13161401    302.           4
*
*htstr   left vol   incr  b.cond  sa code  area/factor   ht str no.
13161501  316010000  10000  1     1     1.6          4
*
*htstr   right vol  incr  b.cond  sa code  area/factor   ht str no.
13161601  -501     0    4591   1    1.6          4
*
```

```
*htstr    s. type   s. mult   left heat  right heat  ht str no.
13161701    0         0         0          0           4
*
*htstr    chf flag   hyd diam   equiv diam   ch. len   ht str no.
13161801  0. 10. 10. 0. 0. 0. 0. 1.  4
*
*htstr    chf flag   hyd diam   equiv diam   ch. len   ht str no.
13161901  0. 10. 10. 0. 0. 0. 0. 1.  4
*
$==================================================================$
$            ht str no. 3163         hx tube             $
*--------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
13163000   4    4    2    1   8.636e-3   0  0     0
*
*htstr      mesh locn      mesh fmt
13163100        0             1
*
*htstr      intervals      rt. coord
13163101        3            9.525e-3
*
*htstr      compxn no.     interval
13163201        1             3
*
*htstr      source         interval
13163301        0.            3
*
*htstr                   temp flg
13163400                     0
*
*htstr      temp           mesh pt.
13163401     302.            4
*
*htstr   left vol   incr  b.cond  sa code  area/factor   ht str no.
13163501  316010000  10000  1      1       2672.          4
*
*htstr   right vol   incr  b.cond  sa code  area/factor   ht str no.
13163601  346040000 -10000  1      1       2672.          4
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
13163701    0         0         0          0           4
*
*htstr    chf flag   hyd diam   equiv diam   ch. len   ht str no.
13163801  0. 10. 10. 0. 0. 0. 0. 1.  4
*
*htstr    chf flag   hyd diam   equiv diam   ch. len   ht str no.
13163901  0. 10. 10. 0. 0. 0. 0. 1.  4
*
$==================================================================$
$            ht str no. 3501         chimney             $
*--------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
13501000   4    4    2    1   0.2287    0  0     0
*
*htstr      mesh locn      mesh fmt
13501100        0             1
*
*htstr      intervals      rt. coord
13501101        3            0.2541
*
*htstr      compxn no.     interval
13501201        1             3
*
*htstr      source         interval
13501301        0.            3
*
*htstr                   temp flg
13501400                     0
*
*htstr      temp           mesh pt.
13501401     302.            4
*
*htstr   left vol   incr  b.cond  sa code  area/factor   ht str no.
13501501  350010000  10000  1      1       0.75           4
*
*htstr   right vol   incr  b.cond  sa code  area/factor   ht str no.
13501601  -501        0     4581   1       0.75           4
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
13501701    0         0         0          0           4
*
*htstr    chf flag   hyd diam   equiv diam   ch. len   ht str no.
13501801  0. 10. 10. 0. 0. 0. 0. 1.  4
*
*htstr    chf flag   hyd diam   equiv diam   ch. len   ht str no.
13501901  0. 10. 10. 0. 0. 0. 0. 1.  4
*
* accumulator heat structure - loop 3
*
$==================================================================$
$            ht str no. 3561         tankwall            $
*--------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
13561000   5     4 2 1   0.7245    0    0     0
*
*htstr      mesh locn      mesh fmt
13561100        0             1
*
*htstr      intervals      rt. coord
13561101        3            0.7396
*
*htstr      compxn no.     interval
13561201        1             3
*
*htstr      source         interval
13561301        0.            3
*
*htstr                   temp flg
13561400                     0
*
*htstr      temp           mesh pt.
13561401     302.            4
*
*htstr   left vol   incr  b.cond  sa code  area/factor   ht str no.
13561501  356010000  10000  1 1      4.09            1
13561502  356020000  10000  1 1      0.12            5
*
*htstr   right vol   incr  b.cond  sa code  area/factor   ht str no.
13561601  0 0        0      1      4.09            1
13561602  0 0        0      1      0.12            5
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
13561701    0 0       0         0          5
*
*htstr    chf flag   hyd diam   equiv diam   ch. len   ht str no.
13561801  0. 10. 10. 0. 0. 0. 0. 1.  5
*
*--------------------------------------------------------------$
*            ht str no. 1011         hotleg              $
*--------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
11011000  3 4 2 1            0.1627   0    0     0
*
*htstr      mesh locn      mesh fmt
11011100        0             1
*
*htstr      intervals      rt. coord
11011101        3            0.1778
```

```
*
*htstr     compxn no.    interval
11011201       1            3
*
*htstr     source        interval
11011301      0.            3
11011401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
11011501  101010000  0    1    1    1.07    1
11011502  101020000  0    1    1    3.66    2
11011503  101030000  0    1    1    2.21    3
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
11011601  -501    0   4511   1    1.07    1
11011602  -501    0   4511   1    3.66    2
11011603  -501    0   4511   1    2.21    3
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
11011701    0        0         0          0          3
*
*htstr
*mod2.5*11011801 0 0.0 0.0 0.0 3
11011801 0. 10. 10. 0. 0. 0. 0. 1. 3
*mod2.5*11011901 0 0.0 0.0 0.0 3
11011901 0. 10. 10. 0. 0. 0. 0. 1. 3
*
*--------------------------------------------------------------$
*            ht str no. 1041        hotleg               $
*--------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
11041000  3  4  2  1          0.1627   0    0    0
*
*htstr      mesh locn      mesh fmt
11041100        0             1
*
*htstr      intervals     rt. coord
11041101        3           0.1778
*
*htstr      compxn no.     interval
11041201        1             3
*
*htstr      source         interval
11041301       0.             3
11041401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
11041501  104010000  0    1    1    0.69     1
11041502  104020000  0    1    1    12.96    2
11041503  104030000  0    1    1    2.51     3
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
11041601  -501    0   4511   1    0.69     1
11041602  -501    0   4511   1    12.96    2
11041603  -501    0   4581   1    2.51     3
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
11041701    0        0         0          0          3
*
*htstr
*mod2.5*11041801 0 0.0 0.0 0.0 3
11041801 0. 10. 10. 0. 0. 0. 0. 1. 3
*mod2.5*11041901 0 0.0 0.0 0.0 3
11041901 0. 10. 10. 0. 0. 0. 0. 1. 3
*
*==============================================================$
*            ht str no. 1221        coldleg              $
*--------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
11221000  3  4  2  1          0.1627   0    0    0
*
*htstr      mesh locn      mesh fmt
11221100        0             1
*
*htstr      intervals     rt. coord
11221101        3           0.1778
*
*htstr      compxn no.     interval
11221201        1             3
*
*htstr      source         interval
11221301       0.             3
11221401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
11221501  122010000  0    1    1    2.31     1
11221502  122020000  0    1    1    2.13     2
11221503  122030000  0    1    1    0.762    3
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
11221601  -501    0   4511   1    2.31     1
11221602  -501    0   4511   1    2.13     2
11221603  -501    0   4581   1    0.762    3
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
11221701    0        0         0          0          3
*
*htstr
*mod2.5*11221801 0 0.0 0.0 0.0 3
11221801 0.0 10. 10. 0. 0. 0. 0. 1. 3
*mod2.5*11221901 0 0.0 0.0 0.0 3
11221901 0.0 10. 10. 0. 0. 0. 0. 1. 3
*
*==============================================================$
*            ht str no. 1261        coldleg              $
*--------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
11261000  1  4  2  1          0.1627   0    0    0
*
*htstr      mesh locn      mesh fmt
11261100        0             1
*
*htstr      intervals     rt. coord
11261101        3           0.1778
*
*htstr      compxn no.     interval
11261201        1             3
*
*htstr      source         interval
11261301       0.             3
11261401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
11261501  126010000  0    1    1    0.9146   1
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
11261601  -501    0   4511   1    0.9146   1
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
11261701    0        0         0          0          1
*
*htstr
*mod2.5*11261801 0 0.0 0.0 0.0 1
11261801 0.0 10. 10. 0. 0. 0. 0. 1. 1
*mod2.5*11261901 0 0.0 0.0 0.0 1
11261901 0.0 10. 10. 0. 0. 0. 0. 1. 1
*--------------------------------------------------------------$
*            ht str no. 1291        14-incdleg           $
```

```
*------------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
11291000  1 4 2 1          0.1627  0    0     0
*
*htstr     mesh locn     mesh fmt
11291100      0             1
*
*htstr     intervals     rt. coord
11291101      3           0.1778
*
*htstr     compxn no.    interval
11291201      1             3
*
*htstr     source        interval
11291301      0.            3
11291401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
11291501  129010000  0     1       1        6.25          1
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
11291601  -501       0     4511    1        6.25          1
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
11291701    0         0          0          0           1
*
*htstr
*mod2.5*11291801 0 0.0 0.0 0.0 1
11291801 0. 10. 10. 0. 0. 0. 0. 1. 1
*mod2.5*11291901 0 0.0 0.0 0.0 1
11291901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*=====================================================================$
*
*          ht str no. 1581       14-in cdleg           $
*------------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
11581000  2 4 2 1          0.1627  0    0     0
*
*htstr     mesh locn     mesh fmt
11581100      0             1
*
*htstr     intervals     rt. coord
11581101      3           0.1778
*
*htstr     compxn no.    interval
11581201      1             3
*
*htstr     source        interval
11581301      0.            3
11581401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
11581501  158010000  0     1       1        4.50          2
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
11581601  -501       0     4511    1        4.50          2
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
11581701    0         0          0          0           2
*
*htstr
*mod2.5*11581801 0 0.0 0.0 0.0 2
11581801 0. 10. 10. 0. 0. 0. 0. 1. 2
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 2
11581901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
```

```
*=====================================================================
*          ht str no. 1621       14-in cdleg           $
*------------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
11621000  4 4 2 1          0.1627  0    0     0
*
*htstr     mesh locn     mesh fmt
11621100      0             1
*
*htstr     intervals     rt. coord
11621101      3           0.1778
*
*htstr     compxn no.    interval
11621201      1             3
*
*htstr     source        interval
11621301      0.            3
11621401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
11621501  162010000  0     1       1        1.83          1
11621502  162020000  0     1       1        1.57          2
11621503  162030000  0     1       1        1.45          3
11621504  162040000  0     1       1        12.10439      4
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
11621601  -501       0     4581    1        1.83          1
11621602  -501       0     4511    1        1.57          2
11621603  -501       0     4511    1        1.45          3
11621604  -501       0     4581    1        12.10439      4
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
11621701    0         0          0          0           4
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 4
11621801 0. 10. 10. 0. 0. 0. 0. 1. 4
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 4
11621901 0. 10. 10. 0. 0. 0. 0. 1. 4
*
*=====================================================================$
*          ht str no. 1711       8-in cdleg            $
*------------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
11711000  3 4 2 1          0.09925  0    0     0
*
*htstr     mesh locn     mesh fmt
11711100      0             1
*
*htstr     intervals     rt. coord
11711101      3           0.1016
*
*htstr     compxn no.    interval
11711201      1             3
*
*htstr     source        interval
11711301      0.            3
11711401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
11711501  171010000  0     1       1        0.300         1
11711502  171020000  0     1       1        2.000         2
11711503  171030000  0     1       1        2.280         3
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
11711601  -501       0     4581    1        0.300         1
11711602  -501       0     4531    1        2.000         2
```

```
11711603 -501     0    4531   1    2.280     3
*
*htstr    s. type    s. mult    left heat  right heat  ht str no.
11711701    0        0         0         0          3
*
*htstr
*mod2.5*11711801 0 0.0 0.0 0.0 3
11711801 0. 10. 10. 0. 0. 0. 0. 1. 3
*
*htstr
*mod2.5*11711901 0 0.0 0.0 0.0 3
11711901 0. 10. 10. 0. 0. 0. 0. 1. 3
*
*==================================================================
*          ht str no. 1741        14-in cdleg            $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
11741000  1  4  2  1            0.1627   0    0     0
*
*htstr       mesh locn       mesh fmt
11741100         0              1
*
*htstr       intervals      rt. coord
11741101         3            0.1778
*
*htstr       compxn no.     interval
11741201         1             3
*
*htstr       source         interval
11741301       0.              3
11741401 400. 4
*
*htstr    left vol   incr  b.cond  sa code  area/factor  ht str no.
11741501  174010000   0     1       1        0.50          1
*
*htstr    right vol  incr  b.cond  sa code  area/factor  ht str no.
11741601  -501        0     4511    1        0.50          1
*
*htstr    s. type    s. mult    left heat  right heat  ht str no.
11741701    0         0          0          0          1
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 1
11741801 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 1
11741901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*----------------------------------------------------------------$
*          ht str no. 2011        hotleg                 $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
12011000  3  4  2  1            0.1627   0    0     0
*
*htstr       mesh locn       mesh fmt
12011100         0              1
*
*htstr       intervals      rt. coord
12011101         3            0.1778
*
*htstr       compxn no.     interval
12011201         1             3
*
*htstr       source         interval
12011301       0.              3
12011401 400. 4
*
*htstr    left vol   incr  b.cond  sa code  area/factor  ht str no.
12011501  201010000  0     1       1        1.07          1
12011502  201020000  0     1       1        3.66          2
12011503  201030000  0     1       1        2.21          3
*
*htstr    right vol  incr  b.cond  sa code  area/factor  ht str no.
12011601  -501        0     4511    1        1.07          1
12011602  -501        0     4511    1        3.66          2
12011603  -501        0     4511    1        2.21          3
*
*htstr    s. type    s. mult    left heat  right heat  ht str no.
12011701    0         0          0          0          3
*
*htstr
*mod2.5*12011801 0 0.0 0.0 0.0 3
12011801 0. 10. 10. 0. 0. 0. 0. 1. 3
*mod2.5*12011901 0 0.0 0.0 0.0 3
12011901 0. 10. 10. 0. 0. 0. 0. 1. 3
*----------------------------------------------------------------$
*          ht str no. 2041        hotleg                 $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
12041000  3  4  2  1            0.1627   0    0     0
*
*htstr       mesh locn       mesh fmt
12041100         0              1
*
*htstr       intervals      rt. coord
12041101         3            0.1778
*
*htstr       compxn no.     interval
12041201         1             3
*
*htstr       source         interval
12041301       0.              3
12041401 400. 4
*
*htstr                      temp flg
*
*htstr       temp           mesh pt.
*
*htstr    left vol   incr  b.cond  sa code  area/factor  ht str no.
12041501  204010000  0     1       1        6.098         1
12041502  204020000  0     1       1        3.048         2
12041503  204030000  0     1       1        2.51          3
*
*htstr    right vol  incr  b.cond  sa code  area/factor  ht str no.
12041601  -501        0     4511    1        6.098         1
12041602  -501        0     4511    1        3.048         2
12041603  -501        0     4581    1        2.51          3
*
*htstr    s. type    s. mult    left heat  right heat  ht str no.
12041701    0         0          0          0          3
*
*htstr
*mod2.5*12041801 0.0 0.0 0.0 0.0 0.0 3
12041801 0. 10. 10. 0. 0. 0. 0. 1. 3
*mod2.5*12041901 0.0 0.0 0.0 0.0 0.0 3
12041901 0. 10. 10. 0. 0. 0. 0. 1. 3
*
*================================================================$
*          ht str no. 2221        coldleg                $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
12221000  3  4  2  1            0.1627   0    0     0
*
*htstr       mesh locn       mesh fmt
12221100         0              1
*
*htstr       intervals      rt. coord
```

```
12221101      3        0.1778
*
*htstr    compxn no.   interval
12221201      1         3
*
*htstr    source       interval
12221301      0.        3
12221401 400. 4
*
*htstr   left vol   incr b.cond sa code area/factor  ht str no.
12221501 222010000  0    1      1      2.31       1
12221502 222020000  0    1      1      2.13       2
12221503 222030000  0    1      1      0.762      3
*
*htstr   right vol  incr b.cond sa code area/factor  ht str no.
12221601   -501     0    4511   1      2.31       1
12221602   -501     0    4511   1      2.13       2
12221603   -501     0    4581   1      0.762      3
*
*htstr    s. type   s. mult   left heat right heat  ht str no.
12221701    0        0          0        0          3
*
*htstr
*mod2.5*12221801 0 0.0 0.0 0.0 3
12221801 0.0 10. 10. 0. 0. 0. 0. 1. 3
*mod2.5*12221901 0 0.0 0.0 0.0 3
12221901 0.0 10. 10. 0. 0. 0. 0. 1. 3
*
*==================================================================$
*          ht str no. 2261        coldleg              $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
12261000  1 4 2 1            0.1627   0    0     0
*
*htstr      mesh locn      mesh fmt
12261100       0              1
*
*htstr      intervals     rt. coord
12261101       3            0.1778
*
*htstr      compxn no.    interval
12261201       1             3
*
*htstr      source        interval
12261301       0.            3
12261401 400. 4
*
*htstr   left vol   incr b.cond sa code area/factor  ht str no.
12261501 226010000  0    1      1      0.9146     1
*
*htstr   right vol  incr b.cond sa code area/factor  ht str no.
12261601   -501     0    4511   1      0.9146     1
*
*htstr    s. type   s. mult   left heat right heat  ht str no.
12261701    0        0          0        0          1
*
*htstr
*mod2.5*12261801 0 0.0 0.0 0.0 1
12261801 0.0 10. 10. 0. 0. 0. 0. 1. 1
*mod2.5*12261901 0 0.0 0.0 0.0 1
12261901 0.0 10. 10. 0. 0. 0. 0. 1. 1
*
*-----------------------------------------------------------------$
*          ht str no. 2291        14-incdleg           $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
12291000  1 4 2 1            0.1627   0    0     0
*
*htstr      mesh locn      mesh fmt
12291100       0              1
*
*htstr      intervals     rt. coord
12291101       3            0.1778
*
*htstr      compxn no.    interval
12291201       1             3
*
*htstr      source        interval
12291301       0.            3
12291401 400. 4
*
*htstr   left vol   incr b.cond sa code area/factor  ht str no.
12291501 229010000  0    1      1      6.25       1
*
*htstr   right vol  incr b.cond sa code area/factor  ht str no.
12291601  -501      0    4511   1      6.25       1
*
*htstr    s. type   s. mult   left heat right heat  ht str no.
12291701    0        0          0        0          1
*
*htstr
*mod2.5*12291801 0 0.0 0.0 0.0 1
12291801 0. 10. 10. 0. 0. 0. 0. 1. 1
*mod2.5*12291901 0 0.0 0.0 0.0 1
12291901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*-----------------------------------------------------------------*
*          ht str no. 2581        14-in cdleg          $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
12581000  2 4 2 1            0.1627   0    0     0
*
*htstr      mesh locn      mesh fmt
12581100       0              1
*
*htstr      intervals     rt. coord
12581101       3            0.1778
*
*htstr      compxn no.    interval
12581201       1             3
*
*htstr      source        interval
12581301       0.            3
12581401 400. 4
*
*htstr   left vol   incr b.cond sa code area/factor  ht str no.
12581501 258010000  0    1      1      4.50       2
*
*htstr   right vol  incr b.cond sa code area/factor  ht str no.
12581601  -501      0    4511   1      4.50       2
*
*htstr    s. type   s. mult   left heat right heat  ht str no.
12581701    0        0          0        0          2
*
*htstr
*mod2.5*12581801 0 0.0 0.0 0.0 2
12581801 0. 10. 10. 0. 0. 0. 0. 1. 2
*
*htstr
*mod2.5*12581901 0 0.0 0.0 0.0 2
12581901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
*==================================================================
*          ht str no. 2621        14-in cdleg          $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
12621000  2 4 2 1            0.1627   0    0     0
*
```

```
*htstr     mesh locn    mesh fmt
12621100      0           1
*
*htstr     intervals    rt. coord
12621101      3          0.1778
*
*htstr     compxn no.   interval
12621201      1           3
*
*htstr     source       interval
12621301      0.          3
12621401 400. 4
*
*htstr   left vol   incr b.cond  sa code  area/factor  ht str no.
12621501  262010000  0   1    1    0.64538    1
12621502  262020000  0   1    1    13.93439   2
*
*htstr   right vol  incr b.cond  sa code  area/factor  ht str no.
12621601  -501     0    4511   1   0.64538    1
12621602  -501     0    4581   1   13.93439   2
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
12621701    0        0         0         0          2
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 2
12621801 0. 10. 10. 0. 0. 0. 0. 1. 2
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 2
12621901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
*=================================================================$
*         ht str no. 2711        8-in cdleg          $
*-------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
12711000  3  4  2  1           0.09925   0    0     0
*
*htstr     mesh locn    mesh fmt
12711100      0           1
*
*htstr     intervals    rt. coord
12711101      3          0.1016
*
*htstr     compxn no.   interval
12711201      1           3
*
*htstr     source       interval
12711301      0.          3
12711401 400. 4
*
*htstr   left vol   incr b.cond  sa code  area/factor  ht str no.
12711501  271010000  0    1    1    0.300     1
12711502  271020000  0    1    1    0.290     2
12711503  271030000  0    1    1    0.940     3
*
*htstr   right vol  incr b.cond  sa code  area/factor  ht str no.
12711601  -501     0    4581   1   0.300     1
12711602  -501     0    4531   1   0.290     2
12711603  -501     0    4531   1   0.940     3
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
12711701    0        0         0         0          3
*
*htstr
*mod2.5*12711801 0 0.0 0.0 0.0 3
12711801 0. 10. 10. 0. 0. 0. 0. 1. 3
*
*htstr
*mod2.5*12711901 0 0.0 0.0 0.0 3
12711901 0. 10. 10. 0. 0. 0. 0. 1. 3
*
*=================================================================
*         ht str no. 2741        14-in cdleg          $
*-------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
12741000  1  4  2  1           0.1627    0    0     0
*
*htstr     mesh locn    mesh fmt
12741100      0           1
*
*htstr     intervals    rt. coord
12741101      3          0.1778
*
*htstr     compxn no.   interval
12741201      1           3
*
*htstr     source       interval
12741301      0.          3
12741401 400. 4
*
*htstr   left vol   incr b.cond  sa code  area/factor  ht str no.
12741501  274010000  0    1    1    0.50      1
*
*htstr   right vol  incr b.cond  sa code  area/factor  ht str no.
12741601  -501     0    4511   1   0.50      1
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
12741701    0        0         0         0          1
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 1
12741801 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 1
12741901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*=================================================================$
*         ht str no. 3011        hotleg          $
*-------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
13011000  1  4  2  1           0.1627    0    0     0
*
*htstr     mesh locn    mesh fmt
13011100      0           1
*
*htstr     intervals    rt. coord
13011101      3          0.1778
*
*htstr     compxn no.   interval
13011201      1           3
*
*htstr     source       interval
13011301      0.          3
13011401 400. 4
*
*htstr   left vol   incr b.cond  sa code  area/factor  ht str no.
13011501  301010000  0    1    1    3.28      1
*
*htstr   right vol  incr b.cond  sa code  area/factor  ht str no.
13011601  -501     0    4511   1   3.28      1
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
13011701    0        0         0         0          1
*
*htstr
*mod2.5*13011801 0 0.0 0.0 0.0 1
```

```
13011801 0. 10. 10. 0. 0. 0. 0. 1. 1
*mod2.5*13011901 0 0.0 0.0 0.0 1
13011901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*-----------------------------------------------------------------$
*        ht str no. 3041       hotleg               $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
13041000  3  4  2  1          0.1627   0    0     0
*
*htstr     mesh locn    mesh fmt
13041100       0          1
*
*htstr     intervals    rt. coord
13041101       3        0.1778
*
*htstr     compxn no.   interval
13041201       1          3
*
*htstr     source      interval
13041301     0.          3
13041401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
13041501  304010000  0    1     1     0.69       1
13041502  304020000  0    1     1     12.96      2
13041503  304030000  0    1     1     2.51       3
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
13041601  -501     0   4511    1     0.69       1
13041602  -501     0   4511    1     12.96      2
13041603  -501     0   4581    1.    2.51       3
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
13041701    0        0        0        0         3
*
*htstr
*mod2.5*13041801 0 0.0 0.0 0.0 3
13041801 0. 10. 10. 0. 0. 0. 0. 1. 3
*mod2.5*13041901 0 0.0 0.0 0.0 3
13041901 0. 10. 10. 0. 0. 0. 0. 1. 3
*
*-----------------------------------------------------------------*
*        ht str no. 3221       coldleg              $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
13221000  3  4  2  1          0.1627   0    0     0
*
*htstr     mesh locn    mesh fmt
13221100       0          1
*
*htstr     intervals    rt. coord
13221101       3        0.1778
*
*htstr     compxn no.   interval
13221201       1          3
*
*htstr     source      interval
13221301     0.          3
13221401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
13221501  322010000  0    1     1     2.31       1
13221502  322020000  0    1     1     2.13       2
13221503  322030000  0    1     1     0.762      3
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
13221601    -501   0    4511    1     2.31       1
13221602    -501   0    4511    1     2.13       2
13221603    -501   0    4581    1     0.762      3
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
13221701    0        0        0        0         3
*
*htstr
*mod2.5*13221801 0 0.0 0.0 0.0 3
13221801 0. 10. 10. 0. 0. 0. 0. 1. 3
*mod2.5*13221901 0 0.0 0.0 0.0 3
13221901 0. 10. 10. 0. 0. 0. 0. 1. 3
*
*-----------------------------------------------------------------*
*        ht str no. 3261       coldleg              $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
13261000  1  4  2  1          0.1627   0    0     0
*
*htstr     mesh locn    mesh fmt
13261100       0          1
*
*htstr     intervals    rt. coord
13261101       3        0.1778
*
*htstr     compxn no.   interval
13261201       1          3
*
*htstr     source      interval
13261301     0.          3
13261401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
13261501  326010000  0    1     1     0.9146     1
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
13261601    -501   0    4511    1     0.9146     1
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
13261701    0        0        0        0         1
*
*htstr
*mod2.5*13261801 0 0.0 0.0 0.0 1
13261801 0. 10. 10. 0. 0. 0. 0. 1. 1
*mod2.5*13261901 0 0.0 0.0 0.0 1
13261901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*-----------------------------------------------------------------$
*        ht str no. 3291       14-incdleg           $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
13291000  1  4  2  1          0.1627   0    0     0
*
*htstr     mesh locn    mesh fmt
13291100       0          1
*
*htstr     intervals    rt. coord
13291101       3        0.1778
*
*htstr     compxn no.   interval
13291201       1          3
*
*htstr     source      interval
13291301     0.          3
13291401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
13291501  329010000  0    1     1     6.25       1
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
13291601  -501     0   4511    1     6.25       1
```

```
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
13291701    0         0         0         0          1
*
*htstr
*mod2.5*13291801 0 0.0 0.0 0.0 1
13291801 0. 10. 10. 0. 0. 0. 0. 1. 1
*mod2.5*13291901 0 0.0 0.0 0.0 1
13291901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*-------------------------------------------------------------*
*          ht str no. 3581        14-in cdleg          $
*-------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
13581000  2  4  2  1          0.1627    0     0      0
*
*htstr     mesh locn     mesh fmt
13581100      0            1
*
*htstr     intervals     rt. coord
13581101      3            0.1778
*
*htstr     compxn no.    interval
13581201      1            3
*
*htstr     source        interval
13581301      0.           3
13581401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor   ht str no.
13581501  358010000  0     1       1        7.24          2
*
*htstr   right vol  incr  b.cond  sa code  area/factor   ht str no.
13581601  -501      0     4511    1        7.24          2
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
13581701    0         0         0         0          2
*
*htstr
*mod2.5*13581801 0 0.0 0.0 0.0 2
13581801 0. 10. 10. 0. 0. 0. 0. 1. 2
*
*htstr
*mod2.5*13581901 0 0.0 0.0 0.0 2
13581901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
*=====================================================================*
*          ht str no. 3621        14-in cdleg          $
*-------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
13621000  2  4  2  1          0.1627    0     0      0
*
*htstr     mesh locn     mesh fmt
13621100      0            1
*
*htstr     intervals     rt. coord
13621101      3            0.1778
*
*htstr     compxn no.    interval
13621201      1            3
*
*htstr     source        interval
13621301      0.           3
13621401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor   ht str no.
13621501  362010000  0     1       1        1.2166        1
13621502  362020000  0     1       1        13.93439      2
*
*htstr   right vol  incr  b.cond  sa code  area/factor   ht str no.
13621601  -501      0     4511    1        1.2166        1
13621602  -501      0     4581    1        13.93439      2
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
13621701    0         0         0         0          2
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 2
13621801 0. 10. 10. 0. 0. 0. 0. 1. 2
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 2
13621901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
*=====================================================================$
*          ht str no. 3711        8-in cdleg          $
*-------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
13711000  3  4  2  1          0.09925   0     0      0
*
*htstr     mesh locn     mesh fmt
13711100      0            1
*
*htstr     intervals     rt. coord
13711101      3            0.1016
*
*htstr     compxn no.    interval
13711201      1            3
*
*htstr     source        interval
13711301      0.           3
13711401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor   ht str no.
13711501  371010000  0     1       1        0.300         1
13711502  371020000  0     1       1        0.510         2
13711503  371030000  0     1       1        0.980         3
*
*htstr   right vol  incr  b.cond  sa code  area/factor   ht str no.
13711601  -501      0     4581    1        0.300         1
13711602  -501      0     4531    1        0.510         2
13711603  -501      0     4531    1        0.980         3
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
13711701    0         0         0         0          3
*
*htstr
*mod2.5*13711801 0 0.0 0.0 0.0 3
13711801 0. 10. 10. 0. 0. 0. 0. 1. 3
*
*htstr
*mod2.5*13711901 0 0.0 0.0 0.0 3
13711901 0. 10. 10. 0. 0. 0. 0. 1. 3
*
*=====================================================================$
*          ht str no. 3741        14-in cdleg          $
*-------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
13741000  1  4  2  1          0.1627    0     0      0
*
*htstr     mesh locn     mesh fmt
13741100      0            1
*
*htstr     intervals     rt. coord
13741101      3            0.1778
*
*htstr     compxn no.    interval
13741201      1            3
```

```
*
*htstr    source    interval
13741301    0.    3
13741401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
13741501  374010000  0  1  1  0.50  1
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
13741601  -501  0  4511  1  0.50  1
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
13741701   0   0   0   0   1
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 1
13741801 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 1
13741901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*==================================================================$
*          ht str no. 4011        hotleg              $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
14011000  1 4 2 1        0.1627  0  0  0
*
*htstr    mesh locn    mesh fmt
14011100    0    1
*
*htstr    intervals    rt. coord
14011101    3    0.1778
*
*htstr    compxn no.    interval
14011201    1    3
*
*htstr    source    interval
14011301    0.    3
14011401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
14011501  451010000  0  1  1  3.28  1
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
14011601  -501  0  4511  1  3.28  1
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
14011701   0   0   0   0   1
*
*htstr
*mod2.5*14011801 0 0.0 0.0 0.0 1
14011801 0. 10. 10. 0. 0. 0. 0. 1. 1
*mod2.5*14011901 0 0.0 0.0 0.0 1
14011901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*----------------------------------------------------------------$
*          ht str no. 4291        14-incdleg          $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
14291000  1 4 2 1        0.1627  0  0  0
*
*htstr    mesh locn    mesh fmt
14291100    0    1
*
*htstr    intervals    rt. coord
14291101    3    0.1778
*
*htstr    compxn no.    interval
14291201    1    3
*
*htstr    source    interval
14291301    0.    3
14291401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
14291501  429010000  0  1  1  6.25  1
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
14291601  -501  0  4511  1  6.25  1
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
14291701   0   0   0   0   1
*
*htstr
*mod2.5*14291801 0 0.0 0.0 0.0 1
14291801 0. 10. 10. 0. 0. 0. 0. 1. 1
*mod2.5*14291901 0 0.0 0.0 0.0 1
14291901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*-----------------------------------------------------------------*
*          ht str no. 4581        14-in cdleg          $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
14581000  2 4 2 1        0.1627  0  0  0
*
*htstr    mesh locn    mesh fmt
14581100    0    1
*
*htstr    intervals    rt. coord
14581101    3    0.1778
*
*htstr    compxn no.    interval
14581201    1    3
*
*htstr    source    interval
14581301    0.    3
14581401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
14581501  458010000  0  1  1  7.24  2
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
14581601  -501  0  4511  1  7.24  2
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
14581701   0   0   0   0   2
*
*htstr
*mod2.5*14581801 0 0.0 0.0 0.0 2
14581801 0. 10. 10. 0. 0. 0. 0. 1. 2
*
*htstr
*mod2.5*14581901 0 0.0 0.0 0.0 2
14581901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
*==================================================================*
*          ht str no. 4621        14-in cdleg          $
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
14621000  2 4 2 1        0.1627  0  0  0
*
*htstr    mesh locn    mesh fmt
14621100    0    1
*
*htstr    intervals    rt. coord
14621101    3    0.1778
*
```

```
*htstr    compxn no.   interval
14621201      1           3
*
*htstr    source       interval
14621301     0.           3
14621401 400. 4
*
*htstr   left vol   incr b.cond  sa code  area/factor  ht str no.
14621501  462010000   0   1    1     1.2166      1
14621502  462020000   0   1    1     13.93439    2
*
*htstr   right vol  incr b.cond  sa code  area/factor  ht str no.
14621601  -501     0    4511   1    1.2166      1
14621602  -501     0    4581   1    13.93439    2
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
14621701     0        0         0          0          2
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 2
14621801 0. 10. 10. 0. 0. 0. 0. 1. 2
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 2
14621901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
*==================================================================$
*           ht str no. 4711        8-in cdleg            $
*-------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
14711000  3  4  2  1           0.09925   0     0      0
*
*htstr     mesh locn      mesh fmt
14711100       0            1
*
*htstr     intervals      rt. coord
14711101       3           0.1016
*
*htstr    compxn no.   interval
14711201      1           3
*
*htstr    source       interval
14711301     0.           3
14711401 400. 4
*
*htstr   left vol   incr b.cond  sa code  area/factor  ht str no.
14711501  471010000  0    1    1     0.300       1
14711502  471020000  0    1    1     0.510       2
14711503  471030000  0    1    1     0.980       3
*
*htstr   right vol  incr b.cond  sa code  area/factor  ht str no.
14711601  -501     0    4581   1    0.300       1
14711602  -501     0    4531   1    0.510       2
14711603  -501     0    4531   1    0.980       3
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
14711701     0        0         0          0          3
*
*htstr
*mod2.5*14711801 0 0.0 0.0 0.0 3
14711801 0. 10. 10. 0. 0. 0. 0. 1. 3
*
*htstr
*mod2.5*14711901 0 0.0 0.0 0.0 3
14711901 0. 10. 10. 0. 0. 0. 0. 1. 3
*
*==================================================================$
*           ht str no. 4741        14-in cdleg           $
*-------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
14741000  1  4  2  1           0.1627   0     0      0
*
*htstr     mesh locn      mesh fmt
14741100       0            1
*
*htstr     intervals      rt. coord
14741101       3           0.1778
*
*htstr    compxn no.   interval
14741201      1           3
*
*htstr    source       interval
14741301     0.           3
14741401 400. 4
*
*htstr   left vol   incr b.cond  sa code  area/factor  ht str no.
14741501  474010000   0    1    1     0.50        1
*
*htstr   right vol  incr b.cond  sa code  area/factor  ht str no.
14741601  -501     0    4511   1    0.50        1
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
14741701     0        0         0          0          1
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 1
14741801 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*htstr
*mod2.5*11581901 0 0.0 0.0 0.0 1
14741901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*-------------------------------------------------------------*
*           ht str no. 4951 ·     cpbt bottom            $
*-------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
14951000  1  4  2  1           0.2865   0     0      0
*
*htstr     mesh locn      mesh fmt
14951100       0            1
*
*htstr     intervals      rt. coord
14951101       3           0.3165
*
*htstr    compxn no.   interval
14951201      1           3
*
*htstr    source       interval
14951301     0.           3
14951401 400. 4
*
*htstr   left vol   incr b.cond  sa code  area/factor  ht str no.
14951501  495010000  0    1    1     1.800       1
*
*htstr   right vol  incr b.cond  sa code  area/factor  ht str no.
14951601  -501     0    4581   1    1.800       1
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
14951701     0        0         0          0          1
*
*htstr
*mod2.5*14951801 0 0.0 0.0 0.0 1
14951801 0. 10. 10. 0. 0. 0. 0. 1. 1
*mod2.5*14951901 0 0.0 0.0 0.0 1
14951901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*core*core*core*core*core*core*core*core*core*core*core*core*core*core*c
*                                  *
```

```
*          heat structures in core region             *
*                                                 *
*-----------------------------------------------------------------*
* ht str 5001 - core inlet pipe wall (lower cpbt wall)            *
*-----------------------------------------------------------------*
*htstr   ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15001000  1  4  2  1            0.2265    0     0     0
*
*htstr      mesh locn      mesh fmt
15001100        0            1
*
*htstr      intervals      rt. coord
15001101        3            0.2465
*
*htstr      compxn no.     interval
15001201        1            3
*
*htstr      source         interval
15001301        0.           3
15001401 400. 4
*
*htstr    left vol   incr  b.cond  sa code  area/factor   ht str no.
15001501  500010000  0     1       1        0.331         1
*
*htstr    right vol  incr  b.cond  sa code  area/factor   ht str no.
15001601  -501       0     4581    1        0.331         1
*
*htstr    s. type    s. mult    left heat  right heat   ht str no.
15001701    0          0          0          0            1
*
*htstr
*mod2.5*15001801 0 0.0 0.0 0.0 1
15001801 0.0  10. 10. 0. 0. 0. 0. 1. 1
*
*htstr
*mod2.5*15001901 0 0.0 0.0 0.0 1
15001901 0.0  10. 10. 0. 0. 0. 0. 1. 1
*
*-----------------------------------------------------------------*
* ht str 5051 - control rod shroud in core inlet region           *
*-----------------------------------------------------------------*
*htstr   ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15051000  1  4  2  1            0.095     0     0     0
*
*htstr      mesh locn      mesh fmt
15051100        0            1
*
*htstr      intervals      rt. coord
15051101        3            0.102
*
*htstr      compxn no.     interval
15051201        2            3
*
*htstr      source         interval
15051301        0.           3
15051401 400. 4
*
*htstr    left vol   incr  b.cond  sa code  area/factor   ht str no.
15051501  560010000  0     1       1        1.545         1
*
*htstr    right vol  incr  b.cond  sa code  area/factor   ht str no.
15051601  505010000  0     1       1        1.545         1
*
*htstr    s. type    s. mult    left heat  right heat   ht str no.
15051701    0          0          0          0            1
*
*htstr
*mod2.5*15051801 0 0.0 0.0 0.0 1
15051801 0.0  10. 10. 0. 0. 0. 0. 1. 1
*
*htstr
*mod2.5*15051901 0 0.0 0.0 0.0 1
15051901 0.0  10. 10. 0. 0. 0. 0. 1. 1
*
*-----------------------------------------------------------------*
* ht str 5052 - core flow separation shroud in core inlet region  *
*-----------------------------------------------------------------*
*htstr   ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15052000  1  4  2  1            0.168     0     0     0
*
*htstr      mesh locn      mesh fmt
15052100        0            1
*
*htstr      intervals      rt. coord
15052101        3            0.175
*
*htstr      compxn no.     interval
15052201        2            3
*
*htstr      source         interval
15052301        0.           3
15052401 400. 4
*
*htstr    left vol   incr  b.cond  sa code  area/factor   ht str no.
15052501  505010000  0     1       1        1.545         1
*
*htstr    right vol  incr  b.cond  sa code  area/factor   ht str no.
15052601  530010000  0     1       1        1.545         1
*
*htstr    s. type    s. mult    left heat  right heat   ht str no.
15052701    0          0          0          0            1
*
*htstr
*mod2.5*15052801 0 0.0 0.0 0.0 1
15052801 0.0 10. 10. 0. 0. 0. 0. 1. 1
*
*htstr
*mod2.5*15052901 0 0.0 0.0 0.0 1
15052901 0.0 10. 10. 0. 0. 0. 0. 1. 1
*
* fuel region heat structures
*
*-----------------------------------------------------------------*
* ht str 5101 - lower core average fuel plates                    *
*-----------------------------------------------------------------*
*htstr   ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15101000  5 11  1  1            0.        0     0     0
*
*htstr      mesh locn      mesh fmt
15101100        0            1
*
*htstr      intervals      rt. coord
15101101        2            1.020e-5
15101102        2            2.5700e-4
15101103        6            6.3800e-4
*
*htstr      compxn no.     interval
15101201        4            2
15101202        2            4
15101203        5            10
*
*htstr      source         interval
15101301        0.           2
15101302        0.00150      4
15101303        0.25440      10
*
15101401 400. 11
*
```

```
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
*mod2.5*15101501  510010000  10000   1   0    4.31     5
15101501  510010000  10000  102   0    4.31     5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15101601  0       0    0    0    4.31        5
*
*htstr    s. type   s. mult   left heat  right heat   ht str no.
15101701   1000  6.0236258d-02  3.0129898d-04  0.0000000d+00   1
15101702   1000  5.4739700d-02  2.7380545d-04  0.0000000d+00   2
15101703   1000  4.7963121d-02  2.3990931d-04  0.0000000d+00   3
15101704   1000  4.4273650d-02  2.2145475d-04  0.0000000d+00   4
15101705   1000  4.4198355d-02  2.2107813d-04  0.0000000d+00   5
*
*htstr
*mod2.5*15101801 0 0.0 0.0 0.0 5
15101801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15101901 0 0.0 0.0 0.0 5
15101901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-------------------------------------------------------------------*
*  ht str 5102 - lower core average channel inner side plate        *
*-------------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15102000   5  4  2  1            0.095    0     0     0
*
*htstr      mesh locn      mesh fmt
15102100       0              1
*
*htstr      intervals     rt. coord
15102101        3           0.102
*
*htstr      compxn no.     interval
15102201        2             3
*
*htstr      source         interval
15102301        1.             3
15102401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
15102501   562010000  10000   1     1    0.10098      5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15102601   510010000  10000   1     1    0.10098      5
*
*htstr    s. type   s. mult   left heat  right heat   ht str no.
15102701   1000  5.1550372d-04  1.3817383d-03  0.0000000d+00   1
15102702   1000  4.6846401d-04  1.2556547d-03  0.0000000d+00   2
15102703   1000  4.1046984d-04  1.1002091d-03  0.0000000d+00   3
15102704   1000  3.7889524d-04  1.0155776d-03  0.0000000d+00   4
15102705   1000  3.7825086d-04  1.0138505d-03  0.0000000d+00   5
*
*htstr
*mod2.5*15102801 0 0.0 0.0 0.0 5
15102801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15102901 0 0.0 0.0 0.0 5
15102901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-------------------------------------------------------------------*
*  ht str 5103 - lower core average channel outer side plate        *
*-------------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15103000   5  4  2  1            0.168    0     0     0
*
*htstr      mesh locn      mesh fmt
15103100       0              1
*
*htstr      intervals     rt. coord
15103101        3           0.175
*
*htstr      compxn no.     interval
15103201        2             3
*
*htstr      source         interval
15103301        1.             3
15103401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
15103501   510010000  10000   1     1    0.10098      5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15103601   530020000   0     1     1    0.10098      5
*
*htstr    s. type   s. mult   left heat  right heat   ht str no.
15103701   1000  4.6136406d-04  0.0000000d+00  8.5681897d-04   1
15103702   1000  4.1926459d-04  0.0000000d+00  7.7863424d-04   2
15103703   1000  3.6736113d-04  0.0000000d+00  6.8224211d-04   3
15103704   1000  3.3910259d-04  0.0000000d+00  6.2976195d-04   4
15103705   1000  3.3852588d-04  0.0000000d+00  6.2869092d-04   5
*
*htstr
*mod2.5*15103801 0 0.0 0.0 0.0 5
15103801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15103901 0 0.0 0.0 0.0 5
15103901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-------------------------------------------------------------------*
*  ht str 5151 - lower core hot channel fuel plates                 *
*-------------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15151000   5 11  1  1             0.     0     0     0
*
*htstr      mesh locn      mesh fmt
15151100       0              1
*
*htstr      intervals     rt. coord
15151101        2           1.02e-5
15151102        2           2.5700e-4
15151103        6           6.3800e-4
*
*htstr      compxn no.     interval
15151201        4             2
15151202        2             4
15151203        5             10
*
*htstr      source         interval
15151301        0.             2
15151302        0.00150        4
15151303        0.25440        10
*
15151401 400. 11
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
*mod2.5*15151501  515010000  10000   1   0    0.017102     5
15151501  515010000  10000  102   0    0.017102     5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15151601  0       0    0    0    0.017102     5
*
*htstr     s.type    s.mult    left heat   right heat   ht str
15151701   1000  5.3240879d-04  2.6630842d-06  0.0000000d+00   1
15151702   1000  4.8831358d-04  2.4425220d-06  0.0000000d+00   2
```

