CALCULATING FAILURE PROBABILITIES OF PASSIVE SYSTEMS DURING TRANSIENTS

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1. ABSTRACT

A time-dependent reliability evaluation of a two-loop passive Decay Heat Removal (DHR) system was performed as part of the iterative design process for a helium-cooled fast reactor. The system was modeled using RELAP5-3D. The uncertainties in input parameters were assessed and were propagated through the model using Latin Hypercube Sampling. An important finding was the discovery that the smaller pressure loss through the DHR heat exchanger than through the core would make the flow to bypass the core through one DHR loop, if two loops operated in parallel. This finding is a warning against modeling only one lumped DHR loop and assuming that n of them will remove n times the decay power. Sensitivity analyses revealed that there are values of some input parameters for which failures are very unlikely. The calculated conditional (i.e., given the LOCA) failure probability was deemed to be too high leading to the identification of several design changes to improve system reliability. This study is an example of the kinds of insights that can be obtained by including a reliability assessment in the design process. It is different from the usual use of PSA in design, which compares different system configurations, because it focuses on the thermal-hydraulic performance of a safety function.

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5. INTRODUCTION

According to the International Atomic Energy Agency (IAEA) definition, a passive system is either a system that is composed of passive components and structures or a system that uses active components in a very limited way to initiate subsequent passive operation (IAEA, 1991). Of great importance are thermal-hydraulic systems (T-H) that fall under IAEA Categories B and C. These are characterized by moving working fluids either without or with moving mechanical parts, such as check or relief valves, respectively.

Passive system reliability analysis has attracted increasing attention over the last decade. The expectation that the overall plant reliability should increase by replacing certain active systems with passive ones is based on the fact that unreliability of active systems is due primarily to the unreliability of the energy source that is required for them to perform. Passive system functionality does not rely on an external source of energy, but on an intelligent use of the naturally available one (gravity), which is always present. As the research in the field advances, the tradeoffs between passive and active systems are becoming clear. Although the energy source is always available for a passive system, it is normally weak. As a result, passive systems are much more sensitive to changes in the surroundings than active ones (Pagani et al, 2005). In addition, the operators cannot control passive systems the way they can control the performance of active systems.

Since the reliability evaluation does not depend on the availability of the driving energy, a new description of the concept of failure is required. The concept of passive function failure, borrowed from reliability physics, has been introduced by Burgazzi

(2003). It describes "failure" in terms of a "load" exerted during the performance of the system on its components and the "capacity" of these components to withstand that load. An example of a load is the temperature at a certain point as the system operates. The temperature limit of the material at that point above which damage occurs is the capacity of the system. In general, both the load and the capacity are uncertain and may depend on time (an example is shown in Figure 1). The probability that the load exceeds the capacity is the failure probability of the system for that point in time. Two models are therefore needed, one for the load and one for the capacity. In general, the capacity model may be correlated with the load model. In other words, the capacity of a component can be a function of its state and therefore time-dependent. An example of this is the dependence of material yield stress on temperature. Therefore, if the analyzed component is a pipe, the pressure required to break it is a function of the temperature, which may vary according to the performance of the system.

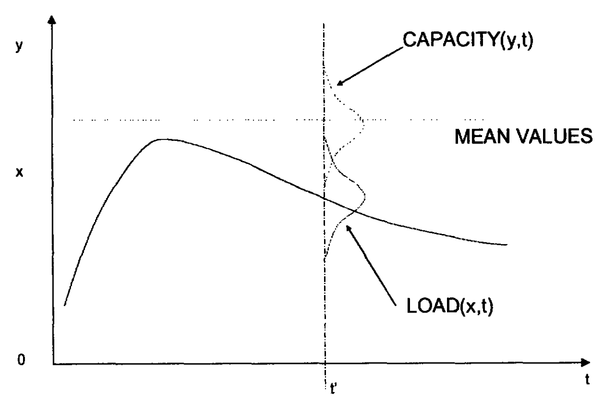

Figure 1. An example of load and capacity stochastic processes.

The following tasks need to be performed to evaluate the reliability of a passive system:

1. Identification of the components (points in the system) where failure may occur and their respective loads and capacities. A component may fail in a number of ways. Failure Modes and Effects Analysis (FMEA) and Hazard and Operability HAZOP Analysis are methods that are helpful in identifying component failure modes (Burgazzi, 2004).

2. Definition of component failure criteria, i.e., the type of capacity model that should be used for each load determined in the previous task. Capacity models may be in the form of deterministic limits (e.g., imposed by a regulatory authority) or probability distributions based on experiments and/or expert opinions.

3. Selection of sets of parameters (boundary conditions, system properties and initial conditions) that affect the behavior of each load determined in Task 1. The Analytical Hierarchy Process (AHP) has been proposed to help identify these important driving parameters (Zio et al, 2003; Marquès et al, 2005).

4. Development of a probability distribution for each parameter input to the model to represent the relevant uncertainties. This is a crucial step and is normally done based on experiments or expert opinions (Jafari et al, 2003; Marquès et al, 2005; Pagani et al, 2005).

5. Propagation of the uncertainty distributions of the input parameters through the models. Many techniques have been proposed to perform this step. They range from Monte Carlo simulation (Pagani et al, 2005) to the development of response

surfaces. A discussion on the advantages and disadvantages of each option is presented by Marquès et al. (2005).

6. Calculation of system reliability. The system is considered failed if one or more of the failure criteria are met. This means that more than one component may fail for the same system realization (Marquès et al, 2005). The result of this calculation is the probability of failure of the system.

These tasks provide the main structure of any passive system reliability calculation. The list does not include tasks aimed at improving the quality and efficiency of the calculations, such as early sensitivity analyses or iteration loops between tasks. A more detailed description of these tasks is presented in (Jafari et al, 2003; Marquès et al, 2005).

This work presents a detailed description of the time-dependent reliability evaluation of a passive decay heat removal system after a Lost-of-Coolant-Accident (LOCA). We emphasize the difficulties found in the process, propose solutions, and describe the lessons learned regarding the design itself. Our focus is on uncertainties and their propagation.

A preliminary design of a helium-cooled fast reactor constitutes the case study. It is part of the MIT studies on a Gas-cooled Fast Reactor (GFR) design. The system and its components were simulated using RELAP5-3D (INEEL, 2001). The entire system operates as one passive system whose initiation is triggered by the reactor scram after a Loss-of-Coolant Accident (LOCA). Section 2 describes the system.

The complete description of the reliability calculation is presented in Section 3, where suggestions for design improvement are also given by identifying the input parameters that are driving the failure of the system. Finally, conclusions on different aspects of the work and future research suggestions are provided in Section 4.

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6. SYSTEM DESCRIPTION

The GFR design considered consists of a 600 MWth helium-cooled fast reactor core inside the Pressure Vessel (PV), a Brayton power cycle within the Power Conversion Unit (PCU), and two 50% Decay Heat Removal (DHR) loops (Figure 2). The core is designed to have very low pressure drop to maximize the natural circulation capability. Moreover, the PV, the PCU and the DHR loops are surrounded by a guard containment with a high design pressure of 2 MPa (20 bars), so that, after primary system depressurization, the final pressure in the guard containment would be high enough to make DHR by natural circulation of helium possible. Each DHR loop is designed to extract 2% of the reactor nominal power (12 MWth) at a backup pressure of 1.3 MPa.

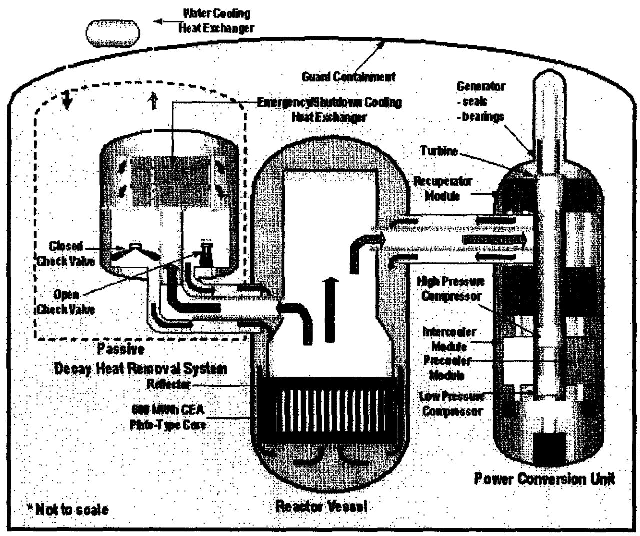

Figure 2. Schematic GFR system layout.

Each DHR loop consists of two separate circuits. The first is connected to the PV through a coaxial pipe with the cold leg running in the outside. Heat is subsequently delivered to the second circuit, filled with water, through a heat exchanger. The water loop delivers the heat to a pool outside the containment building. Check valves are placed in the cold leg of the helium section of each DHR loop. The PCU contains a Brayton power cycle with recuperator, precooler and intercooler. The shaft that is propelled by the turbine provides energy to the generator and to the low and high pressure compressors of the cycle as well. More details on the GFR system layout are in Hejzlar et al. (2005).

As will be seen later, there are several parameters that are of importance for a natural circulation loop to work properly. An intuitive review of the phenomenon gives a good insight into the system's dynamics. Figure 3 shows a generic loop that is the starting point of the discussion. Heat is inserted at point (1) and extracted at point (2). There is no heat transfer at any other point in the circuit. When the fluid is heated at point (1) its density decreases and it begins to flow up and forms the hotter fluid column that is shown in the figure. At the same time, when heat is extracted at point (2), the density of the fluid increases and as a result it moves down forming the colder fluid column shown in the figure. The difference in weight (W-w) between the two columns is the driving force that results in a certain mass flow running through the loop. The mass flow is primarily determined by the driving force and the resistance that the system exerts to the flow through pipes and fittings. To increase the mass flow then one can increase H, the difference in altitude between points (1) and (2), increase the temperature difference between the columns, or replace the fluid by one whose density change per unit temperature is greater.

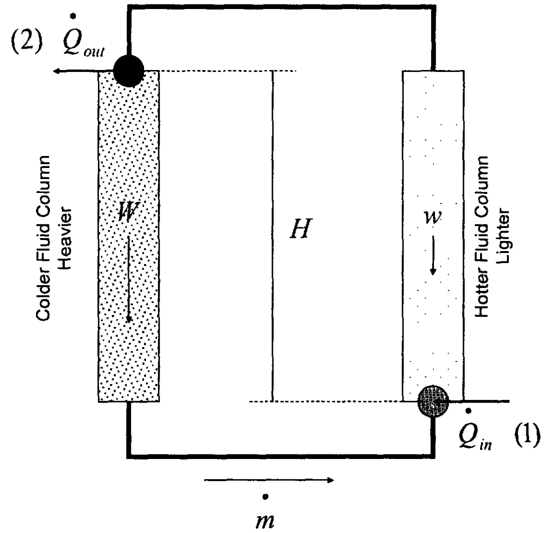

Figure 3. Schematic of a natural circulation loop.

Assuming the loop is at steady state (which implies $\dot{Q}_{out} - \dot{Q}_{in} = 0$), the rate at which the system is extracting heat from the source is equal to $\dot{Q}_{in}$ [J/s]:

$$\dot{Q}_{in} = \dot{m} * Cp * \Delta T \qquad (1)$$

where

$\dot{m} = \rho VA =$ Mass Flow [kg/s]
$Cp =$ Isobaric Heat Capacity [J/kg K]
$\Delta T =$ Temperature Difference between hot and cold legs [K]
$\rho =$ Density [kg/m^3]
$V =$ Velocity [m/s]
$A =$ Flowing Area [m^2]

Therefore, in order to extract more heat either the mass flow or the temperature difference needs to be increased in the passive loop. Increasing the mass flow is normally preferable because to increase ΔT almost always means to increase the temperature of the hot leg consequently reducing the safety margin on the temperature limit. Embedded in this short argument is the importance of the backup pressure. A greater pressure means higher density of the helium and a higher mass flow through the heat exchanger for the same fluid velocity, letting the system extract more heat from the source, while keeping ΔT constant. Although not mentioned in the discussion above, an increase in the density is also beneficial to the natural circulation phenomenon because it reduces the friction factor along the loop due to reduced kinematic viscosity, therefore allowing a larger mass flow.