```
15151703  1000 4.4323848d-04 2.2170584d-06 0.0000000d+00   3
15151704  1000 4.0012317d-04 2.0013976d-06 0.0000000d+00   4
15151705  1000 3.4034967d-04 1.7024133d-06 0.0000000d+00   5
*htstr
*mod2.5*15151801 0 0.0 0.0 0.0 5
15151801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15151901 0 0.0 0.0 0.0 5
15151901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------------*
* ht str 5152 - lower core hot channel inner side plate - (95%)    *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
15152000  5 4 2 1          0.095   0   0    0
*
*htstr      mesh locn     mesh fmt
15152100       0            1
*
*htstr      intervals     rt. coord
15152101       3            0.102
*
*htstr      compxn no.    interval
15152201       2            3
*
*htstr      source        interval
15152301       1.           3
15152401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
15152501  562010000  10000  1     1     0.0004024      5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15152601  515010000  10000  1     1     0.0004024      5
*
*htstr    s. type    s. mult    left heat  right heat  ht str no.
15152701  1000 4.5563705d-06 1.2212737d-05 0.0000000d+00   1
15152702  1000 4.1790024d-06 1.1201253d-05 0.0000000d+00   2
15152703  1000 3.7932484d-06 1.0167291d-05 0.0000000d+00   3
15152704  1000 3.4242662d-06 9.1782843d-06 0.0000000d+00   4
15152705  1000 2.9127228d-06 7.8071610d-06 0.0000000d+00   5
*
*htstr
*mod2.5*15152801 0 0.0 0.0 0.0 5
15152801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15152901 0 0.0 0.0 0.0 5
15152901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------------*
* ht str 5153 - lower core hot channel outer side plate (95%)      *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
15153000  5 4 2 1          0.168   0   0    0
*
*htstr      mesh locn     mesh fmt
15153100       0            1
*
*htstr      intervals     rt. coord
15153101       3            0.175
*
*htstr      compxn no.    interval
15153201       2            3
*
*htstr      source        interval
15153301       1.           3
15153401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
15153501  515010000  10000  1     1     0.0004024      5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15153601  530020000  0      1     1     0.0004024      5
*
*htstr    s. type    s. mult    left heat  right heat  ht str no.
15153701  1000 4.0778476d-06 0.0000000d+00 7.5731456d-06   1
15153702  1000 3.7401118d-06 0.0000000d+00 6.9459218d-06   2
15153703  1000 3.3948707d-06 0.0000000d+00 6.3047598d-06   3
15153704  1000 3.0646401d-06 0.0000000d+00 5.6914744d-06   4
15153705  1000 2.6068204d-06 0.0000000d+00 4.8412378d-06   5
*
*htstr
*mod2.5*15153801 0 0.0 0.0 0.0 5
15153801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15153901 0 0.0 0.0 0.0 5
15153901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------------*
* ht str 5154 - lower core hot stripe - 95% probability - CHF      *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
15154000  5 11 1 1          0.   0   0    0
*
*htstr      mesh locn     mesh fmt
15154100       0            1
*
*htstr      intervals     rt. coord
15154101       2            1.02-5
15154102       2            2.5700e-4
15154103       6            6.3800e-4
*
*htstr      compxn no.    interval
15154201       4            2
15154202       2            4
15154203       5            10
*
*htstr      source        interval
15154301       0.           2
15154302       0.00150      4
15154303       0.25440      10
*
15154401 400. 11
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
*mod2.5*15154501  515010000  10000   1  0    0.00017102      5
15154501  515010000  10000   102 0    0.00017102      5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15154601  0          0      0     0     0.00017102      5
*
*htstr    s.type    s.mult    left heat  right heat  ht str
15154701  1000 8.2364893d-06 0.0000000d+00 0.0000000d+00   1
15154702  1000 7.5810402d-06 0.0000000d+00 0.0000000d+00   2
15154703  1000 6.8822158d-06 0.0000000d+00 0.0000000d+00   3
15154704  1000 6.2894199d-06 0.0000000d+00 0.0000000d+00   4
15154705  1000 5.5231227d-06 0.0000000d+00 0.0000000d+00   5
*
*htstr
*mod2.5*15154801 0 0.0 0.0 0.0 5
15154801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15154901 0 0.0 0.0 0.0 5
15154901 0. 10. 10. 0. 0. 0. 0. 1. 5
```

```
*
*-----------------------------------------------------------------*
* ht str 5155 - lower core hot stripe - 95% probability - FE     *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
15155000  5 11  1  1          0.   0    0    0
*
*htstr     mesh locn     mesh fmt
15155100       0            1
*
*htstr     intervals     rt. coord
15155101       2          1.02-5
15155102       2          2.5700e-4
15155103       6          6.3800e-4
*
*htstr     compxn no.    interval
15155201       4            2
15155202       2            4
15155203       5            10
*
*htstr     source       interval
15155301     0.            2
15155302     0.00150         4
15155303     0.5075         10
*
15155401 400. 11
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
*mod2.5*15155501  515010000  10000   1   0    0.00017102      5
15155501  515010000  10000   102  0    0.00017102     5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15155601  0       0     0     0    0.00017102     5
*
*htstr     s.type    s.mult    left heat   right heat   ht str
15155701  1000  6.1159857d-06  0.0000000d+00  0.0000000d+00    1
15155702  1000  5.5087529d-06  0.0000000d+00  0.0000000d+00    2
15155703  1000  5.1714013d-06  0.0000000d+00  0.0000000d+00    3
15155704  1000  4.5641685d-06  0.0000000d+00  0.0000000d+00    4
15155705  1000  3.0361642d-06  0.0000000d+00  0.0000000d+00    5
*
*htstr
*mod2.5*15155801 0 0.0 0.0 0.0 5
15155801 0. 10. 10. 0. 0. 0. 0. 1.  5
*
*htstr
*mod2.5*15155901 0 0.0 0.0 0.0 5
15155901 0. 10. 10. 0. 0. 0. 0. 1.  5
*
*-----------------------------------------------------------------*
* ht str 5161 - lower core hot channel fuel plates (99.9% probability)*
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
15161000  5 11  1  1          0.   0    0    0
*
*htstr     mesh locn     mesh fmt
15161100       0            1
*
*htstr     intervals     rt. coord
15161101       2          1.02e-5
15161102       2          2.5700e-4
15161103       6          6.3800e-4
*
*htstr     compxn no.    interval
15161201       4            2
15161202       2            4
15161203       5            10
*
*htstr     source       interval
15161301     0.            2
15161302     0.00150         4
15161303     0.25440        10
*
15161401 400. 11
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
*mod2.5*15161501  516010000  10000   1   0    0.017102      5
15161501  516010000  10000   102  0    0.017102     5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15161601  0       0     0     0    0.017102     5
*
*htstr     s.type    s.mult    left heat   right heat   ht str
15161701  1000  5.5174206d-04  2.7597883d-06  0.0000000d+00    1
15161702  1000  5.0604563d-04  2.5312169d-06  0.0000000d+00    2
15161703  1000  4.5933373d-04  2.2975661d-06  0.0000000d+00    3
15161704  1000  4.1465278d-04  2.0740740d-06  0.0000000d+00    4
15161705  1000  3.5270873d-04  1.7642328d-06  0.0000000d+00    5
*htstr
*mod2.5*15161801 0 0.0 0.0 0.0 5
15161801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15161901 0 0.0 0.0 0.0 5
15161901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*
*-----------------------------------------------------------------*
* ht str 5162 - lower core hot channel inner side plate (99.9%)  *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
15162000  5  4  2  1          0.095   0    0    0
*
*htstr     mesh locn     mesh fmt
15162100       0            1
*
*htstr     intervals     rt. coord
15162101       3          0.102
*
*htstr     compxn no.    interval
15162201       2            3
*
*htstr     source       interval
15162301     1.            3
15162401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
15162501  562010000  10000  1     1    0.0004024     5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15162601  516010000  10000  1     1    0.0004024     5
*
*htstr    s. type    s. mult    left heat  right heat   ht str no.
15162701  1000  4.7218253d-06  1.2656217d-05  0.0000000d+00    1
15162702  1000  4.3307538d-06  1.1608002d-05  0.0000000d+00    2
15162703  1000  3.9309919d-06  1.0536494d-05  0.0000000d+00    3
15162704  1000  3.5486110d-06  9.5115738d-06  0.0000000d+00    4
15162705  1000  3.0184920d-06  8.0906611d-06  0.0000000d+00    5
*
*htstr
*mod2.5*15162801 0 0.0 0.0 0.0 5
15162801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15162901 0 0.0 0.0 0.0 5
15162901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------------*
```

```
* ht str 5163 - lower core hot channel outer side plate (99.9%)    *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
15163000  5 4 2 1          0.168   0   0    0
*
*htstr     mesh locn     mesh fmt
15163100      0            1
*
*htstr     intervals     rt. coord
15163101      3           0.175
*
*htstr     compxn no.    interval
15163201      2            3
*
*htstr     source        interval
15163301      1.           3
15163401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
15163501  516010000  10000  1     1     0.0004024     5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15163601  530020000  0     1     1     0.0004024     5
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
15163701  1000  4.2259258d-06  0.0000000d+00  7.8481479d-06   1
15163702  1000  3.8759258d-06  0.0000000d+00  7.1981479d-06   2
15163703  1000  3.5181480d-06  0.0000000d+00  6.5337035d-06   3
15163704  1000  3.1759258d-06  0.0000000d+00  5.8981480d-06   4
15163705  1000  2.7014814d-06  0.0000000d+00  5.0170369d-06   5
*
*htstr
*mod2.5*15163801 0 0.0 0.0 0.0 5
15163801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15163901 0 0.0 0.0 0.0 5
15163901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------------*
* ht str 5164 - lower core hot stripe - 99.9% probability - CHF    *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
15164000  5 11 1 1          0.    0   0    0
*
*htstr     mesh locn     mesh fmt
15164100      0            1
*
*htstr     intervals     rt. coord
15164101      2           1.02-5
15164102      2           2.5700e-4
15164103      6           6.3800e-4
*
*htstr     compxn no.    interval
15164201      4            2
15164202      2            4
15164203      5            10
*
*htstr     source        interval
15164301      0.           2
15164302      0.00150      4
15164303      0.25440      10
*
15164401 400. 11
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
*mod2.5*15164501  516010000  10000   1   0    0.00017102     5
15164501  516010000  10000   102 0    0.00017102     5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15164601  0      0    0    0    0.00017102     5
*
*htstr    s.type    s.mult    left heat   right heat   ht str
15164701  1000  1.0069002d-05  0.0000000d+00  0.0000000d+00   1
15164702  1000  9.2677236d-06  0.0000000d+00  0.0000000d+00   2
15164703  1000  8.4134198d-06  0.0000000d+00  0.0000000d+00   3
15164704  1000  7.6887345d-06  0.0000000d+00  0.0000000d+00   4
15164705  1000  6.7519461d-06  0.0000000d+00  0.0000000d+00   5
*
*htstr
*mod2.5*15164801 0 0.0 0.0 0.0 5
15164801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15164901 0 0.0 0.0 0.0 5
15164901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------------*
* ht str 5165 - lower core hot stripe - 99.9% probability - FE     *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
15165000  5 11 1 1          0.    0   0    0
*
*htstr     mesh locn     mesh fmt
15165100      0            1
*
*htstr     intervals     rt. coord
15165101      2           1.02-5
15165102      2           2.5700e-4
15165103      6           6.3800e-4
*
*htstr     compxn no.    interval
15165201      4            2
15165202      2            4
15165203      5            10
*
*htstr     source        interval
15165301      0.           2
15165302      0.00150      4
15165303      0.25440      10
*
15165401 400. 11
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
*mod2.5*15165501  516010000  10000   1   0    0.00017102     5
15165501  516010000  10000   102 0    0.00017102     5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15165601  0      0    0    0    0.00017102     5
*
*htstr    s.type    s.mult    left heat   right heat   ht str
15165701  1000  7.4610338d-06  0.0000000d+00  0.0000000d+00   1
15165702  1000  6.7202563d-06  0.0000000d+00  0.0000000d+00   2
15165703  1000  6.3087132d-06  0.0000000d+00  0.0000000d+00   3
15165704  1000  5.5679357d-06  0.0000000d+00  0.0000000d+00   4
15165705  1000  3.7038876d-06  0.0000000d+00  0.0000000d+00   5
*
*htstr
*mod2.5*15165801 0 0.0 0.0 0.0 5
15165801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15165901 0 0.0 0.0 0.0 5
15165901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------------*
* ht str 5201 - control rod shroud in mid core region              *
*-----------------------------------------------------------------*
```

```
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15201000  1  4  2  1              0.095    0     0      0
*
*htstr      mesh locn       mesh fmt
15201100         0              1
*
*htstr      intervals      rt. coord
15201101         3            0.102
*
*htstr      compxn no.     interval
15201201         2              3
*
*htstr      source          interval
15201301        0.              3
15201401 400. 4
*
*htstr   left vol    incr  b.cond  sa code  area/factor   ht str no.
15201501   562060000  0     1       1       0.050          1
*
*htstr   right vol  incr  b.cond  sa code  area/factor   ht str no.
15201601   520010000  0     1       1       0.050          1
*
*htstr     s. type     s. mult     left heat  right heat   ht str no.
15201701      0           0           0          0            1
*
*htstr
*mod2.5*15201801 0 0.0 0.0 0.0 1
15201801 0.19 10. 10. 0. 0. 0. 0. 1. 1
*
*htstr
*mod2.5*15201901 0 0.0 0.0 0.0 1
15201901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*-----------------------------------------------------------------*
*  ht str 5202 - core separation shroud in mid core region        *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15202000  1  4  2  1              0.168    0     0      0
*
*htstr      mesh locn       mesh fmt
15202100         0              1
*
*htstr      intervals      rt. coord
15202101         3            0.175
*
*htstr      compxn no.     interval
15202201         2              3
*
*htstr      source          interval
15202301        0.              3
15202401 400. 4
*
*htstr   left vol    incr  b.cond  sa code  area/factor   ht str no.
15202501   520010000  0     1       1       0.050          1
*
*htstr   right vol  incr  b.cond  sa code  area/factor   ht str no.
15202601   535010000  0     1       1       0.050          1
*
*htstr     s. type     s. mult     left heat  right heat   ht str no.
15202701      0           0           0          0            1
*
*htstr
*mod2.5*15202801 0 0.0 0.0 0.0 1
15202801 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*htstr
*mod2.5*15202901 0 0.0 0.0 0.0 1
15202901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*-----------------------------------------------------------------*
*  ht str 5251 - control rod shroud in upper core region          *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15251000  5  4  2  1              0.095    0     0      0
*
*htstr      mesh locn       mesh fmt
15251100         0              1
*
*htstr      intervals      rt. coord
15251101         3            0.102
*
*htstr      compxn no.     interval
15251201         2              3
*
*htstr      source          interval
15251301        1.              3
15251401 400. 4
*
*htstr   left vol    incr  b.cond  sa code  area/factor   ht str no.
15251501   562070000  10000  1      1       0.1014         5
*
*htstr   right vol  incr  b.cond  sa code  area/factor   ht str no.
15251601   525010000  0     1       1       0.1014         2
15251602   525020000  0     1       1       0.1014         5
*
*htstr     s. type     s. mult     left heat  right heat   ht str no.
15251701     0 0. 0. 0.  5
*
*htstr
*mod2.5*15251801 0 0.0 0.0 0.0 5
15251801 0.19 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15251901 0 0.0 0.0 0.0 5
15251901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------------*
*  ht str 5351 - cbpt in mid core region                          *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15351000  1  4  2  1              0.247    0     0      0
*
*htstr      mesh locn       mesh fmt
15351100         0              1
*
*htstr      intervals      rt. coord
15351101         3            0.2595
*
*htstr      compxn no.     interval
15351201         2              3
*
*htstr      source          interval
15351301        0.              3
15351401 400. 4
*
*htstr   left vol    incr  b.cond  sa code  area/factor   ht str no.
15351501   535010000  0     1       1       0.050          1
*
*htstr   right vol  incr  b.cond  sa code  area/factor   ht str no.
15351601   550010000  0     1       1       0.050          1
*
* include all of the d2o heating in cpbt annulus here
*htstr     s. type     s. mult     left heat  right heat   ht str no.
15351701     1000        0.0          0.0      0.00245         1
*
*htstr
*mod2.5*15351801 0 0.0 0.0 0.0 1
15351801 0. 10. 10. 0. 0. 0. 0. 1. 1
```

```
*
*htstr
*mod2.5*15351901 0 0.0 0.0 0.0 1
15351901 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*-----------------------------------------------------------------*
* ht str 5401 - upper core average channel fuel plates            *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
15401000  5 11  1  1            0.   0   0    0
*
*htstr     mesh locn     mesh fmt
15401100       0           1
*
*htstr     intervals     rt. coord
15401101       2          1.02-5
15401102       2          2.5700e-4
15401103       6          6.3800e-4
*
*htstr     compxn no.    interval
15401201       4           2
15401202       2           4
15401203       5           10
*
*htstr     source        interval
15401301  ·  0.            2
15401302    0.00441          4
15401303    0.6485           10
*
15401401 400. 11
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
*mod2.5*15401501  540010000  10000   1    0     5.91        5
15401501  540010000  10000   102   0     5.91       5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15401601  0        0     0     0     5.91       5
*
*htstr    s. type    s. mult    left heat  right heat   ht str no.
15401701  1000  1.2215527d-01  3.2923931d-04  0.0000000d+00   1
15401702  1000  1.3883680d-01  3.7420025d-04  0.0000000d+00   2
15401703  1000  1.3588058d-01  3.6623249d-04  0.0000000d+00   3
15401704  1000  1.3070720d-01  3.5228891d-04  0.0000000d+00   4
15401705  1000  1.2152180d-01  3.2753193d-04  0.0000000d+00   5
*
*htstr
*mod2.5*15401801 0 0.0 0.0 0.0 5
15401801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15401901 0 0.0 0.0 0.0 5
15401901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------------*
* ht str 5402 - upper core average channel inner side plate       *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
15402000  5  4  2  1           0.168   0    0    0
*
*htstr     mesh locn     mesh fmt
15402100       0           1
*
*htstr     intervals     rt. coord
15402101       3          0.175
*
*htstr     compxn no.    interval
15402201       2           3
*
*htstr     source        interval
15402301       1.            3
15402401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
15402501  525010000  0     1     1     0.1012      2
15402502  525020000  0     1     1     0.1012      5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15402601  540010000  10000  1     1     0.1012      5
*
*htstr    s. type    s. mult    left heat  right heat   ht str no.
15402701  1000  2.5628287d-04  5.6868608d-04  0.0000000d+00   1
15402702  1000  2.9128088d-04  6.4634589d-04  0.0000000d+00   2
15402703  1000  2.8507870d-04  6.3258340d-04  0.0000000d+00   3
15402704  1000  2.7422489d-04  6.0849902d-04  0.0000000d+00   4
15402705  1000  2.5495384d-04  5.6573698d-04  0.0000000d+00   5
*
*htstr
*mod2.5*15402801 0 0.0 0.0 0.0 5
15402801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15402901 0 0.0 0.0 0.0 5
15402901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------------*
* ht str 5451 - upper core hot channel fuel plates (95%)          *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
15451000  5 11  1  1            0.   0   0    0
*
*htstr     mesh locn     mesh fmt
15451100       0           1
*
*htstr     intervals     rt. coord
15451101       2          1.02-5
15451102       2          2.5700e-4
15451103       6          6.3800e-4
*
*htstr     compxn no.    interval
15451201       4           2
15451202       2           4
15451203       5           10
*
*htstr     source        interval
15451301      0.            2
15451302    0.00441          4
15451303    0.6485           10
*
15451401 400. 11
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
*mod2.5*15451501  545010000  10000   1    0     0.013711        5
15451501  545010000  10000   102   0     0.013711       5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15451601  0        0     0     0     0.013711       5
*
*htstr    s. type    s. mult    left heat  right heat   ht str no.
15451701  1000  3.9080633d-04  1.0533218d-06  0.0000000d+00   1
15451702  1000  4.2883073d-04  1.1558071d-06  0.0000000d+00   2
15451703  1000  3.9529532d-04  1.0654207d-06  0.0000000d+00   3
15451704  1000  3.6756919d-04  9.9069182d-07  0.0000000d+00   4
15451705  1000  3.3192132d-04  8.9461179d-07  0.0000000d+00   5
*
*htstr
*mod2.5*15451801 0 0.0 0.0 0.0 5
15451801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
```

```
*htstr
*mod2.5*15451901 0 0.0 0.0 0.0 5
15451901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------------*
* ht str 5452 - upper core hot channel inner side plate (95%)     *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
15452000  5 4 2 1          0.168   0   0    0
*
*htstr     mesh locn     mesh fmt
15452100       0            1
*
*htstr     intervals     rt. coord
15452101       3           0.175
*
*htstr     compxn no.    interval
15452201       2            3
*
*htstr     source       interval
15452301       1.           3
15452401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
15452501  525010000  0    1    1    0.000235    2
15452502  525020000  0    1    1    0.000235    5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15452601  545010000  10000  1   1   0.000235    5
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
15452701  1000 8.1991523d-07 1.8193739d-06 0.0000000d+00   1
15452702  1000 8.9969077d-07 1.9963941d-06 0.0000000d+00   2
15452703  1000 8.2933318d-07 1.8402722d-06 0.0000000d+00   3
15452704  1000 7.7116352d-07 1.7111950d-06 0.0000000d+00   4
15452705  1000 6.9637395d-07 1.5452385d-06 0.0000000d+00   5
*
*htstr
*mod2.5*15452801 0 0.0 0.0 0.0 5
15452801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15452901 0 0.0 0.0 0.0 5
15452901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------------*
* ht str 5454 - upper core hot stripe - 95% probability - CHF     *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
15454000  5 11 1 1           0.   0   0    0
*
*htstr     mesh locn     mesh fmt
15454100       0            1
*
*htstr     intervals     rt. coord
15454101       2          1.02-5
15454102       2          2.5700e-4
15454103       6          6.3800e-4
*
*htstr     compxn no.    interval
15454201       4            2
15454202       2            4
15454203       5            10
*
*htstr     source       interval
15454301      0.            2
15454302     0.00441          4
15454303     0.6485           10
*
15454401 400. 11
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
*mod2.5*15454501  545010000  10000   1   0    0.00013711     5
15454501  545010000  10000   102 0    0.00013711     5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15454601  0      0    0    0    0.00013711     5
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
15454701  1000 6.6203063d-06 0.0000000d+00 0.0000000d+00   1
15454702  1000 6.6203063d-06 0.0000000d+00 0.0000000d+00   2
15454703  1000 5.9933244d-06 0.0000000d+00 0.0000000d+00   3
15454704  1000 5.6233661d-06 0.0000000d+00 0.0000000d+00   4
15454705  1000 5.1248960d-06 0.0000000d+00 0.0000000d+00   5
*
*htstr
*mod2.5*15454801 0 0.0 0.0 0.0 5
15454801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15454901 0 0.0 0.0 0.0 5
15454901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------------*
* ht str 5455 - upper core hot stripe - 95% probability - FE      *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
15455000  5 11 1 1           0.   0   0    0
*
*htstr     mesh locn     mesh fmt
15455100       0            1
*
*htstr     intervals     rt. coord
15455101       2          1.02-5
15455102       2          2.5700e-4
15455103       6          6.3800e-4
*
*htstr     compxn no.    interval
15455201       4            2
15455202       2            4
15455203       5            10
*
*htstr     source       interval
15455301      0.            2
15455302     0.00441          4
15455303     0.6485           10
*
15455401 400. 11
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
*mod2.5*15455501  545010000  10000   1   0    0.00013711     5
15455501  545010000  10000   102 0    0.00013711     5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15455601  0      0    0    0    0.00013711     5
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
15455701  .1000 5.3606322d-06 0.0000000d+00 0.0000000d+00   1
15455702  1000 4.9532113d-06 0.0000000d+00 0.0000000d+00   2
15455703  1000 4.5810788d-06 0.0000000d+00 0.0000000d+00   3
15455704  1000 4.2185705d-06 0.0000000d+00 0.0000000d+00   4
15455705  1000 3.9972159d-06 0.0000000d+00 0.0000000d+00   5
*
*htstr
*mod2.5*15455801 0 0.0 0.0 0.0 5
15455801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
```

```
*mod2.5*15455901 0 0.0 0.0 0.0 5
15455901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*---------------------------------------------------------------------*
* ht str 5461 - upper core hot channel fuel plates (99.9%)            *
*---------------------------------------------------------------------*
*htstr   ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15461000  5 11 1 1              0.     0     0     0
*
*htstr      mesh locn     mesh fmt
15461100       0             1
*
*htstr      intervals     rt. coord
15461101       2           1.02-5
15461102       2           2.5700e-4
15461103       6           6.3800e-4
*
*htstr      compxn no.    interval
15461201       4            2
15461202       2            4
15461203       5            10
*
*htstr      source        interval
15461301     0.             2
15461302     0.00441          4
15461303     0.6485           10
*
15461401 400. 11
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
*mod2.5*15461501  546010000  10000   1   0   0.013711      5
15461501  546010000  10000   102  0   0.013711      5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15461601  0      0    0    0   0.013711      5
*
*htstr    s. type   s. mult    left heat  right heat   ht str no.
15461701  1000  4.0499763d-04  1.0915709d-06  0.0000000d+00    1
15461702  1000  4.4440280d-04  1.1977778d-06  0.0000000d+00    2
15461703  1000  4.0964963d-04  1.1041092d-06  0.0000000d+00    3
15461704  1000  3.8091669d-04  1.0266667d-06  0.0000000d+00    4
15461705  1000  3.4397434d-04  9.2709772d-07  0.0000000d+00    5
*
*htstr
*mod2.5*15461801 0 0.0 0.0 0.0 5
15461801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15461901 0 0.0 0.0 0.0 5
15461901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*---------------------------------------------------------------------*
*  ht str 5462 - upper core hot channel inner side plate (99.9%)      *
*---------------------------------------------------------------------*
*htstr   ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15462000  5 4 2 1            0.168    0     0     0
*
*htstr      mesh locn     mesh fmt
15462100       0             1
*
*htstr      intervals     rt. coord
15462101       3           0.175
*
*htstr      compxn no.    interval
15462201       2            3
*
*htstr      source        interval
15462301      1.            3
15462401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
15462501  525010000  0    1    1     0.000235      2
15462502  525020000  0    1    1     0.000235      5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15462601  546010000  10000  1    1     0.000235      5
*
*htstr    s. type   s. mult    left heat  right heat   ht str no.
15462701  1000  8.4968871d-07  1.8854406d-06  0.0000000d+00    1
15462702  1000  9.3236113d-07  2.0688889d-06  0.0000000d+00    2
15462703  1000  8.5944865d-07  1.9070977d-06  0.0000000d+00    3
15462704  1000  7.9916668d-07  1.7733334d-06  0.0000000d+00    4
15462705  1000  7.2166129d-07  1.6013506d-06  0.0000000d+00    5
*
*htstr
*mod2.5*15462801 0 0.0 0.0 0.0 5
15462801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15462901 0 0.0 0.0 0.0 5
15462901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*---------------------------------------------------------------------*
* ht str 5464 - upper core hot stripe - 99.9% probability - CHF       *
*---------------------------------------------------------------------*
*htstr   ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15464000  5 11 1 1              0.     0     0     0
*
*htstr      mesh locn     mesh fmt
15464100       0             1
*
*htstr      intervals     rt. coord
15464101       2           1.02-5
15464102       2           2.5700e-4
15464103       6           6.3800e-4
*
*htstr      compxn no.    interval
15464201       4            2
15464202       2            4
15464203       5            10
*
*htstr      source        interval
15464301     0.             2
15464302     0.00441          4
15464303     0.6485           10
*
15464401 400. 11
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
*mod2.5*15464501  546010000  10000   1  0   0.00013711      5
15464501  546010000  10000   102 0   0.00013711      5
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15464601  0      0    0    0   0.00013711      5
*
*htstr    s. type   s. mult    left heat  right heat   ht str no.
15464701  1000  8.0931850d-06  0.0000000d+00  0.0000000d+00    1
15464702  .1000  8.0931850d-06  0.0000000d+00  0.0000000d+00    2
15464703  1000  7.3267128d-06  0.0000000d+00  0.0000000d+00    3
15464704  1000  6.8744465d-06  0.0000000d+00  0.0000000d+00    4
15464705  1000  6.2650773d-06  0.0000000d+00  0.0000000d+00    5
*
*htstr
*mod2.5*15464801 0 0.0 0.0 0.0 5
15464801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15464901 0 0.0 0.0 0.0 5
```

```
15464901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------*
* ht str 5465 - upper core hot stripe - 99.9% probability - FE     *
*-----------------------------------------------------------*
*htstr   ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15465000  5 11  1  1              0.    0    0     0
*
*htstr     mesh locn     mesh fmt
15465100        0             1
*
*htstr     intervals      rt. coord
15465101        2           1.02-5
15465102        2           2.5700e-4
15465103        6           6.3800e-4
*
*htstr     compxn no.    interval
15465201        4           2
15465202        2           4
15465203        5           10
*
*htstr     source        interval
15465301     0.             2
15465302     0.00441          4
15465303     0.6485          10
*
15465401 400. 11
*
*htstr   left vol   incr  b.cond  sa code  area/factor   ht str no.
*mod2.5*15465501  546010000  10000    1   0     0.00013711        5
15465501  546010000  10000    102  0     0.00013711        5
*
*htstr   right vol   incr  b.cond  sa code  area/factor   ht str no.
15465601  0          0      0     0     0.00013711        5
*
*htstr    s. type    s. mult    left heat  right heat   ht str no.
15465701   1000  6.5395606d-06  0.0000000d+00  0.0000000d+00    1
15465702   1000  6.0425384d-06  0.0000000d+00  0.0000000d+00    2
15465703   1000  5.5885653d-06  0.0000000d+00  0.0000000d+00    3
15465704   1000  5.1463329d-06  0.0000000d+00  0.0000000d+00    4
15465705   1000  4.8762972d-06  0.0000000d+00  0.0000000d+00    5
*
*htstr
*mod2.5*15465801 0 0.0 0.0 0.0 5
15465801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15465901 0 0.0 0.0 0.0 5
15465901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------*
*  ht str 5501 - outer cpbt in uc and lc regions              *
*-----------------------------------------------------------*
*htstr   ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15501000  10 4  2  1           0.245    0    0     0
*
*htstr     mesh locn     mesh fmt
15501100        0             1
*
*htstr     intervals     rt. coord
15501101        3           0.253
*
*htstr     compxn no.    interval
15501201        2           3
*
*htstr     source        interval
15501301       1.           3
15501401 400. 4
*

*htstr    left vol    incr  b.cond  sa code  area/factor   ht str no.
15501501  550020000  10000   1      1     0.1014        5
15501502  550080000  10000   1      1     0.1014        10
*
*htstr    right vol   incr  b.cond  sa code  area/factor   ht str no.
15501601  575010000  0     1      1     0.1014        10
*
*htstr     s. type    s. mult    left heat  right heat   ht str no.
15501701   10775      0.626      0.0       0.0         1
15501702   10774      0.626      0.0       0.0         2
15501703   10773      0.626      0.0       0.0         3
15501704   10772      0.626      0.0       0.0         4
15501705   10771      0.626      0.0       0.0         5
15501706   10735      0.789      0.0       0.0         6
15501707   10734      0.789      0.0       0.0         7
15501708   10733      0.789      0.0       0.0         8
15501709   10732      0.789      0.0       0.0         9
15501710   10731      0.789      0.0       0.0         10
*
*htstr
*mod2.5*15501801 0 0.0 0.0 0.0 10
15501801 0. 10. 10. 0. 0. 0. 0. 1. 10
*
*htstr
*mod2.5*15501901 0 0.0 0.0 0.0 10
15501901 0. 10. 10. 0. 0. 0. 0. 1. 10
*
*-----------------------------------------------------------*
*  ht str 5502 - inner cbpt in lower core region              *
*-----------------------------------------------------------*
*htstr   ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15502000  5  4  2  1           0.235    0    0     0
*
*htstr     mesh locn     mesh fmt
15502100        0             1
*
*htstr     intervals     rt. coord
15502101        3           0.240
*
*htstr     compxn no.    interval
15502201        2           3
*
*htstr     source        interval
15502301       1.           3
15502401 400. 4
*
*htstr    left vol    incr  b.cond  sa code  area/factor   ht str no.
15502501  530020000  10000   1      1     0.1014        5
*
*htstr    right vol   incr  b.cond  sa code  area/factor   ht str no.
15502601  550020000  10000   1      1     0.1014        5
*
*htstr     s. type    s. mult    left heat  right heat   ht str no.
15502701    10775     0.374      0.        0.           1
15502702    10774     0.374      0.        0.           2
15502703    10773     0.374      0.        0.           3
15502704    10772     0.374      0.        0.           4
15502705    10771     0.374      0.        0.           5
*
*htstr
*mod2.5*15502801 0 0.0 0.0 0.0 5
15502801 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15502901 0 0.0 0.0 0.0 5
15502901 0. 10. 10. 0. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------*
*  ht str 5503 - inner cbpt in upper core region              *
```

```
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  Lcoord  refl  b.vol  axl. incr
15503000  5 4 2 1        0.235   0   0   0
*
*htstr    mesh locn    mesh fmt
15503100     0          1
*
*htstr    intervals    rt. coord
15503101     3          0.242
*
*htstr    compxn no.   interval
15503201     2          3
*
*htstr    source       interval
15503301     1.         3
15503401 400. 4
*
*htstr  left vol  incr  b.cond  sa code  area/factor  ht str no.
15503501  540010000  10000  1   1   0.1014   5
*
*htstr  right vol  incr  b.cond  sa code  area/factor  ht str no.
15503601  550080000  10000  1   1   0.1014   5
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
15503701   10735    0.211     0.     0.     1
15503702   10734    0.211     0.     0.     2
15503703   10733    0.211     0.     0.     3
15503704   10732    0.211     0.     0.     4
15503705   10731    0.211     0.     0.     5
*
*htstr
*mod2.5*15503801 0 0.0 0.0 0.0 5
15503801 0. 10. 10. 0. 0. 0. 1. 5
*
*htstr
*mod2.5*15503901 0 0.0 0.0 0.0 5
15503901 0. 10. 10. 0. 0. 0. 1. 5
*
*-----------------------------------------------------------------*
* ht str 5551 - core separation shroud in core outlet region      *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  Lcoord  refl  b.vol  axl. incr
15551000  2 4 2 1        0.168   0   0   0
*
*htstr    mesh locn    mesh fmt
15551100     0          1
*
*htstr    intervals    rt. coord
15551101     3          0.175
*
*htstr    compxn no.   interval
15551201     2          3
*
*htstr    source       interval
15551301     0.         3
15551401 400. 4
*
*htstr  left vol  incr  b.cond  sa code  area/factor  ht str no.
15551501  525010000  0   1   1   0.7715   2
*
*htstr  right vol  incr  b.cond  sa code  area/factor  ht str no.
15551601  555010000  2000000 1   1   0.7715   2
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
15551701    0        0         0        0         2
*
*htstr
*mod2.5*15551801 0 0.0 0.0 0.0 2
15551801 0. 10. 10. 0. 0. 0. 1. 2
*
*htstr
*mod2.5*15551901 0 0.0 0.0 0.0 2
15551901 0. 10. 10. 0. 0. 0. 1. 2
*
*-----------------------------------------------------------------*
* ht str 5552 - cbpt in core outlet region                        *
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  Lcoord  refl  b.vol  axl. incr
15552000  2 4 2 1        0.235   0   0   0
*
*htstr    mesh locn    mesh fmt
15552100     0          1
*
*htstr    intervals    rt. coord
15552101     3          0.240
*
*htstr    compxn no.   interval
15552201     2          3
*
*htstr    source       interval
15552301     0.         3
15552401 400. 4
*
*htstr  left vol  incr  b.cond  sa code  area/factor  ht str no.
15552501  555010000  2000000 1   1   0.7715   2
*
*htstr  right vol  incr  b.cond  sa code  area/factor  ht str no.
15552601  550130000  10000  1   1   0.7715   2
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
15552701    0        0         0        0         2
*
*htstr
*mod2.5*15552801 0 0.0 0.0 0.0 2
15552801 0. 10. 10. 0. 0. 0. 1. 2
*
*htstr
*mod2.5*15552901 0 0.0 0.0 0.0 2
15552901 0. 10. 10. 0. 0. 0. 1. 2
*
*-----------------------------------------------------------------*
*
$     ht str no. 5611  control rod aluminum (8-35 deg sectors)
*-----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  Lcoord  refl  b.vol  axl. incr
15611000   11    4    2    1   0.022   0   0   0
*
*htstr    mesh locn    mesh fmt
15611100     0          1
*
*htstr    intervals    rt. coord
15611101     3          0.0285
*
*htstr    compxn no.   interval
15611201     2          3
*
*htstr    source       interval
15611301     1.         3
15611401 400. 4
*
*htstr  left vol  incr  b.cond  sa code  area/factor  ht str no.
15611501  561010000  10000  1   1   0.23660   5
15611502  561060000  0      1   1   0.11667   6
15611503  561070000  10000  1   1   0.23660   11
*
*htstr  right vol  incr  b.cond  sa code  area/factor  ht str no.
15611601  563010000  10000  1   1   0.23660   5
15611602  563060000  0      1   1   0.11667   6
```

```
15611603  563070000  10000  1    1    0.23660     11
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
15611701   10641    0.166      0.      0.       1
15611702   10641    0.205      0.      0.       2
15611703   10641    0.211      0.      0.       3
15611704   10641    0.210      0.      0.       4
15611705   10641    0.208      0.      0.       5
15611706    0       0          0       0        6
15611707    0       0          0.      0.       7
15611708    0       0          0.      0.       8
15611709    0       0          0.      0.       9
15611710    0       0          0.      0.       10
15611711    0       0          0.      0.       11
*
*htstr    chf flag    hyd diam    equiv diam   ch. len    ht str no.
*mod2.5*15611801    0       0.       0       0        11
15611801   0. 10. 10. 0. 0. 0. 0. 1. 11
*
*htstr    chf flag    hyd diam    equiv diam   ch. len    ht str no.
*mod2.5*15611901    0       0.       0       0        11
15611901   0. 10. 10. 0. 0. 0. 0. 1. 11
*
$======================================================================$
$  ht str no. 5621   control rod hafnium/aluminum (8-10 degree sectors)
*-------------------------------------------------------------------*
*htstr   ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15621000   11    10    2    1    0.022    0    0     0
*
*htstr       mesh locn       mesh fmt
15621100        0              1
*
*htstr       intervals      rt. coord
15621101        3            0.0285
15621102        2            0.03125
15621103        1            0.0315
15621104        3            0.0355
*
*htstr       compxn no.     interval
15621201        2              5
15621202        6              6
15621203        3              9
*
*htstr       source         interval
15621301       0.2             5
15621302       0.              6
15621303       0.8             9
*
15621401  400.  10
*
*htstr    left vol    incr   b.cond  sa code  area/factor   ht str no.
15621501   561010000   10000   1     1      0.0676       5
15621502   561060000   0       1     1      0.0333       6
15621503   561070000   10000   1     1      0.0676       11
*
*htstr    right vol   incr   b.cond  sa code  area/factor   ht str no.
15621601   562010000   10000   1     1      0.0676       5
15621602   562060000   0       1     1      0.0333       6
15621603   562070000   10000   1     1      0.0676       11
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
15621701   10642    0.166      0.      0.       1
15621702   10642    0.205      0.      0.       2
15621703   10642    0.211      0.      0.       3
15621704   10642    0.210      0.      0.       4
15621705   10642    0.208      0.      0.       5
15621706    0       0          0       0        6
15621707    0       0          0.      0.       7
15621708    0       0          0.      0.       8
15621709    0       0          0.      0.       9
15621710    0       0          0.      0.       10
15621711    0       0          0.      0.       11
*
*htstr    chf flag    hyd diam    equiv diam   ch. len    ht str no.
*mod2.5*15621801    0       0.       0       0        11
15621801   0. 10. 10. 0. 0. 0. 0. 1. 11
*
*htstr    chf flag    hyd diam    equiv diam   ch. len    ht str no.
*mod2.5*15621901    0       0.       0       0        11
15621901   0. 10. 10. 0. 0. 0. 0. 1. 11
*
$======================================================================$
$  ht str no. 5631   control rod hafnium structure (8-35 degree sectors)
*-------------------------------------------------------------------*
*htstr   ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15631000   11    4    2    1    0.03125    0    0     0
*
*htstr       mesh locn       mesh fmt
15631100        0              1
*
*htstr       intervals      rt. coord
15631101        3            0.0355
*
*htstr       compxn no.     interval
15631201        3              3
*
*htstr       source         interval
15631301       1.              3
15631401  400.  4
*
*htstr    left vol    incr   b.cond  sa code  area/factor   ht str no.
15631501   563010000   10000   1     1      0.23660      5
15631502   563060000   0       1     1      0.11667      6
15631503   563070000   10000   1     1      0.23660      11
*
*htstr    right vol   incr   b.cond  sa code  area/factor   ht str no.
15631601   562010000   10000   1     1      0.23660      5
15631602   562060000   0       1     1      0.11667      6
15631603   562070000   10000   1     1      0.23660      11
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
15631701   10643    0.166      0.      0.       1
15631702   10643    0.205      0.      0.       2
15631703   10643    0.211      0.      0.       3
15631704   10643    0.210      0.      0.       4
15631705   10643    0.208      0.      0.       5
15631706    0       0          0       0        6
15631707    0       0          0.      0.       7
15631708    0       0          0.      0.       8
15631709    0       0          0.      0.       9
15631710    0       0          0.      0.       10
15631711    0       0          0.      0.       11
*
*htstr    chf flag    hyd diam    equiv diam   ch. len    ht str no.
*mod2.5*15631801    0       0.       0       0        11
15631801   0. 10. 10. 0. 0. 0. 0. 1. 11
*
*htstr    chf flag    hyd diam    equiv diam   ch. len    ht str no.
*mod2.5*15631901    0       0.       0       0        11
15631901   0. 10. 10. 0. 0. 0. 0. 1. 11
*
$======================================================================$
$     ht str no. 5612   structure for gamma heating of inner flow   $
*-------------------------------------------------------------------*
*htstr   ht strs  m pts  geom  init  l.coord   refl  b.vol  axl. incr
15612000   11    2    1    1    0.    0    0     0
*
*htstr       mesh locn       mesh fmt
```

```
15612100      0       1
*
*htstr     intervals    rt. coord
15612101      1         0.001
*
*htstr     compxn no.   interval
15612201      2          1
*
*htstr     source       interval
15612301     1.          1
15612401 400. 2
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
15612501  561010000  10000  1      0       0.01        11
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15612601  0          0     0       0       0.01        11
*
*
*htstr     s. type   s. mult   left heat  right heat  ht str no.
15612701   10613     0.        .166       0.          1
15612702   10613     0.        .205       0.          2
15612703   10613     0.        .211       0.          3
15612704   10613     0.        .210       0.          4
15612705   10613     0.        .208       0.          5
15612706   0     0.     0.     0.     6
15612707   10640     0.        .166       0.          7
15612708   10640     0.        .205       0.          8
15612709   10640     0.        .211       0.          9
15612710   10640     0.        .210       0.          10
15612711   10640     0.        .208       0.          11
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
*mod2.5*15612801    0      0.       0      0       11
15612801  0. 10. 10. 0. 0. 0. 0. 1. 11
*
$==================================================================$
$     ht str no. 5622  structure for gamma heating of flow around rod
*----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  Lcoord  refl  b.vol  axl. incr
15622000  11     2      1     1     0.      0     0      0
*
*htstr     mesh locn    mesh fmt
15622100      0           1
*
*htstr     intervals    rt. coord
15622101      1           0.001
*
*htstr     compxn no.   interval
15622201      2           1
*
*htstr     source       interval
15622301     1.           1
15622401 400. 2
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
15622501  562010000  10000  1      0       0.01        11
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15622601  0          0     0       0       0.01        11
*htstr    s. type   s. mult   left heat  right heat  ht str no.
15622701   10700     0.        1.         0.          1
15622702   10699     0.        1.         0.          2
15622703   10698     0.        1.         0.          3
15622704   10697     0.        1.         0.          4
15622705   10696     0.        1.         0.          5
15622706   0     0.     1.     0.     6
15622707   10675     0.        1.         0.          7
15622708   10674     0.        1.         0.          8
15622709   10673     0.        1.         0.          9
15622710   10672     0.        1.         0.          10
15622711   10671     0.        1.         0.          11
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
*mod2.5*15622801    0      0.       0      0       11
15622801   0.  10. 10. 0. 0. 0. 0. 1. 11
*
*htstr   chf flag   hyd diam   equiv diam   ch. len   ht str no.
*mod2.5*15622901    0      0.       0      0       11
15622901   0.  10. 10. 0. 0. 0. 0. 1. 11
*
*----------------------------------------------------------------*
*  ht str 5651 - core outlet pipe wall                            *
*----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  Lcoord  refl  b.vol  axl. incr
15651000  1 4 2 1           0.28019  0    0      0
*
*htstr     mesh locn    mesh fmt
15651100      0           1
*
*htstr     intervals    rt. coord
15651101      3           0.3048
*
*htstr     compxn no.   interval
15651201      1           3
*
*htstr     source       interval
15651301     0.           3
15651401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
15651501  565010000  0     1       1       0.918       1
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
15651601  0          0     0       1       0.918       1
*
*htstr    s. type   s. mult   left heat  right heat  ht str no.
15651701    0         0         0          0           1
*
*htstr
*mod2.5*15651801 0 0.0 0.0 0.0 1
15651801 0. 10. 10. 0. 0. 0. 0. 1. 1
*
*htstr
*mod2.5*15651901 0 0.0 0.0 0.0 1
15651901 0. 10. 10. 0. 0. 0. 0. 1. 1
*==================================================================$
*          ht str no. 6401        hotpipe            $
*----------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  Lcoord  refl  b.vol  axl. incr
16401000  6 4 2 1           0.28019  0    0      0
*
*htstr     mesh locn    mesh fmt
16401100      0           1
*
*htstr     intervals    rt. coord
16401101      3           0.3048
*
*htstr     compxn no.   interval
16401201      1           3
*
*htstr     source       interval
16401301     0.           3
16401401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
16401501  640010000  10000  1      1       0.91463     3
16401502  641010000  10000  1      1       2.33667     6
```

```
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
16401601  -501    0   4521   1    0.91463     3
16401602  -501    0   4581   1    2.33667     6
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
16401701    0        0         0          0          6
*
*htstr
*mod2.5*16401801 0 0.0 0.0 0.0 6
16401801 0. 10. 10. 0. 0. 0. 0. 1. 6
*
*htstr
*mod2.5*16401901 0 0.0 0.0 0.0 6
16401901 0. 10. 10. 0. 0. 0. 0. 1. 6
*
*==================================================================$
*          ht str no. 6451        hotpipe            $
*---------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
16451000  2  4  2  1        0.28019   0    0     0
*
*htstr     mesh locn     mesh fmt
16451100      0             1
*
*htstr     intervals     rt. coord
16451101      3           0.3048
*
*htstr     compxn no.    interval
16451201      1             3
*
*htstr     source        interval
16451301      0.            3
16451401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
16451501  645010000  0    1      1      4.88       1
16451502  645020000  0    1      1      3.35       2
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
16451601  -501    0   4521   1     4.88       1
16451602  -501    0   4521   1     3.35       2
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
16451701    0        0         0          0          2
*
*htstr
*mod2.5*16451801 0 0.0 0.0 0.0 2
16451801 0. 10. 10. 0. 0. 0. 0. 1. 2
*mod2.5*16451901 0 0.0 0.0 0.0 2
16451901 0. 10. 10. 0. 0. 0. 0. 1. 2
*
*==================================================================$
*          ht str no. 6501        hothead            $
*---------------------------------------------------------------*
*htstr  ht strs  m pts  geom  init  l.coord  refl  b.vol  axl. incr
16501000  4  4  2  1        0.28019   0    0     0
*
*htstr     mesh locn     mesh fmt
16501100      0             1
*
*htstr     intervals     rt. coord
16501101      3           0.3048
*
*htstr     compxn no.    interval
16501201      1             3
*
*htstr     source        interval
16501301      0.            3
```

```
16501401 400. 4
*
*htstr   left vol   incr  b.cond  sa code  area/factor  ht str no.
16501501  650010000  0    1      1      1.68       1
16501502  650020000  0    1      1      3.51       2
16501503  650030000  0    1      1      1.22       3
16501504  650040000  0    1      1      1.83       4
*
*htstr   right vol  incr  b.cond  sa code  area/factor  ht str no.
16501601  -501    0   4521   1     1.68       1
16501602  -501    0   4521   1     3.51       2
16501603  -501    0   4521   1     1.22       3
16501604  -501    0   4521   1     1.83       4
*
*htstr   s. type   s. mult   left heat  right heat  ht str no.
16501701    0        0         0          0          4
*
*htstr
*mod2.5*16501801 0 0.0 0.0 0.0 4
16501801 0. 10. 10. 0. 0. 0. 0. 1. 4
*mod2.5*16501901 0 0.0 0.0 0.0 4
16501901 0. 10. 10. 0. 0. 0. 0. 1. 4
*
*==================================================================*
*                                *
*      G E N E R A L   D A T A   T A B L E S      *
*                                *
*==================================================================*
*
* saturation table (pressure as a fcn. of temperature)
*
20203500 reac-t
20203503 40.    6.549e3
20203505 50.    11.121e3
20203506 60.    18.200e3
20203507 70.    28.80e3
20203508 80.    44.23e3
20203509 90.    66.07e3
20203510 100.   96.25e3
20203511 110.   137.06e3
20203512 120.   191.1e3
20203513 130.   261.5e3
20203514 140.   351.7e3
20203515 150.   465.3e3
20203516 160.   606.7e3
20203517 170.   780.3e3
20203518 180.   991.2e3
20203519 190.   1244.5e3
20203520 200.   1546.0e3
*
* primary coolant pump post-cavitation head degradation factor
*
20203900 reac-t
20203901 0.0 0.0
20203902 0.7 0.0
20203903 0.8 0.95
20203904 1.0 1.0
*
* main circulation pump homologous curve: hvn
*
20204100 reac-t
20204101  0.     -0.35
20204102  0.425   0.
20204103  0.567   0.142
20204104  0.637   0.239
20204105  0.728   0.391
20204106  0.850   0.644
20204107  1.      1.
*
```

```
* main circulation pump homologous curve: hvn inverse
*
20204200 reac-t
20204201 -0.35    0.
20204202 0.       0.425
20204203 0.142    0.567
20204204 0.239    0.637
20204205 0.391    0.728
20204206 0.644    0.850
20204207 1.       1.
*
* main circulation pump speed vs. frictional torque
* Tf = 150 + 10*n**2
*
20204300 reac-t
20204301 .000 150. .100 150.1 .200 150.4 .300 150.9
20204302 .400 151.6 .500 152.5 .600 153.6 .700 154.9
20204303 .800 156.4 .900 158.1 1.0 160.
*
* main circulation pump
* relative speed vs. pony motor torque (N-m)
* the HFIR data have been normalized keeping the ratio between the
* pony motor locked-rotor torque and the main motor rated torque constant.
*
20204400 reac-t
20204401 0.0000 2408.
20204402 0.0731 1035.4
20204403 0.1134 613.1
20204404 0.1537 382.1
20204405 0.2142 203.9
20204406 0.2681 126.8
20204407 0.4032   0.0
20204408 1.00000  0.0
*
*-----------------------------------------------------------------$
*              table no. 135 - mcp coastdown
*-----------------------------------------------------------------*
*
20213500 reac-t 635
20213501 -1. 1.
20213502 0. 1.
20213503 0.001 0.9995
20213504 0.005 0.9975
20213505 0.1   0.9529
20213506 0.2   0.9100
20213507 0.5   0.8021
20213508 1.    0.6704
20213509 2.    0.5064
20213510 3.    0.4091
20213511 6.    0.2644
20213512 9.    0.2010
20213513 10.   0.1874
20213514 15.   0.1457
20213515 20.   0.1256
20213516 50.   0.1012
20213517 100.  0.1000
20213518 1.e6  0.1000
*
20223500 reac-t 635
20223501 -1. 1.
20223502 0. 1.
20223503 0.001 0.9995
20223504 0.005 0.9975
20223505 0.1   0.9529
20223506 0.2   0.9100
20223507 0.5   0.8021
20223508 1.    0.6704
20223509 2.    0.5064
20223510 3.    0.4091
20223511 6.    0.2644
20223512 9.    0.2010
20223513 10.   0.1874
20223514 15.   0.1457
20223515 20.   0.1256
20223516 50.   0.1012
20223517 100.  0.1000
20223518 1.e6  0.1000
*
20233500 reac-t 635
20233501 -1. 1.
20233502 0. 1.
20233503 0.001 0.9995
20233504 0.005 0.9975
20233505 0.1   0.9529
20233506 0.2   0.9100
20233507 0.5   0.8021
20233508 1.    0.6704
20233509 2.    0.5064
20233510 3.    0.4091
20233511 6.    0.2644
20233512 9.    0.2010
20233513 10.   0.1874
20233514 15.   0.1457
20233515 20.   0.1256
20233516 50.   0.1012
20233517 100.  0.1000
20233518 1.e6  0.1000
*
*-----------------------------------------------------------------$
*              table no. 500 - core power
*-----------------------------------------------------------------*
*table      table type  trip no.  factor 1  factor 2
20250000      power       510       1.0      3.5e8
*
*table              time           power
20250001             -1.             1.0
20250002              0.             1.0
20250003             1.e6            1.0
*
*=================================================================$
* table for water pool temperature - used as boundary condition for
* outside surfaces of hot and cold leg piping within the pool
*-----------------------------------------------------------------$
*              table no. 501 - pool temp
*-----------------------------------------------------------------*
*table      table type  trip no.  factor 1  factor 2  constant
20250100      temp
*
*table              time           temp
20250101             0.            311.15
*
*=================================================================$
*   table no. 511 - htc from outside of 14-in. horizontal pipe
*       assumes pool temperature of 311.15 K
*-----------------------------------------------------------------*
20251100 htc-temp
20251101 320.  639.    330.  877.    340.  1056.
20251102 350.  1200.   360.  1315.   370.  1438.
20251103 380.  1594.   390.  1729.   400.  1845.
20251104 410.  1944.   420.  2024.   430.  2143.
20251105 440.  2260.   450.  2364.   460.  2455.
*
*=================================================================$
*   table no. 521 - htc from outside of 24-in. horizontal pipe
*       assumes pool temperature of 311.15 K
*-----------------------------------------------------------------*
20252100 htc-temp
20252101 320.  630.    330.  866.    340.  1044.
```

```
20252102 350.  1186.   360.  1301.   370.  1423.
20252103 380.  1579.   390.  1713.   400.  1829.
20252104 410.  1926.   420.  2006.   430.  2125.
20252105 440.  2242.   450.  2345.   460.  2435.
*
*==================================================================$
*   table no. 531 - htc from outside of 8-in. horizontal pipe
*        assumes pool temperature of 311.15 K
*----------------------------------------------------------------*
20253100 htc-temp
20253101 320.  652.    330.  893.    340.  1073.
20253102 350.  1218.   360.  1334.   370.  1458.
20253103 380.  1616.   390.  1752.   400.  1868.
20253104 410.  1967.   420.  2048.   430.  2168.
20253105 440.  2286.   450.  2390.   460.  2482.
*
*==================================================================$
*   table no. 581 - htc from vertical piping - independent of length
*      assumes pool temperature of 311.15 K.  McAdams 0.13*Ra**1/3
*----------------------------------------------------------------*
20258100 htc-temp
20258101 320.  613.    330.  855.    340.  1042.
20258102 350.  1197.   360.  1327.   370.  1467.
20258103 380.  1639.   390.  1793.   400.  1929.
20258104 410.  2049.   420.  2153.   430.  2295.
20258105 440.  2435.   450.  2562.   460.  2677.
*
*==================================================================$
*   table no. 591 - htc from outside of 43.75-in. horizontal EHX shell
*        assumes pool temperature of 311.15 K
*==================================================================$
*
20259100 htc-temp
20259101 320.  622.    330.  856.    340.  1033.
20259102 350.  1175.   360.  1289.   370.  1411.
20259103 380.  1566.   390.  1700.   400.  1815.
20259104 410.  1912.   420.  1992.   430.  2110.
20259105 440.  2226.   450.  2329.   460.  2419.
*
*==================================================================$
*   table no. 599 - htc from outside of 83-in. horizontal HX shell
*        assumes pool temperature of 311.15 K
*----------------------------------------------------------------*
20259900 htc-temp
20259901 320.  615.    330.  849.    340.  1025.
20259902 350.  1167.   360.  1280.   370.  1402.
20259903 380.  1556.   390.  1689.   400.  1804.
20259904 410.  1901.   420.  1980.   430.  2098.
20259905 440.  2214.   450.  2316.   460.  2407.
*
$==================================================================$
$ table 606 - normalized fission power as a funtion of
$          time after scram
*----------------------------------------------------------------$
*             table no. 606 - norm fis power
*----------------------------------------------------------------*
*table    table type    trip no. factor1 factor2
20260600   reac-t        510    1.0    1.0
*
*table
* time  power
20260601  -1.       1.0000000
+       0.        1.0000000
+       0.0010000  1.0000000
+       0.0020000  1.0000000
+       0.0030000  1.0000000
+       0.0040000  1.0000000
+       0.0050000  1.0000000
+       0.0060000  1.0000000
+       0.0070000  1.0000000
+       0.0080000  1.0000000
+       0.0090000  1.0000000
+       0.0100000  1.0000000
+       0.0110000  1.0000000
+       0.0120000  1.0000000
+       0.0130000  1.0000000
+       0.0140000  1.0000000
+       0.0150000  1.0000000
+       0.0160000  1.0000000
+       0.0170000  1.0000000
+       0.0180000  1.0000000
+       0.0190000  1.0000000
+       0.0200000  1.0000000
+       0.0300000  1.0000000
+       0.0400000  0.9952940
+       0.0500000  0.9706620
+       0.0600000  0.9135980
+       0.0700000  0.8185900
+       0.0800000  0.6913340
+       0.0900000  0.5482860
+       0.1000000  0.4104350
+       0.1100000  0.2948530
+       0.1200000  0.2085720
+       0.1300000  0.1502310
+       0.1400000  0.1155010
+       0.1500000  0.0962423
+       0.1600000  0.0845212
+       0.1700000  0.0766344
+       0.1800000  0.0715573
+       0.1900000  0.0673201
+       0.2000000  0.0634865
+       0.3000000  0.0389523
+       0.4000000  0.0206108
+       0.5000000  0.0200444
+       0.6000000  0.0195264
+       0.7000000  0.0190503
+       0.8000000  0.0187457
+       0.9000000  0.0181940
+       1.0000000  0.0178052
+       1.1000000  0.0174368
+       1.2000000  0.0170881
+       1.3000000  0.0167569
+       1.4000000  0.0164414
+       1.5000000  0.0161401
+       1.6000000  0.0158517
+       1.7000000  0.0155752
+       1.8000000  0.0153096
+       1.9000000  0.0150541
+       2.0000000  0.0148080
+       3.0000000  0.0127552
+       4.0000000  0.0112157
+       5.0000000  0.0100163
+       6.0000000  0.0090598
+       7.0000000  0.0082837
+       8.0000000  0.0076467
+       9.0000000  0.0071162
+       10.000000  0.0066687
+       11.000000  0.0062861
+       12.000000  0.0059539
+       13.000000  0.0056637
+       14.000000  0.0054083
+       15.000000  0.0051792
+       16.000000  0.0049729
+       17.000000  0.0047840
+       18.000000  0.0046092
+       19.000000  0.0044484
+       20.000000  0.0042995
+       30.000000  0.0032245
```

```
+        40.000000  0.0025527
+        50.000000  0.0020821
+        60.000000  0.0017350
+        70.000000  0.0014720
+        80.000000  0.0012695
+        90.000000  0.0011122
+        100.00000  9.890e-04
+        110.00000  8.918e-04
+        120.00000  8.146e-04
+        130.00000  7.529e-04
+        140.00000  7.031e-04
+        150.00000  6.628e-04
+        160.00000  6.299e-04
+        170.00000  6.028e-04
+        180.00000  5.804e-04
+        190.00000  5.618e-04
+        200.00000  5.463e-04
$==================================================================$
$ table 607 - fission product decay power as a function of
$         time after scram
*-------------------------------------------------------------$
*            table no. 607 - norm fpd power
*-------------------------------------------------------------*
* table      type        trip  factor1  factor2
20260700     reac-t       510   1.0      17.378
*
*table       time         power
20260701      -1.          0.0575440
+          0.          0.0575440
+          0.0010000     0.0575440
+          0.0020000     0.0575440
+          0.0030000     0.0575440
+          0.0040000     0.0575440
+          0.0050000     0.0575440
+          0.0060000     0.0575440
+          0.0070000     0.0575440
+          0.0080000     0.0575440
+          0.0090000     0.0575440
+          0.0100000     0.0575440
+          0.0110000     0.0575440
+          0.0120000     0.0575440
+          0.0130000     0.0575440
+          0.0140000     0.0575440
+          0.0150000     0.0575440
+          0.0160000     0.0575440
+          0.0170000     0.0575440
+          0.0180000     0.0575440
+          0.0190000     0.0575440
+          0.0200000     0.0575440
+          0.0300000     0.0575440
+          0.0400000     0.0575440
+          0.0500000 0.0575440
+          0.0600000 0.0575440
+          0.0700000 0.0575440
+          0.0800000 0.0575440
+          0.0900000 0.0575440
+          0.1000000 0.0575440
+          0.1100000 0.0575440
+          0.1200000 0.0575440
+          0.1300000 0.0575440
+          0.1400000 0.0575440
+          0.1500000 0.0575440
+          0.1600000 0.0575440
+          0.1700000 0.0575440
+          0.1800000 0.0575440
+          0.1900000 0.0575440
+          0.2000000 0.0575440
+          0.3000000 0.0575440
+          0.4000000 0.0575440
+          0.5000000 0.0575440
+          0.6000000 0.0575440
+          0.7000000 0.0575440
+          0.8000000 0.0575440
+          0.9000000 0.0575440
+          1.0000000 0.0575440
+          1.1000000 0.0575440
+          1.2000000 0.0571496
+          1.3000000 0.0567496
+          1.4000000 0.0563844
+          1.5000000 0.0560485
+          1.6000000 0.0557379
+          1.7000000 0.0554489
+          1.8000000 0.0551790
+          1.9000000 0.0549257
+          2.0000000 0.0546874
+          3.0000000 0.0528604
+          4.0000000 0.0516186
+          5.0000000 0.0506824
+          6.0000000 0.0499335
+          7.0000000 0.0493110
+          8.0000000 0.0487792
+          9.0000000 0.0483157
+          10.000000 0.0479055
+          11.000000 0.0471744
+          12.000000 0.0464751
+          13.000000 0.0458414
+          14.000000 0.0452628
+          15.000000 0.0447310
+          16.000000 0.0442395
+          17.000000 0.0437828
+          18.000000 0.0433568
+          19.000000 0.0429577
+          20.000000 0.0425827
+          30.000000 0.0397339
+          40.000000 0.0378315
+          50.000000 0.0364198
+          60.000000 0.0353061
+          70.000000 0.0343914
+          80.000000 0.0336184
+          90.000000 0.0329510
+          100.00000 0.0323654
+          110.00000 0.0315756
+          120.00000 0.0308686
+          130.00000 0.0302323
+          140.00000 0.0296548
+          150.00000 0.0291272
+          160.00000 0.0286422
+          170.00000 0.0281940
+          180.00000 0.0277778
+          190.00000 0.0273898
+          200.00000 0.0270268
$==================================================================$
$ table 608 - Al-28 decay power as a function of
$         time after scram
*-------------------------------------------------------------$
*            table no. 608 - al decay power
*-------------------------------------------------------------*
* table      .type       trip  factor1  factor2
20260800     reac-t       510   1.0      1.0
*
*table       time        power
20260801      -1.        1.0
+          0.     1.0
+          0.0010000 0.9999948
+          0.0100000 0.9999487
+          0.1000000 0.9994866
+          1.0000000 0.9948787
+          2.0000000 0.9897835
```

```
+        3.0000000 0.9847148
+        4.0000000 0.9796718
+        5.0000000 0.9746546
+        6.0000000 0.9696631
+        7.0000000 0.9646972
+        8.0000000 0.9597568
+        9.0000000 0.9548416
+        10.000000 0.9499516
+        11.000000 0.9450866
+        12.000000 0.9402466
+        13.000000 0.9354314
+        14.000000 0.9306407
+        15.000000 0.9258747
+        16.000000 0.9211331
+        17.000000 0.9164157
+        18.000000 0.9117225
+        19.000000 0.9070533
+        20.000000 0.9024081
+        30.000000 0.8572440
+        40.000000 0.8143403
+        50.000000 0.7735839
+        60.000000 0.7348672
+        70.000000 0.6980883
+        80.000000 0.6631501
+        90.000000 0.6299605
+        100.00000 0.5984320
+        110.00000 0.5684815
+        120.00000 0.5400299
+        130.00000 0.5130022
+        140.00000 0.4873273
+        150.00000 0.4629373
+        160.00000 0.4397681
+        170.00000 0.4177584
+        180.00000 0.3968502
+        190.00000 0.3769885
+        200.00000 0.3581209
*
*=====================================================================$
*        table no. 820 - sb pzr speed
*-------------------------------------------------------------*
*table    table type  trip no.  factor 1  factor 2
20282000    reac-t     550       1.        1.
*
*table            time          reactivity
20282001           -1.            0.
20282002           0.             0.
20282003           5.             214.7884
20282004           1.e6            214.7884
*
$=====================================================================$
$        table no. 855 - ldvalve
*-------------------------------------------------------------*
*table    table type  trip no.  factor 1  factor 2
*20285500    reac-t     550       1.        1.
*
*table            time          reactivity
*20285501          -1.            1.
*20285502           0.            1.
*20285503           1.            0.
*20285504           1.e6           1.e6
*
*=====================================================================*
*    table 956 - scram rod reactivity as function of time after trip
*-------------------------------------------------------------*
*table    table type  trip no.  factor 1  factor 2
20295600    reac-t     510       1.        1.
*
*table            time          reactivity
20295601           -1.            0.
20295602           0.             0.
20295603           0.005          0.2931
20295604           0.01           0.5802
20295605           0.015          0.8555
20295606           0.02           1.1133
20295607           0.025          1.3485
20295608           0.03           1.5561
20295609           0.035          1.7321
20295610           0.04           1.8727
20295611           0.045          1.9752
20295612           0.0491         2.0292
20295613           0.06           2.1360
20295614           1.0            11.3480
*=====================================================================*
* table 970 - control rod reactivity as function of normalized rod
*         position (biased to zero at initial position)
*-------------------------------------------------------------*
*table    table type  trip no.  factor 1  factor 2
20297000      reac-t
*
*table            time          reactivity
20297001           0.             3.93
20297002           0.1218         3.50
20297003           0.2195         2.33
20297004           0.2790         0.
20297005           0.4391         -6.27
20297006           0.6098         -18.18
20297007           0.7805         -28.89
20297008           1.             -32.78
*
*=====================================================================*
*                             *
*    C O N T R O L   V A R I A B L E   I N P U T          *
*                             *
*=====================================================================*
*
*
* Primary Coolant Pump Speed Control
*
20503900 mcptrip  tripunit  1.000000d+00  0.        1
20503901 635
20504000 mcpntrip tripunit  1.000000d+00  1.        1
20504001 -635
*
*==== loop 1 ===
*
20504100 frtrq-1 function  1.000000d+00  158.6526   0
20504101 cntrlvar,64,43
20504200 motrq-1 function  1.000000d+00  0.         0
20504201 cntrlvar,64,44
* water power = (flow)(pressure difference)
20504300 watpw-1 mult    1.0          1268699.    0
20504301 cntrlvar,62 pmphead,124
* water torque = (water power)/(pump speed)
20504400 watrq-1 div     1.0000000000  7244.24    0
20504401 cntrlvar,48 cntrlvar,43
* sum of torques divided by pump inertia (rate of speed change)
* scaling factor = inertia
*      Pump Inertia = 91.50 kg-m**2
20504500 torq-1  sum     1.092900d-02 -80.9063    0
20504501 0. -1.,cntrlvar,41 1.,cntrlvar,42 -1.,cntrlvar,44
* do not adjust speed unless pumps have been tripped
20504600 adj-1   mult    1.000000d+00  0.         0
20504601 cntrlvar,45 cntrlvar,39
* adjustment to pump speed
20504700 adjus-1 integral 1.000000d+00  0.        0
20504701 cntrlvar,46
* actual pu-1 pump speed after pump trip
20504800 actspd1 sum     1.000000d+00  175.132    0
```

```
20504801 0. 1.,cntrlvar,83 1.,cntrlvar,47
* velocity head
20504900 mcpvsq1 mult   0.5      27885.9    1
20504901 rhofj,124010000 velfj,124010000 velfj,124010000
* saturation pressure for volume 122-02
20505000 tmpidgc sum    1.000000d+00  45.2833    1
20505001 -273.15 1.,tempf,122030000
20505100 satprsi function  1.000000d+00  8964.54    1
20505101 cntrlvar,50,35
* available npsh for loop 1
20505200 npsh-pa  sum     1.000000d+00  1441890.   1
20505201 0. 1.,p,122030000  -1.,cntrlvar,51 1.,cntrlvar,49
*
* calculate NPSH required based on Jose letter dated 4/16/93
* NPSH = n^2 * (1e5 + 1.e8*n/(1500*n - w))
* where NPSH is required suction head in Pa
*      n is normalized pump speed
*      w is pump flow rate in kg/s
*
* divisor of second term for npsh required
20505500 divisor  sum    1.         742.244    1
20505501 0.0  1500.,cntrlvar,64 -1.,mflowj,124010000
* second term for npsh required
20505600 term2    div     1.e8      125172.1    1
20505601 cntrlvar,55 cntrlvar,64
* term in parenthesis for npsh required
20505700 parenth sum    1.0          225172.    1
20505701 1.e5 1.,cntrlvar,56
* normalized speed squared
20505800 velsqrd   mult    1.0   .863194     1
20505801 cntrlvar,64 cntrlvar,64
* NPSH required
20505900 npshreq   mult    1.0  194367.2     1
20505901 cntrlvar,58 cntrlvar,57
* ratio of available npsh to required npsh
20506000 npshral div     1.000000d+00  7.41838     1
20506001 cntrlvar,59 cntrlvar,52
*
* head degradation factor
20506100 degfac1  function  1.000000d+00  1.          1
20506101 cntrlvar,60,39
* volumetric flow rate
20506200 flow-1   div      1.0          .592974     1
20506201 rhofj,124010000 mflowj,124010000
* determine nondimensional homologous variables
20506300 v-1     mult     1.55521      .9222      1
20506301 cntrlvar,62
20506400 alpha-1 mult     5.305040d-03  .929082    1
20506401 cntrlvar,48
20506500 v/alp-1 div      1.000000d+00  .992593    1
20506501 cntrlvar,64 cntrlvar,63
20506600 alp/v-1 div      1.000000d+00  1.007462    1
20506601 cntrlvar,63 cntrlvar,64
20506700 hvn-1   function  1.000000d+00  1.          1
20506701 cntrlvar,66,41
20506800 v/a-tu1 tripunit  1.000000d+00  0.          1
20506801 536
20506900 a/v-tu1 tripunit  1.000000d+00  1.          1
20506901 -536
20507000 hvn-pu1 mult     1.000000d+00  0.          1
20507001 cntrlvar,67 cntrlvar,68 cntrlvar,61
20507100 alpsq-1 mult     1.000000d+00  30671.2    1
20507101 cntrlvar,61 cntrlvar,48 cntrlvar,48 cntrlvar,69
20507200 spdg1-1 powerr   1.000000d+00  175.132     1
20507201 cntrlvar,71,0.5
20507300 a/vdg-1 function  1.000000d+00  .425        1
20507301 cntrlvar,70,42
20507400 spdg2-1 mult     188.5       0.          1
20507401 cntrlvar,73 cntrlvar,63 cntrlvar,68

* degraded pump speed for pump 1
20507500 speed-1 sum      1.000000d+00  175.132     1
20507501 0. 1.,cntrlvar,72 1.,cntrlvar,74
* pump 1 speed after lag
20507600 speedg1 lag      1.000000d+00  175.1338    1
20507601 0.050 cntrlvar,75
*
* control mcp speed to reach new steady-state
*
20507700 tr-tu   tripunit  1.000000d+00  1.          1
20507701 -528
20507800 priflow  constant  2.50000d+01  2.50000d+01 0
20507900 flerror  sum      1.00000d+00  -.01846932  1
20507901 0. 1.,cntrlvar,78 -1.,velfj,537010200
20508000 flerr   mult     1.000000d+00  -.01846932  0
20508001 cntrlvar,77 cntrlvar,79
20508100 flo-pi  prop-int  1.00000d+00  175.1318    0
20508101 0.20 2.0 cntrlvar 80
20508200 flo-d   diffrend  1.00000d-06  1.92897-9   0
20508201 cntrlvar,80
20508300 mcp-vel sum      1.00000d+00  175.1318    1
20508301 0. 1.,cntrlvar,81 1.,cntrlvar,82
20508400 mult1 mult      1.000000d+00  175.1318    1
20508401 cntrlvar,83 cntrlvar,40
20508500 mult2 mult      1.000000d+00  0.          1
20508501 cntrlvar,76 cntrlvar,39
20508600 mcp1-vel sum     1.000000d+00  175.1318    1
20508601 0. 1.,cntrlvar,84 1.,cntrlvar,85
*===================================================================$
*
*==== loop 2 ===
*
20509100 frtrq-2 function  1.000000d+00  158.6526    0
20509101 cntrlvar,114,43
20509200 motrq-2 function  1.000000d+00  0.          0
20509201 cntrlvar,114,44
* water power = (flow)(pressure difference)
20509300 watpw-2 mult     1.0          1294024.    0
20509301 cntrlvar,112 pmphead,224
* water torque = (water power)/(pump speed)
20509400 watrq-2 div      1.0000000000  7388.86     0
20509401 cntrlvar,98 cntrlvar,93
* sum of torques divided by pump inertia (rate of speed change)
* scaling factor = inertia
*      Pump Inertia = 91.50 kg-m**2
20509500 torq-2  sum      1.092900d-02 -82.4867     0
20509501 0. -1.,cntrlvar,91 1.,cntrlvar,92 -1.,cntrlvar,94
* do not adjust speed unless pumps have been tripped
20509600 adj-2   mult     1.000000d+00  0.          0
20509601 cntrlvar,95 cntrlvar,39
* adjustment to pump speed
20509700 adjus-2 integral  1.000000d+00  0.          0
20509701 cntrlvar,96
* actual pu-1 pump speed after pump trip
20509800 actspd2 sum      1.000000d+00  175.1318    0
20509801 0. 1.,cntrlvar,83 1.,cntrlvar,97
* velocity head
20509900 mcpvsq2  mult    0.5       29806.4     1
20509901 rhofj,224010000 velfj,224010000 velfj,224010000
* saturation pressure for volume 222-03
20510000 tmpidgc sum      1.000000d+00  45.6292     1
20510001 -273.15 1.,tempf,222030000
20510100 satprsi function  1.000000d+00  9122.66     1
20510101 cntrlvar,100,35
* available npsh for loop 2
20510200 npsh-pa  sum     1.000000d+00  1435457.   1
20510201 0. 1.,p,222030000  -1.,cntrlvar,101 1.,cntrlvar,99
*
* calculate NPSH required based on Jose letter dated 4/16/93
```

```
* NPSH = n^2 * (1e5 + 1.e8*n/(1500*n - w))
* where NPSH is required suction head in Pa
*      n is normalized pump speed
*      w is pump flow rate in kg/s
*
* divisor of second term for npsh required
20510500 divisor sum  1.       720.233    1
20510501 0.0  1500.,cntrlvar,114 -1.,mflowj,224010000
* second term for npsh required
20510600 term2  div     1.e8     128997.3    1
20510601 cntrlvar,105 cntrlvar,114
* term in parenthesis for npsh required
20510700 parenth sum   1.0          228997.3    1
20510701 1.e5  1.,cntrlvar,106
* normalized speed squared
20510800 velsqrd  mult   1.0  .863193    1
20510801 cntrlvar,114 cntrlvar,114
* NPSH required
20510900 npshreq  mult   1.0  197669.    1
20510901 cntrlvar,108 cntrlvar,107
* ratio of available npsh to required npsh
20511000 npshra2 div      1.000000d+00  7.26193     1
20511001 cntrlvar,109 cntrlvar,102
*
* head degradation factor
20511100 degfac2  function  1.000000d+00  1.          1
20511101 cntrlvar,110,39
* volumetric flow rate
20511200 flow-2  div      1.0         .613097     1
20511201 rhofj,224010000 mflowj,224010000
* determine nondimensional homologous variables
20511300 v-2     mult      1.55521      .953494     1
20511301 cntrlvar,112
20511400 alpha-2 mult     5.305040d-03  .929081     1
20511401 cntrlvar,98
20511500 v/alp-2 div      1.000000d+00  1.026276    1
20511501 cntrlvar,114 cntrlvar,113
20511600 alp/v-2 div      1.000000d+00  .974396     1
20511601 cntrlvar,113 cntrlvar,114
20511700 hvn-2   function  1.000000d+00  .939234     1
20511701 cntrlvar,116,41
20511800 v/a-tu2 tripunit  1.000000d+00  1.          1
20511801 537
20511900 a/v-tu2 tripunit  1.000000d+00  0.          1
20511901 -537
20512000 hvn-pu2 mult      1.000000d+00  .939234     1
20512001 cntrlvar,117 cntrlvar,118 cntrlvar,111
20512100 alpsq-2 mult      1.000000d+00  0.          1
20512101 cntrlvar,111 cntrlvar,98 cntrlvar,98 cntrlvar,119
20512200 spdg1-2 powerr    1.000000d+00  0.          1
20512201 cntrlvar,121,0.5
20512300 a/vdg-2 function  1.000000d+00  .974396     1
20512301 cntrlvar,120,42
20512400 spdg2-2 mult      188.5        175.1318    1
20512401 cntrlvar,123 cntrlvar,113 cntrlvar,118
* degraded pump speed for pump 2
20512500 speed-2 sum       1.000000d+00  175.1318    1
20512501 0. 1.,cntrlvar,122 1.,cntrlvar,124
* pump 2 speed after lag
20512600 speedg2 lag       1.000000d+00  175.1337    1
20512601 0.050 cntrlvar,125
*
* control mcp speed to reach new steady-state
*
20513400 mult1 mult       1.000000d+00  175.1318    1
20513401 cntrlvar,83 cntrlvar,40
20513500 mult2 mult       1.000000d+00  0.          1
20513501 cntrlvar,126 cntrlvar,39
20513600 mcp2-vel sum     1.000000d+00  175.1318    1
20513601 0. 1.,cntrlvar,134 1.,cntrlvar,135
*==================================================================$
*==== loop 3 ===
*
20514100 frtrq-3 function  1.000000d+00  158.6526    0
20514101 cntrlvar,164,43
20514200 motrq-3 function  1.000000d+00  0.          0
20514201 cntrlvar,164,44
* water power = (flow)(pressure difference)
20514300 watpw-3 mult      1.0          1291735.    0
20514301 cntrlvar,162 pmphead,324
* water torque = (water power)/(pump speed)
20514400 watrq-3 div       1.0000000000  7375.78    0
20514401 cntrlvar,148 cntrlvar,143
* sum of torques divided by pump inertia (rate of speed change)
* scaling factor = inertia
*       Pump Inertia = 91.50 kg-m**2
20514500 torq-3  sum       1.092900d-02 -82.3438    0
20514501 0. -1.,cntrlvar,141 1.,cntrlvar,142 -1.,cntrlvar,144
* do not adjust speed unless pumps have been tripped
20514600 adj-3   mult      1.000000d+00  0.          0
20514601 cntrlvar,145 cntrlvar,39
* adjustment to pump speed
20514700 adjus-3 integral  1.000000d+00  0.          0
20514701 cntrlvar,146
* actual pu-1 pump speed after pump trip
20514800 actspd3 sum       1.000000d+00  175.1318    0
20514801 0. 1.,cntrlvar,83 1.,cntrlvar,147
* velocity head
20514900 mcpvsq3  mult     0.5          30045.9     1
20514901 rhofj,324010000 velfj,324010000 velfj,324010000
* saturation pressure for volume 322-03
20515000 tmpkdgc sum       1.000000d+00  45.6608     1
20515001 -273.15 1.,tempf,322030000
20515100 satprsi function  1.000000d+00  9137.12     1
20515101 cntrlvar,150,35
* available npsh for loop 3
20515200 npsh-pa  sum      1.000000d+00  1453142.    1
20515201 0. 1.,p,322030000 -1.,cntrlvar,151 1.,cntrlvar,149
*
* calculate NPSH required based on Jose letter dated 4/16/93
* NPSH = n^2 * (1e5 + 1.e8*n/(1500*n - w))
* where NPSH is required suction head in Pa
*      n is normalized pump speed
*      w is pump flow rate in kg/s
*
* divisor of second term for npsh required
20515500 divisor sum   1.         717.535    1
20515501 0.0  1500.,cntrlvar,164 -1.,mflowj,324010000
* second term for npsh required
20515600 term2   div      1.e8     129482.4    1
20515601 cntrlvar,155 cntrlvar,164
* term in parenthesis for npsh required
20515700 parenth sum   1.0          229482.4    1
20515701 1.e5  1.,cntrlvar,156
* normalized speed squared
20515800 velsqrd  mult   1.0  .863193    1
20515801 cntrlvar,164 cntrlvar,164
* NPSH required
20515900 npshreq  mult   1.0  198087.5    1
20515901 cntrlvar,158 cntrlvar,157
* ratio of available npsh to required npsh
20516000 npshra3 div      1.000000d+00  7.33586     1
20516001 cntrlvar,159 cntrlvar,152
*
* head degradation factor
20516100 degfac3  function  1.000000d+00  1.          1
20516101 cntrlvar,160,39
* volumetric flow rate
```

```
20516200 flow-3  div     1.0        .613097    1
20516201 rhofj,224010000 mflowj,224010000
* determine nondimensional homologous variables
20516300 v-3   mult    1.55521    .953494    1
20516301 cntrlvar,162
20516400 alpha-3 mult    5.305040d-03 .929081    1
20516401 cntrlvar,148
20516500 v/alp-3 div     1.000000d+00 1.026276    1
20516501 cntrlvar,164 cntrlvar,163
20516600 alp/v-3 div     1.000000d+00 .974396    1
20516601 cntrlvar,163 cntrlvar,164
20516700 hvn-2  function 1.000000d+00 .939234    1
20516701 cntrlvar,166,41
20516800 v/a-tu3 tripunit 1.000000d+00 1.        1
20516801 538
20516900 a/v-tu3 tripunit 1.000000d+00 0.        1
20516901 -538
20517000 hvn-pu3 mult    1.000000d+00 .939234    1
20517001 cntrlvar,167 cntrlvar,168 cntrlvar,161
20517100 alpsq-3 mult    1.000000d+00 0.        1
20517101 cntrlvar,161 cntrlvar,148 cntrlvar,148 cntrlvar,169
20517200 spdg1-3 powerr  1.000000d+00 0.        1
20517201 cntrlvar,171,0.5
20517300 a/vdg-3 function 1.000000d+00 .974396    1
20517301 cntrlvar,170,42
20517400 spdg2-3 mult    188.5      175.1318    1
20517401 cntrlvar,173 cntrlvar,163 cntrlvar,168
* degraded pump speed for pump 3
20517500 speed-3 sum     1.000000d+00 175.1318    1
20517501 0. 1.,cntrlvar,172 1.,cntrlvar,174
* pump 3 speed after lag
20517600 speedg3 lag     1.000000d+00 175.1337    1
20517601 0.050 cntrlvar,175
*
* control mcp speed to reach new steady-state
*
20518400 mult1 mult     1.000000d+00 175.1318    1
20518401 cntrlvar,83 cntrlvar,40
20518500 mult2 mult     1.000000d+00 0.        1
20518501 cntrlvar,176 cntrlvar,39
20518600 mcp3-vel sum    1.000000d+00 175.1318    1
20518601 0. 1.,cntrlvar,184 1.,cntrlvar,185
*
*=================================================================$
*
* specified speed coastdown for MCPs
*
*-----------------------------------------------------------------$
20519500 mcp1sp function 182.5778   182.5778  0 3   .00 182.5778
20519501 time 0 135
*
$=================================================================$
*
* These control variables are for purely cosmetic purposes (i.e. the
* solution is not dependend upon) to monitor the limits in the fuel.
*
** costa flow excursion predictions (W/m^2)
* - lower fuel hot channel - 95% uncertainty
20520000 sqrtvelf powerr  1.000000d+00 5.03789    0
20520001 velf 515010000 0.5
20520100 sattemp sum     1.0       500.447    1
20520101 0. 0.5,sattemp,515010000 0.5,sattemp,515020000
20520200 subcoolf sum    1.000000d+00 166.9222    0
20520201 0. 1.,cntrlvar,201 -1.,tempf,515010000
20520300 costaf  mult    7.812500d+04 65698132.  0
20520301 cntrlvar,200 cntrlvar,202
20520400 sqrtvelf powerr  1.000000d+00 5.05627    0
20520401 velf 515020000 0.5
20520500 sattemp sum     1.0       494.721    1
20520501 0. 0.5,sattemp,515020000 0.5,sattemp,515030000
20520600 subcoolf sum    1.000000d+00 147.572    0
20520601 0. 1.,cntrlvar,205 -1.,tempf,515020000
20520700 costaf  mult    7.812500d+04 58294068.  0
20520701 cntrlvar,204 cntrlvar,206
20520800 sqrtvelf powerr  1.000000d+00 5.07606    0
20520801 velf 515030000 0.5
20520900 sattemp sum     1.0       488.389    1
20520901 0. 0.5,sattemp,515030000 0.5,sattemp,515040000
20521000 subcoolf sum    1.000000d+00 128.8313    0
20521001 0. 1.,cntrlvar,209 -1.,tempf,515030000
20521100 costaf  mult    7.812500d+04 51090288.  0
20521101 cntrlvar,208 cntrlvar,210
20521200 sqrtvelf powerr  1.000000d+00 5.09637    0
20521201 velf 515040000 0.5
20521300 sattemp sum     1.0       481.294    1
20521301 0. 0.5,sattemp,515040000 0.5,sattemp,515050000
20521400 subcoolf sum    1.000000d+00 110.5089    0
20521401 0. 1.,cntrlvar,213 -1.,tempf,515040000
20521500 costaf  mult    7.812500d+04 43999572.  0
20521501 cntrlvar,212 cntrlvar,214
20521600 sqrtvelf powerr  1.000000d+00 5.11601    0
20521601 velf 515050000 0.5
20521700 sattemp sum     1.0       473.77     1
20521701 0. 1.5,sattemp,515050000 -0.5,sattemp,515040000
20521800 subcoolf sum    1.000000d+00 93.4404    0
20521801 0. 1.,cntrlvar 217    -1.,tempf,515050000
20521900 costaf  mult    7.812500d+04 3.7347+7    0
20521901 cntrlvar,216 cntrlvar,218
*
* - lower fuel hot channel - 99.9% uncertainty
20522000 sqrtvelf powerr  1.000000d+00 5.03955    0
20522001 velf 516010000 0.5
20522100 sattemp sum     1.0       500.45     1
20522101 0. 0.5,sattemp,516010000 0.5,sattemp,516020000
20522200 subcoolf sum    1.000000d+00 166.325    0
20522201 0. 1.,cntrlvar,221 -1.,tempf,516010000
20522300 costaf  mult    7.812500d+04 65484508.  0
20522301 cntrlvar,220 cntrlvar,222
20522400 sqrtvelf powerr  1.000000d+00 5.0588    0
20522401 velf 516020000 0.5
20522500 sattemp sum     1.0       494.727    1
20522501 0. 0.5,sattemp,516020000 0.5,sattemp,516030000
20522600 subcoolf sum    1.000000d+00 146.4247    0
20522601 0. 1.,cntrlvar,225 -1.,tempf,516020000
20522700 costaf  mult    7.812500d+04 57869836.  0
20522701 cntrlvar,224 cntrlvar,226
20522800 sqrtvelf powerr  1.000000d+00 5.07963    0
20522801 velf 516030000 0.5
20522900 sattemp sum     1.0       488.395    1
20522901 0. 0.5,sattemp,516030000 0.5,sattemp,516040000
20523000 subcoolf sum    1.000000d+00 127.1768    0
20523001 0. 1.,cntrlvar,229 -1.,tempf,516030000
20523100 costaf  mult    7.812500d+04 50469660.  0
20523101 cntrlvar,228 cntrlvar,230
20523200 sqrtvelf powerr  1.000000d+00 5.10107    0
20523201 velf 516040000 0.5
20523300 sattemp sum     1.0       481.295    1
20523301 0. 0.5,sattemp,516040000 0.5,sattemp,516050000
20523400 subcoolf sum    1.000000d+00 108.3906    0
20523401 0. 1.,cntrlvar,233 -1.,tempf,516040000
20523500 costaf  mult    7.812500d+04 4.3196+7    0
20523501 cntrlvar,232 cntrlvar,234
20523600 sqrtvelf powerr  1.000000d+00 5.12184    0
20523601 velf 516050000 0.5
20523700 sattemp sum     1.0       473.762    1
20523701 0. 1.5,sattemp,516050000 -0.5,sattemp,516040000
20523800 subcoolf sum    1.000000d+00 90.928    0
20523801 0. 1.,cntrlvar 237    -1.,tempf,516050000
```