A LOCA on the cold leg of the PCU was chosen as the initiating event of the analysis. The system is designed to survive a 500 cm^2 break, but it was evaluated for a 5 cm^2 break that is much more probable (frequency: $\sim 10^{-3}$ per year) than a large break. The sequence of events is as follows:

1. The cooling function is performed by the helium coming from the PCU from the moment of the accident until the shaft with turbine and compressors stops. During that time the flow coming out from the PCU is divided into two streams at the point of the rupture: the first one goes directly to the containment through the break and the second follows its initial path to the core through the downcomer. How long the shaft runs is a function of the size of the break. For a 500 cm^2 break, the Brayton cycle would work as such, propelled by the decay heat, for a period of time ranging between 30 to 40 minutes. This gives enough time for the decay heat to fall below the 2% nominal power threshold, so the DHR loops can safely take over the cooling function. The situation is different for a 5 cm^2

break. The shaft stops after approximately 10 minutes. The higher density of the helium, sustained in time because of the small break area, plus a smaller temperature difference across the core provide more resistance to compressors and less energy is extracted by the turbine from helium, therefore the reduction in shaft coastdown time. During this period the PCU is cooling down the core and the check valves placed on the cold legs of the natural circulation DHR loops are closed.

2. Once the shaft stops, the pressure difference is reversed and the check valves open, allowing the natural circulation through the DHR loops to start. Two parameters are important here: the pressure inside the PV and DHR loop and the amount of decay heat that is being released at that moment. For the case of a 500 cm^2 break, the pressure inside the PV is already equalized to that of the containment and the decay heat is below the 2% nominal power threshold. Problems could arise, for example, if the structures in the containment absorbed an excessive amount of heat, therefore reducing the backup pressure required for natural circulation, or if the shaft stopped when the decay heat was greater than 12 MWth. For the 5 cm^2 break, the dynamics are different. The shaft stops within 10 minutes of the accident but the pressure inside the PV remains high enough to sustain a natural circulation capable to extract the decay heat that is being produced. Nevertheless, when natural circulation through the DHR loops starts, the temperature difference across the core is not sufficient to extract the decay heat that is being produced, so the outlet

temperature begins to rise until it reaches its operating condition. Meanwhile, the natural circulation is continually deteriorating by the depressurization process that will eventually end about 30 to 40 minutes after the accident. After that time the decay heat is below the 12 MWth mark and, if the backup pressure is by then adequate and decaying slower than the decay heat, the system will be operating safely.

7. ANALYSIS

7.1.Mechanistic Model

The mechanistic model simulates the dynamic behavior of the system given a set of boundary and initial conditions and system physical properties (i.e., it is the "model of the world" in PRA terminology (Apostolakis, 1994)). This model will be used to perform sensitivity analyses and to propagate the uncertainties in the input parameters.

A complete model of the system was built using RELAP5-3D (INEEL, 2001). RELAP5-3D is a thermal-hydraulic code developed by Idaho National Laboratory for the analysis of accidents in nuclear power plants. Figure 4 shows the nodalization of the model of the system.

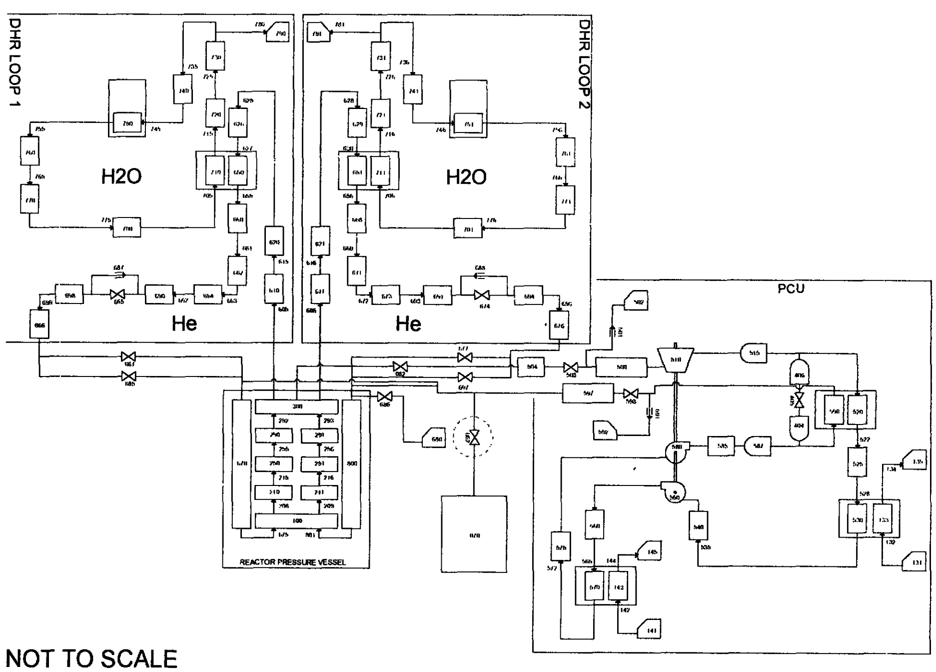

Figure 4. RELAP5-3D Nodalization diagram of the system

The DHR loops are on the top left area of the diagram and show the water and helium sides connected together by heat exchangers. Heat exchangers are represented by rectangles enclosing the volumes involved in the heat transfer balance. The reactor is immediately below the DHR loops. Two long vertical volumes represent the downcomer and, in the center of the core, two channels can be distinguished between the lower and upper plenums; one representing the average and the other the hottest channels in the core. On the lower right-hand corner, the PCU is modeled. The turbine and both high- and low-pressure compressors are connected to the same shaft. There are three heat exchangers in this part of the model and they correspond to the recuperator, the pre-cooler and the intercooler. Finally, enclosed by a dashed line circle is the valve that simulates the rupture generating the LOCA. This valve connects the outlet of the cold leg of the PCU to the volume that represents the containment building.

The following is a list of modeling information relevant to the results:

1. The ANS 79 Decay Heat Model is used (ANS, 1979)

2. All pipe walls are modeled for pipes in each DHR loop. The importance of this practice comes from the fact that the heat capacity of steel is greater than that of helium. A significant amount of mass flow is required then to either heat them up or cool them down, therefore affecting the transient behavior of the natural circulation loops (Hejzlar et al, 2005).

3. The core is modeled by two channels: an average and a hot one. The hot channel simulates the hottest channel in the core in accordance to the core's peaking factor. Attached to each channel, there are heat structures simulating

cladding and fuel. This configuration allows the monitoring of the highest temperature in both fuel and cladding.

4. RELAP5-3D does not allow negative angular velocity for shafts and compressor operation at negligibly small flows. To overcome this issue and continue with calculations beyond this point, as soon as the mass flow entering the PCU becomes smaller than 0.5% of the nominal flow, the PCU is isolated from the rest of the system and an auxiliary external flow is injected into it to keep the shaft running with positive angular velocity, while the rest of the simulation is carried on in parallel. This action prevents simulation of the effect of bypass flow through the PCU on core cooling; hence the failure probabilities reported here are optimistic assuming that PCU can be isolated with 100% reliability.

5. Leakage of the check valves in the DHR loops is simulated with a time-dependent junction running parallel to the respective check valve. A time-dependent junction allows the implementation of a constant negative mass flow rate through the loop, if the pressure drop across the check valve is positive. Otherwise, the mass flow rate is zero.

6. The heat transfer from the water loop to the pool outside the containment building is simulated with a natural convection boundary condition with a fixed T_∞ (bulk temperature of the pool) equal to the ambient temperature.

7. Three heat structures simulating the containment liner, the concrete on the floor, and the equipment inside the containment building are added to the

containment hydrodynamic volume. Their effect is important because they absorb heat reducing the temperature of the helium in the containment and thus the backup pressure.

During the mechanistic analysis, several unexpected effects were discovered. The system was initially designed with two 50% DHR loops that would work in parallel (see flow pattern (1) in Figure 5). This feature needed to be changed because the check valves of one of the DHR loops would never be open at the same time except for short periods of unstable flow. The reason for this behavior is the smaller pressure drop through the DHR heat exchangers than through the core and flow tendency to bypass the core through one of the DHR loops closing check valve on this loop. Thus, if both valves are forced to open, one of the loops would finally work backwards (see flow pattern (2), Loop 2, in Figure 5); stealing the mass flow from the core so that most of the flow from the correctly operating loop proceeds through the common lower plenum to the other loop and ultimately to the upper plenum. Such core bypass reduces substantially core flow rate and rapidly leads to fuel overheating. To overcome this problem, the design was modified to increase the original 2x50% capacity to 2x100% capacity DHR loops. Furthermore, the appearance of this phenomenon clearly emphasizes the importance of modeling the DHR loops separately instead of lumping them up into one loop that extracts as much energy as the sum of the individual loops.

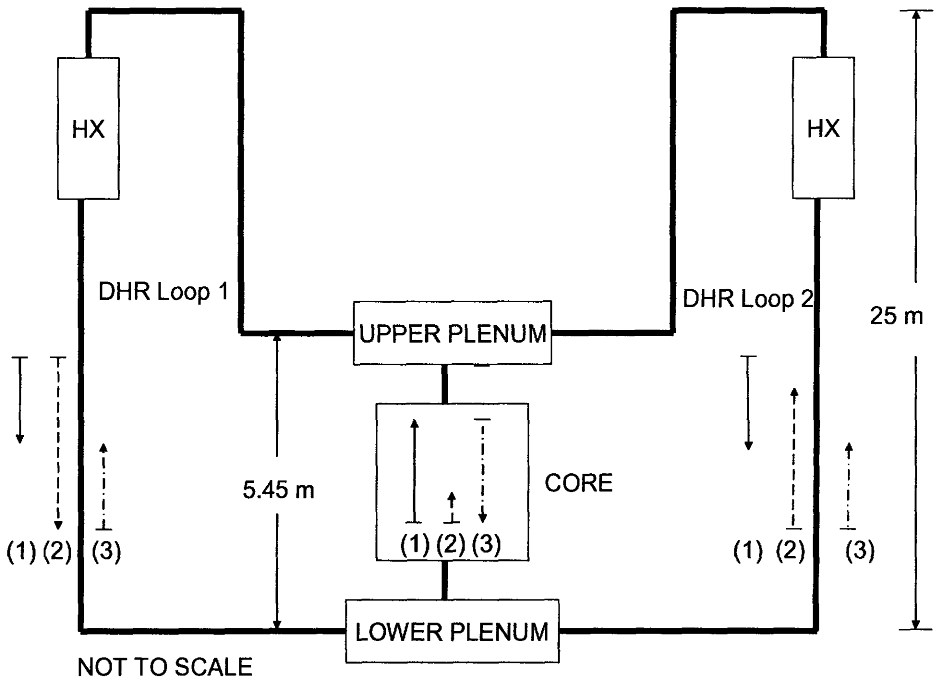

Figure 5. Possible flow patterns.

Another interesting phenomenon happens if the check valves are forced to open before the mass flow that is injected by the compressors on mounted on the coasting down shaft stops. In this case, both loops would work backwards (see flow pattern (3) in Figure 5) because the pressure in the upper plenum would be smaller than that in the lower plenum. This unintended behavior is stable at least for the decay heat levels that occur during the first three hours after the accident. The same phenomenon is observed if there is a leaky check valve. During normal operation the pressure difference across the core produces a continuous flow through the leaking check valves. If the leakage of the check valves is sufficiently high, the continuous leak forces the flow through the emergency heat exchangers where it experiences cooling and the originally hot riser becomes cooler than the downcomer resulting the in the continuous reversed flow. After the shaft stops, both loops continue in reversed operation mode and the sum of leaking flows is not sufficient to cool the core thus leading to failure.