```
20523900 costaf  mult    7.812500d+04 36384216.  0
20523901 cntrlvar,236 cntrlvar,238
*
* - upper fuel hot channel - 95% uncertainty
20524000 sqrtvelf powerr  1.000000d+00 5.02122   0
20524001 velf 545010000 0.5
20524100 sattemp  sum     1.0      499.896   1
20524101 0. 0.5,sattemp,545010000 0.5,sattemp,545020000
20524200 subcoolf sum     1.000000d+00 167.2667   0
20524201 0. 1.,cntrlvar,241 -1.,tempf,545010000
20524300 costaf  mult    7.812500d+04 65615780.  0
20524301 cntrlvar,240 cntrlvar,242
20524400 sqrtvelf powerr  1.000000d+00 5.0395    0
20524401 velf 545020000 0.5
20524500 sattemp  sum     1.0      494.208   1
20524501 0. 0.5,sattemp,545020000 0.5,sattemp,545030000
20524600 subcoolf sum     1.000000d+00 146.793    0
20524601 0. 1.,cntrlvar,245 -1.,tempf,545020000
20524700 costaf  mult    7.812500d+04 57794112.  0
20524701 cntrlvar,244 cntrlvar,246
20524800 sqrtvelf powerr  1.000000d+00 5.0611    0
20524801 velf 545030000 0.5
20524900 sattemp  sum     1.0      487.929   1
20524901 0. 0.5,sattemp,545030000 0.5,sattemp,545040000
20525000 subcoolf sum     1.000000d+00 126.838    0
20525001 0. 1.,cntrlvar,249 -1.,tempf,545030000
20525100 costaf  mult    7.812500d+04 50151540.  0
20525101 cntrlvar,248 cntrlvar,250
20525200 sqrtvelf powerr  1.000000d+00 5.08402   0
20525201 velf 545040000 0.5
20525300 sattemp  sum     1.0      480.893   1
20525301 0. 0.5,sattemp,545040000 0.5,sattemp,545050000
20525400 subcoolf sum     1.000000d+00 107.0479   0
20525401 0. 1.,cntrlvar,253 -1.,tempf,545040000
20525500 costaf  mult    7.812500d+04 42518256.  0
20525501 cntrlvar,252 cntrlvar,254
20525600 sqrtvelf powerr  1.000000d+00 5.10745   0
20525601 velf 545050000 0.5
20525700 sattemp  sum     1.0      473.431   1
20525701 0. 1.5,sattemp,545050000 -0.5,sattemp,545040000
20525800 subcoolf sum     1.000000d+00 88.0411    0
20525801 0. 1.,cntrlvar 257    -1.,tempf,545050000
20525900 costaf  mult    7.812500d+04 35130132.  0
20525901 cntrlvar,256 cntrlvar,258
*
* - upper fuel hot channel - 99.9% uncertainty
20526000 sqrtvelf powerr  1.000000d+00 5.02274   0
20526001 velf 546010000 0.5
20526100 sattemp  sum     1.0      499.9     1
20526101 0. 0.5,sattemp,546010000 0.5,sattemp,546020000
20526200 subcoolf sum     1.000000d+00 166.7146   0
20526201 0. 1.,cntrlvar,261 -1.,tempf,546010000
20526300 costaf  mult    7.812500d+04 6.5419+7   0
20526301 cntrlvar,260 cntrlvar,262
20526400 sqrtvelf powerr  1.000000d+00 5.04191   0
20526401 velf 546020000 0.5
20526500 sattemp  sum     1.0      494.216   1
20526501 0. 0.5,sattemp,546020000 0.5,sattemp,546030000
20526600 subcoolf sum     1.000000d+00 145.6434   0
20526601 0. 1.,cntrlvar,265 -1.,tempf,546020000
20526700 costaf  mult    7.812500d+04 57368772.  0
20526701 cntrlvar,264 cntrlvar,266
20526800 sqrtvelf powerr  1.000000d+00 5.06464   0
20526801 velf 546030000 0.5
20526900 sattemp  sum     1.0      487.938   1
20526901 0. 0.5,sattemp,546030000 0.5,sattemp,546040000
20527000 subcoolf sum     1.000000d+00 125.1292   0
20527001 0. 1.,cntrlvar,269 -1.,tempf,546030000
20527100 costaf  mult    7.812500d+04 49510520.  0
20527101 cntrlvar,268 cntrlvar,270
20527200 sqrtvelf powerr  1.000000d+00 5.08884   0
20527201 velf 546040000 0.5
20527300 sattemp  sum     1.0      480.895   1
20527301 0. 0.5,sattemp,546040000 0.5,sattemp,546050000
20527400 subcoolf sum     1.000000d+00 104.8123   0
20527401 0. 1.,cntrlvar,273 -1.,tempf,546040000
20527500 costaf  mult    7.812500d+04 41669816.  0
20527501 cntrlvar,272 cntrlvar,274
20527600 sqrtvelf powerr  1.000000d+00 5.11364   0
20527601 velf 546050000 0.5
20527700 sattemp  sum     1.0      473.424   1
20527701 0. 1.5,sattemp,546050000 -0.5,sattemp,546040000
20527800 subcoolf sum     1.000000d+00 85.3251    0
20527801 0. 1.,cntrlvar 277    -1.,tempf,546050000
20527900 costaf  mult    7.812500d+04 34087656.  0
20527901 cntrlvar,276 cntrlvar,278
*
* Wall Superheat at CHF hotspots
20528000 shlc95-1  sum    1.0      -69.2095   0
20528001 0. 1.0,httemp,515400101 -1.0,sattemp,515010000
20528100 shlc95-2  sum    1.0      -62.158    0
20528101 0. 1.0,httemp,515400201 -1.0,sattemp,515020000
20528200 shlc95-3  sum    1.0      -54.2956   0
20528201 0. 1.0,httemp,515400301 -1.0,sattemp,515030000
20528300 shlc95-4  sum    1.0      -44.5501   0
20528301 0. 1.0,httemp,515400401 -1.0,sattemp,515040000
20528400 shlc95-5  sum    1.0      -36.7401   0
20528401 0. 1.0,httemp,515400501 -1.0,sattemp,515050000
20528500 shlc99-1  sum    1.0      -46.6058   0
20528501 0. 1.0,httemp,516400101 -1.0,sattemp,516010000
20528600 shlc99-2  sum    1.0      -41.76005  0
20528601 0. 1.0,httemp,516400201 -1.0,sattemp,516020000
20528700 shlc99-3  sum    1.0      -35.7308   0
20528701 0. 1.0,httemp,516400301 -1.0,sattemp,516030000
20528800 shlc99-4  sum    1.0      -27.3032   0
20528801 0. 1.0,httemp,516400401 -1.0,sattemp,516040000
20528900 shlc99-5  sum    1.0      -21.10767  0
20528901 0. 1.0,httemp,516400501 -1.0,sattemp,516050000
20529000 shuc95-1  sum    1.0      -68.332    0
20529001 0. 1.0,httemp,545400101 -1.0,sattemp,545010000
20529100 shuc95-2  sum    1.0      -52.9821   0
20529101 0. 1.0,httemp,545400201 -1.0,sattemp,545020000
20529200 shuc95-3  sum    1.0      -45.3812   0
20529201 0. 1.0,httemp,545400301 -1.0,sattemp,545030000
20529300 shuc95-4  sum    1.0      -33.02814  0
20529301 0. 1.0,httemp,545400401 -1.0,sattemp,545040000
20529400 shuc95-5  sum    1.0      -21.9507   0
20529401 0. 1.0,httemp,545400501 -1.0,sattemp,545050000
20529500 shuc99-1  sum    1.0      -45.4886   0
20529501 0. 1.0,httemp,546400101 -1.0,sattemp,546010000
20529600 shuc99-2  sum    1.0      -30.7554   0
20529601 0. 1.0,httemp,546400201 -1.0,sattemp,546020000
20529700 shuc99-3  sum    1.0      -25.26415  0
20529701 0. 1.0,httemp,546400301 -1.0,sattemp,546030000
20529800 shuc99-4  sum    1.0      -13.91806  0
20529801 0. 1.0,httemp,546400401 -1.0,sattemp,546040000
20529900 shuc99-5  sum    1.0      -109.8019  0
20529901 0. 1.0,httemp,510100501 -1.0,sattemp,510050000
*
* Peclet numbers for hot channels
* Assume hydraulic diameters of 0.002498 for LC and 0.002494 for UC
* LC 95% probability
20530000 dh-g-cp  mult   0.002498      290388. 1
20530001 velf,515010000 rhof,515010000 csubpf,515010000
20530100 pelc95-1  div    1.0          465729. 1
20530101 thconf,515010000 cntrlvar,300
20530200 dh-g-cp  mult   0.002498      289177.6 1
20530201 velf,515020000 rhof,515020000 csubpf,515020000
```

```
20530300 pelc95-2 div    1.0       458999. 1
20530301 thconf,515020000 cntrlvar,302
20530400 dh-g-cp  mult   0.002498      288209. 1
20530401 velf,515030000 rhof,515030000 csubpf,515030000
20530500 pelc95-3 div    1.0       454674.5 1
20530501 thconf,515030000 cntrlvar,304
20530600 dh-g-cp  mult   0.002498      287549. 1
20530601 velf,515040000 rhof,515040000 csubpf,515040000
20530700 pelc95-4 div    1.0       452299. 1
20530701 thconf,515040000 cntrlvar,306
20530800 dh-g-cp  mult   0.002498      287275.7 1
20530801 velf,515050000 rhof,515050000 csubpf,515050000
20530900 pelc95-5 div    1.0       451567. 1
20530901 thconf,515050000 cntrlvar,308
* LC 99.9% probability
20531000 dh-g-cp  mult   0.002498      290439.6 1
20531001 velf,516010000 rhof,516010000 csubpf,516010000
20531100 pelc99-1 div    1.0       465559. 1
20531101 thconf,516010000 cntrlvar,310
20531200 dh-g-cp  mult   0.002498      289172.4 1
20531201 velf,516020000 rhof,516020000 csubpf,516020000
20531300 pelc99-2 div    1.0       458670. 1
20531301 thconf,516020000 cntrlvar,312
20531400 dh-g-cp  mult   0.002498      288178.5 1
20531401 velf,516030000 rhof,516030000 csubpf,516030000
20531500 pelc99-3 div    1.0       454359.5 1
20531501 thconf,516030000 cntrlvar,314
20531600 dh-g-cp  mult   0.002498      287525.5 1
20531601 velf,516040000 rhof,516040000 csubpf,516040000
20531700 pelc99-4 div    1.0       452130. 1
20531701 thconf,516040000 cntrlvar,316
20531800 dh-g-cp  mult   0.002498      287310. 1
20531801 velf,516050000 rhof,516050000 csubpf,516050000
20531900 pelc99-5 div    1.0       451664. 1
20531901 thconf,516050000 cntrlvar,318
* UC 95% probability
20532000 dh-g-cp  mult   0.002498      288674. 1
20532001 velf,545010000 rhof,545010000 csubpf,545010000
20532100 pelc95-1 div    1.0       463360.5 1
20532101 thconf,545010000 cntrlvar,320
20532200 dh-g-cp  mult   0.002498      287195.6 1
20532201 velf,545020000 rhof,545020000 csubpf,545020000
20532300 pelc95-2 div    1.0       455778. 1
20532301 thconf,545020000 cntrlvar,322
20532400 dh-g-cp  mult   0.002498      286112.4 1
20532401 velf,545030000 rhof,545030000 csubpf,545030000
20532500 pelc95-3 div    1.0       451121. 1
20532501 thconf,545030000 cntrlvar,324
20532600 dh-g-cp  mult   0.002498      285360. 1
20532601 velf,545040000 rhof,545040000 csubpf,545040000
20532700 pelc95-4 div    1.0       448679. 1
20532701 thconf,545040000 cntrlvar,326
20532800 dh-g-cp  mult   0.002498      285059.6 1
20532801 velf,545050000 rhof,545050000 csubpf,545050000
20532900 pelc95-5 div    1.0       448222. 1
20532901 thconf,545050000 cntrlvar,328
* UC 99.9% probability
20533000 dh-g-cp  mult   0.002498      288722. 1
20533001 velf,546010000 rhof,546010000 csubpf,546010000
20533100 pelc99-1 div    1.0       463200. 1
20533101 thconf,546010000 cntrlvar,330
20533200 dh-g-cp  mult   0.002498      287175. 1
20533201 velf,546020000 rhof,546020000 csubpf,546020000
20533300 pelc99-2 div    1.0       455429. 1
20533301 thconf,546020000 cntrlvar,332
20533400 dh-g-cp  mult   0.002498      286064. 1
20533401 velf,546030000 rhof,546030000 csubpf,546030000
20533500 pelc99-3 div    1.0       450794.5 1
20533501 thconf,546030000 cntrlvar,334
20533600 dh-g-cp  mult   0.002498      285321.6 1
20533601 velf,546040000 rhof,546040000 csubpf,546040000
20533700 pelc99-4 div    1.0       448537. 1
20533701 thconf,546040000 cntrlvar,336
20533800 dh-g-cp  mult   0.002498      285063. 1
20533801 velf,546050000 rhof,546050000 csubpf,546050000
20533900 pelc99-5 div    1.0       448384. 1
20533901 thconf,546050000 cntrlvar,338
*
* Prandtl numbers for hot channels
* LC 95%
20544400 visc-cp  mult   1.0       2.303466 1
20544401 viscf,515010000 csubpf,515010000
20544500 prand511 div    1.0       3.69433 1
20544501 thconf,515010000 cntrlvar,444
20544600 visc-cp  mult   1.0       1.882408 1
20544601 viscf,515020000 csubpf,515020000
20544700 prand512 div    1.0       2.987863 1
20544701 thconf,515020000 cntrlvar,446
20544800 visc-cp  mult   1.0       1.600136 1
20544801 viscf,515030000 csubpf,515030000
20544900 prand513 div    1.0       2.524353 1
20544901 thconf,515030000 cntrlvar,448
20545000 visc-cp  mult   1.0       1.402134 1
20545001 viscf,515040000 csubpf,515040000
20545100 prand514 div    1.0       2.20548 1
20545101 thconf,515040000 cntrlvar,450
20545200 visc-cp  mult   1.0       1.265612 1
20545201 viscf,515050000 csubpf,515050000
20545300 prand515 div    1.0       1.98941 1
20545301 thconf,515050000 cntrlvar,452
* LC 99.9%
20545400 visc-cp  mult   1.0       2.281734 1
20545401 viscf,516010000 csubpf,516010000
20545500 prand911 div    1.0       3.6575 1
20545501 thconf,516010000 cntrlvar,454
20545600 visc-cp  mult   1.0       1.852684 1
20545601 viscf,516020000 csubpf,516020000
20545700 prand912 div    1.0       2.93863 1
20545701 thconf,516020000 cntrlvar,456
20545800 visc-cp  mult   1.0       1.56783 1
20545801 viscf,516030000 csubpf,516030000
20545900 prand913 div    1.0       2.471935 1
20545901 thconf,516030000 cntrlvar,458
20546000 visc-cp  mult   1.0       1.36955 1
20546001 viscf,516040000 csubpf,516040000
20546100 prand914 div    1.0       2.1536 1
20546101 thconf,516040000 cntrlvar,460
20546200 visc-cp  mult   1.0       1.233793 1
20546201 viscf,516050000 csubpf,516050000
20546300 prand915 div    1.0       1.93958 1
20546301 thconf,516050000 cntrlvar,462
* UC 95%
20546400 visc-cp  mult   1.0       2.336593 1
20546401 viscf,545010000 csubpf,545010000
20546500 prand5u1 div    1.0       3.75055 1
20546501 thconf,545010000 cntrlvar,464
20546600 visc-cp  mult   1.0       1.87551 1
20546601 viscf,545020000 csubpf,545020000
20546700 prand5u2 div    1.0       2.97643 1
20546701 thconf,545020000 cntrlvar,466
20546800 visc-cp  mult   1.0       1.57028 1
20546801 viscf,545030000 csubpf,545030000
20546900 prand5u3 div    1.0       2.475904 1
20546901 thconf,545030000 cntrlvar,468
20547000 visc-cp  mult   1.0       1.35551 1
20547001 viscf,545040000 csubpf,545040000
20547100 prand5u4 div    1.0       2.1313 1
20547101 thconf,545040000 cntrlvar,470
```

```
20547200 visc-cp  mult   1.0          1.20277  1
20547201 viscf,545050000 csubpf,545050000
20547300 prand5u5  div    1.0          1.89121  1
20547301 thconf,545050000  cntrlvar,472
* UC 99.9%
20547400 visc-cp  mult   1.0          2.315973 1
20547401 viscf,546010000 csubpf,546010000
20547500 prand9u1  div    1.0          3.71554  1
20547501 thconf,546010000  cntrlvar,474
20547600 visc-cp  mult   1.0          1.84586  1
20547601 viscf,546020000 csubpf,546020000
20547700 prand9u2  div    1.0          2.92734  1
20547701 thconf,546020000  cntrlvar,476
20547800 visc-cp  mult   1.0          1.537962 1
20547801 viscf,546030000 csubpf,546030000
20547900 prand9u3  div    1.0          2.4236   1
20547901 thconf,546030000  cntrlvar,478
20548000 visc-cp  mult   1.0          1.323142 1
20548001 viscf,546040000 csubpf,546040000
20548100 prand9u4  div    1.0          2.080034 1
20548101 thconf,546040000  cntrlvar,480
20548200 visc-cp  mult   1.0          1.17138  1
20548201 viscf,546050000 csubpf,546050000
20548300 prand9u5  div    1.0          1.842497 1
20548301 thconf,546050000  cntrlvar,482
*
*==================================================================$
*
* control system to control primary coolant system temperature by
* adjusting the secondary flow
*-----------------------------------------------------------------$
*ctlvar   name   type   factor  init  f c   min   max
20558000 terror  sum     1.00000d+00 .03304085   1
20558001  318.75   -1.   tempf     500010000
*
*20558100 picntrl  prop-int -1.00000d+00  1774.07   0
*20558101 30. 3.0 cntrlvar 580
20558100 secflow  constant 1774.07
*
20558200 se-off tripunit  1.0000d+00  0.       0 3    .00  1.0000d+00
20558201  540
*
20558300 deltat   sum    1.00000d+00  40.     0 1 0.
20558301 -10.   1.,time,0
*
20558400 factor mult  0.1  0.  0 3 0.0 0.9677
20558401  cntrlvar,582 cntrlvar,583
*
20558500 se-dec sum   1.0  1.  0
20558501 1. -1.,cntrlvar,584
*
20558600 seflo1   mult    1.00000d+00  1774.07    0
20558601 cntrlvar,581  cntrlvar,585
*
*==================================================================$
*
* control pzr speed to reach new steady-state (587-591)
* these control variables should only be active when
* a new steady pressurizing flow rate is being sought
*-----------------------------------------------------------------$
*
20558700 pzrvel   constant  1.629971 3.465 0
20558800 flerror  sum      1.00000d+00  -.00117527  1
20558801 0. 1.,cntrlvar,587 -1.,velfj,825000000
20558900 flo-pi   prop-int  1.0  229.039  0
20558901 8.0 80. cntrlvar 588
20559000 flo-d    diffrend  1.00000d-06  -1.61498-10  0
20559001 cntrlvar,588
20559100 pzrvel sum    1.0  229.039  1
20559101 0. 1.,cntrlvar,589 1.,cntrlvar,590
$==================================================================$
*
$ the 600 to 700 series inputs the transient powers into the control
$ rods and the surrounding d2o.
*==================================================================*
$ flag for scram 0.0-no  1.0-yes
*ctlvar    name       type    factor   init  f c    min
20560000  "scram"    tripunit   1.0     0.    1 0
*
*ctlvar    trip no.
20560001    510
$==================================================================$
$complement flag for no scram 0.0-yes  1.0-no
*ctlvar    name       type    factor   init  f c    min
20560100 "noscram"   tripunit   1.0     1.    1 0
*
*ctlvar    trip no.
20560101    -510
$==================================================================$
* get current power into system
*ctlvar    name       type    factor   init  f c    min
20560200  "pwcntl"    sum      1.0    3.44001+8  1 0
*
*ctlvar        a0      coeff      variable name  parameter no.
20560201       0.0      1.0          rktpow         0
$==================================================================$
$ multiply current power by no-scram
$ should have no value after scram
*ctlvar    name       type    factor   init  f c    min
20560300  "pwr01"     mult     1.0    3.44001+8  1 0
*
*ctlvar  variable name  parameter no.    variable name  parameter no.
20560301   cntrlvar       601           cntrlvar        602
$==================================================================$
$ multiply current, saved power by scram
$ should have no value before scram
*ctlvar    name       type    factor   init  f c    min
20560400  "pwr02"     mult     1.0     0.       1 0
*
*ctlvar  variable name  parameter no.    variable name  parameter no.
20560401   cntrlvar       600           cntrlvar        605
$==================================================================$
$ add scram-weighted powers together.  before scram, should be true.
$ kinetic power; after scram should be the last saved power before
$ scram
*ctlvar    name       type    factor   init  f c    min
20560500  "savpow"    sum      1.0    3.44001+8  1 0
*
*ctlvar        a0      coeff      variable name  parameter no.
20560501       0.0      1.0         cntrlvar        603
20560502                1.0         cntrlvar        604
*
$ multiplies the no-scram flag by saved power and by the factor which
$ represents the total power by fission neutrons, fission gammas,
$ fission product gammas, and al-28 gamma & beta decay.  factor
$ includes axial peaking.  local heating will follow power until
$ scram, at which point it should go to zero because this heat
$ source is moved to another volume.
$==================================================================$
$ the next 15 controls multiple normalized power from a tabular
$ function of time by a scalar.  table 606 is the fission power
$ table; table 607 is the fission decay power table; table 608 is
$ al-28 decay table.
$ titles fspwxx refer to fission gammas and neutrons.  the factor
$ is the sum of those sources on level xx in the zr/al/hf composite
$ multiplied by a level factor and divided by 3.5e8 watts.
$ titles fsdkxx refer to fission decay gammas.  the factor
$ is the sum of those sources on level xx in the zr/al/hf composite
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$ multiplied by a level factor and divided by 3.5e8 watts.
$ titles aldkxx refer to aluminum beta and gamma decay.  the factor
$ is the sum of those sources on level xx in the zr/al/hf composite
$ multiplied by a level factor and divided by 3.5e8 watts.
$ radial distribution is applied via the heat structure cards.
$ summation and by the last saved power before scram.  the local
$ decay powers are thus scaled by the power at scram and weighted
$ by the scram flag (before scram = no value, after scram = value)
$=====================================================================$
$ as above, these 15 cards multiply the appropriate scalars by the
$ corresponding tables, in this case for the power in the d2o in the
$ central rod hole.
$=====================================================================$
$ the sums are multiplied the th saved power at scram and the scram
$ flag.  as above there is no value before scram.
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20561100 "al1ss"    mult  4.9028e-04  168656.8 1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20561101  cntrlvar      601          cntrlvar      605
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20561200 "hf1ss"    mult  2.3105e-03  794814. 1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20561201  cntrlvar      601          cntrlvar      605
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20561300 "d2o1ss"   mult  2.1391e-04  73585.2 1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20561301  cntrlvar      601          cntrlvar      605
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20561400 "alcomp"   mult  2.1689e-4   74610.4 1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20561401  cntrlvar      601          cntrlvar      605
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20561500 "hfcomp"   mult  6.6004e-4  227054.4 1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20561501  cntrlvar      601          cntrlvar      605
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20561600 "alhfss"   sum     1.0     301665. 1 0
*
*ctlvar       a0     coeff     variable name  parameter no.
20561601     0.0      1.0        cntrlvar       614
20561602              1.0        cntrlvar       615
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20562100 "alfsp"   function 4.8823e-4  4.8823-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20562101       time             0              606
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20562200 "alfsd"   function 3.4996e-5  3.4996-5 1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20562201       time             0              607
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20562300 "alal"    function 1.0733e-5  1.0733-5  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20562301       time             0              608
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20562400 "altot1"   sum     1.0     5.33959-4 1 0
*
*ctlvar       a0     coeff     variable name  parameter no.
20562401     0.0      1.0        cntrlvar       621
20562402              1.0        cntrlvar       622
20562403              1.0        cntrlvar       623
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20562500 "altot2"   mult    1.0     0.       1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20562501  cntrlvar      600          cntrlvar      605
20562502  cntrlvar      624
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20562600 "hffsp"   function 1.8708e-3  .0018708 1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20562601       time             0              606
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20562700 "hffsd"   function 3.9623e-4  3.9623-4 1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20562701       time             0              607
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20562800 "hfal"    function 4.3444e-5  4.3444-5  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20562801       time             0              608
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20562900 "hftot1"   sum     1.0     .002310474 1 0
*
*ctlvar       a0     coeff     variable name  parameter no.
20562901     0.0      1.0        cntrlvar       626
20562902              1.0        cntrlvar       627
20562903              1.0        cntrlvar       628
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20563000 "hftot2"   mult   -1.0    -0.       1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20563001  cntrlvar      600          cntrlvar      605
20563002  cntrlvar      629
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20563100 "sumfsp"  function 7.5041e-4  7.5041-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20563101       time             0              606
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20563200 "sumfsd"  function 1.2868e-4  1.2868-4 1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20563201       time             0              607
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
20563300 "sumal"   function 1.7159e-5  1.7159-5  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20563301       time             0              608
$=====================================================================$
*ctlvar    name      type   factor   init  f c   min   max
```

```
20563400 "sumtot1"   sum    1.0   8.96249-4 1 0
*
*ctlvar      a0    coeff    variable name  parameter no.
20563401     0.0    1.0       cntrlvar     631
20563402            1.0       cntrlvar     632
20563403            1.0       cntrlvar     633
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20563500 "sumtot2"   mult    1.0    0.    1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20563501   cntrlvar      600         cntrlvar      605
20563502   cntrlvar      634
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20563600 "d2ofsp"   function 2.1238e-4  2.1238-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20563601      time            0             606
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20563700 "d2ofsd"   function 7.6092e-6  7.6092-6 1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20563701      time            0             607
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20563800 "d2oal"   function 1.5251e-6  1.5251-6  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20563801      time            0             608
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20563900 "d2otot1"   sum    1.0   2.215143-4 1 0
*
*ctlvar      a0    coeff    variable name  parameter no.
20563901     0.0    1.0       cntrlvar     636
20563902            1.0       cntrlvar     637
20563903            1.0       cntrlvar     638
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20564000 "d2otot2"   mult    1.0    0.    1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20564001   cntrlvar      600         cntrlvar      605
20564002   cntrlvar      639
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20564100  "alhs"    sum      1.   168656.8 0 0
*
*ctlvar      a0    coeff    variable name  parameter no.
20564101     0.     1.        cntrlvar     625
20564102            1.        cntrlvar     611
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20564200  "alhfhs"   sum     1.   301665. 0 0
*
*ctlvar      a0    coeff    variable name  parameter no.
20564201     0.     1.        cntrlvar     635
20564202            1.        cntrlvar     616
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20564300  "hfhs"    sum      1.   794814. 0 0
*
*ctlvar      a0    coeff    variable name  parameter no.
20564301     0.     1.        cntrlvar     630
20564302            1.        cntrlvar     612
* these are the outer d2o cards.  they parallel the above cards
*ctlvar   name      type   factor  init  f c   min   max

20567100  "wohs1"    mult  1.2489e-3   429623.  1
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20567101   cntrlvar      601         cntrlvar      605
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20567200  "wohs2"    mult  1.2610e-3   433785.  1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20567201   cntrlvar      601         cntrlvar      605
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20567300  "wohs3"    mult  1.2670e-3   435849.  1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20567301   cntrlvar      601         cntrlvar      605
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20567400  "wohs4"    mult  1.2310e-3   423465.  1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20567401   cntrlvar      601         cntrlvar      605
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20567500  "wohs5"    mult  9.9681e-4   342903.6 1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20567501   cntrlvar      601         cntrlvar      605
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20567600 "fspwwo1"   function 9.6471e-4   9.6471-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20567601      time            0             606
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20567700 "fsdkwo1"   function 2.6619e-4   2.6619-4 1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20567701      time            0             607
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20567800 "aldkwo1"   function 1.8902e-5   1.8902-5  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20567801      time            0             608
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20567900 "fspwwo2"   function 9.7398e-4   9.7398-4 1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20567901      time            0             606
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20568000 "fsdkwo2"   function 2.6875e-4   2.6875-4 1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20568001      time            0             607
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20568100 "aldkwo2"   function 1.8232e-5   1.8232-5  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20568101      time            0             608
$==============================================================$
*ctlvar   name      type   factor  init  f c   min   max
20568200 "fspwwo3"   function 9.7866e-4   9.7866-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
```

```
20568201      time         0          606
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20568300 "fsdkwo3"  function 2.7003e-4  2.7003-4 1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20568301      time         0          607
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20568400 "akdkwo3"  function 1.8319e-5  1.8319-5  1   0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20568401      time         0          608
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20568500 "fspwwo4"  function 9.5081e-4  9.5081-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20568501      time         0          606
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20568600 "fsdkwo4"  function 2.6235e-4  2.6235-4 1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20568601      time         0          607
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20568700 "akdkwo4"  function 1.7798e-5  1.7798-5  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20568701      time         0          608
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20568800 "fspwwo5"  function 7.6993e-4  7.6993-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20568801      time         0          606
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20568900 "fsdkwo5"  function 2.1244e-4  2.1244-4 1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20568901      time         0          607
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20569000 "akdkwo5"  function 1.4412e-5  1.4412-5  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20569001      time         0          608
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20569100 "wosum01"    sum     1.0    .001249802 1 0
*
*ctlvar     a0     coeff     variable name  parameter no.
20569101    0.0     1.0         cntrlvar       676
20569102            1.0         cntrlvar       677
20569103            1.0         cntrlvar       678
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20569200 "wosum02"    sum     1.0    .001260962 1 0
*
*ctlvar     a0     coeff     variable name  parameter no.
20569201    0.0     1.0         cntrlvar       679
20569202            1.0         cntrlvar       680
20569203            1.0         cntrlvar       681
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20569300 "wosum03"    sum     1.0    .00126701 1 0
*
*ctlvar     a0     coeff     variable name  parameter no.
20569301    0.0     1.0         cntrlvar       682
20569302            1.0         cntrlvar       683
20569303            1.0         cntrlvar       684
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20569400 "wosum04"    sum     1.0    .001230958 1 0
*
*ctlvar     a0     coeff     variable name  parameter no.
20569401    0.0     1.0         cntrlvar       685
20569402            1.0         cntrlvar       686
20569403            1.0         cntrlvar       687
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20569500 "wosum05"    sum     1.0    9.96782-4 1 0
*
*ctlvar     a0     coeff     variable name  parameter no.
20569501    0.0     1.0         cntrlvar       688
20569502            1.0         cntrlvar       689
20569503            1.0         cntrlvar       690
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20569600 "powwo1"    mult     1.0    0.    1 0
*
*ctlvar variable name  parameter no.   variable name  parameter no.
20569601  cntrlvar       600          cntrlvar       605
20569602  cntrlvar       691
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20569700 "powwo2"    mult    '1.0    0.    1 0
*
*ctlvar variable name  parameter no.   variable name  parameter no.
20569701  cntrlvar       600          cntrlvar       605
20569702  cntrlvar       692
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20569800 "powwo3"    mult     1.0    0.    1 0
*
*ctlvar variable name  parameter no.   variable name  parameter no.
20569801  cntrlvar       600          cntrlvar       605
20569802  cntrlvar       693
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20569900 "powwo4"    mult     1.0    0.    1 0
*
*ctlvar variable name  parameter no.   variable name  parameter no.
20569901  cntrlvar       600          cntrlvar       605
20569902  cntrlvar       694
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20570000 "powwo5"    mult     1.0    0.    1 0
*
*ctlvar variable name  parameter no.   variable name  parameter no.
20570001  cntrlvar       600          cntrlvar       605
20570002  cntrlvar       695
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20570100 "cpbt1"     mult  5.3967e-4  185647.  1 0
*
*ctlvar variable name  parameter no.   variable name  parameter no.
20570101  cntrlvar       601          cntrlvar       605
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
20570200 "cpbt2"     mult  5.4486e-4  187432.3 1 0
*
*ctlvar variable name  parameter no.   variable name  parameter no.
20570201  cntrlvar       601          cntrlvar       605
$==================================================================$
*ctlvar   name      type     factor  init  f c   min   max
```

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20570300 "cpbt3"    mult 5.4745e-4  188323.3 1 0
*
*ctlvar variable name parameter no.   variable name parameter no.
20570301  cntrlvar     601        cntrlvar     605
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20570400 "cpbt4"    mult 5.3189e-4  182970.7 1 0
*
*ctlvar variable name parameter no.   variable name parameter no.
20570401  cntrlvar     601        cntrlvar     605
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20570500 "cpbt5"    mult 4.3070e-4  148161.2 1 0
*
*ctlvar variable name parameter no.   variable name parameter no.
20570501  cntrlvar     601        cntrlvar     605
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20570600 "fspwpt1"  function 3.1372e-4  3.1372-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20570601       time          0            606
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20570700 "fsdkpt1"  function 7.5233e-5  7.5233-5 1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20570701       time          0            607
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20570800 "aldkpt1"  function 7.5233e-5  7.5233-5  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20570801       time          0            608
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20570900 "fspwpt2"  function 3.1676e-4  3.1676-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20570901       time          0            606
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20571000 "fsdkpt2"  function 1.5219e-4  1.5219-4 1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20571001       time          0            607
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20571100 "aldkpt2"  function 7.5956e-5  7.5956-5  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20571101       time          0            608
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20571200 "fspwpt3"  function 3.1826e-4  3.1826-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20571201       time          0            606
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20571300 "fsdkpt3"  function 1.5291e-4  1.5291-4 1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20571301       time          0            607
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20571400 "aldkpt3"  function 7.6318e-5  7.6318-5  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20571401       time          0            608
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20571500 "fspwpt4"  function 3.0921e-4  3.0921-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20571501       time          0            606
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20571600 "fsdkpt4"  function 1.4856e-4  1.4856-4 1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20571601       time          0            607
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20571700 "aldkpt4"  function 7.4148e-5  7.4148-5  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20571701       time          0            608
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20571800 "fspwpt5"  function 2.5038e-4  2.5038-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20571801       time          0            606
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20571900 "fsdkpt5"  function 1.2030e-4  1.203-4 1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20571901       time          0            607
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20572000 "aldkpt5"  function 6.0042e-5  6.0042-5  1 0
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20572001       time          0            608
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20572100 "ptsum1"   sum     1.0     4.64186-4  1 0
*
*ctlvar      a0    coeff    variable name  parameter no.
20572101    0.0     1.0       cntrlvar       706
20572102            1.0       cntrlvar       707
20572103            1.0       cntrlvar       708
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20572200 "ptsum2"   sum     1.0     5.44906-4 1 0
*
*ctlvar      a0    coeff    variable name  parameter no.
20572201    0.0     1.0       cntrlvar       709
20572202            1.0       cntrlvar       710
20572203            1.0       cntrlvar       711
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20572300 "ptsum3"   sum     1.0     5.47488-4 1 0
*
*ctlvar      a0    coeff    variable name  parameter no.
20572301    0.0     1.0       cntrlvar       712
20572302            1.0       cntrlvar       713
20572303            1.0       cntrlvar       714
$==================================================================$
*ctlvar   name    type   factor  init  f c   min   max
20572400 "ptsum4"   sum     1.0     5.31918-4 1 0
*
*ctlvar      a0    coeff    variable name  parameter no.
20572401    0.0     1.0       cntrlvar       715
20572402            1.0       cntrlvar       716
20572403            1.0       cntrlvar       717
```

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$================================================================$
*ctlvar   name        type    factor  init f c   min  max
20572500  "ptsum5"    sum     1.0     4.30722-4 1 0
*
*ctlvar        a0     coeff     variable name  parameter no.
20572501       0.0    1.0       cntrlvar       718
20572502              1.0       cntrlvar       719
20572503              1.0       cntrlvar       720
$================================================================$
*ctlvar   name        type    factor  init f c   min  max
20572600  "ptpow1"    mult    1.0     0.     1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20572601  cntrlvar      600             cntrlvar       605
20572602  cntrlvar      721
$================================================================$
*ctlvar   name        type    factor  init f c   min  max
20572700  "ptpow2"    mult    1.0     0.     1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20572701  cntrlvar      600             cntrlvar       605
20572702  cntrlvar      722
$================================================================$
*ctlvar   name        type    factor  init f c   min  max
20572800  "ptpow3"    mult    1.0     0.     1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20572801  cntrlvar      600             cntrlvar       605
20572802  cntrlvar      723
$================================================================$
*ctlvar   name        type    factor  init f c   min  max
20572900  "ptpow4"    mult    1.0     0.     1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20572901  cntrlvar      600             cntrlvar       605
20572902  cntrlvar      724
$================================================================$
*ctlvar   name        type    factor  init f c   min  max
20573000  "ptpow5"    mult    1.0     0.     1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20573001  cntrlvar      600             cntrlvar       605
20573002  cntrlvar      725
$================================================================$
*ctlvar   name        type    factor  init f c   min  max
20573100  "pt1"       sum     1.0     185647. 1 0
*
*ctlvar        a0     coeff     variable name  parameter no.
20573101       0.0    1.0       cntrlvar       701
20573102              1.0       cntrlvar       726
$================================================================$
*ctlvar   name        type    factor  init f c   min  max
20573200  "pt2"       sum     1.0     187432.3 1 0
*
*ctlvar        a0     coeff     variable name  parameter no.
20573201       0.0    1.0       cntrlvar       702
20573202              1.0       cntrlvar       727
$================================================================$
*ctlvar   name        type    factor  init f c   min  max
20573300  "pt3"       sum     1.0     188323.3 1 0
*
*ctlvar        a0     coeff     variable name  parameter no.
20573301       0.0    1.0       cntrlvar       703
20573302              1.0       cntrlvar       728
$================================================================$
*ctlvar   name        type    factor  init f c   min  max
20573400  "pt4"       sum     1.0     182970.7 1 0
*
*ctlvar        a0     coeff     variable name  parameter no.
20573401       0.0    1.0       cntrlvar       704
20573402              1.0       cntrlvar       729
$================================================================$
*ctlvar   name        type    factor  init f c   min  max
20573500  "pt5"       sum     1.0     148161.2 1 0
*
*ctlvar        a0     coeff     variable name  parameter no.
20573501       0.0    1.0       cntrlvar       705
20573502              1.0       cntrlvar       730
$================================================================$
*ctlvar   name        type    factor      init f c   min  max
20574100  "cpbt6"     mult    5.3373e-4   183603.6 1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20574101  cntrlvar      601             cntrlvar       605
$================================================================$
*ctlvar   name        type    factor      init f c   min  max
20574200  "cpbt7"     mult    5.4248e-4   186613.6 1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20574201  cntrlvar      601             cntrlvar       605
$================================================================$
*ctlvar   name        type    factor      init f c   min  max
20574300  "cpbt8"     mult    5.7164e-4   196644.7 1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20574301  cntrlvar      601             cntrlvar       605
$================================================================$
*ctlvar   name        type    factor      init f c   min  max
20574400  "cpbt9"     mult    6.2123e-4   213703.7 1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20574401  cntrlvar      601             cntrlvar       605
$================================================================$
*ctlvar   name        type    factor      init f c   min  max
20574500  "cpbt0"     mult    6.4748e-4   222733.7 1 0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20574501  cntrlvar      601             cntrlvar       605
$================================================================$
*ctlvar   name        type      factor      init f c   min  max
20574600  "fspwpt6"   function  2.9139e-4   2.9139-4 1 0
*
*ctlvar   srch arg. name   srch arg. no.   table no.
20574601  time             0               606
$================================================================$
*ctlvar   name        type      factor      init f c   min  max
20574700  "fsdkpt6"   function  1.1863e-4   1.1863-4 1 0
*
*ctlvar   srch arg. name   srch arg. no.   table no.
20574701  time             0               607
$================================================================$
*ctlvar   name        type      factor      init f c   min  max
20574800  "akdkpt6"   function  1.2370e-4   1.237-4  1 0
*
*ctlvar   srch arg. name   srch arg. no.   table no.
20574801  time             0               608
$================================================================$
*ctlvar   name        type      factor      init f c   min  max
20574900  "fspwpt7"   function  2.9617e-4   2.9617-4 1 0
*
*ctlvar   srch arg. name   srch arg. no.   table no.
20574901  time             0               606
$================================================================$
*ctlvar   name        type      factor      init f c   min  max
20575000  "fsdkpt7"   function  1.2058e-4   1.2058-4 1 0
*
*ctlvar   srch arg. name   srch arg. no.   table no.
20575001  time             0               607
```

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$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20575100 "aldkpt8"  function 1.2573e-4  1.2573-4 1 0
*
*ctlvar   srch arg. name  srch arg. no.    table no.
20575101     time            0             608
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20575200 "fspwpt8"  function 3.1210e-4  3.121-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.    table no.
20575201     time            0             606
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20575300 "fsdkpt8"  function 1.2706e-4  1.2706-4 1 0
*
*ctlvar   srch arg. name  srch arg. no.    table no.
20575301     time            0             607
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20575400 "aldkpt8"  function 1.3249e-4  1.3249-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.    table no.
20575401     time            0             608
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20575500 "fspwpt9"  function 3.3917e-4  3.3917-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.    table no.
20575501     time            0             606
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20575600 "fsdkpt9"  function 1.3808e-4  1.3808-4 1 0
*
*ctlvar   srch arg. name  srch arg. no.    table no.
20575601     time            0             607
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20575700 "aldkpt9"  function 1.4398e-4  1.4398-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.    table no.
20575701     time            0             608
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20575800 "fspwpt0"  function 3.5350e-4  3.535-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.    table no.
20575801     time            0             606
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20575900 "fsdkpt0"  function 1.4392e-4  1.4392-4 1 0
*
*ctlvar   srch arg. name  srch arg. no.    table no.
20575901     time            0             607
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20576000 "aldkpt0"  function 1.5006e-4  1.5006-4  1 0
*
*ctlvar   srch arg. name  srch arg. no.    table no.
20576001     time            0             608
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20576100 "ptsum6"   sum    1.0    5.3372-4  1 0
*
*ctlvar     a0    coeff     variable name  parameter no.
20576101    0.0    1.0        cntrlvar      746
20576102           1.0        cntrlvar      747
20576103           1.0        cntrlvar      748
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20576200 "ptsum7"   sum    1.0    5.4248-4  1 0
*
*ctlvar     a0    coeff     variable name  parameter no.
20576201    0.0    1.0        cntrlvar      749
20576202           1.0        cntrlvar      750
20576203           1.0        cntrlvar      751
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20576300 "ptsum8"   sum    1.0    5.7165-4  1 0
*
*ctlvar     a0    coeff     variable name  parameter no.
20576301    0.0    1.0        cntrlvar      752
20576302           1.0        cntrlvar      753
20576303           1.0        cntrlvar      754
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20576400 "ptsum9"   sum    1.0    6.2123-4  1 0
*
*ctlvar     a0    coeff     variable name  parameter no.
20576401    0.0    1.0        cntrlvar      755
20576402           1.0        cntrlvar      756
20576403           1.0        cntrlvar      757
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20576500 "ptsum0"   sum    1.0    6.4748-4  1 0
*
*ctlvar     a0    coeff     variable name  parameter no.
20576501    0.0    1.0        cntrlvar      758
20576502           1.0        cntrlvar      759
20576503           1.0        cntrlvar      760
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20576600 "ptpow6"   mult   1.0    0.   1 0
*
*ctlvar variable name  parameter no.   variable name  parameter no.
20576601  cntrlvar      600             cntrlvar      605
20576602  cntrlvar      761
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20576700 "ptpow7"   mult   1.0    0.   1 0
*
*ctlvar variable name  parameter no.   variable name  parameter no.
20576701  cntrlvar      600             cntrlvar      605
20576702  cntrlvar      762
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20576800 "ptpow8"   mult   1.0    0.   1 0
*
*ctlvar variable name  parameter no.   variable name  parameter no.
20576801  cntrlvar      600             cntrlvar      605
20576802  cntrlvar      763
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20576900 "ptpow9"   mult   1.0    0.   1 0
*
*ctlvar variable name  parameter no.   variable name  parameter no.
20576901  cntrlvar      600             cntrlvar      605
20576902  cntrlvar      764
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20577000 "ptpow0"   mult   1.0    0.   1 0
*
*ctlvar variable name  parameter no.   variable name  parameter no.
20577001  cntrlvar      600             cntrlvar      605
20577002  cntrlvar      765
$==========================================================$
*ctlvar   name   type   factor  init  f c   min   max
20577100 "pt6"      sum    1.0    183603.6 1 0
```

```
*
*ctlvar       a0    coeff     variable name  parameter no.
20577101      0.0    1.0         cntrlvar      741
20577102             1.0         cntrlvar      766
$=============================================================$
*ctlvar   name    type   factor   init  f c   min   max
20577200  "pt7"    sum    1.0     186613.6 1 0
*
*ctlvar       a0    coeff     variable name  parameter no.
20577201      0.0    1.0         cntrlvar      742
20577202             1.0         cntrlvar      767
$=============================================================$
*ctlvar   name    type   factor   init  f c   min   max
20577300  "pt8"    sum    1.0     196644.7 1 0
*
*ctlvar       a0    coeff     variable name  parameter no.
20577301      0.0    1.0         cntrlvar      743
20577302             1.0         cntrlvar      768
$=============================================================$
*ctlvar   name    type   factor   init  f c   min   max
20577400  "pt9"    sum    1.0     213703.7 1 0
*
*ctlvar       a0    coeff     variable name  parameter no.
20577401      0.0    1.0         cntrlvar      744
20577402             1.0         cntrlvar      769
$=============================================================$
*ctlvar   name    type   factor   init  f c   min   max
20577500  "pt0"    sum    1.0     222733.7 1 0
*
*ctlvar       a0    coeff     variable name  parameter no.
20577501      0.0    1.0         cntrlvar      745
20577502             1.0         cntrlvar      770
$=============================================================$
*
* logic to trip pressurizer pumps when make-up tank empties
*
*-------------------------------------------------------------$
*ctlvar   name    type   factor   init  f c   min   max
20580100 binary tripunit 1.0000d+00 0.    0 3   .00 1.0000d+00
*
*ctlvar    trip no.
20580101    550
*=============================================================$
*ctlvar   name    type   factor   init  f c   min   max
20580200 flow   sum   1.00000d+00 14.6141   0
*
*ctlvar       a0    coeff     variable name  parameter no.
20580201      0.     1.         mflowj      850010000
*=============================================================$
*ctlvar   name    type   factor   init  f c   min   max
20580300 flow   mult   1.00000d+00 0.      0
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20580301  cntrlvar       801            cntrlvar        802
*=============================================================$
*ctlvar   name    type   factor   init  f c   min   max
20580400 intflow  integral 1.00000d+00 0.     0
*
*ctlvar    integrand name   integrand no.
20580401      cntrlvar         803
*=============================================================$
*ctlvar   name    type   factor   init  f c   min   max
20580500 binary tripunit 1.0000d+00 0.    0 3   .00 1.0000d+00
*
*ctlvar    trip no.
20580501    551
*=============================================================$
*ctlvar   name    type   factor   init  f c   min   max
20580600 dnrpm mult   -1.0000d+00 0.     0 3  -1.00 1.0000d+00
```

```
*
*cntrlvar   var. name  parameter no.    var. name  parameter no.
20580601    cntrlvar     943            cntrlvar     805
*=============================================================$
*ctlvar   name    type   factor   init  f c   min   max
20580700 nrpm   sum    1.0000d+00 1.     0 3   .00 1.0000d+00
*
*ctlvar       a0    coeff     variable name  parameter no.
20580701      0.     1.         cntrlvar      807
20580702             1.         cntrlvar      806
*=============================================================$
*ctlvar   name    type   factor   init  f c   min   max
20581500 mpzrsp sum    239.4547  239.4547  0 3   .00 239.4547
*
*ctlvar       a0    coeff     variable name  parameter no.
20581501      0.     1.         cntrlvar      807
*
*=============================================================$
*
* logic to ramp standby pressurizer pump on
*
*ctlvar   name    type   factor   init  f c   min   max
20582000 sbpzrs function 1.0000d+00 0.    0 3   .00 239.4547
*
*ctlvar    srch arg. name   srch arg. no.     table no.
20582001       time              0              820
*=============================================================$
*ctlvar   name    type   factor   init  f c   min   max
20583000 sbpzrs mult    1.0000d+00 0.    0 3   .00 239.4547
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20583001  cntrlvar       820            cntrlvar        807
*=============================================================$
*
* pressure drop from cell center to junction
*
*  Delta P = 1/2 * Ajun/Avol * (Delta x)vol * FWALFvol * VELFjun
*
*=============================================================$
*ctlvar   name    type   factor   init  f c   min   max
20583100  dp-505   mult  0.381903  24945.97 1
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20583101  fwalf          505010000      velfj           507010200
*
*ctlvar   name    type   factor   init  f c   min   max
20583200  dp-520   mult  0.0123587  159.7177 1
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20583201  fwalf          520010000      velfj           522010100
*
*ctlvar   name    type   factor   init  f c   min   max
20583300  dp-535   mult  0.010047  121.5195 1
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20583301  fwalf          535010000      velfj           537010200
*
*ctlvar   name    type   factor   init  f c   min   max
20583400  dp-555   mult  0.191472  2837.923 1
*
*ctlvar  variable name  parameter no.   variable name  parameter no.
20583401  fwalf          555010000      velfj           556010100
*
*=============================================================$
*
* Delta P in average fuel channels including entrance and exit losses
*
*=============================================================$
*
```

```
*
*ctlvar    name     type   factor  init  f c   min   max
20583500   lcexitp  sum    1.0   1708709. 0
*
*ctlvar      a0    coeff     variable name  parameter no.
20583501     0.0    1.0        p          520010000
20583502            1.0        cntrlvar    832
*
*ctlvar    name     type   factor  init  f c   min   max
20583600   lcdeltap  sum    1.0   1514419. 0
*
*ctlvar      a0    coeff     variable name  parameter no.
20583601     0.0    1.0        p          505010000
20583602           -1.0        cntrlvar    831
20583603           -1.0        cntrlvar    835
*
*ctlvar    name     type   factor  init  f c   min   max
20583700   ucexitp  sum    1.0   1690509. 0
*
*ctlvar      a0    coeff     variable name  parameter no.
20583701     0.0    1.0        p          555010000
20583702            1.0        cntrlvar    834
*
*ctlvar    name     type   factor  init  f c   min   max
20583800   ucdeltap  sum    1.0   1512762. 0
*
*ctlvar      a0    coeff     variable name  parameter no.
20583801     0.0    1.0        p          535010000
20583802           -1.0        cntrlvar    833
20583803           -1.0        cntrlvar    837
*
*========================================================$
*
* first order lag applied to sensor location pressure
*
*========================================================*
*ctlvar    name     type   factor  init  f c   min   max
20583900 lagpres  lag    1.00000d+00  1585146.  0
*
*ctlvar      tau-1           variable name  parameter no.
20583901     0.03               p          645010000
*========================================================$
*
* control system to control primary coolant system pressure by
* adjusting the letdown flow area using:
*
* d=K*(P-Ps)
* dx/dt=(d-x)/tau
*
* where:
*  K = proportional constant = 5/MPa
*  tau = time constant = 1 s
*  P = measured sensor pressure
*  Ps = setpoint pressure = 3.2 MPa
*  d = demand (CV 840)
*  x = valve position
*    = -1 for fully closed,
*    = 1 for fully open,
*    = 0 at normal position
*
* NOTE: letdown valve orifice area = 0.00028355 m^2
*      (calibrated for half-open valve at x=0)
*
20584000 perror sum 5. .002546796  1 0
20584001 -1.690000  1.e-6 cntrlvar 837
*
* SF = A0, multiplier on CV860 = 1/A0
20584200 dadt sum .5 3.9108-4   1 0
20584201 1.0 -2. cntrlvar 860
20584202      1.   cntrlvar 840
*
20584400 dt sum 1. .0017    1 0
20584401  0.  1. time 0
20584402     -1. cntrlvar 845
*
20584500 oldtime sum 1. 50.    1 0
20584501  0.  1.  time 0
*
20584700 da mult 1. 6.64836-7   1 0
20584701 cntrlvar 842  cntrlvar 844
*
20586000 ldvarea sum 1. .500883  0 3 0. 1.
20586001 0.  1.  cntrlvar 860
20586002    1.  cntrlvar 847
$========================================================$
*
* heat gain across cores
*
20586100 pvin  div     1.0        3075.66     1
20586101 rhof,490010000  p,490010000
20586200 pvout  div     1.0        1577.124    1
20586201 rhof,565010000  p,565010000
20586300 dhspec  sum     1.0         162603.     1
20586301 0. 1.0,uf,565010000 -1.,uf,490010000
20586302 1.,cntrlvar,862 -1.,cntrlvar,861
20586400 qgain  mult    1.0         3.25346+8    1
20586401 mflowj,567010400 cntrlvar,863
*
*========================================================*
*
* control variables to develop total reactivity for kinetics model
*  (cntrlvar 972 is total reactivity driving the kinetics model)
*
*========================================================*
*
*ctlvar    name    type    factor   init  f c   min   max
20590000 c510rm  sum    7.69000d-02  418.936   1
*
*ctlvar      a0    coeff     variable name  parameter no.
20590001     0.      1.          rho       510010000
20590002             1.          rho       510020000
20590003             1.          rho       510030000
20590004             1.          rho       510040000
20590005             1.          rho       510050000
*========================================================*
*ctlvar    name    type    factor   init  f c   min   max
20590100 c515rm  sum    3.22000d-04  1.730553   1
*
*ctlvar      a0    coeff     variable name  parameter no.
20590101     0.      1.          rho       515010000
20590102             1.          rho       515020000
20590103             1.          rho       515030000
20590104             1.          rho       515040000
20590105             1.          rho       515050000
*========================================================*
*ctlvar    name    type    factor   init  f c   min   max
20590200 c540rm  sum    1.22000d-01  659.27    1
*
*ctlvar      a0    coeff     variable name  parameter no.
20590201     0.      1.          rho       540010000
20590202             1.          rho       540020000
20590203             1.          rho       540030000
20590204             1.          rho       540040000
20590205             1.          rho       540050000
*========================================================*
*ctlvar    name    type    factor   init  f c   min   max
20590300 c545rm  sum    2.94000d-04  1.577857   1
*
```

```
*ctlvar     a0     coeff     variable name  parameter no.
20590301    0.     1.        rho     545010000
20590302           1.        rho     545020000
20590303           1.        rho     545030000
20590304           1.        rho     545040000
20590305           1.        rho     545050000
*=================================================================*
*ctlvar   name    type   factor   init  f c   min   max
20590400 drho    sum     1.00000d+00 1.754422   1
*
*ctlvar     a0     coeff     variable name  parameter no.
20590401    -467.766   0.7600    cntrlvar    900
20590402               0.7600    cntrlvar    901
20590403               0.2267    cntrlvar    902
20590404               0.2267    cntrlvar    903
*=================================================================*
*ctlvar   name    type   factor   init  f c   min   max
20590500 cdenrx  sum     7.50000d-02 .0121447   1
*
*ctlvar     a0     coeff     variable name  parameter no.
20590501    0.     0.0922978     cntrlvar    904
*=================================================================*
*ctlvar   name    type   factor   init  f c   min   max
20590800 c510dtm sum     7.69000d-02 13.09115   1
*
*ctlvar     a0     coeff     variable name  parameter no.
20590801    0.     1.        htvat   5101001
20590802           -.5       htvat   5102001
20590803           -.5       htvat   5103001
20590804           1.        htvat   5101002
20590805           -.5       htvat   5102002
20590806           -.5       htvat   5103002
20590807           1.        htvat   5101003
20590808           -.5       htvat   5102003
20590809           -.5       htvat   5103003
20590810           1.        htvat   5101004
20590811           -.5       htvat   5102004
20590812           -.5       htvat   5103004
20590813           1.        htvat   5101005
20590814           -.5       htvat   5102005
20590815           -.5       htvat   5103005
*=================================================================*
*ctlvar   name    type   factor   init  f c   min   max
20590900 c515dtm sum     3.22000d-04 .1164084   1
*
*ctlvar     a0     coeff     variable name  parameter no.
20590901    0.     1.        htvat   5151001
20590902           -.5       htvat   5152001
20590903           -.5       htvat   5153001
20590904           1.        htvat   5151002
20590905           -.5       htvat   5152002
20590906           -.5       htvat   5153002
20590907           1.        htvat   5151003
20590908           -.5       htvat   5152003
20590909           -.5       htvat   5153003
20590910           1.        htvat   5151004
20590911           -.5       htvat   5152004
20590912           -.5       htvat   5153004
20590913           1.        htvat   5151005
20590914           -.5       htvat   5152005
20590915           -.5       htvat   5153005
*=================================================================*
*ctlvar   name    type   factor   init  f c   min   max
20591000 c540dtm sum     1.22000d-01 249.3547   1
*
*ctlvar     a0     coeff     variable name  parameter no.
20591001    0.     1.        htvat   5401001
20591002           -.1       htvat   5402001
20591004           1.        htvat   5401002
20591005           -.1       htvat   5402002
20591007           1.        htvat   5401003
20591008           -.1       htvat   5402003
20591010           1.        htvat   5401004
20591011           -.1       htvat   5402004
20591013           1.        htvat   5401005
20591014           -.1       htvat   5402005
*=================================================================*
*ctlvar   name    type   factor   init  f c   min   max
20591100 c545dtm sum     2.92000d-04 .644613   1
*
*ctlvar     a0     coeff     variable name  parameter no.
20591101    0.     1.        htvat   5451001
20591102           -.1       htvat   5452001
20591104           1.        htvat   5451002
20591105           -.1       htvat   5452002
20591107           1.        htvat   5451003
20591108           -.1       htvat   5452003
20591110           1.        htvat   5451004
20591111           -.1       htvat   5452004
20591113           1.        htvat   5451005
20591114           -.1       htvat   5452005
*=================================================================*
*ctlvar   name    type   factor   init  f c   min   max
20591200 dtfsp   sum     1.00000d+00 -22.4217   1
*
*ctlvar     a0     coeff     variable name  parameter no.
20591201    -89.1343   0.7600    cntrlvar    908
20591202               0.7600    cntrlvar    909
20591203               0.2267    cntrlvar    910
20591204               0.2267    cntrlvar    911
*=================================================================*
*ctlvar   name    type   factor   init  f c   min   max
20591300 expanrx sum     -6.19000d-04 .01387904   1
*
*ctlvar     a0     coeff     variable name  parameter no.
20591301    0.     1.        cntrlvar    912
*=================================================================*
*ctlvar   name    type   factor   init  f c   min   max
20591700 drho    sum     1.00000d+00 -.0588618   1
*
*ctlvar     a0     coeff     variable name  parameter no.
20591701    -1085.22   0.14586    rho     500010000
20591702               0.07207    rho     505010000
20591703               0.12983    rho     530010000
20591704               0.01712    rho     530020000
20591705               0.01712    rho     530030000
20591706               0.01453    rho     530040000
20591707               0.01453    rho     530050000
20591708               0.01453    rho     530060000
20591709               0.18451    rho     555010000
20591710               0.01550    rho     525010000
20591711               0.12177    rho     525020000
20591712               0.25263    rho     565010000
*=================================================================*
*ctlvar   name    type   factor   init  f c   min   max
20591800 axmodrx sum     3.33000d-02 -1.806175-4   1
*
*ctlvar     a0     coeff     variable name  parameter no.
20591801    0.     0.0921472     cntrlvar    917
*=================================================================*
*ctlvar   name    type   factor   init  f c   min   max
20592200 drho    sum     1.00000d+00 4.50818   1
*
*ctlvar     a0     coeff     variable name  parameter no.
20592201    -1088.98   0.34802    rho     520010000
20592202               0.65198    rho     535010000
*=================================================================*
*ctlvar   name    type   factor   init  f c   min   max
```

```
20592300 midplrx sum     3.33000d-02 .01378562  1
*
*ctlvar      a0    coeff      variable name  parameter no.
20592301      0.   0.0918291       cntrlvar       922
$===============================================================$
*ctlvar    name       type   factor   init  f c   min   max
20592700 "prelim"     sum     1.      500.527 1 0
*
*ctlvar      a0    coeff      variable name  parameter no.
20592701      0.   0.24883        rho      560010000
20592702           0.00669        rho      561010000
20592703           0.00669        rho      561020000
20592704           0.00669        rho      561030000
20592705           0.02418        rho      562010000
20592706           0.02418        rho      562020000
20592707           0.02418        rho      562030000
20592708           0.001936       rho      563010000
20592709           0.001936       rho      563020000
20592710           0.001936       rho      563030000
20592711           0.00888        rho      561040000
20592712           0.00888        rho      561050000
20592713           0.00438        rho      561060000
20592714           0.03206        rho      562040000
20592715           0.03206        rho      562050000
20592716           0.01581        rho      562060000
20592717           0.00257        rho      563040000
20592718           0.00257        rho      563050000
20592719           0.00127        rho      563060000
$===============================================================$
*ctlvar    name     type    factor       init  f c   min   max
20592800 drho     sum     1.00000d+00 .9188   1 0
*
*ctlvar      a0    coeff      variable name  parameter no.
20592801   -1095.32  1.0           cntrlvar       927
20592802           0.006274       rho      561070000
20592803           0.006274       rho      561080000
20592804           0.02266        rho      562070000
20592805           0.02266        rho      562080000
20592806           0.001815       rho      563070000
20592807           0.001815       rho      563080000
20592808           0.005407       rho      561090000
20592809           0.005407       rho      561100000
20592810           0.005407       rho      561110000
20592811           0.01953        rho      562090000
20592812           0.01953        rho      562100000
20592813           0.01953        rho      562110000
20592814           0.001564       rho      563090000
20592815           0.001564       rho      563100000
20592816           0.001564       rho      563110000
20592817           0.403272       rho      564010000
*===============================================================*
*ctlvar    name     type    factor       init  f c   min   max
20592900 centrx   sum     9.10000d-02 .00763345    1
*
*ctlvar      a0    coeff      variable name  parameter no.
20592901      0.   0.0912975       cntrlvar       928
*===============================================================*
*ctlvar    name     type    factor       init  f c   min   max
20593400 tankrx   sum     -1.74000d-02 .02925516   1
*
*ctlvar      a0    coeff      variable name  parameter no.
20593401     -301.747   1.         tempf     575010000
*===============================================================*
*ctlvar    name     type    factor       init  f c   min   max
* nominal power = 330,000,000 W and nominal flow = 2000 kg/s
20594000 powflor  div     6.06061d-06 1.041974   0
*
*ctlvar divisor name   divisor no.   dividend name  dividend no.
20594001   mflowj       650010000       rktpow         0
```

```
*===============================================================*
*ctlvar    name     type    factor       init  f c   min   max
20594300 timest   sum     1.00000d+00 .0017     0
*
*ctlvar      a0    coeff      variable name  parameter no.
20594301      0.     1.          time          0
20594302            -1.          cntrlvar      944
*===============================================================*
*ctlvar    name     type    factor       init  f c   min   max
20594400 oldtime  sum     1.00000d+00 50.       0
*
*ctlvar      a0    coeff      variable name  parameter no.
20594401      0.     1.          time          0
*===============================================================*
*ctlvar    name     type    factor       init  f c   min   max
20594500 noscram  tripunit  1.00000d+00 1.       1
*
*ctlvar    trip no.
20594501    -510
*===============================================================*
*ctlvar    name     type    factor       init  f c   min   max
20594600 scram    tripunit  1.00000d+00 0.       1
*
*ctlvar    trip no.
20594601    510
*===============================================================*
*ctlvar    name     type    factor       init  f c   min   max
20594900 powerr   sum     1.00000d+00 9.30424-4  0
*
*ctlvar      a0    coeff      variable name  parameter no.
20594901     -344.   1.e-6        rktpow         0
*===============================================================*
*ctlvar    name     type    factor       init  f c   min   max
20595000 lagerr   lag     1.00000d+00 4.13774-4  0
*
*ctlvar     tau-1               variable name  parameter no.
20595001     0.5                   cntrlvar       949
*===============================================================*
*ctlvar    name     type    factor       init  f c   min   max
20595400 shimsp sum     1.0000d+00 3.28123-8   0 3 -1.59  1.5900d-03
*
*ctlvar      a0    coeff      variable name  parameter no.
20595401      0.   7.93e-5       cntrlvar       950
*===============================================================*
*ctlvar    name     type    factor       init  f c   min
20595600 scramsp  function  6.51000d-01 0.       0 1  0.00000d+00
*
*ctlvar   srch arg. name  srch arg. no.     table no.
20595601       time            0             956
*===============================================================*
*ctlvar    name     type    factor       init  f c   min   max
20595900 shimsp   mult    1.00000d+00 3.28123-8   0
*
*ctlvar variable name  parameter no.   variable name  parameter no.
20595901   cntrlvar       954            cntrlvar       945
*===============================================================*
*ctlvar    name     type    factor       init  f c   min   max
20596000 scramsp  mult    1.00000d+00 0.       0
*
*ctlvar variable name  parameter no.   variable name  parameter no.
20596001   cntrlvar       956            cntrlvar       946
*===============================================================*
*ctlvar    name     type    factor       init  f c   min   max
20596100 rodspeed sum     1.00000d+00 3.28123-8   0
*
*ctlvar      a0    coeff      variable name  parameter no.
20596101      0.     1.          cntrlvar      959
20596102             1.          cntrlvar      960
*===============================================================*
```

APPENDIX B: FORTRAN USED TO LOAD RELAP5 INPUT FILE WITH FUEL SOURCE TERMS (power.f)

```
c
c This program modifies the ans RELAP5 input
c fuel heat structure source terms
c
      implicit double precision (a-h,p-z)
      character*80 arec
c
c  Variable Definition
c  avpdua - average power density in upper core average fuel ht str
c  avpdla - average power density in lower core average fuel ht str
c  avpduh - average power density in upper core hot fuel ht str
c  avpdlh - average power density in lower core hot fuel ht str
c  avpdus - avg pwr density in upper core hot stripe ht str (CHF,FE)
c  avpdls - avg pwr density in lower core hot stripe ht str (CHF,FE)
c  pducac - power density, upper core, average channel
c  pduchc - power density, upper core, hot channel
c  pduchs - power density, upper core, hot stripe (CHF,FE)
c  pdlcac - power density, lower core, average channel
c  pdlchc - power density, lower core, hot channel
c  pdlchs - power density, lower core, hot stripe (CHF,FE)
c  pf95hc - peaking factor, 95% uncertainty, hot channel
c  pf95hs - peaking factor, 95% uncertainty, hot stripe (CHF,FE)
c  pf99hc - peaking factor, 99.9% uncertainty, hot channel
c  pf99hs - peaking factor, 99.9% uncertainty, hot stripe (CHF,FE)
c
      real mavgl, mavgu, ml99, ml95, mu99, mu95
      dimension avpdus(2),avpdls(2)
      dimension pducac(5),pduchc(5),pduchs(5,2)
      dimension pdlcac(5),pdlchc(5),pdlchs(5,2)
      dimension pf95hc(5),pf95hs(5,2),pf99hc(5),pf99hs(5,2)
      open(unit=21,file='indta',status='old',form='formatted')
      open(unit=23,file='pd.dat',status='old',form='formatted')
      open(unit=24,file='pf.dat',status='old',form='formatted')
      open(unit=22,file='INDTA',status='unknown',form='formatted')
c-------------------------------------------------------------------c
c
c read in power densities and peaking factors
c
c
c power densities
c
      read(23,9998)arec
      read(23,9998)arec
      read(23,9998)arec
      read(23,9998)arec
      read(23,9998)arec
      do 5 i=1,5
    5  read(23,9992)iz,pducac(iz),pduchc(iz),pduchs(iz,1),pduchs(iz,2)
      read(23,9998)arec
      read(23,9998)arec
      read(23,9998)arec
      read(23,9998)arec
      read(23,9998)arec
      do 6 i=1,5
    6  read(23,9992)iz,pdlcac(iz),pdlchc(iz),pdlchs(iz,1),pdlchs(iz,2)
c
c peaking factors
c
      read(24,9998)arec
      read(24,9998)arec
      read(24,9998)arec
      read(24,9998)arec
      read(24,9998)arec
      do 9 i=1,5
    9  read(24,9992)iz,pf95hc(iz),pf95hs(iz,1),
     .                pf95hs(iz,2)
      read(24,9998)arec
      read(24,9998)arec
      read(24,9998)arec
      read(24,9998)arec
      read(24,9998)arec
      do 16 i=1,5
   16  read(24,9992)iz,pf99hc(iz),pf99hs(iz,1),
     .                pf99hs(iz,2)
c
c calculate average power densities
c
            avpdua = (pducac(1)+pducac(2)+pducac(3)+pducac(4)
     .               + pducac(5))/5.
            avpdla = (pdlcac(1)+pdlcac(2)+pdlcac(3)+pdlcac(4)
     .               + pdlcac(5))/5.
            avpduh = (pduchc(1)+pduchc(2)+pduchc(3)+pduchc(4)
     .               + pduchc(5))/5.
            avpdlh = (pdlchc(1)+pdlchc(2)+pdlchc(3)+pdlchc(4)
     .               + pdlchc(5))/5.
            avpdus(1) = (pduchs(1,1)+pduchs(2,1)+pduchs(3,1)
     .               + pduchs(4,1)+pduchs(5,1))/5.
            avpdus(2) = (pduchs(1,2)+pduchs(2,2)+pduchs(3,2)
     .               + pduchs(4,2)+pduchs(5,2))/5.
            avpdls(1) = (pdlchs(1,1)+pdlchs(2,1)+pdlchs(3,1)
     .               + pdlchs(4,1)+pdlchs(5,1))/5.
            avpdls(2) = (pdlchs(1,2)+pdlchs(2,2)+pdlchs(3,2)
     .               + pdlchs(4,2)+pdlchs(5,2))/5.
c-------------------------------------------------------------------c
c
c calculate the power fractions
c
c hot channels
      ml99 = avpdlh/avpdla*pf99hc(1)/252.
      ml95 = avpdlh/avpdla*pf95hc(1)/252.
      mu99 = avpduh/avpdua*pf99hc(1)/432.
      mu95 = avpduh/avpdua*pf95hc(1)/432.
c average channels
      mavgl = 1. - ml99 - ml95
      mavgu = 1. - mu99 - mu95
c-------------------------------------------------------------------c
c
c zero summations
c
      sum = 0.
      sumif = 0.
      sumof = 0.
      sumoth = 0.
      sumcll = 0.
      sumclu = 0.
      sumclo = 0.
      sumisp = 0.
      sumosp = 0.
      sumcpc = 0.
c-------------------------------------------------------------------c
c
c Read input data to modify heat structure sources
c
   10 read(21,9998,end=999)arec
c IF THIS IS A HEAT STRUCTURE CARD
      if(arec(1:1).eq.'1'.and.arec(8:8).ne.' '.and.
     .   arec(6:6).eq.'7') then
         iptr =  9
         iw1 = iread(iptr,arec)
         if(iw1.ne.0) then
           w2 = dread(iptr,arec)
           w3 = dread(iptr,arec)
           w4 = dread(iptr,arec)
           iw5 = iread(iptr,arec)
         endif
c IF THE SOURCE TERM IS 1000 (POINT KINETICS)
         if(iw1.eq.1000) then
           read(arec(8:8),'(i1)')n
c
c LOWER FUEL LOWER FUEL LOWER FUEL LOWER FUEL LOWER FUEL LOWER FUEL
c
c                Lower fuel heat structures
c
c LOWER FUEL LOWER FUEL LOWER FUEL LOWER FUEL LOWER FUEL LOWER FUEL
c
c IF THIS HEAT STRUCTURE IS IN THE LOWER FUEL
           if(arec(3:3).eq.'1') then
c average fuel heat structure
            if(arec(2:5).eq.'5101') then
             w2 = 0.05118*mavgl*pdlcac(n)/avpdla
             w3 = 2.56d-4*mavgl*pdlcac(n)/avpdla
             w4 = 0.0
             sumif = sumif+w2
             sumcll = sumcll+w3+w4
c inner side plate heat structure
            else if(arec(2:5).eq.'5102') then
             w2 = 4.38d-4*mavgl*pdlcac(n)/avpdla
             w3 = 1.174d-3*mavgl*pdlcac(n)/avpdla
             w4 = 0.0
             sumisp = sumisp+w2
             sumcll = sumcll+w3+w4
c outer side plate heat structure
```

```
          else if(arec(2:5).eq.'5103') then
           w2 = 3.92d-4*mavgl*pdlcac(n)/avpdla
           w3 = 0.0
           w4 = 7.28d-4*mavgl*pdlcac(n)/avpdla
           sumisp = sumisp+w2
           sumcll = sumcll+w3+w4
c 95% 95% 95% 95% 95% 95% 95% 95% 95% 95% 95% 95% 95% 95% 95% 95%
c hot channel fuel plate
          else if(arec(2:5).eq.'5151') then
           w2 = 0.05118*ml95*pdlchc(n)/avpdlh
           w3 = 2.56d-4*ml95*pdlchc(n)/avpdlh
           w4 = 0.0
           sumif = sumif+w2
           sumcll = sumcll+w3+w4
c hot channel inner side plate heat structure
          else if(arec(2:5).eq.'5152') then
           w2 = 4.38d-4*ml95*pdlchc(n)/avpdlh
           w3 = 1.174d-3*ml95*pdlchc(n)/avpdlh
           w4 = 0.0
           sumisp = sumisp+w2
           sumcll = sumcll+w3+w4
c hot channel outer side plate heat structure
          else if(arec(2:5).eq.'5153') then
           w2 = 3.92d-4*ml95*pdlchc(n)/avpdlh
           w3 = 0.0
           w4 = 7.28d-4*ml95*pdlchc(n)/avpdlh
           sumisp = sumisp+w2
           sumcll = sumcll+w3+w4
c CHF hot stripe heat structure
          else if(arec(2:5).eq.'5154') then
           a1 = ml95/5.*0.2559/100.
           a2 = (pdlchs(1,1)*pf95hs(1,1)+
     .           pdlchs(2,1)*pf95hs(2,1)+
     .           pdlchs(3,1)*pf95hs(3,1)+
     .           pdlchs(4,1)*pf95hs(4,1)+
     .           pdlchs(5,1)*pf95hs(5,1))/5.
           a3 = (pdlchc(1)*pf95hc(1)+
     .           pdlchc(2)*pf95hc(2)+
     .           pdlchc(3)*pf95hc(3)+
     .           pdlchc(4)*pf95hc(4)+
     .           pdlchc(5)*pf95hc(5))/5.
           w2 = pdlchs(n,1)/avpdls(1)*a1*a2/a3
           w3 = 0.
           w4 = 0.
           sumif = sumif+w2
           sumcll = sumcll+w3+w4
c FE hot stripe heat structure
          else if(arec(2:5).eq.'5155') then
           a1 = ml95/5.*.2559/100.
           a2 = (pdlchs(1,2)*pf95hs(1,2)+
     .           pdlchs(2,2)*pf95hs(2,2)+
     .           pdlchs(3,2)*pf95hs(3,2)+
     .           pdlchs(4,2)*pf95hs(4,2)+
     .           pdlchs(5,2)*pf95hs(5,2))/5.
           a3 = (pdlchc(1)*pf95hc(1)+
     .           pdlchc(2)*pf95hc(2)+
     .           pdlchc(3)*pf95hc(3)+
     .           pdlchc(4)*pf95hc(4)+
     .           pdlchc(5)*pf95hc(5))/5.
           w2 = pdlchs(n,2)/avpdls(2)*a1*a2/a3
           w3 = 0.
           w4 = 0.
           sumif = sumif+w2
           sumcll = sumcll+w3+w4
c 99.9% 99.9% 99.9% 99.9% 99.9% 99.9% 99.9% 99.9% 99.9% 99.9% 99.9%
c hot channel fuel plate
          else if(arec(2:5).eq.'5161') then
           w2 = 0.05118*ml99*pdlchc(n)/avpdlh
           w3 = 2.56d-4*ml99*pdlchc(n)/avpdlh
           w4 = 0.0
           sumif = sumif+w2
           sumcll = sumcll+w3+w4
c hot channel inner side plate heat structure
          else if(arec(2:5).eq.'5162') then
           w2 = 4.38d-4*ml99*pdlchc(n)/avpdlh
           w3 = 1.174d-3*ml99*pdlchc(n)/avpdlh
           w4 = 0.0
           sumisp = sumisp+w2
           sumcll = sumcll+w3+w4
c hot channel outer side plate heat structure
          else if(arec(2:5).eq.'5163') then
           w2 = 3.92d-4*ml99*pdlchc(n)/avpdlh
           w3 = 0.0
           w4 = 7.28d-4*ml99*pdlchc(n)/avpdlh
           sumisp = sumisp+w2
           sumcll = sumcll+w3+w4
c CHF hot stripe heat structure
          else if(arec(2:5).eq.'5164') then
           a1 = ml99/5.*.2559/100.
           a2 = (pdlchs(1,1)*pf99hs(1,1)+
     .           pdlchs(2,1)*pf99hs(2,1)+
     .           pdlchs(3,1)*pf99hs(3,1)+
     .           pdlchs(4,1)*pf99hs(4,1)+
     .           pdlchs(5,1)*pf99hs(5,1))/5.
           a3 = (pdlchc(1)*pf99hc(1)+
     .           pdlchc(2)*pf99hc(2)+
     .           pdlchc(3)*pf99hc(3)+
     .           pdlchc(4)*pf99hc(4)+
     .           pdlchc(5)*pf99hc(5))/5.
           w2 = pdlchs(n,1)/avpdls(1)*a1*a2/a3
           w3 = 0.
           w4 = 0.
           sumif = sumif+w2
           sumcll = sumcll+w3+w4
c FE hot stripe heat structure
          else if(arec(2:5).eq.'5165') then
           a1 = ml99/5.*0.2559/100.
           a2 = (pdlchs(1,2)*pf99hs(1,2)+
     .           pdlchs(2,2)*pf99hs(2,2)+
     .           pdlchs(3,2)*pf99hs(3,2)+
     .           pdlchs(4,2)*pf99hs(4,2)+
     .           pdlchs(5,2)*pf99hs(5,2))/5.
           a3 = (pdlchc(1)*pf99hc(1)+
     .           pdlchc(2)*pf99hc(2)+
     .           pdlchc(3)*pf99hc(3)+
     .           pdlchc(4)*pf99hc(4)+
     .           pdlchc(5)*pf99hc(5))/5.
           w2 = pdlchs(n,2)/avpdls(2)*a1*a2/a3
           w3 = 0.
           w4 = 0.
           sumif = sumif+w2
           sumcll = sumcll+w3+w4
          endif
c
          write(arec(9:80),9988)iw1,w2,w3,w4,iw5
          do 12 ii=1,80
           if(arec(ii:ii).eq.'D')arec(ii:ii)='d'
   12      if(arec(ii:ii).eq.'E')arec(ii:ii)='e'
*
c UPPER FUEL UPPER FUEL UPPER FUEL UPPER FUEL UPPER FUEL UPPER FUEL
c
c                  Upper fuel heat structures
c
c UPPER FUEL UPPER FUEL UPPER FUEL UPPER FUEL UPPER FUEL UPPER FUEL
*
c IF THIS HEAT STRUCTURE IS IN THE UPPER FUEL
          else if(arec(3:3).eq.'4') then
c average fuel heat structure
           if(arec(2:5).eq.'5401') then
            w2 = 0.1306*mavgu*pducac(n)/avpdua
            w3 = 3.52d-4*mavgu*pducac(n)/avpdua
            w4 = 0.0
            sumof = sumof+w2
            sumclu = sumclu+w3+w4
c inner side plate heat structure
           else if(arec(2:5).eq.'5402') then
            w2 = 2.74d-4*mavgu*pducac(n)/avpdua
            w3 = 6.080d-4*mavgu*pducac(n)/avpdua
            w4 = 0.0
            sumosp = sumosp+w2
            sumclu = sumclu+w3+w4
c outer side plate heat structure
           else if(arec(2:5).eq.'5403') then
            w2 = 3.256d-4*mavgu*pducac(n)/avpdua
            w3 = 0.0
            w4 = 6.00d-5*mavgu*pducac(n)/avpdua
            sumosp = sumosp+w2
            sumclu = sumclu+w3+w4
c 95% 95% 95% 95% 95% 95% 95% 95% 95% 95% 95% 95% 95% 95% 95% 95%
c hot channel fuel plate
           else if(arec(2:5).eq.'5451') then
            w2 = 0.1306*mu95*pduchc(n)/avpduh
```

```
         w3 = 3.52d-4*mu95*pduchc(n)/avpduh
         w4 = 0.0
         sumof = sumof+w2
         sumclu = sumclu+w3+w4
c hot channel inner side plate heat structure
        else if(arec(2:5).eq.'5452') then
         w2 = 2.74d-4*mu95*pduchc(n)/avpduh
         w3 = 6.080d-4*mu95*pduchc(n)/avpduh
         w4 = 0.0
         sumosp = sumosp+w2
         sumclu = sumclu+w3+w4
c hot channel outer side plate heat structure
        else if(arec(2:5).eq.'5453') then
         w2 = 3.256d-4*mu95*pduchc(n)/avpduh
         w3 = 0.0
         w4 = 6.00d-5*mu95*pduchc(n)/avpduh
         sumosp = sumosp+w2
         sumclu = sumclu+w3+w4
c CHF hot stripe heat structure
        else if(arec(2:5).eq.'5454') then
         a1 = mu95/5.*0.6529/100.
         a2 = (pduchs(1,1)*pf95hs(1,1)+
     .         pduchs(2,1)*pf95hs(2,1)+
     .         pduchs(3,1)*pf95hs(3,1)+
     .         pduchs(4,1)*pf95hs(4,1)+
     .         pduchs(5,1)*pf95hs(5,1))/5.
         a3 = (pduchc(1)*pf95hc(1)+
     .         pduchc(2)*pf95hc(2)+
     .         pduchc(3)*pf95hc(3)+
     .         pduchc(4)*pf95hc(4)+
     .         pduchc(5)*pf95hc(5))/5.
         w2 = pduchs(n,1)/avpdus(1)*a1*a2/a3
         w3 = 0.
         w4 = 0.
         sumof = sumof+w2
         sumclu = sumclu+w3+w4
c FE hot stripe heat structure
        else if(arec(2:5).eq.'5455') then
         a1 = mu95/5.*0.6529/100.
         a2 = (pduchs(1,2)*pf95hs(1,2)+
     .         pduchs(2,2)*pf95hs(2,2)+
     .         pduchs(3,2)*pf95hs(3,2)+
     .         pduchs(4,2)*pf95hs(4,2)+
     .         pduchs(5,2)*pf95hs(5,2))/5.
         a3 = (pduchc(1)*pf95hc(1)+
     .         pduchc(2)*pf95hc(2)+
     .         pduchc(3)*pf95hc(3)+
     .         pduchc(4)*pf95hc(4)+
     .         pduchc(5)*pf95hc(5))/5.
         w2 = pduchs(n,2)/avpdus(2)*a1*a2/a3
         w3 = 0.
         w4 = 0.
         sumof = sumof+w2
         sumclu = sumclu+w3+w4
c 99.9% 99.9% 99.9% 99.9% 99.9% 99.9% 99.9% 99.9% 99.9% 99.9% 99.9%
c hot channel fuel plate
        else if(arec(2:5).eq.'5461') then
         w2 = 0.1306*mu99*pduchc(n)/avpduh
         w3 = 3.52d-4*mu99*pduchc(n)/avpduh
         w4 = 0.0
         sumof = sumof+w2
         sumclu = sumclu+w3+w4
c hot channel inner side plate heat structure
        else if(arec(2:5).eq.'5462') then
         w2 = 2.74d-4*mu99*pduchc(n)/avpduh
         w3 = 6.080d-4*mu99*pduchc(n)/avpduh
         w4 = 0.0
         sumosp = sumosp+w2
         sumclu = sumclu+w3+w4
c hot channel outer side plate heat structure
        else if(arec(2:5).eq.'5463') then
         w2 = 3.256d-4*mu99*pduchc(n)/avpduh
         w3 = 0.0
         w4 = 6.00d-4*mu99*pduchc(n)/avpduh
         sumosp = sumosp+w2
         sumclu = sumclu+w3+w4
c CHF hot stripe heat structure
        else if(arec(2:5).eq.'5464') then
         a1 = mu99/5.*0.6529/100.
         a2 = (pduchs(1,1)*pf99hs(1,1)+
     .         pduchs(2,1)*pf99hs(2,1)+
     .         pduchs(3,1)*pf99hs(3,1)+
     .         pduchs(4,1)*pf99hs(4,1)+
     .         pduchs(5,1)*pf99hs(5,1))/5.
         a3 = (pduchc(1)*pf99hc(1)+
     .         pduchc(2)*pf99hc(2)+
     .         pduchc(3)*pf99hc(3)+
     .         pduchc(4)*pf99hc(4)+
     .         pduchc(5)*pf99hc(5))/5.
         w2 = pduchs(n,1)/avpdus(1)*a1*a2/a3
         w3 = 0.
         w4 = 0.
         sumof = sumof+w2
         sumclu = sumclu+w3+w4
c FE hot stripe heat structure
        else if(arec(2:5).eq.'5465') then
         a1 = mu99/5.*0.6529/100.
         a2 = (pduchs(1,2)*pf99hs(1,2)+
     .         pduchs(2,2)*pf99hs(2,2)+
     .         pduchs(3,2)*pf99hs(3,2)+
     .         pduchs(4,2)*pf99hs(4,2)+
     .         pduchs(5,2)*pf99hs(5,2))/5.
         a3 = (pduchc(1)*pf99hc(1)+
     .         pduchc(2)*pf99hc(2)+
     .         pduchc(3)*pf99hc(3)+
     .         pduchc(4)*pf99hc(4)+
     .         pduchc(5)*pf99hc(5))/5.
         w2 = pduchs(n,2)/avpdus(2)*a1*a2/a3
         w3 = 0.
         w4 = 0.
         sumof = sumof+w2
         sumclu = sumclu+w3+w4
        endif
c
        write(arec(9:80),9988)iw1,w2,w3,w4,iw5
        do 22 ii=1,80
         if(arec(ii:ii).eq.'D')arec(ii:ii)='d'
   22    if(arec(ii:ii).eq.'E')arec(ii:ii)='e'
       else
        sumoth = sumoth+w2
        sumclo = sumclo+w3+w4
c ENDIF THE SOURCE TERM is 1000
       endif
       write(6,9987)arec(2:5),iw1,w2,w3,w4,iw5
      else if(iw1.eq.10775) then
       sum775 = sum775 +  w2*222733./3.44d8
       sumcpc = sumcpc + (w3 + w4)*222733./3.44d8
      else if(iw1.eq.10774) then
       sum774 = sum774 +  w2*213703./3.44d8
       sumcpc = sumcpc + (w3 + w4)*213703./3.44d8
      else if(iw1.eq.10773) then
       sum773 = sum773 +  w2*196644./3.44d8
       sumcpc = sumcpc + (w3 + w4)*196644./3.44d8
      else if(iw1.eq.10772) then
       sum772 = sum772 +  w2*186613./3.44d8
       sumcpc = sumcpc + (w3 + w4)*186613./3.44d8
      else if(iw1.eq.10771) then
       sum771 = sum771 +  w2*183603./3.44d8
       sumcpc = sumcpc + (w3 + w4)*183603./3.44d8
      else if(iw1.eq.10735) then
       sum735 = sum735 +  w2*148160./3.44d8
       sumcpc = sumcpc + (w3 + w4)*148160./3.44d8
      else if(iw1.eq.10734) then
       sum734 = sum734 +  w2*182970./3.44d8
       sumcpc = sumcpc + (w3 + w4)*182970./3.44d8
      else if(iw1.eq.10733) then
       sum733 = sum733 +  w2*188323./3.44d8
       sumcpc = sumcpc + (w3 + w4)*188323./3.44d8
      else if(iw1.eq.10732) then
       sum732 = sum732 +  w2*187432./3.44d8
       sumcpc = sumcpc + (w3 + w4)*187432./3.44d8
      else if(iw1.eq.10731) then
       sum731 = sum731 +  w2*185646.5/3.44d8
       sumcpc = sumcpc + (w3 + w4)*185646.5/3.44d8
      else if(iw1.eq.10641) then
       sum641 = sum641 +  w2*168656.3/3.44d8
       sumcpc = sumcpc + (w3 + w4)*168656.3/3.44d8
      else if(iw1.eq.10642) then
       sum642 = sum642 +  w2*301664./3.44d8
       sumcpc = sumcpc + (w3 + w4)*301664./3.44d8
      else if(iw1.eq.10643) then
       sum643 = sum643 +  w2*794812./3.44d8
```

```
          sumcpc = sumcpc + (w3 + w4)*794812./3.44d8
        else if(iwl.eq.10613) then
          sum613 = sum613 +  w2*73585./3.44d8
          sumcpc = sumcpc + (w3 + w4)*73585./3.44d8
        else if(iwl.eq.10671) then
          sum671 = sum671 +  w2*429622./3.44d8
          sumcpc = sumcpc + (w3 + w4)*429622./3.44d8
        else if(iwl.eq.10672) then
          sum672 = sum672 +  w2*433784./3.44d8
          sumcpc = sumcpc + (w3 + w4)*433784./3.44d8
        else if(iwl.eq.10673) then
          sum673 = sum673 +  w2*435848./3.44d8
          sumcpc = sumcpc + (w3 + w4)*435848./3.44d8
        else if(iwl.eq.10674) then
          sum674 = sum674 +  w2*423464./3.44d8
          sumcpc = sumcpc + (w3 + w4)*423464./3.44d8
        else if(iwl.eq.10675) then
          sum675 = sum675 +  w2*342903./3.44d8
          sumcpc = sumcpc + (w3 + w4)*342903./3.44d8
        else if(iwl.ne.0) then
          write(6,9994)iwl
        endif
      endif
      write(22,9998)arec
      go to 10
  999 continue
      sumcpb = sum775+sum774+sum773+sum772+sum771+sum735+
     . sum734+sum733+sum732+sum731
      totlk = sumif+sumof+sumoth
      write(6,9999) sumif,sumisp,sumof,sumosp,sumoth,totlk,sumcll,
     .sumclu,sumclo
      write(6,9996) sumcpb,sum641,sum642,sum643,sum613,sum671,
     .sum672,sum673,sum674,sum675,sumcpc
      write(6,9995) totlk+sumcpb+sum641+sum642+sum643+sum613
     . +sumcll+sumclu+sumclo+sumcpc
 9999 format(/' Lower Fuel Heating        = ',f10.7,/
     .         ' Lower Side-Plate Heating  = ',f10.7,/
     .         ' Upper Fuel Heating        = ',f10.7,/
     .         ' Upper Side-Plate Heating  = ',f10.7,/
     .         ' Other Heating (1000)      = ',f10.7,/
     .         '                             __________',/
     .         ' Total Heating for 1000    = ',f10.7,//
     .         ' Lower Fuel Coolant        = ',f10.7,/
     .         ' Upper Fuel Coolant        = ',f10.7,/
     .         ' CPBT Coolant              = ',f10.7)
 9998 format(a80)
 9997 format(2x,a4,'-00',a1,3(1x,d14.4))
 9996 format(/' CPBT  Heating             = ',f10.7,/
     .         ' CR CV641 Heating (Al)     = ',f10.7,/
     .         ' CR CV642 Heating (Hf)     = ',f10.7,/
     .         ' CR CV643 Heating (Hf)     = ',f10.7,/
     .         ' Structures for Gamma Heating in CR Region  ',/
     .         '                     CV613  = ',f10.7,/
     .         '                     CV671  = ',f10.7,/
     .         '                     CV672  = ',f10.7,/
     .         '                     CV673  = ',f10.7,/
     .         '                     CV674  = ',f10.7,/
     .         '                     CV675  = ',f10.7,/
     .         ' Control Rod Coolant       = ',f10.7)
 9995 format(//' GRAND TOTAL =             = ',f10.7)
 9994 format(' ***** WARNING ***** SOURCE ',i6,' ASSUMED TO BE ZERO AT S
     .TEADY-STATE')
 9993 format(f10.7)
 9992 format(i5,4f10.7)
 9989 format(' Input factor by which to multiply hot channel fuel heat s
     .tructures')
 9988 format(1x,i6,3(1x,1pd14.7),1x,i6,8x)
 9987 format(1x,a4,1x,i5,3(1x,d12.6),1x,i3)
      end
c
c Function to read a real number
c
      function dread(iptr,arec)
c
c Finds the first real number on the record after the iptr character
c
      character*80 arec
      character*8 format
      data format /'(      )'/
      idec1 = 0
      idec2 = 0
      do 10 i=iptr+1,80
       if(arec(i:i).ne.' ') then
        i1 = i
        go to 15
       endif
   10 continue
      dread = 0.d0
      return
   15 do 20 i=i1+1,80
       if(arec(i:i).eq.' ') then
        length = i-i1
        iptr = i
        go to 25
       endif
   20 continue
   25 do 30 i=i1,i1+length
       if(arec(i:i).eq.'.') then
        idec1 = i+1
       else if(arec(i:i).eq.'d'.or.arec(i:i).eq.'e'.or.i.eq.i1+length
     & .or.arec(i:i).eq.'+'.or.arec(i:i).eq.'-') then
        idec2 = i-1
       endif
   30 continue
      if(idec2.eq.0) then
       dread = 0.
       return
      endif
      ndec = idec2-idec1+1
      write(format(2:7),'(a1,i2,a1,i2)') 'd',length,'.',ndec
      read(arec(i1:i1+length-1),format)dread
      return
      end
c
c Function to read integer data
c
      function iread(iptr,arec)
c
c Finds the first integer on the record after the iptr character
c
      character*80 arec
      character*4 format
      data format /'(  )'/
      do 10 i=iptr+1,80
       if(arec(i:i).ne.' ') then
        i1 = i
        go to 15
       endif
   10 continue
      iread = 0
      return
   15 do 20 i=i1+1,80
       if(arec(i:i).eq.' ') then
        length = i-i1
        iptr = i
        go to 25
       endif
   20 continue
   25 continue
      write(format(2:3),'(a1,i1)') 'i',length
      read(arec(i1:i1+length-1),format)iread
      return
      end
c
c Function to read alphanumeric data
c
      function aread(iptr,arec,length)
c
c Finds the first alphanumeric on the record after the iptr character
c
      character*10 aread
      character*80 arec
      character*5 format
      format = '(   )'
      do 10 i=iptr+1,80
       if(arec(i:i).ne.' ') then
        i1 = i
        go to 15
       endif
   10 continue
      return
   15 do 20 i=i1+1,80
```

```
     if(arec(i:i).eq.' ') then
      length = i-i1
      iptr = i
      go to 25
     endif
20  continue
25  continue
    if(length.lt.10) then
     write(format(3:4),'(a1,i1)') 'a',length
    else
     write(format(2:4),'(a1,i2)') 'a',length
    endif
    read(arec(i1:i1+length-1),format)aread
    return
    end
```