As discussed earlier, the heat absorption from the structures inside the containment building was expected to have an impact on the evolution of its pressure and therefore on the backup pressure once the PV and the containment pressures are equalized. The results from a sensitivity analysis on this parameter showed that the liner needed to be isolated and the free volume to be reduced.

After these changes to the design, the model is ready for the next stage on the analysis: uncertainty analysis.

7.2. Uncertainties

As stated in the introduction, passive systems are sensitive to changes in the boundary and initial conditions and to changes in the numerical values of the parameters that define the system properties. All these conditions and parameters are called input parameters. This sensitivity is due primarily to the weakness and uncontrollability of the driving force, gravity.

A set of six input parameters were selected to be propagated through the model. Table 1 shows these parameters and their probability distribution functions. The selection was made based on sensitivity analyses done on several parameters and expert opinion.

INPUT PARAMETER	DISTRUBUTION	EXTREME VALUES		UNITS	EXTREME VALUES CORRESPOND TO PERCENTILES	
		LOWER	UPPER		LOWER	UPPER
Core Roughness	Lognormal	1.00E-05	1.00E-04	[m]	5	85
DHR1 Check Valve Leakage	Exponential	-	0.50	[kg/s]	-	80
DHR2 Check Valve Leakage	Exponential	-	0.50	[kg/s]	-	80
Heat Transfer Coefficient, Containment Structures	Lognormal	0.50	2.00	[Dimensionless]	20	75
Moment of Inertia of the Shaft	Normal	656.88	802.86	[kg*m2]	20	80
Core Heat Transfer Coefficient	Lognormal	0.40	1.60	[Dimensionless]	20	80

Table 1 Selected Input Parameters and their probability distributions

Roughness in the Core refers to the roughness of the surfaces in the core that are in contact with helium. Even though it is small in absolute terms, the pressure drop in the core accounts for about 70% of the overall pressure drop along the DHR loops under nominal operation. An increase in the roughness translates into a larger pressure drop in the core with the consequent reduction in the mass flow rate. As the mass flow rate decreases, the required temperature difference across the core increases for the same amount of heat removal.

Check Valve Leakage: The first assumption is that the check valves are always leaking. The effect of leakage is to delay the opening the valves. A backward flow through the DHR loops is present during normal operation and during the time the PCU is cooling the core after the accident, therefore the system has to overcome the inertia of that flow in order to open the check valves once the PCU has stopped.

Heat Transfer Coefficient of Structures in the Containment Building (HTCS): The result of having a greater HTCS is that blown down helium in the containment is cooled down faster and therefore reducing the pressure that at the same point in time the containment would have had under adiabatic conditions. Since this is a preliminary design, the containment layout and geometry and positions of internal structures inside are not known. Each modeled structure corresponds to the lumping of several objects and each of these would have its own time-dependent heat transfer coefficient, so the modeled HTCS correspond to average values. Furthermore, RELAP5-3D calculates the heat transfer coefficient for each structure in the containment volume according to its respective boundary condition, so the uncertainty is represented by a multiplicative factor that modifies the HTCS calculated by the code.

Heat Transfer Coefficient in the Core (HTCC): The effect of a smaller heat transfer coefficient is that a greater temperature gradient across the core would be required in order to remove the same amount of heat. In this case, there is uncertainty in heat transfer correlations implemented RELAP5-3D in calculating the correct value of heat transfer coefficient under low-Reynolds number, high heat-flux flows where local buoyancy and acceleration forces can significantly reduce heat transfer coefficient (Lee and Hejzlar, 2006). The uncertainty is represented by a multiplicative factor that modifies the HTCC calculated by the code.

Moment of Inertia of the Shaft: A shaft with a greater moment of inertia is more difficult to decelerate and therefore could run longer. This is important because as the coastdown time is increased, the moment at which the DHR loops are initiated is also increased placing the system in a safer operating condition with a smaller decay heat.

7.3. Uncertainty Propagation

Monte Carlo simulation is used to propagate the uncertainties in the input parameters through the model. In order to reduce the number of trials, Latin Hypercube Sampling (LHS) was employed. In short, this technique divides the six-dimensional probability defined by the input parameters into a set of equiprobable six-dimensional cubes (hypercubes) from which the samples are then chosen. The fundamental assumption of the method is that the input variables are independent. Since only one sample point is chosen from each hypercube, the sample points are equiprobable. More information on LHS can be found in Helton and Davis (2003).

Once the sample is chosen, a RELAP5-3D simulation is made for each unique set of sample points (one from each hypercube). Each set defines a scenario. Since these sets are equiprobable, the corresponding results of RELAP5-3D are also equiprobable. A three-hour time span starting at the moment of the accident was chosen as the simulation interval. This selection was made based on sensitivity analyses that showed that the pressure in the containment becomes equal to the pressure in the PV (consequently, the flow through the rupture is negligible) after two hours. The pressure rate of change inside the containment was never less than -17 Pa/s at the end of three hours. The sensitivity analyses also showed that the temperature gradient at the same point was never less than -9.0×10^{-3} K. Furthermore, the power that is being generated at the core by then is about 6.8 MWth, well below the design specifications of the DHR loops. For the present work, it is assumed that the containment has no leakage.

7.4. Failure Criteria

After the simulations are finished, a screening of the output parameters is again required in order to define which of them are going to be considered for the unreliability evaluation. It is important to do so because new failure modes may be discovered in the process. Figure 6 shows an example (not an actual result) for an output parameter. Each curve corresponds to a particular scenario (set of sample points).

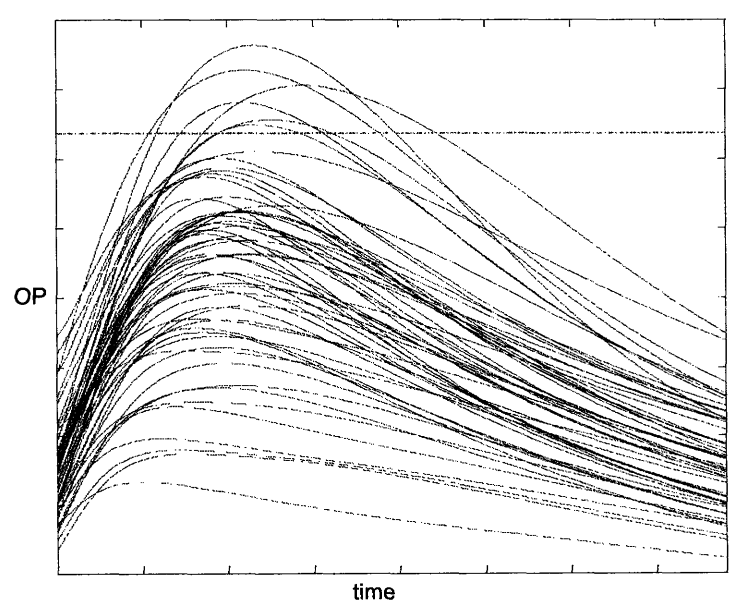

Figure 6 Example of the output from an LHS uncertainty propagation

The next step is to define the failure criterion for each selected output parameter. In traditional reliability assessments, this task is done much earlier in the process and in fact it can be made during the mechanistic analysis, after structuring the set of potentially relevant output parameters, but it must be reviewed here because new failure modes may have been discovered. The failure criteria used in this work are deterministic limits such as the horizontal dashed line shown in Figure 6. Any realization that exceeds the limit is considered a failure. Since all realizations are equally likely, the probability of failure during the time span of the graph is equal to the number of curves that exceed the limit divided by the total number of curves.

To write this down more formally, let A(i) be a binary variable that is equal to unity when the i^{th} scenario (realization) leads to failure and equal to zero otherwise. Then, the probability of failure is:

$$PF_S \equiv \frac{\sum_{i=1}^{M} A(i)}{M} \qquad \textbf{(2)}$$

where M is the total number of realizations.

7.5. System Failure Criteria

Multiple failure criteria should be used whenever more than one output parameter may lead to failure. This means that a specific scenario may lead to no failure or at least one failure. The overall failure probability can be calculated as follows:

Let $A_1, A_2, \dots A_N$ be the failure vectors associated to N failure modes over M realizations. Define $F(i) = \max(A_1(i), A_2(i), \dots, A_N(i)) \ \forall i \in \{1,2,3,\dots,M\}$, then the mean probability of multiple failure PF is define as:

$$PF_M \equiv \frac{\sum_{i=1}^{M} F(i)}{M} \qquad (3)$$

Figure 7 shows an example of this procedure.

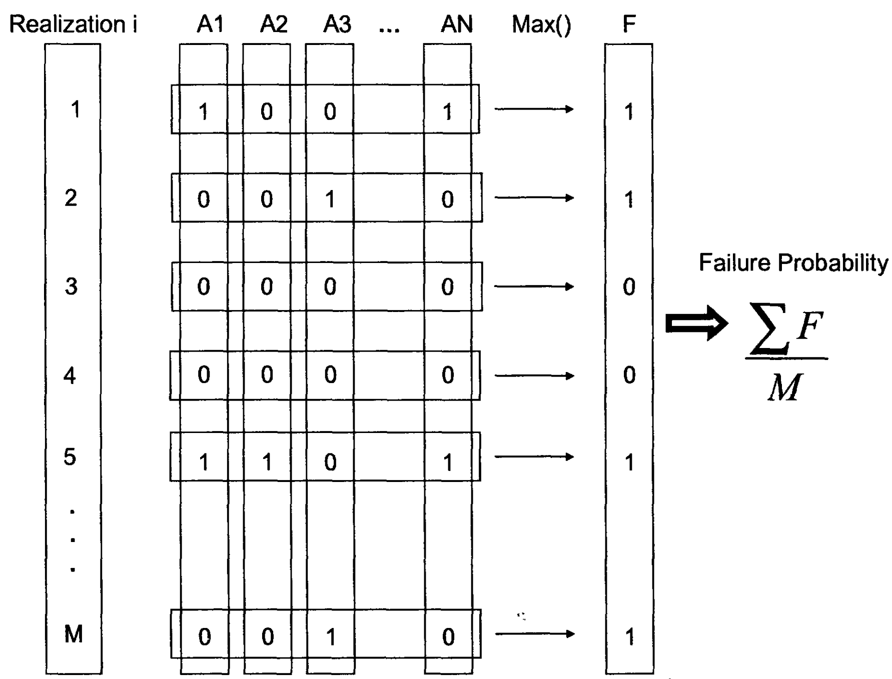

Figure 7 Multiple Failure Criteria

7.6. Results

After reviewing the parameters of the system at various points, two failure modes were finally selected for the reliability evaluation of the system: Cladding damage in the hot channel and structural failure in the hot legs of the DHR Loops. A limit of 1600 °C

(1873 K) was set as the maximum temperature for cladding damage. It is assumed that the silicon carbide cladding would release fission products if that temperature were exceeded. The imposed limit on the DHR pipe walls is 850 ˚C (1123 K). It is assumed that the DHR loop would suffer a structural collapse if this limit were exceeded leading to the loss of mass flow rate through the core. Figure 8 shows 128 realizations for the maximum cladding temperature. The horizontal dashed line corresponds to the previously mentioned limit.