APPENDIX C: RELAP5 INPUT FOR MAIN HEAT EXCHANGER COMPARISON WITH DATA

```
=advanced neutron source relap5 system model
*
0000001   8     10        22
*-----------------------------------------------------------------------
0000100                new                transnt
*-----------------------------------------------------------------------
0000101               run
*-----------------------------------------------------------------------
0000102                si                 si
*-----------------------------------------------------------------------
0000105 30. 40.  1800.
*----------------------------------------------------------------------
0000110  nitrogen
*----------------------------------------------------------------------
*
0000120 106010000 0. d2o primary
0000202 100.0  1.e-7 0.01 03 100 100000 100000
*-----------------------------------------------------------------------
*      minor edit requests
*-----------------------------------------------------------------------
0000301    mflowj         113010000
0000308    cntrlvar 45
0000312    p              106010000
0000313    p              112010000
*
1040000 source  tmdpvol
1040101 0.0832 1.0 0. 0. 0. 0. 0.0000457 0.3255  0
1040200 3 0
1040201 0.   1.527020e6   354.15
*
*-----------------------------------------------------------------------*
*hydro             component name      component type
1210000             'pritdj1'            tmdpjun
*-----------------------------------------------------------------------*
*hydro    from          to            area
1210101   113010000     122000000     0.08322
*
*hydro    vel/flw       trip no.      alpha vrc      numeric vrc
1210200     1             0
*
*hydro    time          f flow        g flow         j flow
1210201   0.             705.          705.             0
*
1220000 sink    tmdpvol
1220101 0.0832 1.0 0. 0. 0. 0. 0.0000457 0.3255  0
1220200 3 0
1220201 0.   1.5e6       357.068
*
*----------------------------------------------------------------------$
*hydro             component name      component type
1060000               hxplin1              branch
*----------------------------------------------------------------------$
*hydro            no. juns            vel/flw
1060001              2                  0
*
*hydro             area              length              volume
1060101           0.08322              1.0                 0.
*
*hydro          horz angle          vert angle           delta z
1060102            0.                  0.                  0.
*
*hydro           roughness           hyd diam              fe
1060103          0.0000457            0.3255               0
*
*hydro  ebt pressure     tempe
1060200 0  1558998.    325442.  2411284. 0.
*
*hydro    from            to            area       f loss     r loss    vcahs
1061101 106000000    108000000          0.         0.15       0.15    01000
1062101 104000000    106000000          0.         0.         0.       01000
*
*hydro   hyd diam
1061110 0.3255    0.0 1.0 1.0
1062110 0.3255    0.0 1.0 1.0
*
*hydro                 f velocity    g velocity     j velocity
1061201    7.85698     7.85698 0. * 705.
1062201    7.85898     7.85898 0. * 705.
*
*-----------------------------------------------------------------------*
*hydro             component name      component type
```

```
1080000                *mhx-prim*            pipe
*---------------------------------------------------------------------$
1080001           11
*
*hydro           vol area                                        vol
1080101           0.8258                                          5
1080102           0.841                                           6
1080103           0.8258                                         11
*
*hydro            length                                         vol
1080301             1.11                                          5
1080302             2.03                                          6
1080303             1.11                                         11
*
*hydro            volume                                         vol
1080401             0.                                           11
*
*hydro          vert angle                                       vol
1080601             0.                                           11
*
*hydro           delta z                                         vol
1080701            0.0                                           11
*
*hydro          roughness       hyd diam                         vol
1080801          0.0000457      0.636                             5
1080802          0.0000457      0.894                             6
1080803          0.0000457      0.636                            11
*
*hydro              fe                                           vol
1081001             00                                           11
*
*hydro            vcahs                                          jun
1081101           01000                                          10
*
*hydro   ebt pressure       tempe                                vol
1081201  0  1552339.      294260.   2411199. 0.        0. 1
1081202  0  1552334.      267031.   2411199. 0.        0. 2
1081203  0  1552328.      243136.4  2411199. 0.        0. 3
1081204  0  1552322.      222074.   2411199. 0.        0. 4
1081205  0  1552316.      203427.8  2411199. 0.        0. 5
1081206  0  1552320.      203427.8  2411199. 0.        0. 6
1081207  0  1552300.      198400.   2411199. 0.        0. 7
1081208  0  1552292.      193865.8  2411199. 0.        0. 8
1081209  0  1552285.      189772.   2411198. 0.        0. 9
1081210  0  1552277.      186072.7  2411198. 0.        0. 10
1081211  0  1552270.      182726.4  2411198. 0.        0. 11
*
*hydro          f velocity   g velocity    j velocity            jun
1081300 0
1081301    .788157     .788157  0. 1  * 705.
1081302    .785223     .785223  0. 2  * 705.
1081303    .782838     .782838  0. 3  * 705.
1081304    .780888     .780888  0. 4  * 705.
1081305    .779285     .779285  0. 5  * 705.
1081306    .779285     .779285  0. 6  * 705.
1081307    .778874     .778874  0. 7  * 705.
1081308    .77851      .77851   0. 8  * 705.
1081309    .778189     .778189  0. 9  * 705.
1081310    .777903     .777903  0. 10 * 705.
*
*hydro    jun hyd diam                                           jun
1081401       0.100        0.0 1.0 1.0                           10
*
*---------------------------------------------------------------------$
*hydro             component name      component type
1120000              hxplout1              branch
*---------------------------------------------------------------------$
*hydro            no. juns             vel/flw
1120001              2                   0
*
*hydro             area               length              volume
1120101           0.08322               1.0                 0.
*
*hydro          horz angle          vert angle           delta z
1120102             0.                  0.                  0.
*
*hydro          roughness            hyd diam              fe
1120103          0.0000457            0.3255                0
*
*hydro  ebt pressure      tempe
1120200 0  1514344.     182727.6 2410712. 0.
```

```
*
*hydro    from          to            area       f loss     r loss    vcahs
1121101 108010000    112000000       0.          0.15        0.15     01000
1122101 112010000    113000000       0.08322    0.          0.        01000
*
*hydro   hyd diam
1121110 0.3255  0.0 1.0 1.0
1122110 0.3255 0.0 1.0 1.0
*
*hydro                f velocity     g velocity     j velocity
1121201   7.71669     7.71669 0. * 705.
1122201   7.71681     7.71681 0. * 705.
*
*------------------------------------------------------------------------$
*hydro              component name       component type
1130000               *joinhx*                 pipe
*------------------------------------------------------------------------$
1130001          3
*
*hydro            vol area                                            vol
1130101            0.08322                                              3
*
*hydro             length                                             vol
1130301            1.981                                                1
1130302            1.23                                                 2
1130303            0.6096                                               3
*
*hydro             volume                                             vol
1130401             0.                                                  3
*
*hydro           vert angle                                           vol
1130601              -22.6                                              1
1130602              -29.7                                              2
1130603              -90.                                               3
*
*hydro           elev. change                                         vol
1130701              -0.762                                             1
1130702              -0.6093                                            2
1130703              -0.6096                                            3
*
*hydro           roughness      hyd diam                              vol
1130801          0.0000457       0.3255                                 3
*
*hydro             f loss         r loss                              jun
1130901             0.182          0.182                                2
*
*hydro               fe                                               vol
1131001              00                                                 3
*
*hydro              vcahs                                             jun
1131101             01000                                               2
*
*hydro  ebt pressure      tempe                                       vol
1131201  0  1516478.     182730.   2410740. 0.         0. 1
1131202  0  1515786.     182731.5 2410730. 0.          0. 2
1131203  0  1515177.     182731.8 2410723. 0.          0. 3
*
*hydro            vel/flw
1131300             0
*
*hydro          f flowrate   g flowrate    j flowrate                 jun
1131301   7.71681     7.71681 0. 1 * 705.
1131302   7.71681     7.71681 0. 2 * 705.
*
*------------------------------------------------------------------------$
*       main heat exchanger secondary flow system (tube side)            $
*------------------------------------------------------------------------$
*
*------------------------------------------------------------------------*
*hydro              component name       component type
1300000               *secsrc1*               tmdpvol
*------------------------------------------------------------------------*
*hydro          area        length         volume
1300101         1.e6          .0          1.0e+06
*
*hydro      horz angle  vert angle      delta z
1300102         .0          .0             .0
*
*hydro      roughness    hyd diam         fe
1300103         .0          .0            10
*
```

```
*hydro  ebt         trip no.       alpha vrc       numeric vrc
1300200 003
*
*hydro  time       pressure      tempe
1300201  0.        5.000e5       302.15
*
*------------------------------------------------------------------------*
*hydro              component name       component type
1320000               *sectdj1*              tmdpjun
*------------------------------------------------------------------------*
*hydro   from            to            area
1320101  130000000     134000000       0.7122
*
*hydro   vel/flw        trip no.       alpha vrc       numeric vrc
1320200    1              0
*
*hydro  time            f flow         g flow          j flow
1320202  10.             1490.          1490.             0
*
*------------------------------------------------------------------------*
*hydro              component name       component type
1340000               *mhx-sec*               pipe
*------------------------------------------------------------------------$
1340001          10
*
*hydro           vol area                                              vol
1340101          0.776                                                  10
*
*hydro            length                                               vol
1340301            1.314                                                10
*
*hydro            volume                                               vol
1340401             0.                                                  10
*
*hydro          vert angle                                             vol
1340601            0.                                                   10
*
*hydro            delta z                                              vol
1340701            0.0                                                  10
*
*hydro          roughness       hyd diam                               vol
1340801          0.0000457      0.01588                                 10
*
*hydro              fe                                                 vol
1341001             00                                                  10
*
*hydro             vcahs                                               jun
1341101            01000                                                 9
*
*hydro  ebt pressure      tempe                                        vol
1341201  0   484549.     130261.4 2558934. 0.         0. 1
1341202  0   480172.     140233.  2558648. 0.         0. 2
1341203  0   475815.     151544.6 2558362. 0.         0. 3
1341204  0   471478.     164434.7 2558074. 0.         0. 4
1341205  0   467162.     179195.  2557786. 0.         0. 5
1341206  0   462826.5    180783.  2557494. 0.         0. 6
1341207  0   458469.     182538.  2557199. 0.         0. 7
1341208  0   454114.     184479.4 2556902. 0.         0. 8
1341209  0   449762.     186629.4 2556602. 0.         0. 9
1341210  0   445413.     189013.  2556300. 0.         0. 10
*
*hydro         f velocity   g velocity    j velocity                   jun
1341300 0
1341301   1.92863    1.92863    0. 1 * 1490.
1341302   1.930136   1.930136   0. 2 * 1490.
1341303   1.931957   1.931957   0. 3 * 1490.
1341304   1.934175   1.934175   0. 4 * 1490.
1341305   1.936895   1.936895   0. 5 * 1490.
1341306   1.9372     1.9372     0. 6 * 1490.
1341307   1.937543   1.937543   0. 7 * 1490.
1341308   1.937923   1.937923   0. 8 * 1490.
1341309   1.938347   1.938347   0. 9 * 1490.
*
*hydro  jun hyd diam                                                   jun
1341401     0.01588      0.0 1.0 1.0                                     9
*
*------------------------------------------------------------------------*
*hydro              component name       component type
1350000               *tubeout*              sngljun
*------------------------------------------------------------------------*
*hydro    from           to          area       f loss     r loss     vcahs
```

```
1350101   134010000    136000000    0.0         0.        0.       01000
*
*hydro    hyd diam
1350110    0.01588      0.0       1.0       1.0
*
*hydro     vel/flw       f velocity    g velocity     j velocity
1350201      0             1.93882        1.93882        0. * 1490.
*
*----------------------------------------------------------------------*
*hydro               component name      component type
1360000                *secsnk1*               tmdpvol
*----------------------------------------------------------------------*
*hydro          area        length        volume
1360101         1.e6          .0          1.0e+06
*
*hydro       horz angle  vert angle    delta z
1360102         .0           .0           .0
*
*hydro        roughness    hyd diam       fe
1360103          .0           .0          10
*
*hydro  ebt          trip no.        alpha vrc       numeric vrc
1360200 003
*
*hydro   time      pressure      tempe
1360201  0.        4.451e5       319.
*
*calibrate*
*calibrate$=====================================================================
*calibrate$                    ht str no. 1081          hx shell
*calibrate*---------------------------------------------------------------------
*calibrate*htstr   ht strs  m pts  geom  init  l.coord    refl  b.vol  axl. incr
*calibrate11081000    2       4      2     0     1.009  0   0         0
*calibrate*
*calibrate*htstr         mesh locn        mesh fmt
*calibrate11081100           0               1
*calibrate*
*calibrate*htstr         intervals        rt. coord
*calibrate11081101           3               1.054
*calibrate*
*calibrate*htstr         compxn no.       interval
*calibrate11081201           1               3
*calibrate*
*calibrate*htstr         source           interval
*calibrate11081301          0.               3
*calibrate*
*calibrate*htstr                          temp flg
*calibrate11081400                           0
*calibrate*
*calibrate*htstr         temp             mesh pt.
*calibrate11081401       302.                4
*calibrate*
*calibrate*htstr     left vol     incr  b.cond  sa code  area/factor    ht str no.
*calibrate11081501   108010000    10000  1        1         1.11            5
*calibrate11081502   108070000    10000  1        1         1.11            11
*calibrate*
*calibrate*htstr     right vol    incr  b.cond  sa code  area/factor    ht str no.
*calibrate11081601   -501         0      4599    1         1.11            11
*calibrate*
*calibrate*htstr      s. type      s. mult      left heat  right heat    ht str no.
*calibrate11081701      0            0             0          0             11
*calibrate*
*calibrate*htstr     chf flag     hyd diam     equiv diam    ch. len     ht str no.
*calibrate11081801   0. 10. 10. 0. 0. 0. 0. 1.  11
*calibrate*
*calibrate*htstr     chf flag     hyd diam     equiv diam    ch. len     ht str no.
*calibrate11081901   0. 10. 10. 0. 0. 0. 0. 1.  11
*calibrate*
*calibrate$=====================================================================
*calibrate$                    ht str no. 1082          hx shell
*calibrate*---------------------------------------------------------------------
*calibrate*htstr   ht strs  m pts  geom  init  l.coord    refl  b.vol  axl. incr
*calibrate11082000    1       4      1     0     0.00  0   0         0
*calibrate*
*calibrate*htstr         mesh locn        mesh fmt
*calibrate11082100           0               1
*calibrate*
*calibrate*htstr         intervals        rt. coord
*calibrate11082101           3               0.0445
*calibrate*
*calibrate*htstr         compxn no.       interval
*calibrate11082201                  1                 3
*calibrate*
*calibrate*htstr          source            interval
*calibrate11082301         0.                  3
*calibrate*
*calibrate*htstr                            temp flg
*calibrate11082400                             0
*calibrate*
*calibrate*htstr          temp              mesh pt.
*calibrate11082401        302.                 4
*calibrat*
*calibrate*htstr     left vol     incr  b.cond  sa code  area/factor    ht str no.
*calibrate11082501   108060000    00000  1        1         3.49            1
*calibrate*
*calibrate*htstr     right vol    incr  b.cond  sa code  area/factor    ht str no.
*calibrate11082601   -501         0      4581    1         3.49            1
*calibrate*
*calibrate*htstr      s. type      s. mult      left heat  right heat    ht str no.
*calibrate11082701      0            0             0          0             1
*calibrate*
*calibrate*htstr     chf flag     hyd diam     equiv diam    ch. len     ht str no.
*calibrate11082801   0. 10. 10. 0. 0. 0. 0. 1.  1
*calibrate*
*calibrate*htstr     chf flag     hyd diam     equiv diam    ch. len     ht str no.
*calibrate11082901   0. 10. 10. 0. 0. 0. 0. 1.  1
*
$====================================================================$
$                       ht str no. 1083          hx tube              $
*--------------------------------------------------------------------*
*htstr   ht strs  m pts  geom  init  l.coord    refl  b.vol  axl. incr
11083000    10      4      2     0    7.049e-3    0     0       0
*
*htstr         mesh locn         mesh fmt
11083100           0                1
*
*htstr         intervals         rt. coord
11083101           3                7.938e-3
*
*htstr         compxn no.        interval
11083201           1                3
*
*htstr         source            interval
11083301          0.                3
*
*htstr                           temp flg
11083400                            0
*
*htstr         temp              mesh pt.
11083401       302.                 4
*
*htstr     left vol     incr  b.cond  sa code  area/factor    ht str no.
11083501   108010000    10000  1        1         8700.4          5
11083502   108070000    10000  1        1         8700.4          10
*
*htstr     right vol    incr  b.cond  sa code  area/factor    ht str no.
11083601   134050000    -10000  1       1         8700.4          5
11083602   134100000    -10000  1       1         8700.4          10
*
*htstr      s. type      s. mult      left heat  right heat    ht str no.
11083701      0            0             0          0             10
*
*htstr     chf flag     hyd diam     equiv diam    ch. len     ht str no.
11083801   0. 10. 10. 0. 0. 0. 0. 1.  10
*
*htstr     chf flag     hyd diam     equiv diam    ch. len     ht str no.
11083901   0. 10. 10. 0. 0. 0. 0. 1.  10
*
*   thermal properties of composition   1  -  ss3041                   $
*--------------------------------------------------------------------$
*compxn      composition    th.con flg      ht.cap flg        material
20100100       tbl/fctn         1               1             $ss3041
*
*compxn      temperature          th. cond.
20100101       273.2                14.7
20100102       300.                 15.2
20100103       400.                 17.0
20100104       500.                 18.4
20100105       600.                 19.8
20100106       700.                 21.2
20100107       800.                 22.5
20100108       900.                 23.9
.
```

```
20100109       1000.                  25.3
20100110       1200.                  28.1
20100111       1400.                  30.9
20100112      20000.                  30.9
*
*compxn        temperature           vol ht cap
20100151        273.2                 10.0
20100152        20000.                10.0
*20100151        250.                   2.97e6
*20100152        478.                   3.00e6
*20100153        700.                   3.13e6
*20100154        811.                   3.23e6
*20100155        866.                   3.33e6
*20100156        922.                   3.43e6
*20100157       1033.                   3.59e6
*20100158       1200.                   3.76e6
*20100159       1311.                   3.82e6
*20100160       1400.                   3.82e6
*20100161      20000.                   3.82e6
*
20504500 heattr  sum       385.342      -100632184.   0
20504501 0. 1.,htrnr,108300100
20504502    1.,htrnr,108300200
20504503    1.,htrnr,108300300
20504504    1.,htrnr,108300400
20504505    1.,htrnr,108300500
20504507    1.,htrnr,108300600
20504508    1.,htrnr,108300700
20504509    1.,htrnr,108300800
20504510    1.,htrnr,108300900
20504511    1.,htrnr,108301000
. end of case
```

APPENDIX D: RELAP5 INPUT FOR EMERGENCY HEAT EXCHANGER COMPARISON WITH DATA

```
=advanced neutron source relap5 system model
*
0000001   8     10       22
*-----------------------------------------------------------------------
0000100              new                  transnt
*-----------------------------------------------------------------------
0000101            run
*-----------------------------------------------------------------------
0000102              si                     si
*-----------------------------------------------------------------------
0000105 30. 40.  1800.
*----------------------------------------------------------------------
0000110  nitrogen
*----------------------------------------------------------------------
*
0000120 113010000 0. d2o primary
0000202 100.0  1.e-7 0.07 03 10 100000 100000
*-----------------------------------------------------------------------
*      minor edit requests
*------------------------------------------------------------------------
0000301    mflowj          111000000
0000302    mflowj          148000000
*0000308    cntrlvar 45
0000312    p               113010000
0000313    p               122010000
0000314    htrnr           116300100
0000315    htrnr           116300200
0000316    htrnr           116300300
0000317    htrnr           116300400
0000318    tempf           150010000
*
1100000 source  tmdpvol
1100101 0.0832 1.0 0. 0. 0. 0. 0.0000457 0.3255  0
1100200 3 0
1100201 0.   1.527020e6   318.71
*
*-----------------------------------------------------------------------*
*hydro              component name       component type
1210000               'pritdj1'            tmdpjun
*-----------------------------------------------------------------------*
*hydro    from           to            area
1210101   122010000      124000000     0.08322
*
*hydro    vel/flw        trip no.      alpha vrc      numeric vrc
1210200     1               0
*
*hydro   time           f flow         g flow         j flow
1210201    0.             706.           706.              0
*
1240000 sink    tmdpvol
1240101 0.0832 1.0 0. 0. 0. 0. 0.0000457 0.3255  0
1240200 3 0
1240201 0.    1.5e6       357.068
*
*-----------------------------------------------------------------------*
*hydro              component name       component type
1520000               'sectdj1'            tmdpjun
*-----------------------------------------------------------------------*
*hydro    from           to            area
1520101   150010000      154000000     0.08322
*
*hydro    vel/flw        trip no.      alpha vrc      numeric vrc
1520200     1               0
*
*hydro   time           f flow         g flow         j flow
1520202    1.             44.14          44.14             0
*
1240000 sink    tmdpvol
1240101 0.0832 1.0 0. 0. 0. 0. 0.0000457 0.3255  0
1240200 3 0
1240201 0.    1.5e6       357.068
*
*-----------------------------------------------------------------------*
*hydro              component name       component type
1110000               'tubeout'            sngljun
*-----------------------------------------------------------------------*
*hydro    from           to            area        f loss      r loss      vcahs
1110101   110000000      113000000     0.0            0.          0.        01000
*
*hydro   hyd diam
1110110   0.01588        0.0        1.0        1.0
```

```
*
*hydro    vel/flw        f velocity      g velocity      j velocity
1110201      0              7.72521         7.72521          0. * 706.
*
*------------------------------------------------------------------------$
*hydro              component name       component type
1130000               'joinhx'               pipe
*------------------------------------------------------------------------$
1130001          3
*
*hydro          vol area                                                  vol
1130101           0.08322                                                   3
*
*hydro           length                                                   vol
1130301           1.981                                                     1
1130302           1.23                                                      2
1130303           0.6096                                                    3
*
*hydro           volume                                                   vol
1130401            0.                                                       3
*
*hydro          vert angle                                                vol
1130601             -22.6                                                   1
1130602             -29.7                                                   2
1130603             -90.                                                    3
*
*hydro          elev. change                                              vol
1130701             -0.762                                                  1
1130702             -0.6093                                                 2
1130703             -0.6096                                                 3
*
*hydro          roughness      hyd diam                                   vol
1130801         0.0000457        0.3255                                     3
*
*hydro             f loss         r loss                                  jun
1130901             0.182          0.182                                    2
*
*hydro              fe                                                    vol
1131001             00                                                      3
*
*hydro             vcahs                                                  jun
1131101            01000                                                    2
*
*hydro  ebt pressure      tempe                                           vol
1131201  0  1529830.     176808.3 2410912. 0.        0. 1
1131202  0  1529122.     176809.8 2410902. 0.        0. 2
1131203  0  1528500.     176810.5 2410894. 0.        0. 3
*
*hydro          vel/flw
1131300            0
*
*hydro          f flowrate    g flowrate     j flowrate                   jun
1131301   7.72335            7.72335 0. 1 * 706.
1131302   7.72335            7.72335 0. 2 * 706.
*
*------------------------------------------------------------------------$
*hydro              component name       component type
1140000               hxplin1                branch
*------------------------------------------------------------------------$
*hydro          no. juns            vel/flw
1140001             2                  0
*
*hydro            area               length              volume
1140101          0.08322              1.0                  0.
*
*hydro          horz angle          vert angle           delta z
1140102             0.                  0.                   0.
*
*hydro           roughness          hyd diam               fe
1140103          0.0000457           0.3255                 0
*
*hydro  ebt pressure      tempe
1140200 0  1562835.     176811.8 2411332. 0.
*
*hydro    from           to             area        f loss      r loss      vcahs
1141101 114000000      116000000         0.          0.15        0.15       01000
1142101 113010000      114000000        0.          0.         0.          01000
*
*hydro    hyd diam
1141110 0.3255    0.0 1.0 1.0
1142110 0.3255    0.0 1.0 1.0
```

```
*
*hydro                   f velocity     g velocity     j velocity
1141201   7.72324 7.72324 0. * 706.
1142201   7.72335 8.32625 0. * 706.
*
*----------------------------------------------------------------------*
*hydro              component name      component type
1160000                *ehx-prim*             pipe
*---------------------------------------------------------------------$
1160001          4
*
*hydro         vol area                                            vol
1160101         0.894                                               4
*
*hydro          length                                             vol
1160301          1.6                                                4
*
*hydro          volume                                             vol
1160401          0.                                                 4
*
*hydro        vert angle                                           vol
1160601          0.                                                 4
*
*hydro         delta z                                             vol
1160701          0.0                                                4
*
*hydro        roughness      hyd diam                              vol
*1160801         0.0000457      0.0346                              4
1160801        0.0000457      0.00170                              4
*
*hydro          f loss        r loss                               jun
1160901          0.0           0.0                                  3
*
*hydro            fe                                               vol
1161001           00                                                4
*
*hydro          vcahs                                              jun
1161101         01000                                               3
*
*hydro  ebt pressure     tempe                                     vol
1161201  0  1551824.     176543.  2411193. 0.         0. 1
1161202  0  1542812.     176132.4 2411078. 0.         0. 2
1161203  0  1533778.     175510.7 2410962. 0.         0. 3
1161204  0  1524708.     174581.  2410846. 0.         0. 4
*
*hydro        f velocity   g velocity    j velocity                jun
1161300 0
1161301   .71892  .71892  0. 1 * 706.
1161302   .718895 .718895 0. 2 * 706.
1161303   .718856 .718856 0. 3 * 706.
*
*hydro   jun hyd diam                                              jun
1161401      0.00170      0.0 1.0 1.0                               3
*
*---------------------------------------------------------------------$
*hydro              component name      component type
1200000                hxplout1              branch
*---------------------------------------------------------------------$
*hydro           no. juns             vel/flw
1200001              2                   0
*
*hydro             area               length              volume
1200101          0.08322                1.0                 0.
*
*hydro          horz angle           vert angle           delta z
1200102             0.                  0.                  0.
*
*hydro           roughness            hyd diam              fe
1200103          0.0000457            0.3255                0
*
*hydro  ebt pressure      tempe
1200200 0  1482113.    174582.3 2410243. 0.
*
*hydro    from           to             area        f loss     r loss     vcahs
1201101 116010000     120000000         0.           0.15        0.15     01000
1202101 120010000     122000000         0.08322      0.          0.       01000
*
*hydro   hyd diam
1201110 0.3255  0.0 1.0 1.0
1202110 0.3255 0.0 1.0 1.0
*
```

```
*hydro                   f velocity     g velocity     j velocity
1201201   7.72175 7.72175 0. * 706.
1202201   7.7219  7.7219  0. * 706.
*
$=====================================================================$
*hydro              component name      component type
1220000                *coldleg*              pipe
*---------------------------------------------------------------------$
1220001          3
*
*hydro         vol area                                            vol
1220101        0.08322                                              3
*
*hydro          length                                             vol
1220301          2.31                                               1
1220302          2.13                                               2
1220303          0.762                                              3
*
*hydro          volume                                             vol
1220401          0.                                                 3
*
*hydro          volume                                             vol
1220501          0.                                                 3
*
*hydro        vert angle                                           vol
1220601         -7.6                                                1
1220602          0.                                                 2
1220603          90.                                                3
*
*hydro         delta z                                             vol
1220701         -0.305                                              1
1220702          0.                                                 2
1220703          0.762                                              3
*
*hydro        roughness      hyd diam                              vol
1220801        0.0000457      0.3255                                3
*
*hydro          f loss        r loss                               jun
1220901          0.182         0.182                                2
*
*hydro            fe                                               vol
1221001           00                                                3
*
*hydro          vcahs                                              jun
1221101         01000                                               2
*
*hydro  ebt pressure     tempe                                     vol
1221201  0  1481566.     174585.  2410234. 0.         0. 1
1221202  0  1474303.     174587.7 2410119. 0.         0. 2
1221203  0  1462316.     174588.  2409927. 0.         0. 3
*
*hydro         vel/flw
1221300           0
*
*hydro        f flowrate   g flowrate    j flowrate                jun
1221301   7.7219  7.7219  0. 1 * 706.
1221302   7.72193 7.72193 0. 2 * 706.
*
*---------------------------------------------------------------------$
*       emergency heat exchanger secondary flow system (tube side)       $
*---------------------------------------------------------------------$
*
*----------------------------------------------------------------------*
*hydro              component name      component type
1380000                *secsrc1*             tmdpvol
*----------------------------------------------------------------------*
*hydro          area       length       volume
1380101         1.e6         .0         1.0e+06
*
*hydro      horz angle  vert angle     delta z
1380102          .0          .0           .0
*
*hydro       roughness    hyd diam       fe
1380103          .0          .0          10
*
*hydro  ebt        trip no.        alpha vrc       numeric vrc
1380200 003
*
*hydro   time     pressure      tempe
*calibrate1380201  0.       1.800e5       306.
1380201   0.       1.800e5       308.15
```

```
*
*----------------------------------------------------------------------*
*hydro              component name      component type
1400000               "tubein"             sngljun
*----------------------------------------------------------------------*
*hydro    from          to            area       f loss    r loss    vcahs
1400101   138000000     142000000     0.0          0.        0.      01100
*
*hydro   hyd diam
1400110   0.4573        0.0      1.0      1.0
*
*hydro    vel/flw        f velocity     g velocity     j velocity
1400201      0            .104126        .104126        0. * 44.14
*
*----------------------------------------------------------------------*
*hydro              component name      component type
1420000               "ehx-sec"              pipe
*----------------------------------------------------------------------$
1420001            2
*
*hydro          vol area                                           vol
1420101         0.4264                                              2
*
*hydro           length                                            vol
1420301          0.7622                                             2
*
*hydro           volume                                            vol
1420401            0.                                               2
*
*hydro         vert angle                                          vol
1420601            0.                                               2
*
*hydro          delta z                                            vol
1420701           0.0                                               2
*
*hydro         roughness      hyd diam                             vol
1420801         0.0000457      0.4573                               2
*
*hydro             fe                                              vol
1421001            00                                               2
*
*hydro            vcahs                                            jun
1421101           01000                                             1
*
*hydro  ebt pressure      tempe                                    vol
1421201  0   179992.3    146533.   2525552. 0.         0. 1
1421202  0   179992.     146533.   2525552. 0.         0. 2
*
*hydro          f velocity   g velocity    j velocity              jun
1421300 0
1421301    .104126   .104126    0. 1 * 44.14
*
*hydro    jun hyd diam                                             jun
1421401      0.4573      0.0 1.0 1.0                                1
*
*----------------------------------------------------------------------*
*hydro              component name      component type
1440000               "tubein"             sngljun
*----------------------------------------------------------------------*
*hydro    from          to            area       f loss    r loss    vcahs
1440101   142010000     146000000     0.0          0.        0.      01100
*
*hydro   hyd diam
1440110   0.01905       0.0      1.0      1.0
*
*hydro    vel/flw        f velocity     g velocity     j velocity
1440201      0            .104126        .104126        0. * 44.14
*
*----------------------------------------------------------------------*
*hydro              component name      component type
1460000               "ehx-sec"              pipe
*----------------------------------------------------------------------$
1460001            4
*
*hydro          vol area                                           vol
1460101         0.476                                               4
*
*hydro           length                                            vol
1460301          1.6                                                4
*
*hydro           volume                                            vol
1460401            0.                                               4
*
*hydro         vert angle                                          vol
1460601            0.                                               4
*
*hydro          delta z                                            vol
1460701           0.0                                               4
*
*hydro         roughness      hyd diam                             vol
1460801         0.0000457      0.01905                              4
*
*hydro             fe                                              vol
1461001            00                                               4
*
*hydro            vcahs                                            jun
1461101           01000                                             3
*
*hydro  ebt pressure      tempe                                    vol
1461201  0   179986.     161535.6 2525551. 0.          0. 1
1461202  0   179971.5    171612.  2525548. 0.          0. 2
1461203  0   179956.2    178313.5 2525546. 0.          0. 3
1461204  0   179940.5    182741.5 2525542. 0.          0. 4
*
*hydro          f velocity   g velocity    j velocity              jun
1461300 0
1461301   .0933978  .0933978  0. 1 * 44.14
1461302   .0934851  .0934851  0. 2 * 44.14
1461303   .0935455  .0935455  0. 3 * 44.14
*
*hydro    jun hyd diam                                             jun
1461401     0.01905      0.0 1.0 1.0                                3
*
*----------------------------------------------------------------------*
*hydro              component name      component type
1480000               "tubeout"            sngljun
*----------------------------------------------------------------------*
*hydro    from          to            area       f loss    r loss    vcahs
1480101   146010000     150000000     0.0          0.        0.      01100
*
*hydro   hyd diam
1480110   0.01905       0.0      1.0      1.0
*
*hydro    vel/flw        f velocity     g velocity     j velocity
1480201      0            .219444        .219444        0. * 44.14
*
*----------------------------------------------------------------------$
*hydro              component name      component type
1500000               "chimney"              pipe
*----------------------------------------------------------------------$
1500001            4
*
*hydro          vol area                                           vol
1500101         0.203                                               4
*
*hydro           length                                            vol
1500301          0.75                                               4
*
*hydro           volume                                            vol
1500401            0.                                               4
*
*hydro         vert angle                                          vol
1500601            90.                                              4
*
*hydro        elev. change                                         vol
1500701           0.75                                              4
*
*hydro         roughness      hyd diam                             vol
1500801         0.0000457      0.508                                4
*
*hydro           f loss        r loss                              jun
1500901            0.            0.                                 3
*
*hydro             fe                                              vol
1501001            00                                               4
*
*hydro            vcahs                                            jun
1501101           01000                                             3
*
*hydro  ebt pressure      tempe                                    vol
1501201  0   176261.6    182709.2 2524835. 0.          0. 1
1501202  0   168973.2    182677.  2523398. 0.          0. 2
```

```
1501203  0  161685.      182644.7 2521909. 0.         0. 3
1501204  0  154396.5     182612.5 2520364. 0.         0. 4
*
*hydro          vel/flw
1501300            0
*
*hydro         f flowrate   g flowrate    j flowrate                jun
1501301   .2194437    .269489  0. 1 * 44.14
1501302   .2194436    .269489  0. 2 * 44.14
1501303   .2194436    .269489  0. 3 * 44.14
*calibrate*
*calibrate*---------------------------------------------------------------------
*calibrate*hydro              component name      component type
*calibrate1520000              'tubeout'            sngljun
*calibrate*---------------------------------------------------------------------
*calibrate*hydro     from          to           area       f loss    r loss     vca
*calibrate1520101    150010000     154000000    0.0         0.        0.        011
*calibrate*
*calibrate*hydro   hyd diam
*calibrate1520110   0.508          0.0      1.0       1.0
*calibrate*
*calibrate*hydro     vel/flw        f velocity     g velocity      j velocity
*calibrate1520201      0              .0797832        .0801986        0. * 16.1127
*
*------------------------------------------------------------------------*
*hydro              component name      component type
1540000               'secsnk1'            tmdpvol
*------------------------------------------------------------------------*
*hydro          area        length        volume
1540101         1.e6          .0          1.0e+06
*
*hydro      horz angle  vert angle     delta z
1540102         .0          .0           .0
*
*hydro       roughness    hyd diam       fe
1540103         .0          .0          10
*
*hydro  ebt          trip no.       alpha vrc       numeric vrc
1540200 003
*
*hydro   time      pressure       tempe
1540201   0.       150720.        306.
*
*calibrate*
*calibrate$======================================================================
*calibrate$                    ht str no. 1161          hx shell
*calibrate*---------------------------------------------------------------------
*calibrate*htstr   ht strs  m pts  geom  init  l.coord    refl  b.vol  axl. incr
*calibrate11161000    4       4      2     0     0.5334 0   0          0
*calibrate*
*calibrate*htstr          mesh locn       mesh fmt
*calibrate11161100            0              1
*calibrate*
*calibrate*htstr          intervals       rt. coord
*calibrate11161101            3             0.5556
*calibrate*
*calibrate*htstr          compxn no.      interval
*calibrate11161201            1              3
*calibrate*
*calibrate*htstr          source          interval
*calibrate11161301          0.               3
*calibrate*
*calibrate*htstr                          temp flg
*calibrate11161400                           0
*calibrate*
*calibrate*htstr          temp            mesh pt.
*calibrate11161401         302.              4
*calibrate*
*calibrate*htstr     left vol     incr  b.cond   sa code  area/factor    ht str no.
*calibrate11161501   116010000    10000   1        1         1.6             4
*calibrate*
*calibrate*htstr     right vol    incr  b.cond   sa code  area/factor    ht str no.
*calibrate11161601   -501         0      4591      1         1.6             4
*calibrate*
*calibrate*htstr      s. type     s. mult     left heat  right heat    ht str no.
*calibrate11161701     0            0            0          0              4
*calibrate*
*calibrate*htstr     chf flag     hyd diam     equiv diam    ch. len     ht str no.
*calibrate11161801   0. 10. 10. 0. 0. 0. 0. 1.    4
*calibrate*
*calibrate*htstr     chf flag     hyd diam     equiv diam    ch. len     ht str no.
*calibrate11161901   0. 10. 10. 0. 0. 0. 0. 1.   4
*calibrate*
*
$==================================================================$
$                    ht str no. 1163          hx tube               $
*------------------------------------------------------------------*
*htstr   ht strs  m pts  geom  init  l.coord    refl  b.vol  axl. incr
11163000    4       4      2     1    8.636e-3    0     0        0
*
*htstr        mesh locn       mesh fmt
11163100          0              1
*
*htstr        intervals       rt. coord
11163101          3             9.525e-3
*
*htstr        compxn no.      interval
11163201          1              3
*
*htstr        source          interval
11163301        0.               3
*
*htstr                        temp flg
11163400                         0
*
*htstr        temp            mesh pt.
11163401       302.              4
*
*htstr    left vol     incr  b.cond   sa code  area/factor    ht str no.
11163501   116010000    10000   1        1         2672.           4
*
*htstr    right vol    incr  b.cond   sa code  area/factor    ht str no.
11163601   146040000   -10000   1        1         2672.           4
*
*htstr     s. type     s. mult     left heat  right heat    ht str no.
11163701     0            0            0          0              4
*
*htstr    chf flag     hyd diam     equiv diam    ch. len     ht str no.
11163801   0. 10. 10. 0. 0. 0. 0. 1.    4
*
*htstr    chf flag     hyd diam     equiv diam    ch. len     ht str no.
11163901   0. 10. 10. 0. 0. 0. 0. 1.    4
*
$==================================================================$
$                    ht str no. 1501          hx tube               $
*------------------------------------------------------------------*
*htstr   ht strs  m pts  geom  init  l.coord    refl  b.vol  axl. incr
11501000    4       4      2     1    0.2287      0     0        0
*
*htstr        mesh locn       mesh fmt
11501100          0              1
*
*htstr        intervals       rt. coord
11501101          3             0.2541
*
*htstr        compxn no.      interval
11501201          1              3
*
*htstr        source          interval
11501301        0.               3
*
*htstr                        temp flg
11501400                         0
*
*htstr        temp            mesh pt.
11501401       302.              4
*
*htstr    left vol     incr  b.cond   sa code  area/factor    ht str no.
11501501   150010000    10000   1        1         0.75            4
*
*htstr    right vol    incr  b.cond   sa code  area/factor    ht str no.
11501601   -501          0     4581      1         0.75            4
*
*htstr     s. type     s. mult     left heat  right heat    ht str no.
11501701     0            0            0          0              4
*
*htstr    chf flag     hyd diam     equiv diam    ch. len     ht str no.
11501801   0. 10. 10. 0. 0. 0. 0. 1.    4
*
*htstr    chf flag     hyd diam     equiv diam    ch. len     ht str no.
11501901   0. 10. 10. 0. 0. 0. 0. 1.    4
*
```

```
*----------------------------------------------------------------------$
*
*   thermal properties of composition   1  -  ss3041                   $
*----------------------------------------------------------------------$
*compxn       composition    th.con flg      ht.cap flg      material
20100100        tbl/fctn         1               1          $ss3041
*
*compxn       temperature            th. cond.
20100101        273.2                  14.7
20100102        300.                   15.2
20100103        400.                   17.0
20100104        500.                   18.4
20100105        600.                   19.8
20100106        700.                   21.2
20100107        800.                   22.5
20100108        900.                   23.9
20100109       1000.                   25.3
20100110       1200.                   28.1
20100111       1400.                   30.9
20100112      20000.                   30.9
*
*compxn       temperature            vol ht cap
20100151        273.2                  10.0
20100152        20000.                 10.0
*20100151        250.                    2.97e6
*20100152        478.                    3.00e6
*20100153        700.                    3.13e6
*20100154        811.                    3.23e6
*20100155        866.                    3.33e6
*20100156        922.                    3.43e6
*20100157       1033.                    3.59e6
*20100158       1200.                    3.76e6
*20100159       1311.                    3.82e6
*20100160       1400.                    3.82e6
*20100161      20000.                    3.82e6
*
*20504500 heattr  sum       385.342      -100632184.   0
*20504501 0. 1.,htrnr,108300100
*20504502    1.,htrnr,108300200
*20504503    1.,htrnr,108300300
*20504504    1.,htrnr,108300400
*20504505    1.,htrnr,108300500
*20504507    1.,htrnr,108300600
*20504508    1.,htrnr,108300700
*20504509    1.,htrnr,108300800
*20504510    1.,htrnr,108300900
*20504511    1.,htrnr,108301000
*
*======================================================================$
* table for water pool temperature - used as boundary condition for
* outside surfaces of hot and cold leg piping within the pool
*----------------------------------------------------------------------$
*                    table no. 501 - pool temp
*----------------------------------------------------------------------*
*table        table type   trip no.    factor 1    factor 2    constant
20250100        temp
*
*table                     time                  temp
20250101                   0.                  311.15
*
*======================================================================$
*      table no. 581 - htc from vertical piping - independent of length
*         assumes pool temperature of 311.15 K,  McAdams 0.13*Ra**1/3
*----------------------------------------------------------------------*
20258100  htc-temp
20258101  320.    613.       330.    855.       340.    1042.
20258102  350.   1197.       360.   1327.       370.    1467.
20258103  380.   1639.       390.   1793.       400.    1929.
20258104  410.   2049.       420.   2153.       430.    2295.
20258105  440.   2435.       450.   2562.       460.    2677.
*
. end of case
```