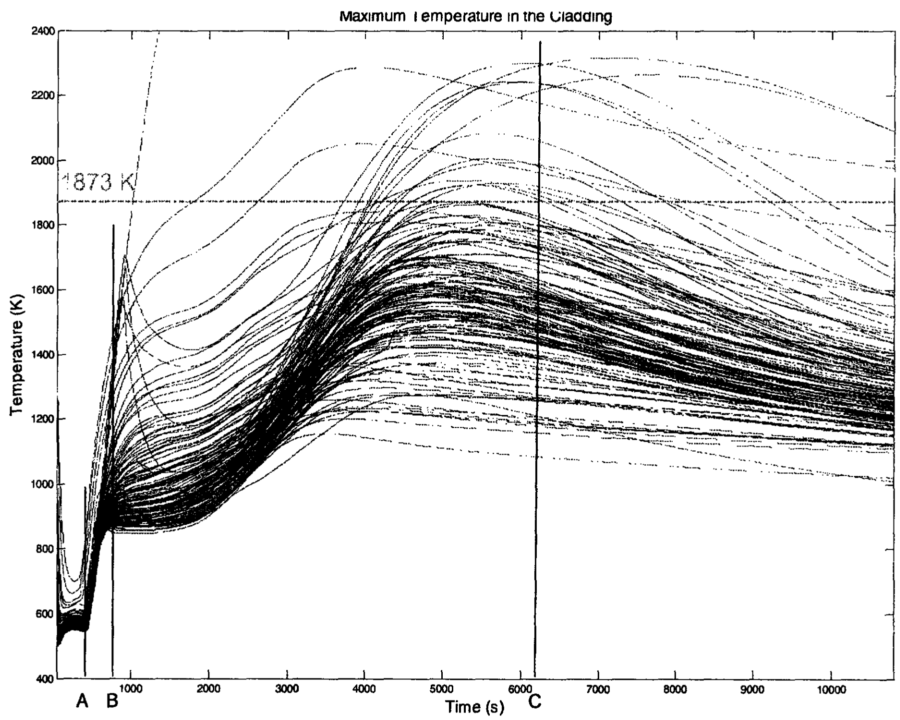

Figure 8 Realizations for Maximum Temperature in the Cladding

As expected, the maximum temperature in the cladding occurs after the shaft stops (about 500 seconds after the LOCA – Point A in Figure 8). During this period, the mass flow rate through the core reaches its minimum and the helium in the core, becoming less dense because of the increasing temperature, tries to overcome the negative flow coming down from the leaking (both check valves are assumed to leak) of the DHR loops. Eventually, one of the DHR check valves opens (Point B in Figure 8) initiating the natural circulation through the core and the maximum temperature in the cladding reduces its rate of change and ultimately comes down (Point C in Figure 8). It is during this last period of time when realizations reach their maxima. There is one realization for which the temperature never comes down and corresponds to the only case in which the check valves never open because of the significant leakage in both of them. There were 15 curves that exceeded the limit, so the overall probability for this failure mode is 0.12. This probability is conditional on the LOCA.

The second failure mode corresponds to the structural failure of the operating DHR Loop. As already stated, a limit of 850 C (1123 K) to the maximum temperature on the hot legs (MTHL) was set as the failure criterion for this failure mode. Figure 9 shows the 128 resulting realizations. Each realization is represented in the graph by two curves; one for each DHR loop. The always decreasing curves correspond to the DHR loop with the check valve closed. In the initial conditions of the simulation, the MTHL is set as if there were no leakage in either loop. This is the worst possible initial condition because the MTHL is smaller with leakage than without. This is due to the fact that the leaking helium comes from the downcomer and passes through water cooled heat exchanger where it cools down substantially. There were 26 curves that exceeded the limit, thus the calculated conditional probability for this failure mode is 0.20.

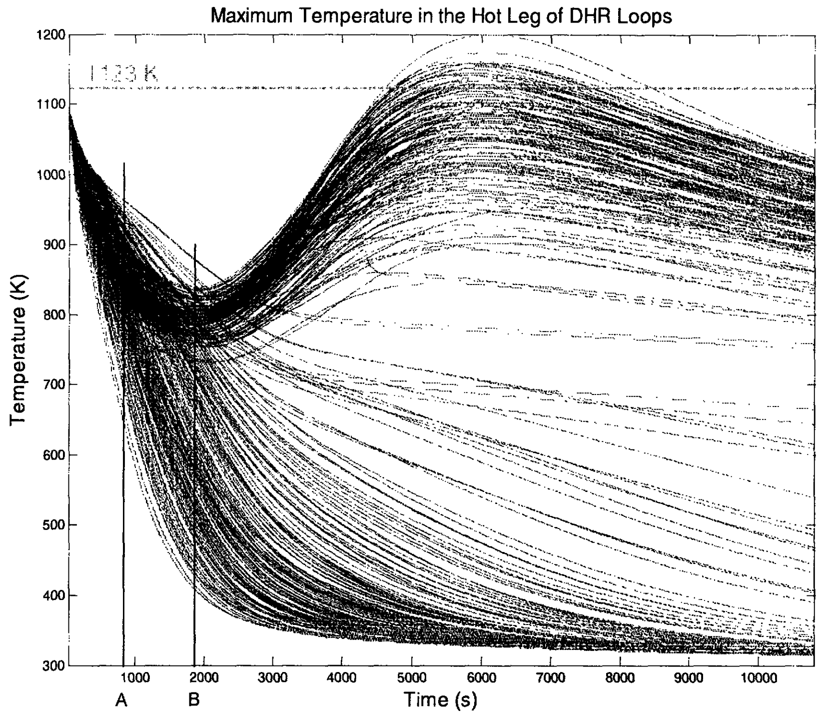

Figure 9 Realizations for the Maximum Temperature in the Hot Leg of DHR Loops

As soon as the LOCA occurs, the MTHL starts decreasing in both loops because of the injection of cold helium from the downcomer. When the check valve opens (Point A in Figure 9), the behavior of the operating loop starts departing from the one that is still leaking until it reaches a minimum at about 30 minutes (Point B in Figure 9). The reason is that, once the valve opens, natural circulation starts building up and hotter helium coming from the upper plenum heats up the pipes. From then on, the MTHL is well correlated to the behavior of the maximum temperature in the cladding presented in Figure 8.

The conditional failure probability is 0.305 when both failure modes are included. Referring to the discussion in Section 3.5, we find that $\sum F = 39$ over a total of 128 realizations. There were 15 and 26 failures for each respective failure mode, therefore the total would be 41 instead of 39, if each realization led to a single failure. We conclude that two realizations led to failures by both failure modes.

3.7 Insights

Interesting insights into the behavior of the system can be produced by developing scatter plots of failures and successes for two parameters at a time (Ghosh and Apostolakis, 2006). Figure 10 shows such a plot for the two leakages associated with each Monte Carlo realization (one for each DHR loop) for the maximum temperature in the cladding. On the horizontal axis we plot the maximum of the two leakages and on the vertical axis the minimum. The plus signs indicate a realization and the square around a plus sign indicates that this realization is, in fact, a failure of the cladding. Looking at the lower left corner of the plot we observe that no failures exist below the dashed line. Thus, we conclude that no cladding failure occurs when the maximum leakage in the loops is less than about 0.8 kg/s and the minimum leakage is less than about 0.5 kg/s.

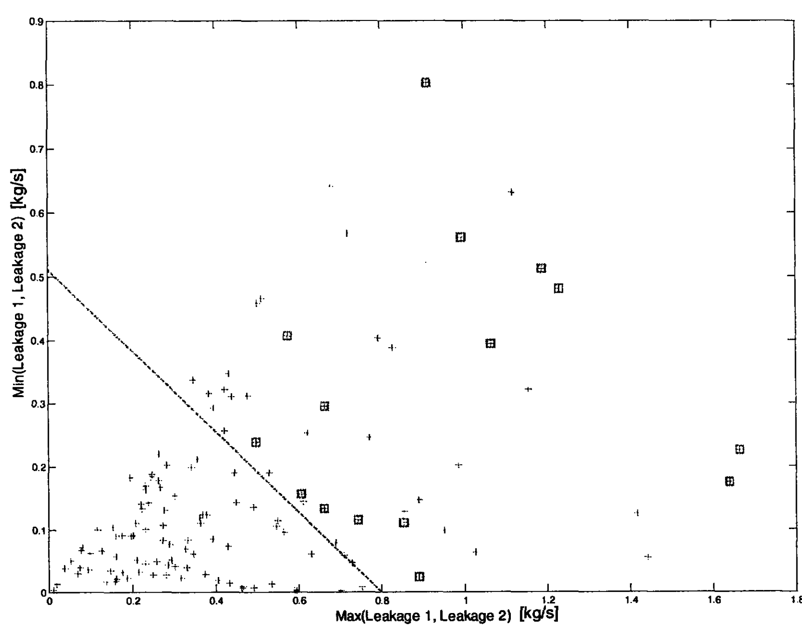

Figure 10 Leakage Threshold Effect (cladding failure)

The explanation for this behavior is the following: After the shaft stops, the system attempts to open the check valves by overcoming the leakage. The valve with the smallest leakage is the one that eventually opens. The higher the minimum leakage the later the check valve opens. Such a delay means that more heat has been deposited in the core with no extraction and therefore the temperature has increased.

Once the valve opens, natural circulation develops through the corresponding DHR loop, but part of the fluid in the lower plenum is taken by the other DHR loop's leakage and transferred directly to the upper plenum, thus bypassing the core. The higher the maximum leakage, the smaller mass flow is available to the core for heat removal. Failure is the combined effect of the two quantities and, as Figure 10 shows, only values outside the lower triangle can lead to failure.

Threshold effects can be found for the structural failure mode as well. Figure 11 shows a similar plot for the effect of the HTCS and the maximum leakage of the valves. The effect of the leakage is easily understood. The maximum leakage corresponds to the loop whose check valve never opens and remains leaking after the other DHR loop starts operating. That flow is inserting cold helium to the inlet of the operating DHR loop through common upper plenum. Thus, if the maximum leakage is sufficiently high, it cools down the upper plenum enough, preventing failure. As Figure 11 shows, there is no structural damage when the HTCS factor is larger than 0.86 <u>and</u> the maximum leakage is larger than 0.63 [kg/s]. Figure 11 also shows that there is no cladding damage when the HTCS factor is smaller than 0.86 regardless of the value of the maximum leakage. The explanation for this behavior is as follows: the lower the HTCS, the higher the pressure in the containment and, therefore, inside the PV after the pressures are equalized. Higher pressure means higher helium density and, as explained in Section 2 (Equation 1), this corresponds to a smaller temperature difference across the core for the same amount of extracted heat. Finally, the smaller temperature difference is translated into a smaller core outlet temperature that reduces the probability of failure by MTHL.

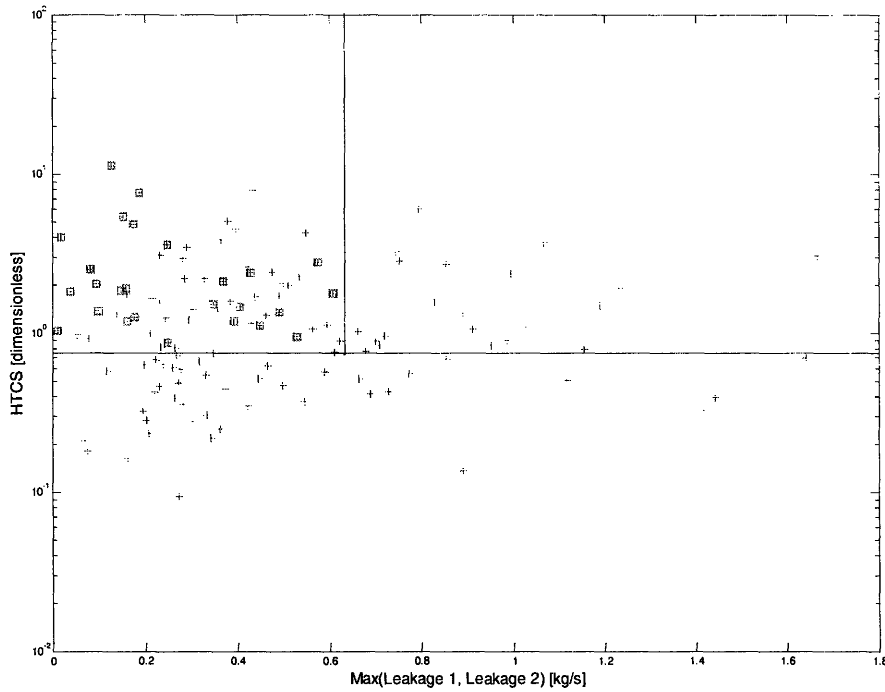

Figure 11 Maximum leakage and HTCS Threshold Effect (structural failure)

Insights into the behavior of the system can also be produced using the Generalized Sensitivity Analysis (GSA) developed in (Hornberger and Spear, 1981) for environmental systems. A GSA application to nuclear waste repositories is in (Ghosh and Apostolakis, 2006). GSA partitions Monte Carlo realizations into two bins: one bin contains all the realizations leading to failure and the other all the realizations not leading to failure. We then look at the realizations in the failure bin and ask whether there are any threshold effects, i.e., intervals of values of the input parameters that guarantee no failure. The process will become clear using concrete examples.