APPENDIX E: RELAP5/TECPLOT TRANSLATOR AND P0ST-PROCESSOR (rlptec5.f)

```
c
c This program reads a RELAP5 generated strip file and creates a
c TECPLOT-readable ASCII data file.
c
c Written by M. W. Wendel (615-574-2825)
c
c........1.........2.........3.........4.........5.........6.........7..
      implicit double precision (a-h,o-z)
      dimension calc(600,10000),calc1(600,10000)
      dimension costar(20),chfavr(10),chfr(20),szmodr(20),suphtr(20),
     .          vel(20),szr(20)
      real ibr(20), ibmin
      common /pool/  pool(4,138)
      dimension qmhxp(10000),qehxp(10000),qhl1(10000),qhlc(10000),
     .          qcl(10000)
      character*8 names(600),adummy
      character*5 tecnam(600)
      character*10 nums(600),filnam
      character*40 title
      real al1, al2, al3
c dimension peaking factors corresponding to three standard deviation levels
      dimension pfsz95(3),pfsz99(3),pftw95(3),pftw99(3),pfib95(3),
     .          pfib99(3)
c
c Peaking factors for Costa, Saha-Zuber, and Twall = Tsat
c For Costa, a standard deviation of 10% was assumed.
c For Saha-Zuber and Twall=Tsat, three standard deviations are used:
c
c                                        Saha-Zuber    Twall=Tsat
c     Pe > 70,000 and velocity > 8 m/s       16%           3.3% (3)
c     Pe > 70,000 and velocity < 8 m/s       30% (1)       3.3%
c     Pe < 70,000 and velocity < 8 m/s       75% (2)       3.3%
c
c (1) not applied for 99.9% probability due to very large peaking factor.
c (2) not applied for either probability due to very large peaking factor.
c (3) not applied for 95% probability.
c
c  For 95% probability level in the Costa correlation
      data pfco95 /1.305/
c  For 99.9% probability level in the Costa correlation
      data pfco99 /1.592/
c
c  Saha Zuber peaking factors (used only for Pe > 70,000)
c  95% probability
      data pfsz95 /1.52,2.08,1.d6/
c  99.9% probability
      data pfsz99 /2.30,1.d6,1.d6/
c
c  Twall=Tsat  peaking factors
c  95% probability
      data pftw95 /1.16,1.16,1.16/
c  99.9% probability
      data pftw99 /1.25,1.25,1.25/
c
c  Incipient boiling peaking factors  (same as for chf)
c  95% probability
      data pfib95 /1.30,1.30,1.30/
c  99.9% probability
      data pfib99 /1.59,1.59,1.59/
c
c  Critical Heat FLux peaking factors
c  95% probability
      data pfg95a /1.631/
      data pfg95b /1.554/
c  99.9% probability
      data pfg99a /1.995/
      data pfg99b /1.899/
c
      data dh /0.0025/
conversion=conversion=conversion=conversion=conversion=conversion=conver
c
c Conversion factors from SI to British
c
c   Pressure
      data cpres /1.0/
c   Mass
      data cmass /1.0/
c   Internal energy
      data cu /1.0/
c   Temperature
      data ctemp1,ctemp2 /1.0,1.0/
c   Heat flux
      data chtflx /1.0/
c   Pump velocity
      data cpmpv /1.0/
c   Power
      data cpower /1.0/
c   Density
      data cdens /1.0/
c   Velocity
      data cvel /1.0/
c   Interfacial area heat transfer coeff. density
      data chi /1.0/
conversion=conversion=conversion=conversion=conversion=conversion=conver
c
      open(unit=21,file='strip.dat',status='old',form='formatted')
      open(unit=22,file='tecdat',status='unknown',form='formatted')
      open(unit=23,file='chf4dat',status='unknown')
      open(unit=24,file='chf5dat',status='unknown')
      open(unit=28,file='twalldat',status='unknown')
      open(unit=29,file='ibdat',status='unknown')
c      open(unit=26,file='axialldat',status='unknown')
c      open(unit=27,file='axialudat',status='unknown')
c      open(unit=17,file='debug',status='unknown',form='formatted')
      write(28,9100)
 9100 format('time,qlim,hflx,sbcool,hlim')
      write(29,9101)
 9101 format('time,qib,hflx,twalib,hib')
      pi = 4.*atan(1.0)
      write(6,985)
      read(6,979) title
      if(title(1:1).eq.'-') then
        copf95 = pfco95
        copf99 = pfco99
        do 3 m=1,3
          pfsz95(m) = 1.0
          pfsz99(m) = 1.0
          pfib95(m) = 1.0
          pfib99(m) = 1.0
          pftw95(m) = 1.0
          pftw99(m) = 1.0
    3   continue
      else
        copf95 = 1.0
        copf99 = 1.0
      endif
    5 continue
      zero = 0.d0
      ithin = 1
      nn = 0
c
c Read list of variables from strip file
c
      read(21,990)adummy
      read(21,990)adummy
      read(21,999) nt
      nt=nt-1
      ntw = nt
      nl = nt/8
      last = min(nt,7)
      read(21,998)(names(i),i=1,last)
      if(nl.gt.0) then
       do 10 j=1,nl
        last = min(nt,7+j*8)
        ifirst = 8*j
        read(21,988)(names(i),i=ifirst,last)
   10  continue
      endif
      read(21,991)(nums(i)(2:10),i=1,nt)
c
c Read time-dependent data for requested variables
c
      do 20 i=1,10000
       n1 = 1
       n2 = 4
       n2 = min(nt,n2)
       read(21,982,end=30)(calc(j,i),j=n1,n2)
       n1 = 5
       do 25 ii=1,2000
        if(n2.ge.nt) go to 21
        n2 = n1+4
        read(21,986,end=30)(calc(j,i),j=n1,n2)
```

```fortran
      n1 = n1+5
   25 continue
   21 if(mod(i,100).eq.0)write(6,984)i
   20 continue
   30 ilst=i-1
      write(6,994)ilst
c
c Scan the data, change some names, define pointers
c
      do 40 n=1,nt
       conv1 = 1.
       conv2 = 0.
       if(names(n).eq.'p       ')then
        tecnam(n) = ' p    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = cpres
       else if(names(n).eq.'hig     ') then
        tecnam(n) = 'hi    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = 1.0
        conv2 = 0.
       else if(names(n).eq.'floreg  ') then
        tecnam(n) = 'fr    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = 1.0
        conv2 = 0.
       else if(names(n).eq.'tempf   ') then
        if(nums(n)(2:6).eq.'51501') ltempf = n-1
        tecnam(n) = 'tf    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = ctempl
        conv2 = ctemp2
       else if(names(n).eq.'httemp  ') then
        if(nums(n)(2:10).eq.'550100204') lh=n-1
        if(nums(n)(2:10).eq.'515500501') lhstr=n-1
        tecnam(n) = 't     '
        tecnam(n)(2:5) = nums(n)(2:5)
        conv1 = ctempl
        conv2 = ctemp2
       else if(names(n).eq.'hthtc   ') then
        tecnam(n) = 'h     '
        tecnam(n)(3:5) = nums(n)(2:5)
        conv1 = 1.0
        conv2 = 0.0
       else if(names(n).eq.'htmode  ') then
        tecnam(n) = 'hm    '
        tecnam(n)(3:5) = nums(n)(3:5)
        conv1 = 1.0
        conv2 = 0.0
       else if(names(n).eq.'hthtc   ') then
        tecnam(n) = 'hm    '
        tecnam(n)(3:5) = nums(n)(3:5)
        conv1 = 1.0
        conv2 = 0.0
       else if(names(n).eq.'htvat   ') then
        tecnam(n) = 'ha    '
        tecnam(n)(3:5) = nums(n)(3:5)
        conv1 = ctempl
        conv2 = ctemp2
       else if(names(n).eq.'tempg   ') then
        tecnam(n) = 'tg    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = ctempl
        conv2 = ctemp2
       else if(names(n).eq.'sattemp ')then
        tecnam(n) = 'st    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = ctempl
        conv2 = ctemp2
        if(nums(n)(2:6).eq.'51501') lsat = n-1
       else if(names(n).eq.'mflowj  ') then
        tecnam(n) = 'mf    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = cmass
       else if(names(n).eq.'emass   ') then
        tecnam(n) = 'emass'
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = cmass
       else if(names(n).eq.'tmass   ') then
        tecnam(n) = 'tmass'
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = cmass
       else if(names(n).eq.'htchf   ') then
        if(nums(n)(2:8).eq.'5101001') lchfav=n-1
        if(nums(n)(2:8).eq.'5154001') lchfht=n-1
        tecnam(n) = 'c     '
        tecnam(n)(2:5) = nums(n)(2:5)
        conv1 = chtflx
       else if(names(n).eq.'htrnr   ') then
        if(nums(n)(2:8).eq.'5101001') lflxav=n-1
        if(nums(n)(2:8).eq.'5155001') lflxht=n-1
        if(nums(n)(2:8).eq.'5154001') lflchf=n-1
        if(nums(n)(2:8).eq.'1081001') lpool=n-1
        if(nums(n)(2:8).eq.'1083001') lmhx=n-1
        if(nums(n)(2:5).eq.'1083'.or.nums(n)(2:5).eq.'2083'.
     .     or.nums(n)(2:5).eq.'3083') then
          nmhx = nmhx+1
          conv1 = 433.9405
          tecnam(n) = 'Q     '
          tecnam(n)(2:5) = nums(n)(2:5)
        else if(nums(n)(2:5).eq.'1081'.or.npool.ne.0) then
          npool=npool+1
          rad = pool(2,npool)
          xfac = pool(3,npool)
          geo = pool(4,npool)
          if(geo.gt.1) then
           conv1 = xfac*2*pi*rad*chtflx
          endif
          if(geo.lt.1.5) conv1 = xfac*chtflx
          tecnam(n) = 'Q     '
          tecnam(n)(2:5) = nums(n)(2:5)
        else
          tecnam(n) = 'Q     '
          tecnam(n)(2:5) = nums(n)(2:5)
          conv1 = chtflx
        endif
       else if(names(n).eq.'Costa fl') then
        tecnam(n) = 'Co    '
        tecnam(n)(3:5) = nums(n)(3:5)
        conv1 = chtflx
       else if(names(n).eq.'rhofj   ') then
        tecnam(n) = 'rj    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = cdens
       else if(names(n).eq.'vapgen  ') then
        tecnam(n) = 'vg    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = cdens
       else if(names(n).eq.'rhog    ') then
        tecnam(n) = 'rg    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = cdens
       else if(names(n).eq.'rhof    ') then
        tecnam(n) = 'rf    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = cdens
       else if(names(n).eq.'rhogj   ') then
        tecnam(n) = 'rj    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = cdens
       else if(names(n).eq.'thconf  ') then
        tecnam(n) = ' k    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = 1.0
        if(nums(n)(2:6).eq.'51501') lk = n-1
       else if(names(n).eq.'viscf   ') then
        tecnam(n) = 'mu    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = 1.0
        if(nums(n)(2:6).eq.'51501') lvis = n-1
       else if(names(n).eq.'rho     ') then
        tecnam(n) = ' r    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = cdens
       else if(names(n).eq.'gammaw  ') then
        tecnam(n) = 'ga    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = cdens
       else if(names(n).eq.'hif     ') then
        tecnam(n) = 'hf    '
        tecnam(n)(3:5) = nums(n)(2:4)
        conv1 = chi
```

```
        else if(names(n).eq.'hig     ') then
         tecnam(n) = 'hg   '
         tecnam(n)(3:5) = nums(n)(2:4)
         convl = chi
        else if(names(n).eq.'pmphead ') then
         tecnam(n) = 'ph   '
         tecnam(n)(3:5) = nums(n)(8:10)
         convl = cpres
        else if(names(n).eq.'pmpvel  ') then
         tecnam(n) = 'pv   '
         tecnam(n)(3:5) = nums(n)(8:10)
         convl = cpmpv
        else if(names(n).eq.'uf      ') then
         tecnam(n) = 'uf   '
         tecnam(n)(3:5) = nums(n)(2:4)
         convl = cu
        else if(names(n).eq.'ug      ') then
         tecnam(n) = 'ug   '
         tecnam(n)(3:5) = nums(n)(2:4)
         convl = cu
        else if(names(n).eq.'ufj     ') then
         tecnam(n) = 'uj   '
         tecnam(n)(3:5) = nums(n)(2:4)
         convl = cu
        else if(names(n).eq.'ugj     ') then
         tecnam(n) = 'uj   '
         tecnam(n)(3:5) = nums(n)(2:4)
         convl = cu
        else if(names(n).eq.'q       ') then
         tecnam(n) = ' q   '
         tecnam(n)(3:5) = nums(n)(2:4)
         convl = cpower
        else if(names(n).eq.'qwg     ') then
         tecnam(n) = 'qw   '
         tecnam(n)(3:5) = nums(n)(2:4)
         convl = cpower
        else if(names(n).eq.'velfj   ') then
         tecnam(n) = 'vj   '
         tecnam(n)(3:5) = nums(n)(2:4)
         convl = cvel
        else if(names(n).eq.'velgj   ') then
         tecnam(n) = 'vj   '
         tecnam(n)(3:5) = nums(n)(2:4)
         convl = cvel
        else if(names(n).eq.'velf    ') then
         if(nums(n)(2:10).eq.'515010000') lvel = n-1
         tecnam(n) = 'vf   '
         tecnam(n)(3:5) = nums(n)(2:4)
         convl = cvel
        else if(names(n).eq.'velg    ') then
         tecnam(n) = 'vg   '
         tecnam(n)(3:5) = nums(n)(2:4)
         convl = cvel
        else if(names(n).eq.'sounde  ') then
         tecnam(n) = 'so   '
         tecnam(n)(3:5) = nums(n)(2:4)
         convl = cvel
        else if(names(n).eq.'voidg   ') then
         tecnam(n) = 'vd   '
         tecnam(n)(3:5) = nums(n)(2:4)
        else if(names(n).eq.'voidf   ') then
         if(nums(n)(2:6).eq.'15601') lp = n-1
         tecnam(n) = 'vl   '
         tecnam(n)(3:5) = nums(n)(2:4)
        else if(names(n).eq.'quals   ') then
         tecnam(n) = 'qs   '
         tecnam(n)(3:5) = nums(n)(2:4)
        else if(names(n).eq.'quale   ') then
         tecnam(n) = 'qe   '
         tecnam(n)(3:5) = nums(n)(2:4)
        else if(names(n).eq.'quala   ') then
         tecnam(n) = 'qa   '
         tecnam(n)(3:5) = nums(n)(2:4)
        else if(names(n).eq.'cputime ') then
         tecnam(n) = 'cpu-s'
        else if(names(n).eq.'acvliq  ') then
         tecnam(n) = 'ac   '
         tecnam(n)(3:5) = nums(n)(2:4)
        else if(names(n).eq.'rkfipow ') then
         tecnam(n) = 'rkfis'
        else if(names(n).eq.'rkfipow ') then
         tecnam(n) = 'rkfis'
        else if(names(n).eq.'rkgapow ') then
         tecnam(n) = 'rkgam'
        else if(names(n).eq.'rkreac  ') then
         tecnam(n) = 'react'
        else if(names(n).eq.'rktpow  ') then
         tecnam(n) = 'rktpw'
        else if(names(n).eq.'cntrlvar') then
         tecnam(n) = 'cv   '
         if(nums(n)(8:10).eq.'203') lco = n-1
         if(nums(n)(8:10).eq.'280') lsh = n-1
         if(nums(n)(8:10).eq.'301') then
           lpe = n-1
           tecnam(n) = 'pe   '
         endif
         if(nums(n)(8:10).eq.'445') lpr = n-1
         if(nums(n)(8:10).eq.'202') lsc = n-1
         if(nums(n)(8:10).eq.'835') lpexl = n-1
         if(nums(n)(8:10).eq.'837') lpexu = n-1
         tecnam(n)(3:5) = nums(n)(8:10)
        endif
         nn = nn+1
          do 35 i=1,ilst
           calcl(nn,i) = convl*calc(n,i)-conv2
 35       continue
 40   continue
c.......1.........2.........3.........4.........5.........6.........7..
c
c Write tecdat information
c
      tecnam(1) = ' time'
      write(22,992) title,tecnam(1)
      write(23,992)title,tecnam(1)
      write(24,992)title,tecnam(1)
      do 11 i=2,ntw
        if((i.lt.lpool+1.or.i.gt.lpool+npool+nmhx+1) .and.
     .    (i.lt.lvis+1.or.i.gt.lvis+120)) write(22,997)tecnam(i)
 11   continue
      write(22,997)'alev1'
      write(22,997)'alev2'
      write(22,997)'alev3'
      write(22,997)'accfl'
      write(22,997)'CPBTM'
      write(22,997)'CRAlM'
      write(22,997)'CRHfM'
      write(22,997)'CPBTS'
      write(22,997)'CRAlS'
      write(22,997)'CRHfS'
c Upper core hot stripe surface temperatures
      write(22,997)'S1CHF'
      write(22,997)'S2CHF'
      write(22,997)'S3CHF'
      write(22,997)'S4CHF'
      write(22,997)'S5CHF'
      write(22,997)'S1FE '
      write(22,997)'S2FE '
      write(22,997)'S3FE '
      write(22,997)'S4FE '
      write(22,997)'S5FE '
c Upper core hot stripe centerline temperatures
      write(22,997)'C1CHF'
      write(22,997)'C2CHF'
      write(22,997)'C3CHF'
      write(22,997)'C4CHF'
      write(22,997)'C5CHF'
      write(22,997)'C1FE '
      write(22,997)'C2FE '
      write(22,997)'C3FE '
      write(22,997)'C4FE '
      write(22,997)'C5FE '
c Thermal Limits in Hot Channels
      write(22,997)'tL5-1'
      write(22,997)'iL5-1'
      write(22,997)'cL5-1'
      write(22,997)'mL5-1'
      write(22,997)'zL5-1'
      write(22,997)'fL5-1'
      write(22,997)'tL5-2'
      write(22,997)'iL5-2'
      write(22,997)'cL5-2'
      write(22,997)'mL5-2'
```

```
      write(22,997)'zL5-2'
      write(22,997)'fL5-2'
      write(22,997)'tL5-3'
      write(22,997)'iL5-3'
      write(22,997)'cL5-3'
      write(22,997)'mL5-3'
      write(22,997)'zL5-3'
      write(22,997)'fL5-3'
      write(22,997)'tL5-4'
      write(22,997)'iL5-4'
      write(22,997)'cL5-4'
      write(22,997)'mL5-4'
      write(22,997)'zL5-4'
      write(22,997)'fL5-4'
      write(22,997)'tL5-5'
      write(22,997)'iL5-5'
      write(22,997)'cL5-5'
      write(22,997)'mL5-5'
      write(22,997)'zL5-5'
      write(22,997)'fL5-5'
      write(22,997)'tL9-1'
      write(22,997)'iL9-1'
      write(22,997)'cL9-1'
      write(22,997)'mL9-1'
      write(22,997)'zL9-1'
      write(22,997)'fL9-1'
      write(22,997)'tL9-2'
      write(22,997)'iL9-2'
      write(22,997)'cL9-2'
      write(22,997)'mL9-2'
      write(22,997)'zL9-2'
      write(22,997)'fL9-2'
      write(22,997)'tL9-3'
      write(22,997)'iL9-3'
      write(22,997)'cL9-3'
      write(22,997)'mL9-3'
      write(22,997)'zL9-3'
      write(22,997)'fL9-3'
      write(22,997)'tL9-4'
      write(22,997)'iL9-4'
      write(22,997)'cL9-4'
      write(22,997)'mL9-4'
      write(22,997)'zL9-4'
      write(22,997)'fL9-4'
      write(22,997)'tL9-5'
      write(22,997)'iL9-5'
      write(22,997)'cL9-5'
      write(22,997)'mL9-5'
      write(22,997)'zL9-5'
      write(22,997)'fL9-5'
* upper core
      write(22,997)'tU5-1'
      write(22,997)'iU5-1'
      write(22,997)'cU5-1'
      write(22,997)'mU5-1'
      write(22,997)'zU5-1'
      write(22,997)'fU5-1'
      write(22,997)'tU5-2'
      write(22,997)'iU5-2'
      write(22,997)'cU5-2'
      write(22,997)'mU5-2'
      write(22,997)'zU5-2'
      write(22,997)'fU5-2'
      write(22,997)'tU5-3'
      write(22,997)'iU5-3'
      write(22,997)'cU5-3'
      write(22,997)'mU5-3'
      write(22,997)'zU5-3'
      write(22,997)'fU5-3'
      write(22,997)'tU5-4'
      write(22,997)'iU5-4'
      write(22,997)'cU5-4'
      write(22,997)'mU5-4'
      write(22,997)'zU5-4'
      write(22,997)'fU5-4'
      write(22,997)'tU5-5'
      write(22,997)'iU5-5'
      write(22,997)'cU5-5'
      write(22,997)'mU5-5'
      write(22,997)'zU5-5'
      write(22,997)'fU5-5'
      write(22,997)'tU9-1'
      write(22,997)'iU9-1'
      write(22,997)'cU9-1'
      write(22,997)'mU9-1'
      write(22,997)'zU9-1'
      write(22,997)'fU9-1'
      write(22,997)'tU9-2'
      write(22,997)'iU9-2'
      write(22,997)'cU9-2'
      write(22,997)'mU9-2'
      write(22,997)'zU9-2'
      write(22,997)'fU9-2'
      write(22,997)'tU9-3'
      write(22,997)'iU9-3'
      write(22,997)'cU9-3'
      write(22,997)'mU9-3'
      write(22,997)'zU9-3'
      write(22,997)'fU9-3'
      write(22,997)'tU9-4'
      write(22,997)'iU9-4'
      write(22,997)'cU9-4'
      write(22,997)'mU9-4'
      write(22,997)'zU9-4'
      write(22,997)'fU9-4'
      write(22,997)'tU9-5'
      write(22,997)'iU9-5'
      write(22,997)'cU9-5'
      write(22,997)'mU9-5'
      write(22,997)'zU9-5'
      write(22,997)'fU9-5'
c critical heat flux ratio limits at average channels
      write(22,997)'favL1'
      write(22,997)'favL2'
      write(22,997)'favL3'
      write(22,997)'favL4'
      write(22,997)'favL5'
      write(22,997)'favU1'
      write(22,997)'favU2'
      write(22,997)'favU3'
      write(22,997)'favU4'
      write(22,997)'favU5'
      write(22,997)'COmin'
      write(22,997)'SZmin'
      write(22,997)'CFmin'
      write(22,997)'shmin'
      write(22,997)'ibmin'
      write(22,997)'SHmax'
      if(lpool.gt.0) then
        write(22,997)'qpool'
        write(22,997)'qmhx'
        write(22,997)'qmhxp'
        write(22,997)'qehxp'
        write(22,997)'qhll'
        write(22,997)'qhlc'
        write(22,997)'qcl'
      endif
      write(23,997)'CHFU4'
      write(24,997)'CHFU5'
c
c sum heat transfer components from piping to pool
c
c  qpool = total heat from piping and heat exchanger shells to pool
c  qmhx  = heat removal from main heat exchanger primary to secondary system
c  qmhxp = heat removal from main heat exchanger shell to pool
c  qehxp = heat removal from emergency heat exchanger shell to pool
c  qhll  = heat removal from all four hot leg loop piping to pool
c  qhlc  = heat removal from common hot leg to pool
c  qcl   = total heat removal from all four cold legs to pool
c          (including CPBT inlet volumes)
c
      do 143 i=1,ilst
      qmhxp(i) = 0.
      qehxp(i) = 0.
      qhll(i) = 0.
      qhlc(i) = 0.
      qcl(i) = 0.
       do 144 ih=1,11
        qmhxp(i) = qmhxp(i) + calcl(lpool+ih,i)
  144  continue
       do 145 ih=12,19
        qehxp(i) = qehxp(i) + calcl(lpool+ih,i)
```

```
  145 continue
      do 146 ih=20,30
       qmhxp(i) = qmhxp(i) + calc1(lpool+ih,i)
  146 continue
      do 147 ih=31,38
       qehxp(i) = qehxp(i) + calc1(lpool+ih,i)
  147 continue
      do 148 ih=39,49
       qmhxp(i) = qmhxp(i) + calc1(lpool+ih,i)
  148 continue
      do 149 ih=50,57
       qehxp(i) = qehxp(i) + calc1(lpool+ih,i)
  149 continue
      do 150 ih=58,63
       qhll(i) = qhll(i) + calc1(lpool+ih,i)
  150 continue
      do 151 ih=64,78
       qcl(i) = qcl(i) + calc1(lpool+ih,i)
  151 continue
      do 160 ih=79,84
       qhll(i) = qhll(i) + calc1(lpool+ih,i)
  160 continue
      do 161 ih=85,97
       qcl(i) = qcl(i) + calc1(lpool+ih,i)
  161 continue
      do 170 ih=98,101
       qhll(i) = qhll(i) + calc1(lpool+ih,i)
  170 continue
      do 171 ih=102,114
       qcl(i) = qcl(i) + calc1(lpool+ih,i)
  171 continue
      qhll(i) = qhll(i) + calc1(lpool+115,i)
      do 172 ih=116,126
      qcl(i) = qcl(i) + calc1(lpool+ih,i)
  172 continue
      do 173 ih=127,138
      qhlc(i) = qhlc(i) + calc1(lpool+ih,i)
  173 continue
  143 continue
c
      ii = 0
      write(22,995)
      do 45 i=1,ilst
       ii = ii+1
        l1 = lp
        comin = 1.d6
        szmin = 1.d6
        shmax = -900.
        shmin = 1.d6
        chfmin = 1.d6
        icomin = 0
        iszmin = 0
        ishmax = 0
        ishmin = 0
        ichmin = 0
        do 39 m=1,20
          vel(m) = calc1(lvel+m,i)
   39   continue
c
c translate time variable backwards by 10 s (start transient at time=0)
c
        calc1(1,i) = calc1(1,i)-10.
        if(calc1(1,i).lt.0.d0) go to 45
        if(calc1(1,i).eq.0.d0) calc1(1,i)=1.d-6
        al1 = calc1(l1+1,i)*4.09+(calc1(l1+2,i)+calc1(l1+3,i)+
     .        calc1(l1+4,i)+calc1(l1+5,i))*0.12-4.88*(1.-calc(l1+6,i))
c
        l1 = lp+6
        al2 = calc1(l1+1,i)*4.09+(calc1(l1+2,i)+calc1(l1+3,i)+
     .        calc1(l1+4,i)+calc1(l1+5,i))*0.12-4.88*(1.-calc(l1+6,i))
c
        l1 = lp+12
        al3 = calc1(l1+1,i)*4.09+(calc1(l1+2,i)+calc1(l1+3,i)+
     .        calc1(l1+4,i)+calc1(l1+5,i))*0.12-4.88*(1.-calc(l1+6,i))
c
        accfl = calc1(2,i)+calc1(3,i)+calc1(4,i)
        qpool = 0.
        qmhx = 0.
        do 43 ih= 1,30
         qmhx = qmhx+calc1(lmhx+ih,i)
   43   continue
        do 44 ih= 1,npool
         qpool = qpool+calc1(lpool+ih,i)
   44   continue
c
c........1.........2.........3.........4.........5.........6.........7..
c
c  Costa ratios
        do 46 m = 1,5
        costar(m) = max(0.00001d0,copf95*calc1(lco+m,i)/
     .                  calc1(lflxht+m,i))
        if(costar(m).lt.comin) then
          comin = costar(m)
          icomin = m
        endif
        if(costar(m).lt.1.0) icowrn = icowrn+1
   46   continue
        do 47 m = 6,10
        costar(m) = max(0.00001d0,copf99*calc1(lco+m,i)/
     .                  calc1(lflxht+m,i))
        if(costar(m).lt.comin) then
          comin = costar(m)
          icomin = 10+m
        endif
        if(costar(m).lt.1.0) icowrn = icowrn+1
   47   continue
        do 48 m = 11,15
        costar(m) = max(0.00001d0,copf95*calc1(lco+m,i)/
     .                  calc1(lflxht+m,i))
        if(costar(m).lt.comin) then
          comin = costar(m)
          icomin = -5+m
        endif
        if(costar(m).lt.1.0) icowrn = icowrn+1
   48   continue
        do 49 m = 16,20
        costar(m) = max(0.00001d0,copf99*calc1(lco+m,i)/
     .                  calc1(lflxht+m,i))
        if(costar(m).lt.comin) then
          comin = costar(m)
          icomin = m
        endif
        if(costar(m).lt.1.0) icowrn = icowrn+1
   49   continue
c
c........1.........2.........3.........4.........5.........6.........7..
c
c Calculate Modified and Unmodified Saha-Zuber thermal limit ratio
        do 56 m=1,20
          pe = abs(calc1(lpe+m,i))
          pr = calc1(lpr+m,i)
          ckb = calc1(lk+m,i)
          re = pe/pr
          sbcool = calc1(lsc+m,i)
          dh = 0.002498
          if(m.gt.10) dh = 0.002494
          fact = 0.55 + 11.21/sbcool
c
c Determine peaked heat flux
c
          if(pe.ge.70000.) then
            qlim = 0.0065*re*pr*ckb/dh*sbcool*fact
            if(vel(m).gt.8.) then
              if(m.le.5.or.(m.ge.11.and.m.le.15)) then
                pf = pfsz95(1)
                hflx = pf*calc1(lflxht+m,i)/pfco95
              else
                pf = pfsz99(1)
                hflx = pf*calc1(lflxht+m,i)/pfco99
              endif
            else
              if(m.le.5.or.(m.ge.11.and.m.le.15)) then
                pf = pfsz95(2)
                hflx = pf*calc1(lflxht+m,i)/pfco95
              else
                pf = pfsz99(2)
                hflx = pf*calc1(lflxht+m,i)/pfco99
              endif
            endif
          else
            qlim = 455.*ckb/dh*sbcool*fact
            if(m.le.5.or.(m.ge.11.and.m.le.15)) then
```

```
            pf = pfsz95(3)
            hflx = pf*calc1(lflxht+m,i)/pfco95
          else
            hflx = pf*calc1(lflxht+m,i)/pfco99
            pf = pfsz99(3)
          endif
        endif
c
        szmodr(m) = max(0.00001d0,qlim/hflx)
        szr(m) = max(0.00001d0,qlim/hflx/fact)
        if(szmodr(m).lt.shmin.and.szmodr(m).gt.0.0001d0) then
          szmin  = szmodr(m)
          iszmin = m
        endif
        if(szmodr(m).lt.1.0) iszwrn = iszwrn+1
   56   continue
c
c........1.........2.........3.........4.........5.........6.........7..
c
c  CHF ratios
c
c Average Fuel
       do 70 m = 1,10
       chfavr(m) = max(0.00001d0,calc1(lchfav+m,i)/calc1(lflxav+m,i))
       if(chfavr(m).lt.chfmin.and.chfavr(m).gt.0.000011d0) then
         chfmin = chfavr(m)
         ichmin = m+20
       endif
       if(chfavr(m).gt.100.) ichwrn = ichwrn+1
   70  continue
c Hot Fuel
       do 75 m = 1,20
       fp = 1.
c divide out the peaking factor from CHF hot stipe flux if requested
       if(title(1:1).eq.'-') then
         if(m.le.5.or.(m.ge.11.and.m.le.15)) then
           if(m.eq.5.or.m.eq.10.or.m.eq.11.or.m.eq.15) then
             fp = 1./pfg95a
           else
             fp = 1./pfg95b
           endif
         else
           if(m.eq.5.or.m.eq.10.or.m.eq.11.or.m.eq.15) then
             fp = 1./pfg99a
           else
             fp = 1./pfg99b
           endif
         endif
       endif
c........1.........2.........3.........4.........5.........6.........7..
       chfr(m) = max(0.00001d0,calc1(lchfht+m,i)/
     .                (calc1(lflchf+m,i)*fp))
       if(chfr(m).lt.chfmin.and.chfr(m).gt.0.000011d0) then
         chfmin = chfr(m)
         ichmin = m
       endif
       if(chfr(m).gt.100.) ichwrn = ichwrn+1
   75  continue
c
c Calculate Petukhov heat flux based on Tbulk and Tsat
c at hot channel exit locations only
       do 76 m=1,20
         pe = abs(calc1(lpe+m,i))
         pr = calc1(lpr+m,i)
         re = pe/pr
         tsat = calc1(lsat+m,i)
         sbcool = calc1(lsc+m,i)
         const = 1.0875 - 0.1125*(1.143/87.35)
         dh = 0.002498
         vissat = d2ovis(tsat)
         visrat = calc1(lvis+m,i)/vissat
cmwq 8-3-95 ERROR: SHOULD BE m.gt.10
         if(m.gt.2) then
           const = 1.0875 - 0.1125*(1.143/70.29)
           dh = 0.002494
         endif
         fd = const/(1.82*log10(re)-1.64)**2
         hturb = fd/8.*calc1(lk+m,i)/dh*pe*visrat**0.11/
     .          ((1+3.4*fd)+(11.7+1.8/pr**0.3333)*(fd/8.)**0.5*
     .          (pr**0.6667-1.))
         hlam = 7.63*calc1(lk+m,i)/dh
         if(hlam.gt.hturb) then
           write(6,962)calc1(1,i),m,re
           hlim = hlam
         else
           hlim = hturb
         endif
         qlim = hlim*sbcool
c
c Determine peaked heat flux
c
         if(pe.ge.70000.) then
           if(vel(m).gt.8.) then
             if(m.le.5.or.(m.ge.11.and.m.le.15)) then
               pf = pftw95(1)
               hflx = pf*calc1(lflxht+m,i)/pfco95
             else
               pf = pftw99(1)
               hflx = pf*calc1(lflxht+m,i)/pfco99
             endif
           else
             if(m.le.5.or.(m.ge.11.and.m.le.15)) then
               pf = pftw95(2)
               hflx = pf*calc1(lflxht+m,i)/pfco95
             else
               pf = pftw99(2)
               hflx = pf*calc1(lflxht+m,i)/pfco99
             endif
           endif
         else
           if(m.le.5.or.(m.ge.11.and.m.le.15)) then
             pf = pftw95(3)
             hflx = pf*calc1(lflxht+m,i)/pfco95
           else
             pf = pftw99(3)
             hflx = pf*calc1(lflxht+m,i)/pfco99
           endif
         endif
c
      if(m.eq.10) write(28,9102) calc1(1,i),qlim,hflx,sbcool,hlim
         suphtr(m) = max(0.00001d0,qlim/hflx)
         if(suphtr(m).lt.shmin.and.suphtr(m).gt.0.0001d0) then
           shmin  = suphtr(m)
           ishmin = m
         endif
   76  continue
c
c........1.........2.........3.........4.........5.........6........7..
c
c Calculate Bergles-Rohsenow heat flux at hot channel exit locations only
       do 77 m=1,20
         pe = abs(calc1(lpe+m,i))
         pr = calc1(lpr+m,i)
         ckb = calc1(lk+m,i)
         tsat = calc1(lsat+m,i)
         sbcool = calc1(lsc+m,i)
         visblk = calc1(lvis+m,i)
         re = pe/pr
         if(m.gt.10) then
           const = 1.0875 - 0.1125*(1.143/70.29)
           dh = 0.002494
           pexit = calc1(lpexl+1,i)
         else
           const = 1.0875 - 0.1125*(1.143/87.35)
           dh = 0.002498
           pexit = calc1(lpexu+1,i)
         endif
         call incip(tsat-sbcool,tsat,pexit,re,pr,dh,visblk,const,
     .              ckb,qib,hib,twalib,ilam,ierr)
         if(ierr.eq.1) write(6,970)twalib,qib,calc1(1,i),m
         if(ilam.eq.1) write(6,963)calc1(1,i),m,re
c
c Determine peaked heat flux
c
         if(m.le.5.or.(m.ge.11.and.m.le.15)) then
           pf = pfib95(1)
           hflx = pf*calc1(lflxht+m,i)/pfco95
         else
           pf = pfib99(1)
           hflx = pf*calc1(lflxht+m,i)/pfco99
         endif
         ibr(m) = max(0.00001d0,qib/hflx)
```

```
          if(ibr(m).lt.ibmin.and.ibr(m).gt.0.0001d0) then
            ibmin  = ibr(m)
            xibmin = float(m)
          endif
        if(m.eq.10) write(29,9102) calc1(1,i),qib,hflx,twalib,hib
 9102 format(5(1X,e15.7))
   77   continue
c
c SUPERHEAT MAXIMUM
        do 79 ish=1,30
        if(calc1(lsh+ish,i).gt.shmax) then
          shmax  = calc1(lsh+ish,i)
          ishmax = lsh+ish
        endif
        if(calc1(lsh+ish,i).gt.0.0) ishwrn = ishwrn+1
   79   continue
c
      xcomin = float(icomin)
      xchmin = float(ichmin)
      xszmin = float(iszmin)
      xshmin = float(ishmin)
      xshmax = float(ishmax)
c
c.......1.........2.........3.........4.........5.........6........7..
      if(lpool.eq.0) then
       write(22,993)(calc1(j,i),j=1,lvis),(calc1(j,i),j=lvis+121,ntw),
     .al1,al2,al3,accfl,(calc1(lh+ih,i)-calc1(lh+ih,1),ih=1,26),
     .(suphtr(m),ibr(m),costar(m),szmodr(m),szr(m),chfr(m),m=1,20),
     .(chfavr(m),m=1,10),comin,szmin,chfmin,shmin,ibmin,shmax
      else
       write(22,993)(calc1(j,i),j=1,lvis),
     .          (calc1(j,i),j=lvis+121,lpool),
     .(calc1(j,i),j=lpool+npool+nmhx+1,ntw),al1,al2,al3,accfl,
     .(calc1(lh+ih,i)-calc1(lh+ih,1),ih=1,26),
     .(suphtr(m),ibr(m),costar(m),szmodr(m),szr(m),chfr(m),m=1,20),
     .(chfavr(m),m=1,10),
     .comin,szmin,chfmin,shmin,ibmin,shmax,
     . qpool,qmhx,qmhxp(i),qehxp(i),qhll(i),qhlc(i),qcl(i)
      endif
c
c write axial distributions on every 10th time step
c
c       if(mod(i,10).eq.2) then
c        write(26,961)calc1(1,i),(calc1(ltempf+iax,i),calc1(lhstr+iax,i),
c     .    calc1(lsat+iax,i),calc1(lflxht+iax,i),suphtr(iax),iax=1,5)
c        write(27,961)calc1(1,i),(calc1(ltempf+iax,i),calc1(lhstr+iax,i),
c     .    calc1(lsat+iax,i),calc1(lflxht+iax,i),suphtr(iax),iax=11,15)
c       endif
c
      if(chfr(14).gt.1.d-4)then
        if(ichf4.eq.0) write(23,995)
        ichf4 = 1
        write(23,993) calc1(1,i),chfr(14)
      else
        ichf4 = 0
      endif
      if(chfr(15).gt.1.d-4)then
        if(ichf5.eq.0) write(24,995)
        ichf5 = 1
        write(24,993) calc1(1,i),chfr(15)
      else
        ichf5 = 0
      endif
*
   45 continue
      if(ichwrn.gt.0) write(6,975)ichwrn
      if(icowrn.gt.0) write(6,974)icowrn
      if(iszwrn.gt.0) write(6,973)iszwrn
      if(ishwrn.gt.0) write(6,972)ishwrn
c
c Formats
c
  999 format(17x,i3)
  998 format(10x,7(2x,a8))
  997 format(12x,('"',a5,'"'))
  995 format('ZONE T=" ", J=1, F=POINT')
  994 format(' number of records found =',i5)
  993 format(1x,1p,8(e12.5,2x))
  992 format('TITLE="',a40,'"',/,'VARIABLES="',a5,'"')
  991 format(10x,7(1x,a9)/(8(1x,a9)))
  990 format(a8)
```

```
  989 format(6(1x,a10,2x))
  988 format(8(2x,a8))
  987 format(7x,i3)
  986 format(5e15.6)
c.......1.........2.........3.........4.........5.........6........7..
  985 format(' Input title for this case. ',/,' First character should
     .be "-" for no uncertainties')
  984 format(i5)
  982 format(15x,4e15.6)
  980 format(i5)
  979 format(a40)
  978 format(a10)
  977 format(i5)
  976 format(1x,i4,1x,d12.4,1x,a10,1x,a10)
  975 format(' WARNING: CHF RATIO ABOVE 100.',2x,i5)
  974 format(' WARNING: COSTA RATIO LESS THAN 1.0 ',2x,i5)
  973 format(' WARNING: SAHA-ZUBER RATIO LESS THAN 1.0 ',i5)
  972 format(' WARNING: WALL SUPERHEAT IS POSITIVE.',i5)
  971 format(' WARNING: convergence not obtained for limit')
  970 format(' NO IB SOLUTION: tw=',f9.3,' q=',e13.4,' time=',e13.4,
     .       ' ib index = ',i2)
  964 format(' WARNING: Low Pe regime is being used for Modified Saha-Zu
     .ber',/,'        with a high velocity (> 8 m/s)')
  963 format(' Laminar HTC for IB      at time,m,re =',f10.3,1x,i5,
     . f10.1)
  962 format(' Laminar HTC for Tw=Tsat at time,m,re =',f10.3,1x,i5,
     . f10.1)
  961 format('ZONE T="',f5.1,'"',5(/,5e14.6))
      stop
      end
      block data
      implicit double precision (a-h,o-z)
      common /pool/  pool(4,138)
      data pool  / 1081., 1.0540,     0.555,    2.,
     .1081.,1.0540,     0.555,    2.,
     .1081.,1.0540,     0.555,    2.,
     .1081.,1.0540,     0.555,    2.,
     .1081.,1.0540,     0.555,    2.,
     .1081.,1.0540,     0.555,    2.,
     .1081.,1.0540,     0.555,    2.,
     .1081.,1.0540,     0.555,    2.,
     .1081.,1.0540,     0.555,    2.,
     .1081.,1.0540,     0.555,    2.,
     .1082.,0.0445,     3.49,     1.,
     .1161.,0.008636,2672.,       2.,
     .1161.,0.008636,2672.,       2.,
     .1161.,0.008636,2672.,       2.,
     .1161.,0.008636,2672.,       2.,
     .1501.,0.2541,     0.75,     2.,
     .1501.,0.2541,     0.75,     2.,
     .1501.,0.2541,     0.75,     2.,
     .1501.,0.2541,     0.75,     2.,
     .2081.,1.0540,     0.555,    2.,
     .2081.,1.0540,     0.555,    2.,
     .2081.,1.0540,     0.555,    2.,
     .2081.,1.0540,     0.555,    2.,
     .2081.,1.0540,     0.555,    2.,
     .2081.,1.0540,     0.555,    2.,
     .2081.,1.0540,     0.555,    2.,
     .2081.,1.0540,     0.555,    2.,
     .2081.,1.0540,     0.555,    2.,
     .2081.,1.0540,     0.555,    2.,
     .2082.,0.0445,     3.49,     1.,
     .2161.,0.5556,     1.6,      2.,
     .2161.,0.5556,     1.6,      2.,
     .2161.,0.5556,     1.6,      2.,
     .2161.,0.5556,     1.6,      2.,
     .2501.,0.2541,     0.75,     2.,
     .2501.,0.2541,     0.75,     2.,
     .2501.,0.2541,     0.75,     2.,
     .2501.,0.2541,     0.75,     2.,
     .3081.,1.0540,     0.555,    2.,
     .3081.,1.0540,     0.555,    2.,
     .3081.,1.0540,     0.555,    2.,
     .3081.,1.0540,     0.555,    2.,
     .3081.,1.0540,     0.555,    2.,
     .3081.,1.0540,     0.555,    2.,
     .3081.,1.0540,     0.555,    2.,
     .3081.,1.0540,     0.555,    2.,
     .3081.,1.0540,     0.555,    2.,
     .3081.,1.0540,     0.555,    2.,
```

```
     .3082.,0.0445,     3.49,      1.,
     .3161.,0.5556,     1.6,       2.,
     .3161.,0.5556,     1.6,       2.,
     .3161.,0.5556,     1.6,       2.,
     .3161.,0.5556,     1.6,       2.,
     .3501.,0.2541,     0.75,      2.,
     .3501.,0.2541,     0.75,      2.,
     .3501.,0.2541,     0.75,      2.,
     .3501.,0.2541,     0.75,      2.,
     .1011.,0.1778,     1.07,      2 .,
     .1011.,0.1778,     3.66,      2.,
     .1011.,0.1778,     2.21,      2.,
     .1041.,0.1778,     0.69,      2.,
     .1041.,0.1778,    12.96,      2.,
     .1041.,0.1778,     2.51,      2.,
     .1221.,0.1778,     2.31,      2.,
     .1221.,0.1778,     2.13,      2.,
     .1221.,0.1778,     0.762,     2.,
     .1261.,0.1778,     0.9146,    2.,
     .1291.,0.1778,     6.25,      2.,
     .1581.,0.1778,     4.50,      2.,
     .1581.,0.1778,     4.50,      2.,
     .1621.,0.1778,     1.83,      2.,
     .1621.,0.1778,     1.57,      2.,
     .1621.,0.1778,     1.45,      2.,
     .1621.,0.1778,    12.10439,   2.,
     .1711.,0.1016,     0.300,     2.,
     .1711.,0.1016,     2.000,     2.,
     .1711.,0.1016,     2.280,     2.,
     .1741.,0.1778,     0.50,      2.,
     .2011.,0.1778,     1.07,      2.,
     .2011.,0.1778,     3.66,      2.,
     .2011.,0.1778,     2.21,      2.,
     .2041.,0.1778,     6.098,     2.,
     .2041.,0.1778,     3.048,     2.,
     .2041.,0.1778,     2.51,      2.,
     .2221.,0.1778,     2.31,      2.,
     .2221.,0.1778,     2.13,      2.,
     .2221.,0.1778,     0.762,     2.,
     .2261.,0.1778,     0.9146,    2.,
     .2291.,0.1778,     6.25,      2.,
     .2581.,0.1778,     4.50,      2.,
     .2581.,0.1778,     4.50,      2.,
     .2621.,0.1778,     0.64538,   2.,
     .2621.,0.1778,    13.93439,   2.,
     .2711.,0.1016,     0.300,     2.,
     .2711.,0.1016,     0.290,     2.,
     .2711.,0.1016,     0.940,     2.,
     .2741.,0.1778,     0.50,      2.,
     .3011.,0.1778,     3.28,      2.,
     .3041.,0.1778,     0.69,      2.,
     .3041.,0.1778,    12.96,      2.,
     .3041.,0.1778,     2.51,      2.,
     .3221.,0.1778,     2.31,      2.,
     .3221.,0.1778,     2.13,      2.,
     .3221.,0.1778,     0.762,     2.,
     .3261.,0.1778,     0.9146,    2.,
     .3291.,0.1778,     6.25,      2.,
     .3581.,0.1778,     7.24,      2.,
     .3581.,0.1778,     7.24,      2.,
     .3621.,0.1778,     1.2166,    2.,
     .3621.,0.1778,    13.93439,   2.,
     .3711.,0.1016,     0.300,     2.,
     .3711.,0.1016,     0.510,     2.,
     .3711.,0.1016,     0.980,     2.,
     .3741.,0.1778,     0.50,      2.,
     .4011.,0.1778,     3.28,      2.,
     .4291.,0.1778,     6.25,      2.,
     .4581.,0.1778,     7.24,      2.,
     .4581.,0.1778,     7.24,      2.,
     .4621.,0.1778,     1.2166,    2.,
     .4621.,0.1778,    13.93439,   2.,
     .4711.,0.1016,     0.300,     2.,
     .4711.,0.1016,     0.510,     2.,
     .4711.,0.1016,     0.980,     2.,
     .4741.,0.1778,     0.50,      2.,
     .4951.,0.3165,     1.800,     2.,
     .5001.,0.2465,     0.331,     2.,
     .6401.,0.3048,     0.91463,   2.,
     .6401.,0.3048,     0.91463,   2.,
     .6401.,0.3048,     0.91463,   2.,
     .6401.,0.3048,     2.33667,   2.,
     .6401.,0.3048,     2.33667,   2.,
     .6401.,0.3048,     2.33667,   2.,
     .6451.,0.3048,     4.88,      2.,
     .6451.,0.3048,     3.35,      2.,
     .6501.,0.3048,     1.68,      2.,
     .6501.,0.3048,     3.51,      2.,
     .6501.,0.3048,     1.22,      2.,
     .6501.,0.3048,     1.83,      2./
      end
      function d2ovis(t)
      implicit double precision (a-h,o-z)
      tf = (t-273.15)*1.8 + 32.
      d2ovis = -1.111606e-4 + 9.46e-8*tf + 0.0873655375/tf +
     .         0.4111103409/tf/tf
      end
c
c
c  This program calculates the incipient boiling heat flux
c  and wall superheat given the wall temperature, saturation
c  temperature and bulk coolant temperature.
c
c Uses the Bergles/Rohsenhow IB correlation to determine heat flux limit
c
c.......1.........2.........3.........4.........5.........6.........7..
      subroutine incip(tbulk,tsat,p,reb,prb,dh,vsb,const,ckb,qib,hfc,
     . twalib,ilam,ierr)
      implicit double precision (a-h,o-z)
      data eps /0.001/
      ierr = 0
      ilam = 0
c
      fd = const/(1.82*log10(reb)-1.64)**2
      imax = 2000
      tlow = tsat
      thi = tsat + 100.
c
      do 10 i=1,imax
      tw = tsat+float(i)
      visrat = vsb/d2ovis(tw)
      tw = 0.5*(thi+tlow)
c
c Calculate heat transfer coefficient
c
c
c heat transfer coefficient in kW/m^2-K
c
c dittus boelter
c
       hfcd = 0.023*ckb/dh*prb**.4*reb**.8
c
c hausen
c
       hfch = 0.9*0.0235*ckb/dh*(1.8*prb**0.3-0.8)*(reb**.8-230)*
     .        (visrat)**0.14
c
c laminar heat transfer through rectangular channel
c
       hlam = 7.63d0*ckb/dh
c
c natural convection heat transfer coefficient
c
c        gr = 9.8d0*beta*abs(tw-tbulk)*rhos**2*ptans(iv)**3/viscs**2
c        ray = gr*pr
c  Incropera & DeWitt page 514, eq. 939 by Elenbaas; S=ptans cancels out
c  for ORNL ANS reactor, vertical parallel plates
c        hnat = ray/(24.d0*htlen)
c        hnat = thcons*hnat
c
c petukhov in units of W/m^2 (ckb is in W/m-K)
c
      hfc = ckb/dh*fd/8.*reb*prb*visrat**0.11/
     .       ((1+3.4*fd)+(11.7+1.8/prb**0.3333)*(fd/8.)**0.5*
     .       (prb**0.6667-1.))
c
c compare turbulent and laminar forced convection htc
c
      if(hfc.lt.hlam) then
        ilam = 1
        hfc = hlam
      endif
```

```
c
c Heat flux removed by convection
c
      qleft = hfc*(tw-tbulk)
c
c IB Heat Flux constraint
c
c Bergles Rohsenow in units of W/m^2
c........1.........2.........3.........4.........5.........6.........7..
      qright = 0.9*1.7978e-3*p**1.156*
     .         (1.8*(tw-tsat))**(2.8285/p**0.0234)
c
      if(abs(thi-tlow).le.eps)then
       qib = qleft
       twalib = tw
       return
      else if(qleft.gt.qright) then
       tlow = tw
      else
       thi = tw
      endif
   10 continue
      ierr = 1
      return
      end
```

```
= strip file for ans model
100 strip fmtout
103 0
104 noaction
*------------------------------------------------------------------------
1001    mflowj 157000000 * Accumulator 1
1002    mflowj 257000000 * Accumulator 2
1003    mflowj 357000000 * Accumulator 3
1004    mflowj 148000000 * EHX Chimney Flow
1005    mflowj 169000000 * Break Flow - Core Inlet (TD only)
1007    mflowj 124010000 * pump mass flow - loop 1
1008    mflowj 224010000 * pump mass flow - loop 2
1009    mflowj 324010000 * pump mass flow - loop 3
1010    mflowj 567010400 * Total Core Flow
1011    mflowj 865010000 * Letdown Flow Rate
1012    mflowj 850010000 * Pressurizing Flow Rate
1013    mflowj 132000000 * Secondary
1014    rktpow  0
1015    rkfipow 0
1016    rkgapow 0
1017    rkreac  0
* Pressures
1019    cntrlvar 835 * lower core exit pressure
1020    cntrlvar 836 * lower core pressure drop
1021    cntrlvar 837 * upper core exit pressure
1022    cntrlvar 838 * upper core pressure drop
1023    p 490010000
1024    p 500010000
1025    p 505010000
1026    p 520010000
1027    p 535010000
1028    p 555010000
1029    p 545010000
1030    p 545020000
1031    p 545030000
1032    p 545040000
1033    p 545050000
1034    p 122260000 * pump suction pressure
1035    p 126010000 * pump suction pressure
1036    p 156010000
1037    p 104010000
1038    p 106010000
1039    p 650030000
1040    sattemp 650030000
1041    pmpvel 124
1042    pmpvel 224
1043    pmpvel 324
1044    pmpvel 815
1045    pmpvel 830
1046    cntrlvar 48
1047    cntrlvar 98
1048    cntrlvar 148
1049    cntrlvar 52
1050    cntrlvar 102
1051    cntrlvar 152
1052    cntrlvar 60
1053    cntrlvar 110
1054    cntrlvar 160
1055    tempf 490010000
1056    tempf 565010000
1057    tempf 645150000
1058    tempf 106010000
1059    tempf 650030000
1060    tempf 545050000
1061    tempf 546050000
1062    cntrlvar 258  * UC 95% hot channel exit subcooling
1063    cntrlvar 278  * UC 99.9% hot channel exit subcooling
1066    velfj 537010300 * upper core 95% inlet velocity
1067    velfj 556010200 * upper core 95% exit velocity
1068    velfj 537010200 * upper average inlet velocity
1069    velfj 510040000
1070    velfj 515040000
1071    velfj 516040000
1072    velfj 540040000
1073    velfj 545040000
1074    velfj 546040000
1075    voidg 515010000
1076    voidg 515020000
1077    voidg 515030000
1078    voidg 515040000
1079    voidg 515050000
1080    voidg 516010000
1081    voidg 516020000
1082    voidg 516030000
1083    voidg 516040000
1084    voidg 516050000
1085    voidg 545010000
1086    voidg 545020000
1087    voidg 545030000
1088    voidg 545040000
1089    voidg 545050000
1090    voidg 546010000
1091    voidg 546020000
1092    voidg 546030000
1093    voidg 546040000
1094    voidg 546050000
1095    voidg 650030000
1096    quala 106010000
1097    quala 126010000
1098    quala 490010000
1099    quala 545050000
1100    quala 645150000
1101    httemp 550100204 * Max CPBT Temp
1102    httemp 562100306 * Max CR- Al Temp
1103    httemp 562100307 * Max CR- Hf Temp
1104    httemp 550100201 * Sur CPBT Temp
1105    httemp 562100301 * Sur CR- Al Temp
1106    httemp 562100310 * Sur CR- Hf Temp
* Bulk Temperatures
1107    tempf 515010000
1108    tempf 515020000
1109    tempf 515030000
1110    tempf 515040000
1111    tempf 515050000
1112    tempf 516010000
1113    tempf 516020000
1114    tempf 516030000
1115    tempf 516040000
1116    tempf 516050000
1117    tempf 545010000
1118    tempf 545020000
1119    tempf 545030000
1120    tempf 545040000
1121    tempf 545050000
1122    tempf 546010000
1123    tempf 546020000
1124    tempf 546030000
1125    tempf 546040000
1126    tempf 546050000
1127    cputime 0
1128    voidf           156010000
1129    voidf           156020000
1130    voidf           156030000
1131    voidf           156040000
1132    voidf           156050000
1133    voidf           156060000
1134    voidf           256010000
1135    voidf           256020000
1136    voidf           256030000
1137    voidf           256040000
1138    voidf           256050000
1139    voidf           256060000
1140    voidf           356010000
1141    voidf           356020000
1142    voidf           356030000
1143    voidf           356040000
1144    voidf           356050000
1145    voidf           356060000
* Heat fluxes at average and hot channels
1146    htrnr 510100100 * LC average channel fuel
1147    htrnr 510100200
1148    htrnr 510100300
1149    htrnr 510100400
1150    htrnr 510100500
1151    htrnr 540100100 * UC average channel fuel
1152    htrnr 540100200
1153    htrnr 540100300
1154    htrnr 540100400
1155    htrnr 540100500
1156    htrnr 515500100 * LC FE 95% hot stripe
1157    htrnr 515500200
1158    htrnr 515500300
```

```
* strip file for ans model
100 strip fmtout
103 0
104 noaction
*-----------------------------------------------------------------------
1001    mflowj 157000000 * Accumulator 1
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1009    mflowj 324010000 * pump mass flow - loop 3
1010    mflowj 567010400 * Total Core Flow
1011    mflowj 865010000 * Letdown Flow Rate
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1014    rktpow  0
1015    rkfipow 0
1016    rkgapow 0
1017    rkreac  0
* Pressures
1019    cntrlvar 835 * lower core exit pressure
1020    cntrlvar 836 * lower core pressure drop
1021    cntrlvar 837 * upper core exit pressure
1022    cntrlvar 838 * upper core pressure drop
1023    p 490010000
1024    p 500010000
1025    p 505010000
1026    p 520010000
1027    p 535010000
1028    p 555010000
1029    p 545010000
1030    p 545020000
1031    p 545030000
1032    p 545040000
1033    p 545050000
1034    p 122260000 * pump suction pressure
1035    p 126010000 * pump suction pressure
1036    p 156010000
1037    p 104010000
1038    p 106010000
1039    p 650030000
1040    sattemp 650030000
1041    pmpvel 124
1042    pmpvel 224
1043    pmpvel 324
1044    pmpvel 815
1045    pmpvel 830
1046    cntrlvar 48
1047    cntrlvar 98
1048    cntrlvar 148
1049    cntrlvar 52
1050    cntrlvar 102
1051    cntrlvar 152
1052    cntrlvar 60
1053    cntrlvar 110
1054    cntrlvar 160
1055    tempf 490010000
1056    tempf 565010000
1057    tempf 645150000
1058    tempf 106010000
1059    tempf 650030000
1060    tempf 545050000
1061    tempf 546050000
1062    cntrlvar 258  * UC 95% hot channel exit subcooling
1063    cntrlvar 278  * UC 99.9% hot channel exit subcooling
1066    velfj 537010300 * upper core 95% inlet velocity
1067    velfj 556010200 * upper core 95% exit velocity
1068    velfj 537010200 * upper average inlet velocity
1069    velfj 510040000
1070    velfj 515040000
1071    velfj 516040000
1072    velfj 540040000
1073    velfj 545040000
1074    velfj 546040000
1075    voidg 515010000
1076    voidg 515020000
1077    voidg 515030000
1078    voidg 515040000
1079    voidg 515050000
1080    voidg 516010000
1081    voidg 516020000
1082    voidg 516030000
1083    voidg 516040000
1084    voidg 516050000
1085    voidg 545010000
1086    voidg 545020000
1087    voidg 545030000
1088    voidg 545040000
1089    voidg 545050000
1090    voidg 546010000
1091    voidg 546020000
1092    voidg 546030000
1093    voidg 546040000
1094    voidg 546050000
1095    voidg 650030000
1096    quala 106010000
1097    quala 126010000
1098    quala 490010000
1099    quala 545050000
1100    quala 645150000
1101    httemp 550100204 * Max CPBT Temp
1102    httemp 562100306 * Max CR- Al Temp
1103    httemp 562100307 * Max CR- Hf Temp
1104    httemp 550100201 * Sur CPBT Temp
1105    httemp 562100301 * Sur CR- Al Temp
1106    httemp 562100310 * Sur CR- Hf Temp
* Bulk Temperatures
1107    tempf 515010000
1108    tempf 515020000
1109    tempf 515030000
1110    tempf 515040000
1111    tempf 515050000
1112    tempf 516010000
1113    tempf 516020000
1114    tempf 516030000
1115    tempf 516040000
1116    tempf 516050000
1117    tempf 545010000
1118    tempf 545020000
1119    tempf 545030000
1120    tempf 545040000
1121    tempf 545050000
1122    tempf 546010000
1123    tempf 546020000
1124    tempf 546030000
1125    tempf 546040000
1126    tempf 546050000
1127    cputime 0
1128    voidf            156010000
1129    voidf            156020000
1130    voidf            156030000
1131    voidf            156040000
1132    voidf            156050000
1133    voidf            156060000
1134    voidf            256010000
1135    voidf            256020000
1136    voidf            256030000
1137    voidf            256040000
1138    voidf            256050000
1139    voidf            256060000
1140    voidf            356010000
1141    voidf            356020000
1142    voidf            356030000
1143    voidf            356040000
1144    voidf            356050000
1145    voidf            356060000
* Heat fluxes at average and hot channels
1146    htrnr 510100100 * LC average channel fuel
1147    htrnr 510100200
1148    htrnr 510100300
1149    htrnr 510100400
1150    htrnr 510100500
1151    htrnr 540100100 * UC average channel fuel
1152    htrnr 540100200
1153    htrnr 540100300
1154    htrnr 540100400
1155    htrnr 540100500
1156    htrnr 515500100 * LC FE 95% hot stripe
1157    htrnr 515500200
1158    htrnr 515500300
```