Figure 12 shows the cumulative distribution function of the parameter on the horizontal axis in the realizations that did not lead to cladding failure (continuous curve) and the cumulative distribution function in the realizations that did lead to such failure (staircase curve). Only the parameter HTCS shows a potential threshold effect in the sense that failure would be very unlikely if the HTCS factor were less than about 0.48.

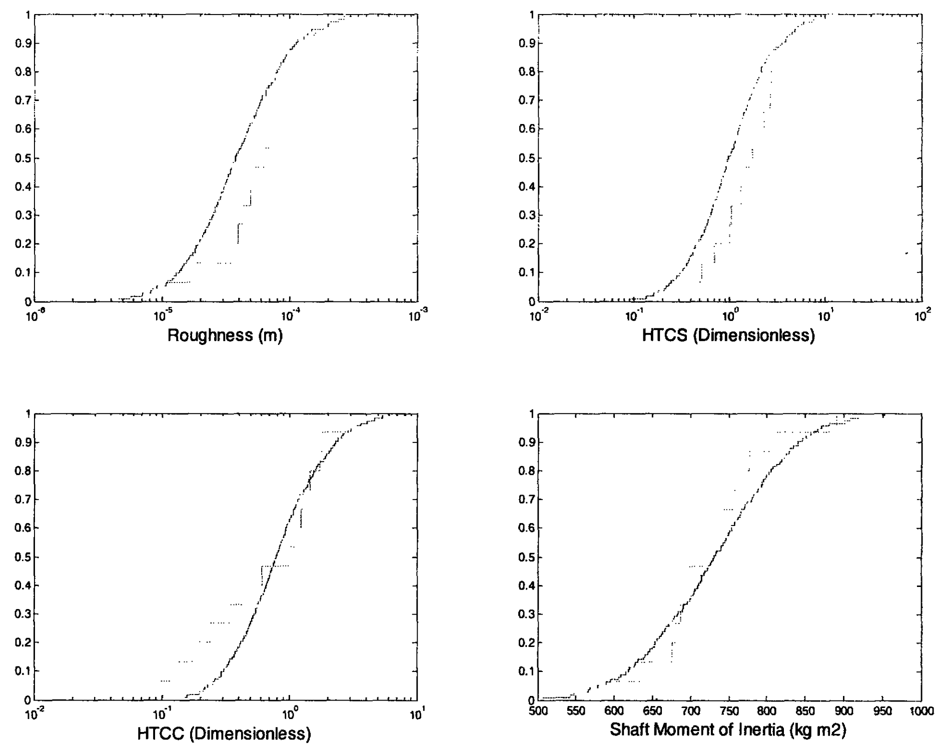

Figure 12 Search for threshold effects (Failure Mode 1, cladding failure)

Figure 13 shows the same type of graphs for the second failure mode (structural failure). This time, the threshold effect on the HTCS is more pronounced. Failure only occurs if the value of the HTCS factor is greater than about 0.86, as found earlier (Fig. 10).

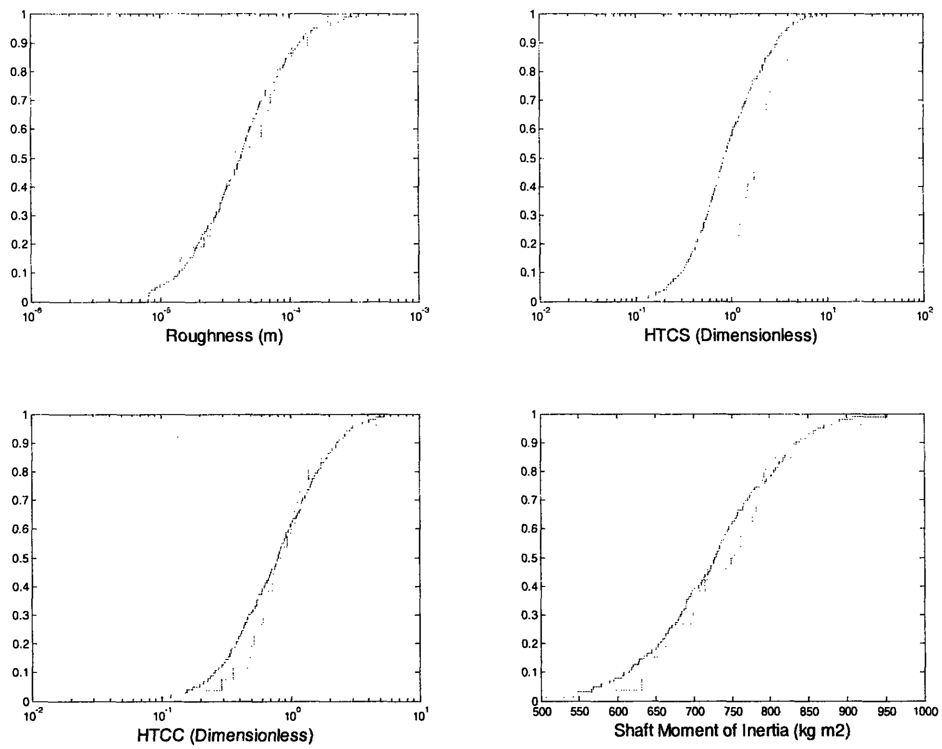

Figure 13 Search for threshold effects (Failure Mode 2, structural failure)

Both failure modes present threshold effects for the HTCS. Both failure modes become very unlikely for small values of the HTCS factor because the pressure in the containment can be maintained high for a longer period of time. This confirms an earlier finding by Pagani et al., (2005) that containment pressure is a key parameter for the success of natural circulation decay heat removal in gas cooled systems. Also, it is important to note that containment leakage, which was not part of our studies, is another important parameter that will negatively affect system performance in a similar manner as HTCS. On the other hand, for check valve leakage, what is beneficial for one failure mode is not for the other. To prevent failure due to melting of the cladding, a small maximum check valve leakage is desirable; but to prevent a structural collapse of the DHR loops, a large maximum leakage is preferred.

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8. RISK-BASED DESIGN CHANGES

The failure probability of 0.305 (conditional on the LOCA occurrence) is deemed to be too high. Since a good amount of information about the system behavior under different scenarios has been gathered, several actions can be taken. Since the dominant failure mode is the structural collapse of a DHR loop (accounts for ~2/3 of the total failure probability), it is there where the first design change can be made. In the design analyzed, the hot legs were simulated with adiabatic heat flux boundary conditions at the outer periphery, which effectively corresponds to perfect insulation at this surface. The design has been modified by placing the insulation on the inner surface of the pipe. This way, the outer perimeter is cooled down by the cold leg flow (recall that cold leg is a coaxial pipe surrounding the hot leg). However, heat losses through the insulation heat up the cold leg flow reducing the buoyancy driving head and affecting the natural circulation capability. Therefore, this solution also requires raising containment backup pressure to achieve desired DHR performance.

Additional design changes are necessary to reduce the failure probability. The backup pressure is a relatively strong factor on both failure modes since threshold effects are visible for the HTCS factor in both failure modes, though they are of different magnitudes. Therefore, an increase in containment backup pressure would substantially reduce the failure probability. One possible way to achieve this is to insulate the steel structures in the containment to minimize heat transfer to these structures and their effect on pressure decrease. Another option is a gradual depressurization of the helium inventory storage tanks, which are part of the system and have a large helium coolant inventory, into the containment. However, an increase in containment design pressure with an associated cost increase would be required.

The primary concerns are the check valve leakage and core bypass phenomena because of their strong effect on the performance of the passive system as a whole. The use of more reliable check valves is of great significance to this design, but most important is the observation that the redundancy of DHR loops can actually impair the performance of the DHR system because the parallel loop can itself become a bypass. Therefore, the smaller than 100% capacity DHR loops cannot be used and 100% capacity loops are necessary. Nevertheless, any leak of check valves in parallel loops affects the cooling capability of the core negatively. Thus, use of just one 100% DHR loop with a reliable and leak-proof check valve would eliminate the possibility of core bypass and provide the best performance, but such a solution is unrealistic since no perfect valves exist. Consequently, the use of a combination of active and passive systems for DHR or of a fully active DHR with reliable backup power need to be considered and, in fact, may provide lower failure probabilities.

9. CONCLUSIONS

From an overall perspective, the first important conclusion is that the passive system design process has to incorporate a reliability assessment. The complexity of the system and the overall impact of the simultaneous variation of several input parameters makes it impossible for the designer to foresee every possible situation.

The reliability evaluation process provides useful information to the designer. At an early stage, the analysis of the system components gives a starting point as to where the hazards may be; the most insightful view, however, comes later with the second and third screenings during the mechanistic analysis and after the uncertainty propagation. During the mechanistic analysis, improvements to the design can be made in view of the evidence given by nominal simulations and sensitivity analyses. The probabilistic analysis produces insights that the nominal analysis does not produce. In Figures 8 and 9, the curves that exceed the damage limits are the results of specific combinations of the values of the input parameters. The curves corresponding to the nominal values are below the limits and do not reveal the possibility of failure. In addition, the sensitivity analysis allows the discovery of threshold effects in the input parameters and the potential combined effect of two of them in two-dimensional scatter plots.

We point out that the probabilistic analysis presented here is different from the usual use of PSA in design. In the latter case, several design configurations are analyzed and compared using a metric such as the core damage frequency (Mizuno et al, 2005; Delaney et al, 2005). These studies are performed at the system level and usually lead to changes in the redundancy and diversity of the system. The present work uses a mechanistic model for a safety function and investigates the impact of uncertainties in the input parameters on the probability of function failure. This process reveals the significance of certain possible values of the input parameters and leads to design changes that affect these values. It is closer to the analysis presented by Ghosh and Apostolakis (2006) for nuclear waste repositories.

The sensitivity analyses identify potential threshold effects in the input parameters and lead to a better understanding of the dynamics of the system. This understanding is very helpful in efforts to improve the design in an effective way. Since one design change may affect the behavior of several failure modes differently, it is crucial to understand their interactions for the success of the design improvement. Finally, the single failure probabilities and the safety function failure probability provide a framework within which to assess the impact of design changes quantitatively.

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Jafari, J., D'Auria, F., Kazeminejad, H., Davilu, H., 2003. "Reliability evaluation of a natural circulation system." *Nuclear Engineering and Design*, 224:79-104.

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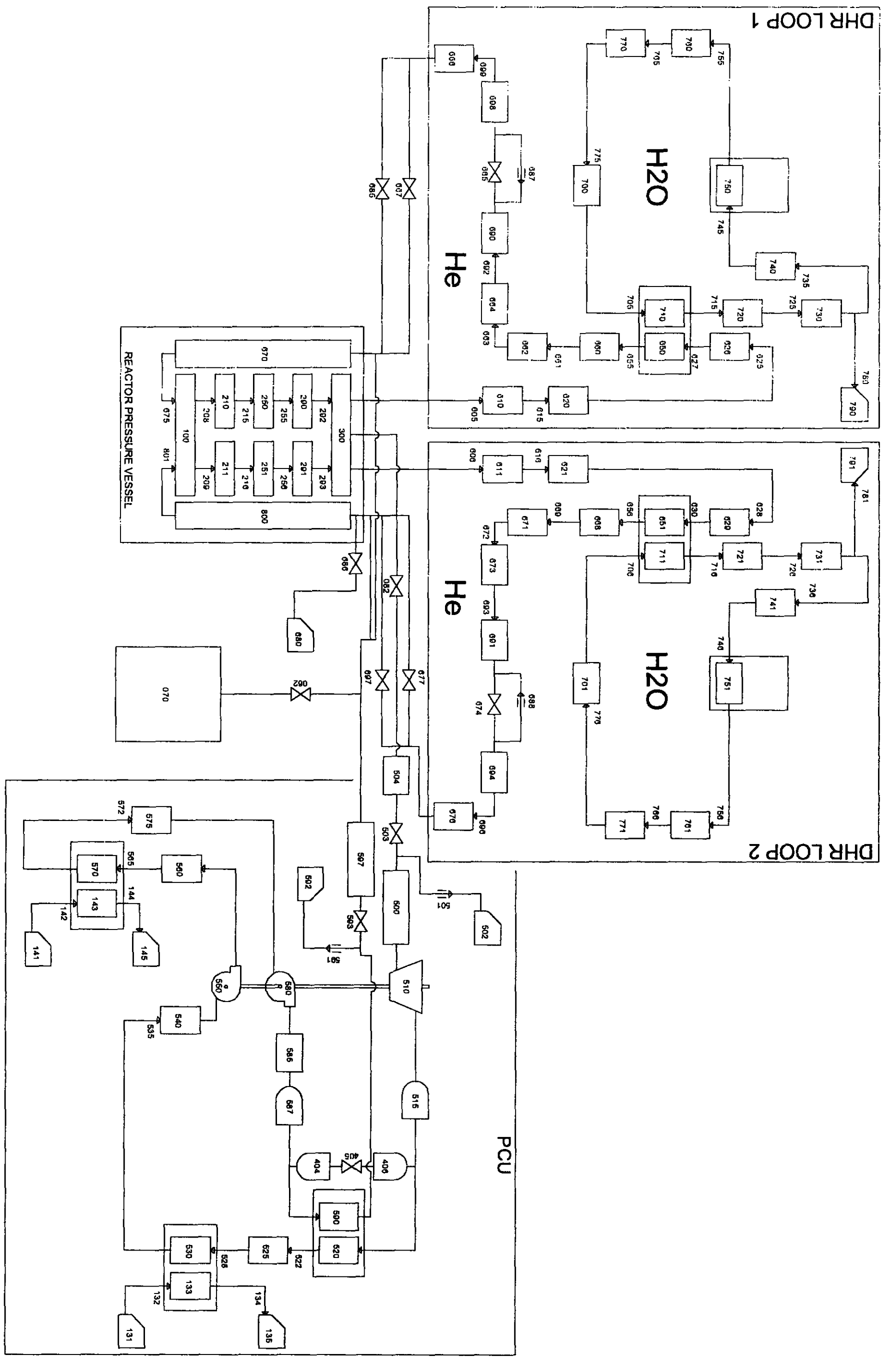
11. APPENDICES