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1159    htrnr 515500400
1160    htrnr 515500500
1161    htrnr 516500100 * LC FE 99.9% hot stripe
1162    htrnr 516500200
1163    htrnr 516500300
1164    htrnr 516500400
1165    htrnr 516500500
1166    htrnr 545500100 * UC FE 95% hot stripe
1167    htrnr 545500200
1168    htrnr 545500300
1169    htrnr 545500400
1170    htrnr 545500500
1171    htrnr 546500100 * UC FE 99.9% hot stripe
1172    htrnr 546500200
1173    htrnr 546500300
1174    htrnr 546500400
1175    htrnr 546500500
1176    htrnr 515400100 * LC CHF 95% hot stripe
1177    htrnr 515400200
1178    htrnr 515400300
1179    htrnr 515400400
1180    htrnr 515400500
1181    htrnr 516400100 * LC CHF 99.9% hot stripe
1182    htrnr 516400200
1183    htrnr 516400300
1184    htrnr 516400400
1185    htrnr 516400500
1186    htrnr 545400100 * UC CHF 95% hot stripe
1187    htrnr 545400200
1188    htrnr 545400300
1189    htrnr 545400400
1190    htrnr 545400500
1191    htrnr 546400100 * UC CHF 99.9% hot stripe
1192    htrnr 546400200
1193    htrnr 546400300
1194    htrnr 546400400
1195    htrnr 546400500
1196    cputime 0
* CHF indicated by RELAP5
1197    htchf 510100100 * LC average channel fuel
1198    htchf 510100200
1199    htchf 510100300
1200    htchf 510100400
1201    htchf 510100500
1202    htchf 540100100 * UC average channel fuel
1203    htchf 540100200
1204    htchf 540100300
1205    htchf 540100400
1206    htchf 540100500
1207    htchf 515400100 * LC CHF 95% hot stripe
1208    htchf 515400200
1209    htchf 515400300
1210    htchf 515400400
1211    htchf 515400500
1212    htchf 516400100 * LC CHF 99.9% hot stripe
1213    htchf 516400200
1214    htchf 516400300
1215    htchf 516400400
1216    htchf 516400500
1217    htchf 545400100 * UC CHF 95% hot stripe
1218    htchf 545400200
1219    htchf 545400300
1220    htchf 545400400
1221    htchf 545400500
1222    htchf 546400100 * UC CHF 99.9% hot stripe
1223    htchf 546400200
1224    htchf 546400300
1225    htchf 546400400
1226    htchf 546400500
1227    cputime 0
1228    hthtc 515500500
1229    hthtc 545500500
* Costa heat flux limits
1230    cntrlvar 203 * LC 95% hot stripe
1231    cntrlvar 207
1232    cntrlvar 211
1233    cntrlvar 215
1234    cntrlvar 219
1235    cntrlvar 223 * LC 99.9% hot stripe
1236    cntrlvar 227
1237    cntrlvar 231
1238    cntrlvar 235
1239    cntrlvar 239
1240    cntrlvar 243 * UC 95% hot stripe
1241    cntrlvar 247
1242    cntrlvar 251
1243    cntrlvar 255
1244    cntrlvar 259
1245    cntrlvar 263 * UC 99.9% hot stripe
1246    cntrlvar 267
1247    cntrlvar 271
1248    cntrlvar 275
1249    cntrlvar 279
1250    cputime 0
* wall superheat at hot spots and average fuel
1251    cntrlvar 280 * LC 95% hot stripe
1252    cntrlvar 281
1253    cntrlvar 282
1254    cntrlvar 283
1255    cntrlvar 284
1256    cntrlvar 285 * LC 99.9% hot stripe
1257    cntrlvar 286
1258    cntrlvar 287
1259    cntrlvar 288
1260    cntrlvar 289
1261    cntrlvar 290 * UC 95% hot stripe
1262    cntrlvar 291
1263    cntrlvar 292
1264    cntrlvar 293
1265    cntrlvar 294
1266    cntrlvar 295 * UC 99.9% hot stripe
1267    cntrlvar 296
1268    cntrlvar 297
1269    cntrlvar 298
1270    cntrlvar 299
* viscosities in hot channels
1271    viscf 515010000
1272    viscf 515020000
1273    viscf 515030000
1274    viscf 515040000
1275    viscf 515050000
1276    viscf 516010000
1277    viscf 516020000
1278    viscf 516030000
1279    viscf 516040000
1280    viscf 516050000
1281    viscf 545010000
1282    viscf 545020000
1283    viscf 545030000
1284    viscf 545040000
1285    viscf 545050000
1286    viscf 546010000
1287    viscf 546020000
1288    viscf 546030000
1289    viscf 546040000
1290    viscf 546050000
* thermal conductivities in hot channels
1291    thconf 515010000
1292    thconf 515020000
1293    thconf 515030000
1294    thconf 515040000
1295    thconf 515050000
1296    thconf 516010000
1297    thconf 516020000
1298    thconf 516030000
1299    thconf 516040000
1300    thconf 516050000
1301    thconf 545010000
1302    thconf 545020000
1303    thconf 545030000
1304    thconf 545040000
1305    thconf 545050000
1306    thconf 546010000
1307    thconf 546020000
1308    thconf 546030000
1309    thconf 546040000
1310    thconf 546050000
* velocities in hot channels
1311    velf 515010000
1312    velf 515020000
1313    velf 515030000
1314    velf 515040000
```

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1315    velf 515050000
1316    velf 516010000
1317    velf 516020000
1318    velf 516030000
1319    velf 516040000
1320    velf 516050000
1321    velf 545010000
1322    velf 545020000
1323    velf 545030000
1324    velf 545040000
1325    velf 545050000
1326    velf 546010000
1327    velf 546020000
1328    velf 546030000
1329    velf 546040000
1330    velf 546050000
* Subcooling
1331    cntrlvar 202
1332    cntrlvar 206
1333    cntrlvar 210
1334    cntrlvar 214
1335    cntrlvar 218
1336    cntrlvar 222
1337    cntrlvar 226
1338    cntrlvar 230
1339    cntrlvar 234
1340    cntrlvar 238
1341    cntrlvar 242
1342    cntrlvar 246
1343    cntrlvar 250
1344    cntrlvar 254
1345    cntrlvar 258
1346    cntrlvar 262
1347    cntrlvar 266
1348    cntrlvar 270
1349    cntrlvar 274
1350    cntrlvar 278
* Prandtl numbers
1356    cntrlvar  445 * lower core 95% hot channel
1357    cntrlvar  447
1358    cntrlvar  449
1359    cntrlvar  451
1360    cntrlvar  453
1361    cntrlvar  455 * lower core 99.9% hot channel
1362    cntrlvar  457
1363    cntrlvar  459
1364    cntrlvar  461
1365    cntrlvar  463
1366    cntrlvar  465 * lower core 95% hot channel
1367    cntrlvar  467
1368    cntrlvar  469
1369    cntrlvar  471
1370    cntrlvar  473
1371    cntrlvar  475 * lower core 99.9% hot channel
1372    cntrlvar  477
1373    cntrlvar  479
1374    cntrlvar  481
1375    cntrlvar  483
* Peclet numbers
1376    cntrlvar 301 * lower core 95% hot channel
1377    cntrlvar 303
1378    cntrlvar 305
1379    cntrlvar 307
1380    cntrlvar 309
1381    cntrlvar 311 * lower core 99.9% hot channel
1382    cntrlvar 313
1383    cntrlvar 315
1384    cntrlvar 317
1385    cntrlvar 319
1386    cntrlvar 321 * upper core 95% hot channel
1387    cntrlvar 323
1388    cntrlvar 325
1389    cntrlvar 327
1390    cntrlvar 329
1391    cntrlvar 331 * upper core 99.9% hot channel
1392    cntrlvar 333
1393    cntrlvar 335
1394    cntrlvar 337
1395    cntrlvar 339
* saturation temperatures in hot channels
1411    sattemp 515010000
1412    sattemp 515020000
1413    sattemp 515030000
1414    sattemp 515040000
1415    sattemp 515050000
1416    sattemp 516010000
1417    sattemp 516020000
1418    sattemp 516030000
1419    sattemp 516040000
1420    sattemp 516050000
1421    sattemp 545010000
1422    sattemp 545020000
1423    sattemp 545030000
1424    sattemp 545040000
1425    sattemp 545050000
1426    sattemp 546010000
1427    sattemp 546020000
1428    sattemp 546030000
1429    sattemp 546040000
1430    sattemp 546050000
* Fuel surface temperatures
1436    httemp 515500101
1437    httemp 515500201
1438    httemp 515500301
1439    httemp 515500401
1440    httemp 515500501
1441    httemp 516500101
1442    httemp 516500201
1443    httemp 516500301
1444    httemp 516500401
1445    httemp 516500501
1446    httemp 545500101
1447    httemp 545500201
1448    httemp 545500301
1449    httemp 545500401
1450    httemp 545500501
1451    httemp 546500101
1452    httemp 546500201
1453    httemp 546500301
1454    httemp 546500401
1455    httemp 546500501
*
. end of case
```

APPENDIX G: TABLE OF ALL CONTROL VOLUMES

VOLUME	AREA	LENGTH	dZ	Dh	ε	
101-01	0.08322	1.07	0.	0.3255	45.7	* lp1 hot leg
101-02	0.08322	3.66	0.	0.3255	45.7	* lp1 hot leg
101-03	0.08322	2.21	0.	0.3255	45.7	* lp1 hot leg
104-01	0.08322	0.69	0.	0.3255	45.7	* lp1 hot leg
104-02	0.08322	12.95	0.	0.3255	45.7	* lp1 hot leg
104-03	0.08322	2.51	2.44	0.3255	45.7	* lp1 hot leg
106-01	0.08322	1.0	0.	0.3255	45.7	* lp1 MHX primary inlet plenum
108-01	0.8258	1.11	0.	0.636	45.7	* lp1 MHX primary (shell)
108-02	0.8258	1.11	0.	0.636	45.7	* lp1 MHX primary (shell)
108-03	0.8258	1.11	0.	0.636	45.7	* lp1 MHX primary (shell)
108-04	0.8258	1.11	0.	0.636	45.7	* lp1 MHX primary (shell)
108-05	0.8258	1.11	0.	0.636	45.7	* lp1 MHX primary (shell)
108-06	0.841	2.03	0.	0.894	45.7	* lp1 MHX primary (shell)
108-07	0.8258	1.11	0.	0.636	45.7	* lp1 MHX primary (shell)
108-08	0.8258	1.11	0.	0.636	45.7	* lp1 MHX primary (shell)
108-09	0.8258	1.11	0.	0.636	45.7	* lp1 MHX primary (shell)
108-10	0.8258	1.11	0.	0.636	45.7	* lp1 MHX primary (shell)
108-11	0.8258	1.11	0.	0.636	45.7	* lp1 MHX primary (shell)
112-01	0.08322	1.0	0.	0.3255	45.7	* lp1 MHX primary exit plenum
113-01	0.08322	1.981	-0.762	0.3255	45.7	* lp1 pipe joining HXs
113-02	0.08322	1.23	-0.6093	0.3255	45.7	* lp1 pipe joining HXs
113-03	0.08322	0.6096	-0.6096	0.3255	45.7	* lp1 pipe joining HXs
114-01	0.08322	1.0	0.	0.3255	45.7	* lp1 EHX primary inlet plenum
116-01	0.894	1.6	0.	0.00170	45.7	* lp1 EHX primary (shell)
116-02	0.894	1.6	0.	0.00170	45.7	* lp1 EHX primary (shell)
116-03	0.894	1.6	0.	0.00170	45.7	* lp1 EHX primary (shell)
116-04	0.894	1.6	0.	0.00170	45.7	* lp1 EHX primary (shell)
120-01	0.08322	1.0	0.	0.3255	45.7	* lp1 EHX primary exit plenum
122-01	0.08322	2.31	-0.305	0.3255	45.7	* lp1 col leg
122-02	0.08322	2.13	0.	0.3255	45.7	* lp1 cold leg
122-03	0.08322	0.762	0.762	0.3255	45.7	* lp1 cold leg
124-01	1.5478	0.5	0.000	-	-	* lp1 primary coolant pump
126-01	0.08322	0.9146	0.0	0.3255	45.7	* lp1 pc pump discharge
129-01	0.08322	6.25	0.0	0.3255	45.7	* lp1 cold leg
130-01	1.e6	1.	0.	0.	0.	* lp1 MHX sec src 302.55 K
134-01	0.776	1.314	0.	0.01588	45.7	* lp1 MHX secondary (tube)
134-02	0.776	1.314	0.	0.01588	45.7	* lp1 MHX secondary (tube)
134-03	0.776	1.314	0.	0.01588	45.7	* lp1 MHX secondary (tube)
134-04	0.776	1.314	0.	0.01588	45.7	* lp1 MHX secondary (tube)
134-05	0.776	1.314	0.	0.01588	45.7	* lp1 MHX secondary (tube)
134-06	0.776	1.314	0.	0.01588	45.7	* lp1 MHX secondary (tube)
134-07	0.776	1.314	0.	0.01588	45.7	* lp1 MHX secondary (tube)
134-08	0.776	1.314	0.	0.01588	45.7	* lp1 MHX secondary (tube)
134-09	0.776	1.314	0.	0.01588	45.7	* lp1 MHX secondary (tube)
134-10	0.776	1.314	0.	0.01588	45.7	* lp1 MHX secondary (tube)
136-01	1.e6	1.	0.	0.	0.	* lp1 MHX sec sink 0.449 MPa
138-01	1.e6	1.	0.	0.	0.	* lp1 EHX sec source 311.15 K
142-01	0.4264	0.7622	0.	0.4573	45.7	* lp1 EHX secondary inlet pipe
142-02	0.4264	0.7622	0.	0.4573	45.7	* lp1 EHX secondary inlet pipe
146-01	0.476	1.6	0.	0.01905	45.7	* lp1 EHX secondary (tube)
146-02	0.476	1.6	0.	0.01905	45.7	* lp1 EHX secondary (tube)
146-03	0.476	1.6	0.	0.01905	45.7	* lp1 EHX secondary (tube)
146-04	0.476	1.6	0.	0.01905	45.7	* lp1 EHX secondary (tube)
150-01	0.203	0.75	0.75	0.508	45.7	* lp1 EHX secondary chimney
150-02	0.203	0.75	0.75	0.508	45.7	* lp1 EHX secondary chimney
150-03	0.203	0.75	0.75	0.508	45.7	* lp1 EHX secondary chimney
150-04	0.203	0.75	0.75	0.508	45.7	* lp1 EHX secondary chimney
154-01	1.e6	1.	0.	0.	0.	* lp1 EHX sec snk 0.15077366 MPa
156-01	1.65	4.09	-4.09	1.449	45.7	* lp1 ACCUM tank top volume
156-02	1.65	0.12	-0.12	1.449	45.7	* lp1 ACCUM tank top
156-03	1.65	0.12	-0.12	1.449	45.7	* lp1 ACCUM tank top
156-04	1.65	0.12	-0.12	1.449	45.7	* lp1 ACCUM tank top
156-05	1.65	0.12	-0.12	1.449	45.7	* lp1 ACCUM tank top
156-06	0.08322	4.88	-4.88	0.3255	45.7	* lp1 ACCUM standpipe
158-01	0.08322	4.50	0.	0.3255	45.7	* lp1 cold-leg horizontal
158-02	0.08322	4.50	0.	0.3255	45.7	* lp1 cold-leg horizontal
162-01	0.08322	1.83	-1.83	0.3255	45.7	* lp1 cold-leg downcomer pipe
162-02	0.08322	1.57	0.	0.3255	45.7	* lp1 cold-leg downcomer pipe
162-03	0.08322	1.45	0.	0.3255	45.7	* lp1 cold-leg downcomer pipe
162-04	0.08322	12.10439	-12.10439	0.3255	45.7	* lp1 cold-leg downcomer pipe
171-01	0.03095	0.30	-0.3	0.1985	45.7	* lp1 IFD throat
171-02	0.03095	2.00	0.0	0.1985	45.7	* lp1 IFD throat
171-03	0.03095	2.28	0.0	0.1985	45.7	* lp1 IFD throat
174-01	0.08322	0.50	0.50	0.3255	45.7	* lp1 PSVAW join pipe

*

-LOOP2-LOOP2-LOOP2-LOOP2-LOOP2-LOOP2-LOOP2-LOOP2-LOOP2-LOOP2-LOOP2-

201-01	0.08322	1.07	0.	0.3255	45.7	* lp2 hot leg
201-02	0.08322	3.66	0.	0.3255	45.7	* lp2 hot leg
201-03	0.08322	2.21	0.	0.3255	45.7	* lp2 hot leg
204-01	0.08322	0.69	0.	0.3255	45.7	* lp2 hot leg
204-02	0.08322	12.95	0.	0.3255	45.7	* lp2 hot leg
204-03	0.08322	2.51	2.44	0.3255	45.7	* lp2 hot leg

206-01	0.08322	1.0	0.	0.3255	45.7	* lp2 MHX primary inlet plenum
208-01	0.8258	1.11	0.	0.636	45.7	* lp2 MHX primary (shell)
208-02	0.8258	1.11	0.	0.636	45.7	* lp2 MHX primary (shell)
208-03	0.8258	1.11	0.	0.636	45.7	* lp2 MHX primary (shell)
208-04	0.8258	1.11	0.	0.636	45.7	* lp2 MHX primary (shell)
208-05	0.8258	1.11	0.	0.636	45.7	* lp2 MHX primary (shell)
208-06	0.841	2.03	0.	0.894	45.7	* lp2 MHX primary (shell)
208-07	0.8258	1.11	0.	0.636	45.7	* lp2 MHX primary (shell)
208-08	0.8258	1.11	0.	0.636	45.7	* lp2 MHX primary (shell)
208-09	0.8258	1.11	0.	0.636	45.7	* lp2 MHX primary (shell)
208-10	0.8258	1.11	0.	0.636	45.7	* lp2 MHX primary (shell)
208-11	0.8258	1.11	0.	0.636	45.7	* lp2 MHX primary (shell)
212-01	0.08322	1.0	0.	0.3255	45.7	* lp2 MHX primary exit plenum
213-01	0.08322	1.981	-0.762	0.3255	45.7	* lp2 pipe joining HXs
213-02	0.08322	1.23	-0.6093	0.3255	45.7	* lp2 pipe joining HXs
213-03	0.08322	0.6096	-0.6096	0.3255	45.7	* lp2 pipe joining HXs
214-01	0.08322	1.0	0.	0.3255	45.7	* lp2 EHX primary inlet plenum
216-01	0.894	1.6	0.	0.00170	45.7	* lp2 EHX primary (shell)
216-02	0.894	1.6	0.	0.00170	45.7	* lp2 EHX primary (shell)
216-03	0.894	1.6	0.	0.00170	45.7	* lp2 EHX primary (shell)
216-04	0.894	1.6	0.	0.00170	45.7	* lp2 EHX primary (shell)
220-01	0.08322	1.0	0.	0.3255	45.7	* lp2 EHX primary exit plenum
222-01	0.08322	2.31	-0.305	0.3255	45.7	* lp2 cold leg
222-02	0.08322	2.13	0.	0.3255	45.7	* lp2 cold leg
222-03	0.08322	0.762	0.762	0.3255	45.7	* lp2 cold leg
224-01	1.5478	0.5	0.000	-	-	* lp2 primary coolant pump
226-01	0.08322	0.9146	0.0	0.3255	45.7	* lp2 pc pump discharge
229-01	0.08322	6.25	0.0	0.3255	45.7	* lp2 cold leg
230-01	1.e6	1.	0.	0.	0.	* lp2 MHX sec src 302.55 K
234-01	0.776	1.314	0.	0.01588	45.7	* lp2 MHX secondary (tube)
234-02	0.776	1.314	0.	0.01588	45.7	* lp2 MHX secondary (tube)
234-03	0.776	1.314	0.	0.01588	45.7	* lp2 MHX secondary (tube)
234-04	0.776	1.314	0.	0.01588	45.7	* lp2 MHX secondary (tube)
234-05	0.776	1.314	0.	0.01588	45.7	* lp2 MHX secondary (tube)
234-06	0.776	1.314	0.	0.01588	45.7	* lp2 MHX secondary (tube)
234-07	0.776	1.314	0.	0.01588	45.7	* lp2 MHX secondary (tube)
234-08	0.776	1.314	0.	0.01588	45.7	* lp2 MHX secondary (tube)
234-09	0.776	1.314	0.	0.01588	45.7	* lp2 MHX secondary (tube)
234-10	0.776	1.314	0.	0.01588	45.7	* lp2 MHX secondary (tube)
236-01	1.e6	1.	0.	0.	0.	* lp2 MHX sec sink 0.449 MPa
238-01	1.e6	1.	0.	0.	0.	* lp2 EHX sec source 311.15 K
242-01	0.4264	0.7622	0.	0.4573	45.7	* lp2 EHX secondary inlet pipe
242-02	0.4264	0.7622	0.	0.4573	45.7	* lp2 EHX secondary inlet pipe
246-01	0.476	1.6	0.	0.01905	45.7	* lp2 EHX secondary (tube)
246-02	0.476	1.6	0.	0.01905	45.7	* lp2 EHX secondary (tube)
246-03	0.476	1.6	0.	0.01905	45.7	* lp2 EHX secondary (tube)
246-04	0.476	1.6	0.	0.01905	45.7	* lp2 EHX secondary (tube)
250-01	0.203	0.75	0.75	0.508	45.7	* lp2 EHX secondary chimney
250-02	0.203	0.75	0.75	0.508	45.7	* lp2 EHX secondary chimney
250-03	0.203	0.75	0.75	0.508	45.7	* lp2 EHX secondary chimney
250-04	0.203	0.75	0.75	0.508	45.7	* lp2 EHX secondary chimney
254-01	1.e6	1.	0.	0.	0.	* lp2 EHX sec snk 0.15077366 MPa
256-01	1.65	4.09	-4.09	1.449	45.7	* lp2 ACCUM tank top volume
256-02	1.65	0.12	-0.12	1.449	45.7	* lp2 ACCUM tank top
256-03	1.65	0.12	-0.12	1.449	45.7	* lp2 ACCUM tank top
256-04	1.65	0.12	-0.12	1.449	45.7	* lp2 ACCUM tank top
256-05	1.65	0.12	-0.12	1.449	45.7	* lp2 ACCUM tank top
256-06	0.08322	4.88	-4.88	0.3255	45.7	* lp2 ACCUM standpipe
258-01	0.08322	4.50	0.	0.3255	45.7	* lp2 cold-leg horizontal
258-02	0.08322	4.50	0.	0.3255	45.7	* lp2 cold-leg horizontal
262-01	0.08322	0.64538	0.0	0.3255	45.7	* lp2 cold-leg downcomer pipe
262-02	0.08322	13.93439	-13.93439	0.3255	45.7	* lp2 cold-leg downcomer pipe
271-01	0.03095	0.30	-0.3	0.1985	45.7	* lp2 IFD throat
271-02	0.03095	0.29	0.0	0.1985	45.7	* lp2 IFD throat
271-03	0.03095	0.94	0.0	0.1985	45.7	* lp2 IFD throat
274-01	0.08322	0.50	0.50	0.3255	45.7	* lp2 PSVAW join pipe

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-LOOP3-LOOP3-LOOP3-LOOP3-LOOP3-LOOP3-LOOP3-LOOP3-LOOP3-LOOP3-LOOP3-

301-01	0.08322	3.28	0.	0.3255	45.7	* lp3 hot leg
304-01	0.08322	0.69	0.	0.3255	45.7	* lp3 hot leg
304-02	0.08322	12.95	0.	0.3255	45.7	* lp3 hot leg
304-03	0.08322	2.51	2.44	0.3255	45.7	* lp3 hot leg
306-01	0.08322	1.0	0.	0.3255	45.7	* lp3 MHX primary inlet plenum
308-01	0.8258	1.11	0.	0.636	45.7	* lp3 MHX primary (shell)
308-02	0.8258	1.11	0.	0.636	45.7	* lp3 MHX primary (shell)
308-03	0.8258	1.11	0.	0.636	45.7	* lp3 MHX primary (shell)
308-04	0.8258	1.11	0.	0.636	45.7	* lp3 MHX primary (shell)
308-05	0.8258	1.11	0.	0.636	45.7	* lp3 MHX primary (shell)
308-06	0.841	2.03	0.	0.894	45.7	* lp3 MHX primary (shell)
308-07	0.8258	1.11	0.	0.636	45.7	* lp3 MHX primary (shell)
308-08	0.8258	1.11	0.	0.636	45.7	* lp3 MHX primary (shell)
308-09	0.8258	1.11	0.	0.636	45.7	* lp3 MHX primary (shell)
308-10	0.8258	1.11	0.	0.636	45.7	* lp3 MHX primary (shell)

308-11	0.8258	1.11	0.	0.636	45.7	* lp3 MHX primary (shell)
312-01	0.08322	1.0	0.	0.3255	45.7	* lp3 MHX primary exit plenum
313-01	0.08322	1.981	-0.762	0.3255	45.7	* lp3 pipe joining HXs
313-02	0.08322	1.23	-0.6093	0.3255	45.7	* lp3 pipe joining HXs
313-03	0.08322	0.6096	-0.6096	0.3255	45.7	* lp3 pipe joining HXs
314-01	0.08322	1.0	0.	0.3255	45.7	* lp3 EHX primary inlet plenum
316-01	0.894	1.6	0.	0.00170	45.7	* lp3 EHX primary (shell)
316-02	0.894	1.6	0.	0.00170	45.7	* lp3 EHX primary (shell)
316-03	0.894	1.6	0.	0.00170	45.7	* lp3 EHX primary (shell)
316-04	0.894	1.6	0.	0.00170	45.7	* lp3 EHX primary (shell)
320-01	0.08322	1.0	0.	0.3255	45.7	* lp3 EHX primary exit plenum
322-01	0.08322	2.31	-0.305	0.3255	45.7	* lp3 cold leg
322-02	0.08322	2.13	0.	0.3255	45.7	* lp3 cold leg
322-03	0.08322	0.762	0.762	0.3255	45.7	* lp3 cold leg
324-01	1.5478	0.5	0.000	-	-	* lp3 primary coolant pump
326-01	0.08322	0.9146	0.0	0.3255	45.7	* lp3 pc pump discharge
329-01	0.08322	6.25	0.0	0.3255	45.7	* lp3 cold leg
330-01	1.e6	1.	0.	0.	0.	* lp3 MHX sec src 302.55 K
334-01	0.776	1.314	0.	0.01588	45.7	* lp3 MHX secondary (tube)
334-02	0.776	1.314	0.	0.01588	45.7	* lp3 MHX secondary (tube)
334-03	0.776	1.314	0.	0.01588	45.7	* lp3 MHX secondary (tube)
334-04	0.776	1.314	0.	0.01588	45.7	* lp3 MHX secondary (tube)
334-05	0.776	1.314	0.	0.01588	45.7	* lp3 MHX secondary (tube)
334-06	0.776	1.314	0.	0.01588	45.7	* lp3 MHX secondary (tube)
334-07	0.776	1.314	0.	0.01588	45.7	* lp3 MHX secondary (tube)
334-08	0.776	1.314	0.	0.01588	45.7	* lp3 MHX secondary (tube)
334-09	0.776	1.314	0.	0.01588	45.7	* lp3 MHX secondary (tube)
334-10	0.776	1.314	0.	0.01588	45.7	* lp3 MHX secondary (tube)
336-01	1.e6	1.	0.	0.	0.	* lp3 MHX sec sink 0.449 MPa
338-01	1.e6	1.	0.	0.	0.	* lp3 EHX sec source 311.15 K
342-01	0.4264	0.7622	0.	0.4573	45.7	* lp3 EHX secondary inlet pipe
342-02	0.4264	0.7622	0.	0.4573	45.7	* lp3 EHX secondary inlet pipe
346-01	0.476	1.6	0.	0.01905	45.7	* lp3 EHX secondary (tube)
346-02	0.476	1.6	0.	0.01905	45.7	* lp3 EHX secondary (tube)
346-03	0.476	1.6	0.	0.01905	45.7	* lp3 EHX secondary (tube)
346-04	0.476	1.6	0.	0.01905	45.7	* lp3 EHX secondary (tube)
350-01	0.203	0.75	0.75	0.508	45.7	* lp3 EHX secondary chimney
350-02	0.203	0.75	0.75	0.508	45.7	* lp3 EHX secondary chimney
350-03	0.203	0.75	0.75	0.508	45.7	* lp3 EHX secondary chimney
350-04	0.203	0.75	0.75	0.508	45.7	* lp3 EHX secondary chimney
354-01	1.e6	1.	0.	0.	0.	* lp3 EHX sec snk 0.15077366 MPa
356-01	1.65	4.09	-4.09	1.449	45.7	* lp3 ACCUM tank top volume
356-02	1.65	0.12	-0.12	1.449	45.7	* lp3 ACCUM tank top
356-03	1.65	0.12	-0.12	1.449	45.7	* lp3 ACCUM tank top
356-04	1.65	0.12	-0.12	1.449	45.7	* lp3 ACCUM tank top
356-05	1.65	0.12	-0.12	1.449	45.7	* lp3 ACCUM tank top
356-06	0.08322	4.88	-4.88	0.3255	45.7	* lp3 ACCUM standpipe
358-01	0.08322	7.24	0.	0.3255	45.7	* lp3 cold-leg horizontal
358-02	0.08322	7.24	0.	0.3255	45.7	* lp3 cold-leg horizontal
362-01	0.08322	1.2166	0.0	0.3255	45.7	* lp3 cold-leg downcomer pipe
362-02	0.08322	13.93439	-13.93439	0.3255	45.7	* lp3 cold-leg downcomer pipe
371-01	0.03095	0.30	-0.3	0.1985	45.7	* lp3 IFD throat
371-02	0.03095	0.51	0.0	0.1985	45.7	* lp3 IFD throat
371-03	0.03095	0.98	0.0	0.1985	45.7	* lp3 IFD throat
374-01	0.08322	0.50	0.50	0.3255	45.7	* lp3 PSVAW join pipe
*						
-LOOP4-LOOP4-LOOP4-LOOP4-LOOP4-LOOP4-LOOP4-LOOP4-LOOP4-LOOP4-LOOP4-						
451-01	0.08322	3.28	0.	0.3255	45.7	* lp4 hot leg
429-01	0.08322	6.25	0.0	0.3255	45.7	* lp4 col leg
458-01	0.08322	7.24	0.	0.3255	45.7	* lp4 cold-leg horizontal
458-02	0.08322	7.24	0.	0.3255	45.7	* lp4 cold-leg horizontal
462-01	0.08322	1.2166	0.0	0.3255	45.7	* lp4 cold-leg downcomer pipe
462-02	0.08322	13.93439	-13.93439	0.3255	45.7	* lp4 cold-leg downcomer pipe
471-01	0.03095	0.30	-0.3	0.1985	45.7	* lp4 IFD throat
471-02	0.03095	0.51	0.0	0.1985	45.7	* lp4 IFD throat
471-03	0.03095	0.98	0.0	0.1985	45.7	* lp4 IFD throat
474-01	0.08322	0.50	0.50	0.3255	45.7	* lp4 PSVAW join pipe

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