11.1. APPENDIX A: RELAP5-3D NODALIZATION DIAGRAM



11.2. APPENDIX B: RELAP5-3D NOMINAL INPUT DECK

```
= MIT-GCFR Plate DHR
100  newath  transnt
101  run
102  si  si
105  5.0  6.0
110  air
115  1.0
*              g=1, no noncond
120  100010000  0.0  he  primary  1
121  133010000  0.0  h2o  h2opc  1
122  143010000  0.0  h2o  h2oit  1
123  700010000  0.0  h2o  uhsloop1
124  701010000  0.0  h2o  uhsloop2
*crdno end time  min dt  max dt  control  minor ed  major ed  restart
201    10800.0    1.0-10  0.0025     23     400       800000    400000
*
*
*
*--------------------------------------------------------
*  MINOR EDITS
*--------------------------------------------------------
*
*--------------------------------------------------------
*  Reactor Coolant System
*--------------------------------------------------------
*
301  p         750010000     *  Water Loops Data
302  tempf     750010000     *
303  p         751010000     *
304  tempf     751010000     *
305  p         750200000     *
306  tempf     750200000     *
307  p         751200000     *
308  tempf     751200000     *
309  mflowj    750010000     *
310  mflowj    751010000     *
311  cntrlvar 126            * q from 710
312  cntrlvar 127            * q from 711
313  cntrlvar 128            * q from 750
314  cntrlvar 129            * q from 751
315  p         710010000     *
316  tempf     710010000     *
317  p         711010000     *
318  tempf     711010000     *
319  p         710050000     *
320  tempf     710050000     *
321  p         711050000     *
322  tempf     711050000     *


*
*
```

```
323  p        650010000    *  DHR Loops Data
324  p        651010000    *
325  p        650050000    *
326  p        651050000    *
327  tempg    650010000    *
328  tempg    651010000    *
329  tempg    650050000    *
330  tempg    651050000    *
331  mflowj   665000000    *
332  mflowj   674000000    *
333  cntrlvar 120          * q from 650
334  cntrlvar 125          * q from 651
335  p        610050000    *
336  tempg    610050000    *
337  p        611050000    *
338  tempg    611050000    *
339  p        666010000    *
340  tempg    666010000    *
341  p        676010000    *
342  tempg    676010000    *
343  p        666050000    *
344  tempg    666050000    *
345  p        676050000    *
346  tempg    676050000    *
347  httemp   610100101    *
348  httemp   611100101    *
*
*
349  p        250010000    *  Reactor and
350  p        251010000    *  Downcomer Data
351  p        250080000    *
352  p        251080000    *
353  tempg    250010000    *
354  tempg    251010000    *
355  tempg    250080000    *
356  tempg    251080000    *
357  p        670010000    *
358  p        670080000    *
359  p        800010000    *
360  p        800080000    *
361  tempg    670010000    *
362  tempg    670080000    *
363  tempg    800010000    *
364  tempg    800080000    *
365  mflowj   250010000    *
367  mflowj   251010000    *
368  mflowj   670010000    *
369  mflowj   800010000    *
370  mflowj   300040000    *
371  p        300050000    *
372  tempg    300050000    *
373  p        100010000    *
374  tempg    100010000    *
375  cntrlvar 111          * Q extracted from rector
376  cntrlvar 102          * Estimated Q extracted
377  cntrlvar 123          * Q generated by the reactor
378  cntrlvar 110          * Max temp fuel  251 httemp
```

```
379  cntrlvar 103          * MAx temp clad  251 httemp
*
*
380  mflowj   062000000     * Break and Containment Data
381  sonicj   062000000
382  p        070010000     *
383  tempg    070010000     *
*
*
384  mflowj   082000000     *  PCU Data
385  p        520300000     *
386  tempg    520300000     *
387  cntrlvar 40            *
388  mflowj   550010000     *
389  cntrlvar 42            *
390  mflowj   580010000     *
391  mflowj   597010000     *
392  turvel   510           * Turbine velocity rad/s
393  cntrlvar 32            * q from pc
394  cntrlvar 34            * q from ic

20800001  sonicj  062000000


*---------------------------------------------------------
*  TRIPS               *
*---------------------------------------------------------
*
20600000  expanded
*Time to be taken for Steady-State: 50 seconds
20603500  time  0  ge  timeof  522  5.  n  * trip LP cmpr, HP cmpr  and
Turbine
20603600  time  0  ge  timeof  522  5.  l  * generator trip
20604810  time  0  ge  null  0  5.e6  l  * open bypass valve
20604820  time  0  ge  null  0  1.0e6  l  * close bypass valve
*
20605010  time  0  ge  timeof  522  5.  l  *@Rx Trip'
*20605020  time  0  ge  timeof  501  0.0  l  -1. *@Rx Trip'
*
20605210  time  0  lt  null  0  5.e6  n  *trpvlv from tmdpvol
20605220  time  0  ge  null  0  5.  l  *break junction (valve 062)
20605230  time  0  ge  timeof  522  180.  n

20605240  cntrlvar 102 lt cntrlvar 123 -2.e6 n
20605250  time  0  ge  null  0  0.   n  *valves connecting DHRs to 670
20605260  time  0  lt  null  0  5.  n  *OPEN valve 685 & 686
20605270  time  0  lt  null  0  5.  n  *open valve 082
20605280  cntrlvar 110 gt null 0 900. n
20605290  time  0  ge  timeof  1003  0.  l  *connect external torque
20605300  time  0  ge  null  0  20000.  n
20605310  time  0  lt  null  0  20000. n
20605320  vlvarea 665  eq  null 0 0. n

20605340  vlvarea 674  eq  null 0 0. n

20605350  turvel  510  lt  null  0  0.01  n   *trip cprssrs
20605360  mflowj  597010000  gt null 0 1.67  n
```

```
20605370  mflowj  082000000  le null 0 1.67  n
20605380  time  0  gt  null  0  10.  n
20605390  p       690010000  ge p     698010000  0. n
20605400  p       691010000  ge p     694010000  0. n
20605410  p       690010000  lt p     698010000  0. n
20605420  p       691010000  lt p     694010000  0. n
20605430  time  0  ge  timeof  522  40.  n


20610010  530 and 534  n                           *valve 694
20610020  530 and 532  n                           *valve 692
20610030  523 and 1006  l                           *close valve 082
20610040  525 xor 1005  n                           *open vlvs 593 & 503
20610050  537 and 538  l                           *open vlvs 501 & 591
20610060  524 and 528 n


*

*
**%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
**                %
**      HYDRODYNAMIC COMPONENTS      %
**                %
**%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
*
*====================================================================
*
*  PRIMARY COOLANT SYSTEM
*
*====================================================================
*-------------------------------------------------------

*-------------------------------------------------------
*  Reactor Inlet Plenum
*-------------------------------------------------------
*   name  pipe/annulus
1000000  rx-in-pl  pipe
*   number of volumes
1000001  5
*   area  no of vol
1000101  6.7117  5
*   length  no of vol
1000301  0.2   5
*   volume  no of vol
1000401  0.0   5
*   azi ang  no of vol
1000501  90.   5
*   ver ang  no of vol
1000601  90.   5
*   elev.  no of vol
1000701  0.1   5
*   rough  dhydr.  no of vol
1000801  1.0e-5  0.15  5
*   kforw  kbackw  no of jun
1000901  0.0   0.0   4
*   v-flag  no of vol
```

```
1001001  00000  5
*   j-flag  no of jun
1001101  000000  4
*   cntrl  pressure  temperature  *  *  *  no of vol
1001201  0   7152053. 2310826.  2310826. 1. 0.  1
1001202  0   7152044. 2310826.  2310826. 1. 0.  2
1001203  0   7152034. 2310826.  2310826. 1. 0.  3
1001204  0   7152024. 2310826.  2310826. 1. 0.  4
1001205  0   7152014. 2310826.  2310826. 1. 0.  5
*   cntrl
1001300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
1001301  9.97593  9.97593  0.    1 * 319.2105
1001302  9.97594  9.97594  0.    2 * 319.2105
1001303  9.97595  9.97595  0.    3 * 319.2105
1001304  9.97596  9.97596  0.    4 * 319.2105
*---------------------------------------------------------
*  Junction: Reactor Inlet Plenum to Lower Reflector
*---------------------------------------------------------
*   name   junction
2080000  rip-lrc  sngljun
*   from   to    area  kforw  kbackw  j-flag
2080101  100050002  210000000  1.39801  0.23  0.23  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
2080201  0  47.4743  47.4743  0. * 316.416
*
*---------------------------------------------------------
*  Junction: Reactor Inlet Plenum to Lower Reflector
*---------------------------------------------------------
*   name   junction
2090000  rip-lrh  sngljun
*   from   to    area  kforw  kbackw  j-flag
2090101  100010000  211000000  0.01259  0.23  0.23  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
2090201  0  46.5594  46.5594 0. * 2.79462
*---------------------------------------------------------
*  Reactor Inlet Reflector
*---------------------------------------------------------
*   name   volume
2100000  in-rflt  snglvol
*   area  length  vol. a.ang. in.ang. elev. rough.  hDe  v-flag
2100101  1.39801  1.0  0.0  90.0  90.0  1.0  1.0e-5  0.0127 000000
*   cntrl  press  temp
2100200  0    7140967.  2311218. 2311218. 1.
*
*---------------------------------------------------------
*  Reactor Inlet Reflector Hot Channel
*---------------------------------------------------------
*   name   volume
2110000  in-rfhc  snglvol
*   area  length  vol. a.ang. in.ang. elev. rough.  hDe  v-flag
2110101  0.01259  1.0  0.0  90.0  90.0  1.0  1.0e-5  0.0127 000000
*   cntrl  press  temp
2110200  0    7141388.  2311206. 2311206. 1.
*
*---------------------------------------------------------
*  Junction: Reactor Inlet Reflector to Core
```

```
*-----------------------------------------------------------
*   name   junction
2150000  irf-cor  sngljun
*   from    to    area  kforw  kbackw  j-flag
2150101  210010000  250000000  1.39801  3.00  0.00  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
2150201  0  47.5237  47.5237  0. * 316.416
*
*-----------------------------------------------------------
*  Junction: Reactor Inlet Reflector to Core Hot Channel
*-----------------------------------------------------------
*   name   junction
2160000  irf-chc  sngljun
*   from    to    area  kforw  kbackw  j-flag
2160101  211010000  251000000  0.01259  3.00  0.00  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
2160201  0  46.6061  46.6061  0. * 2.79462
*
*-----------------------------------------------------------
*  Reactor Core
*-----------------------------------------------------------
*   name  pipe/annulus
2500000  rx-core  pipe
*   number of volumes
2500001  8
*   area  no of vol
2500101  1.39801  8
*   length  no of vol
2500301  0.24375  8
*   volume  no of vol
2500401  0.0   8
*   azi ang  no of vol
2500501  90.   8
*   ver ang  no of vol
2500601  90.   8
*   elev.  no of vol
2500701  0.24375  8
*   rough  dhydr.  no of vol
2500801  1.0e-5  0.0127  8
*   kforw  kbackw  no of jun
2500901  0.0   0.0   7
*   v-flag  no of vol
2501001  00000  8
*   j-flag  no of jun
2501101  000000  7
*   cntrl  pressure  temperature  *  *  *  no of vol
2501201  0    7118911.  2407030.  2407030. 1. 0.  1
2501202  0    7116096.  2541886.  2541886. 1. 0.  2
2501203  0    7113010.  2703636.  2703636. 1. 0.  3
2501204  0    7109660.  2879407.  2879407. 1. 0.  4
2501205  0    7106074.  3055207.  3055207. 1. 0.  5
2501206  0    7102302.  3217043.  3217043. 1. 0.  6
2501207  0    7098412.  3352028.  3352028. 1. 0.  7
2501208  0    7094483.  3449417.  3449417. 1. 0.  8

*   cntrl
2501300  0
```

```
*   w/v.liq  w/v.vap  w/v.int  no of jun
2501301  49.585  49.585  0.   1 * 316.416
2501302  52.3795  52.3795  0.   2 * 316.416
2501303  55.7317  55.7317  0.   3 * 316.416
2501304  59.3765  59.3765  0.   4 * 316.416
2501305  63.0252  63.0252  0.   5 * 316.416
2501306  66.3886  66.3886  0.   6 * 316.416
2501307  69.2    69.2    0.   7 * 316.416
*
*---------------------------------------------------------
*  Reactor Core Hot Channel
*---------------------------------------------------------
*   name  pipe/annulus
2510000  rx-core  pipe
*   number of volumes
2510001  8
*   area  no of vol
2510101  0.01259  8
*   length  no of vol
2510301  0.24375  8
*   volume  no of vol
2510401  0.0   8
*   azi ang  no of vol
2510501  90.   8
*   ver ang  no of vol
2510601  90.   8
*   elev.  no of vol
2510701  0.24375  8
*   rough  dhydr.  no of vol
2510801  1.0e-5  0.0127  8
*   kforw  kbackw  no of jun
2510901  0.0   0.0   7
*   v-flag  no of vol
2511001  00000  8
*   j-flag  no of jun
2511101  000000  7
*   cntrl  pressure  temperature  *  *  *  no of vol
2511201  0    7120148.  2423867.  2423867. 1. 0.  1
2511202  0    7117354.  2582030.  2582030. 1. 0.  2
2511203  0    7114255.  2771736.  2771736. 1. 0.  3
2511204  0    7110856.  2977891.  2977891. 1. 0.  4
2511205  0    7107192.  3184081.  3184081. 1. 0.  5
2511206  0    7103315.  3373888.  3373888. 1. 0.  6
2511207  0    7099301.  3532202.  3532202. 1. 0.  7
2511208  0    7095240.  3646411.  3646411. 1. 0.  8

*   cntrl
2511300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
2511301  48.9652  48.9652  0.    1 * 2.79462
2511302  52.1772  52.1772  0.    2 * 2.79462
2511303  56.0307  56.0307  0.    3 * 2.79462
2511304  60.2206  60.2206  0.    4 * 2.79462
2511305  64.4151  64.4151  0.    5 * 2.79462
2511306  68.2815  68.2815  0.    6 * 2.79462
2511307  71.5131  71.5131  0.    7 * 2.79462
*
```

```
*----------------------------------------------------------
*  Junction: Reactor Core to Outlet Reflector
*----------------------------------------------------------
*   name   junction
2550000  cor-orf  sngljun
*   from   to    area  kforw  kbackw  j-flag
2550101  250010000  290000000  1.39801  3.00  0.00  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
2550201  0  71.2362  71.2362  0. * 316.416
*
*----------------------------------------------------------
*  Junction: Reactor Core Hot Channel to Outlet Reflector
*----------------------------------------------------------
*   name   junction
2560000  cor-ohc  sngljun
*   from   to    area  kforw  kbackw  j-flag
2560101  251010000  291000000  0.01259  3.00  0.00  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
2560201  0  73.853  73.853  0. * 2.79462
*
*----------------------------------------------------------
*  Reactor Outlet Reflector
*----------------------------------------------------------
*   name  volume
2900000  o-rflt  snglvol
*   area  length  vol. a.ang. in.ang. elev. rough.  hDe  v-flag
2900101  1.39801  1.0  0.0  90.0  90.0  1.0  1.0e-5  0.0127 000000
*   cntrl  press    temp
2900200  0    7061007.  3448288. 3448288. 1.
*
*----------------------------------------------------------
*  Reactor Outlet Reflector HC
*----------------------------------------------------------
*   name  volume
2910000  o-rflt  snglvol
*   area  length  vol. a.ang. in.ang. elev. rough.  hDe  v-flag
2910101  0.01259  1.0  0.0  90.0  90.0  1.0  1.0e-5  0.0127 000000
*   cntrl  press   temp
2910200  0    7061106.  3645208. 3645208. 1.
*
*----------------------------------------------------------
*  Junction: Reactor Core to Outlet Plenum
*----------------------------------------------------------
*   name   junction
2920000  cor-orf  sngljun
*   from   to    area  kforw  kbackw  j-flag
2920101  290010000  300000000  0.0  0.46  0.46  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
2920201  0  71.4177  71.4177  0. * 316.416
*
*----------------------------------------------------------
*  Junction: Reactor Core Hot Channel to Outlet Plenum
*----------------------------------------------------------
*   name   junction
2930000  cor-ohc  sngljun
*   from   to    area  kforw  kbackw  j-flag
2930101  291010000  300000000  0.0  0.46  0.46  0000000
```

```
*   cntrl  w/v.liq  w/v.vap  w/v.int
2930201  0  74.045  74.045  0. * 2.79462
*-------------------------------------------------------------
*  Reactor Outlet Plenum
*-------------------------------------------------------------
*   name  pipe/annulus
3000000  rx-o-pl  pipe
*   number of volumes
3000001  5
*   area  no of vol
3000101  43.0080  5
*   length  no of vol
3000301  0.2   5
*   volume  no of vol
3000401  0.0   5
*   azi ang  no of vol
3000501  90.   5
*   ver ang  no of vol
3000601  90.   5
*   elev.  no of vol
3000701  0.20   5
*   rough  dhydr.  no of vol
3000801  4.5e-5  7.4   5
*   kforw  kbackw  no of jun
3000901  0.0   0.0   4
*   v-flag  no of vol
3001001  00000  5
*   j-flag  no of jun
3001101  000000  4
*   cntrl  pressure  temperature  *  *  *  no of vol
3001201  0   7058110.  3449668.  3449668. 1. 0.  1
3001202  0   7058104.  3449667.  3449667. 1. 0.  2
3001203  0   7058098.  3449666.  3449666. 1. 0.  3
3001204  0   7058092.  3449666.  3449666. 1. 0.  4
3001205  0   7058085.  3449665.  3449665. 1. 0.  5
*   cntrl
3001300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
3001301  2.34353  2.34353  0.   1 * 319.2105
3001302  2.34353  2.34353  0.   2 * 319.2105
3001303  2.34353  2.34353  0.   3 * 319.2105
3001304  2.34353  2.34353  0.   4 * 319.2105
*-------------------------------------------------------------
*  Junction: Plenum to Pressure controller
*-------------------------------------------------------------
*   name   junction
*3200000  cor-orf  valve
*   from   to    area  kforw  kbackw  j-flag
*3200101  300010000  340000000  1.e5  0.  1.e9  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
*3200201  1  0.    312.20  0.0
*crdno  valve type
*3200300  trpvlv
*crdno  open trip
*3200301   521
*
*-------------------------------------------------------------
```

```
*  Reactor Pressure Controller
*-----------------------------------------------------------
*   name   volume
*3400000  rx-vent  tmdpvol
*   area  length  vol. a.ang. in.ang. elev. rough.  hDe  v-flag
*3400101  500.0  100.0  0.0  0.0  0.0  0.  0.00046 7.4  000000
*   cntrl
*3400200  003
*      press  temp
*3400201  0.0  6.94220e6  1122.15
*
*-----------------------------------------------------------
*  RPV Downcomer #1
*-----------------------------------------------------------
*   name  pipe/annulus
6700000  hp-hxcl  pipe
*   number of volumes
6700001  8
*   area  no of vol
6700101  3.62855  8
*   length  no of vol
6700301  1.05625  8
*   volume  no of vol
6700401  0.0   8
*   azi ang  no of vol
6700501  -90.  8
*   ver ang  no of vol
6700601  -90.  8
*   elev.  no of vol
6700701  -0.68125  8
*   rough  dhydr.  no of vol
6700801  4.5e-5  0.6   8
*   kforw  kbackw  no of jun
6700901  0.0   0.0   7
*   v-flag  no of vol
6701001  00000  8
*   j-flag  no of jun
6701101  000000  7
*   cntrl  pressure   temperature  *  *  *  no of vol
6701201  0    7151890.   2310802.  2310802. 1. 0.  1
6701202  0    7151917.   2310805.  2310805. 1. 0.  2
6701203  0    7151944.   2310808.  2310808. 1. 0.  3
6701204  0    7151971.   2310812.  2310812. 1. 0.  4
6701205  0    7.152+6    2310816.  2310816. 1. 0.  5
6701206  0    7152025.   2310819.  2310819. 1. 0.  6
6701207  0    7152052.   2310823.  2310823. 1. 0.  7
6701208  0    7152079.   2310827.  2310827. 1. 0.  8
*  cntrl
6701300  0
*  w/v.liq  w/v.vap  w/v.int  no of jun
6701301  9.22622  9.22622  0.   1 * 319.2105
6701302  9.22622  9.22622  0.   2 * 319.2105
6701303  9.22621  9.22621  0.   3 * 319.2105
6701304  9.2262  9.2262  0.   4 * 319.2105
6701305  9.2262  9.2262  0.   5 * 319.2105
6701306  9.2262  9.2262  0.   6 * 319.2105
6701307  9.22619  9.22619  0.   7 * 319.2105
```

```
*
*-------------------------------------------------------
*  RPV Downcomer #2
*-------------------------------------------------------
*   name  pipe/annulus
8000000  hp-hxcl  pipe
*   number of volumes
8000001  8
*   area  no of vol
8000101  3.62855  8
*   length  no of vol
8000301  1.05625  8
*   volume  no of vol
8000401  0.0   8
*   azi ang  no of vol
8000501  -90.  8
*   ver ang  no of vol
8000601  -90.  8
*   elev.  no of vol
8000701  -0.68125  8
*   rough  dhydr.  no of vol
8000801  4.5e-5  0.6   8
*   kforw  kbackw  no of jun
8000901  0.0   0.0   7
*   v-flag  no of vol
8001001  00000  8
*   j-flag  no of jun
8001101  000000  7
*   cntrl  pressure   temperature  *  *  *  no of vol
8001201  0    7151890.   2310802.  2310802. 1. 0.  1
8001202  0    7151917.   2310805.  2310805. 1. 0.  2
8001203  0    7151944.   2310808.  2310808. 1. 0.  3
8001204  0    7151971.   2310812.  2310812. 1. 0.  4
8001205  0    7.152+6    2310816.  2310816. 1. 0.  5
8001206  0    7152025.   2310819.  2310819. 1. 0.  6
8001207  0    7152052.   2310823.  2310823. 1. 0.  7
8001208  0    7152079.   2310827.  2310827. 1. 0.  8
*   cntrl
8001300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
8001301  9.22622  9.22622  0.   1 * 319.2105
8001302  9.22622  9.22622  0.   2 * 319.2105
8001303  9.22621  9.22621  0.   3 * 319.2105
8001304  9.2262  9.2262  0.   4 * 319.2105
8001305  9.2262  9.2262  0.   5 * 319.2105
8001306  9.2262  9.2262  0.   6 * 319.2105
8001307  9.22619  9.22619  0.   7 * 319.2105
*
*----------------------------------------------------------------
*  Junction:  Pressure Controller to RPV Downcomer
*----------------------------------------------------------------
*crdno    name   type
6850000  j-contr  valve
*
*crdno  from    to    area    jefvcahs
6850101  680000000  670000000  1.0  0. 0.  00000100
6850110  0.6  0.0  1.0  1.0
```

```
*crdno  var  flowf  flowg  velj
6850201  0   0.  0.    0. * 0.
*crdno  valve type
6850300  trpvlv
*crdno  open trip
6850301   526
*
*------------------------------------------------------------------
*  Junction:  Pressure Controller to RPV Downcomer
*------------------------------------------------------------------
*crdno    name   type
6860000  j-contr  valve
*
*crdno  from    to    area    jefvcahs
6860101  680000000  800000000  1.0  0. 0.  00000100
6860110  0.6  0.0  1.0  1.0
*crdno  var  flowf  flowg  velj
6860201  0   0.  0.    0. * 0.
*crdno  valve type
6860300  trpvlv
*crdno  open trip
6860301   526
*
*-----------------------------------------------------------
*  Pressure Controller for steady state
*-----------------------------------------------------------
*   name   volume
6800000  p-contr  tmdpvol
*   area  length  vol. a.ang. in.ang. elev. rough.  hDe  v-flag
6800101  500.00  100.0  0.0  0.0  0.0  0.  0.00046 7.4  000000
*   cntrl
6800200  3
*      press  temp
6800201  0.0  7.08000e6  761.15

*-----------------------------------------------------------
*  SNGLJ: RPV Cold Duct to Rx Inlet Plenum
*-----------------------------------------------------------
*   name   junction
6750000  cd-iplm  sngljun
*   from   to    area  kforw  kbackw  j-flag
6750101  670010000  100000000  0.0  1.0  1.0  0000001
*   cntrl  w/v.liq  w/v.vap  w/v.int
6750201  0  9.97592  9.97592 0. * 319.2105
*
*-----------------------------------------------------------
*  SNGLJ: RPV Cold Duct to Rx Inlet Plenum
*-----------------------------------------------------------
*   name   junction
8010000  cd-iplm  sngljun
*   from   to    area  kforw  kbackw  j-flag
8010101  800010000  100000000  0.0  1.0  1.0  0000001
*   cntrl  w/v.liq  w/v.vap  w/v.int
8010201  0  9.97592  9.97592 0. * 319.2105
*
**    Name  Valve
5010000  bypass  tmdpjun
```

```
*           from        to      area   j-flag
5010101  500000000  502000000  0.00   0000000
*      cntrl trp
5010200  1   1005
*
5010201  -0.1 0. 0.  0.
5010202   0.  0. -10. 0.
*
*-----------------------------------------------------------
*crdno    name     type
5020000   cprbp2    tmdpvol
*
*crdno   area  lngth  vol  h-a v-ang delz  rgh  dhy  pvbfe
5020101  78.  .9104  0  0  0.  .0  0  1.5  00010
*
*crdno  ebt
5020200  3
*crdno  time  press  temp
5020201  0.0  5.e6  1150.
*
***
*  500  Hot Duct volume
***
*
*crdno    name   type
5000000   hotduct   pipe
*
*crdno  no.vols.
5000001   4
*
*crdno  area         vol.no.
5000101  1.606          4
*
*crdno  length          vol.no.
5000301  1.85           4
*
*crdno  v-ang         vol.no.
5000601  0.0           4
*
*crdno  rough  dhy      vol.no.
5000801  0.    1.43       4
*
*crdno    ff  rf      jun.no.
5000901  10.  0.        3
*
*crdno  tlpvbfe        vol.no.
5001001  10010          4
*
*crdno  jefvcahs        jun.no.
5001101  0000000         3
*
*crdno   ebt pressure  temp  qual  vol.no.
5001201    0  7001960. 3442779. 3442779. 1. 0. 1
5001202    0  6939344. 3434540. 3434540. 1. 0. 2
5001203    0  6876488. 3425628. 3425628. 1. 0. 3
5001204    0  6813382. 3415980. 3415980. 1. 0. 4
*
```

```
*crdno  i.c.
5001300  0
*
*crdno  flowf  flowg    velj  jun.no.
5001301  62.9543 62.9543    0.   1 * 319.2105
5001302  63.1902 63.1902    0.   2 * 319.2105
5001303  63.4479 63.4479    0.   3 * 319.2105
*
*crdno  dhy          jun.no
5001401  1.43   1.0  1.0  1.0    3
*
*
*=======================================================================
$
*hydro     component name  component type
5100000    turbine1     turbine
*-----------------------------------------------------------------------
$
*   no. juns  vel/flow
5100001  1   0
*hydro    area     length    volume
5100101    0.4857     4.2      0.0
*
*hydro   horz angle    vert angle    delta z
5100102    0.0       90.0      4.2
*
*hydro    roughness    hyd diam     fe
5100103    6.0e-4      0.7864      10
*
*hydro  ebt  pressure  tempe
5100200  0  3335696.  2520473. 2520473. 1.
*   from  to    area  Kf  Kr  efvcahs
5101101  500010000 510000000 0.193  0.555  0.555  0000010
*   velf   velg  veli
5101201  530.307 530.307  0. * 319.2105
*    speed  iner  fric  shaft  trip  sep eff
5100300  376.991 5478.2  0.39  600  0
*    type  eff  r  radius
5100400  2  0.93  0.5  0.6
*=======================================================================
$
*crdno  name  type
5150000  trbout  branch
5150001  2   0
5150101  0.5    1.3848  0.0
5150102  0.0    -90.0  -1.3848
5150103  0.0  0.7979   11000
5150200  0   2944520. 2419992. 2419992. 1.
*crdno  from     to    area  floss rloss  flag
5151101  510010000  515000000  0.0  3.0  0.0  000100
5152101  515010000  520000000  0.0  3.0  0.0  000000
*crdno  flowf  flowg  velj
5151201  345.128 345.128  0. * 319.2105
5152201  357.214 357.214  0. * 319.2105
*
*=======================================================================
========*
```

```
5200000  rc-hot  pipe
*---------------------------------------------------------------------------
--------*
*   no. vols
5200001  30
*   vol area
5200101  10.98  30
*   length
5200301  0.09384  30
*   volume
5200401  0.0  30
*   azim angle
5200501  0.0  30
*   incl angle
5200601  -90.0  30
*   roughness hyd dia
5200801  0.3-6  2.4384e-3 30
*   kf    kr
5200901  0.0   0.0  29
*   pvbfe
5201001  00000  30
*   fvcahs
5201101  001000  29
*   ebt  press   temp
5201201  0  2706427.  2322732. 2322732. 1. 0. 1
5201202  0  2706121.  2286169. 2286169. 1. 0. 2
5201203  0  2705834.  2249496. 2249496. 1. 0. 3
5201204  0  2705555.  2212712. 2212712. 1. 0. 4
5201205  0  2705283.  2175820. 2175820. 1. 0. 5
5201206  0  2705019.  2138822. 2138822. 1. 0. 6
5201207  0  2704762.  2101724. 2101724. 1. 0. 7
5201208  0  2704513.  2064526. 2064526. 1. 0. 8
5201209  0  2704272.  2027234. 2027234. 1. 0. 9
5201210  0  2704037.  1989851. 1989851. 1. 0. 10
5201211  0  2703810.  1952383. 1952383. 1. 0. 11
5201212  0  2703588.  1914833. 1914833. 1. 0. 12
5201213  0  2703366.  1877206. 1877206. 1. 0. 13
5201214  0  2703143.  1839506. 1839506. 1. 0. 14
5201215  0  2702920.  1801740. 1801740. 1. 0. 15
5201216  0  2702696.  1763912. 1763912. 1. 0. 16
5201217  0  2702473.  1726028. 1726028. 1. 0. 17
5201218  0  2702250.  1688096. 1688096. 1. 0. 18
5201219  0  2702027.  1650121. 1650121. 1. 0. 19
5201220  0  2701805.  1612112. 1612112. 1. 0. 20
5201221  0  2701583.  1574077. 1574077. 1. 0. 21
5201222  0  2701362.  1536022. 1536022. 1. 0. 22
5201223  0  2701141.  1497958. 1497958. 1. 0. 23
5201224  0  2700922.  1459893. 1459893. 1. 0. 24
5201225  0  2700704.  1421836. 1421836. 1. 0. 25
5201226  0  2700487.  1383799. 1383799. 1. 0. 26
5201227  0  2700272.  1345792. 1345792. 1. 0. 27
5201228  0  2700059.  1307826. 1307826. 1. 0. 28
5201229  0  2699848.  1269914. 1269914. 1. 0. 29
5201230  0  2699634.  1232069. 1232069. 1. 0. 30
*   vel/flow
5201300  0
*   liquid  vapor  int-face
```

```
5201301  16.6594  16.6594 0.      1 * 319.2105
5201302  16.39818  16.39818 0.      2 * 319.2105
5201303  16.13603  16.13603 0.      3 * 319.2105
5201304  15.873  15.873 0.      4 * 319.2105
5201305  15.60912  15.60912 0.      5 * 319.2105
5201306  15.3444  15.3444 0.      6 * 319.2105
5201307  15.0789  15.0789 0.      7 * 319.2105
5201308  14.8126  14.8126 0.      8 * 319.2105
5201309  14.54556  14.54556 0.      9 * 319.2105
5201310  14.2778  14.2778 0.      10 * 319.2105
5201311  14.00935  14.00935 0.      11 * 319.2105
5201312  13.74027  13.74027 0.      12 * 319.2105
5201313  13.4706  13.4706 0.      13 * 319.2105
5201314  13.20037  13.20037 0.      14 * 319.2105
5201315  12.92963  12.92963 0.      15 * 319.2105
5201316  12.6584  12.6584 0.      16 * 319.2105
5201317  12.38676  12.38676 0.      17 * 319.2105
5201318  12.11472  12.11472 0.      18 * 319.2105
5201319  11.84234  11.84234 0.      19 * 319.2105
5201320  11.56968  11.56968 0.      20 * 319.2105
5201321  11.29678  11.29678 0.      21 * 319.2105
5201322  11.02372  11.02372 0.      22 * 319.2105
5201323  10.75055  10.75055 0.      23 * 319.2105
5201324  10.47733  10.47733 0.      24 * 319.2105
5201325  10.20414  10.20414 0.      25 * 319.2105
5201326  9.93105  9.93105 0.      26 * 319.2105
5201327  9.65813  9.65813 0.      27 * 319.2105
5201328  9.38548  9.38548 0.      28 * 319.2105
5201329  9.11317  9.11317 0.      29 * 319.2105
*hydro jun diam  beta  intercept slope  jun
5201401  2.4384e-3  0.0  1.0  1.0  29
*
*=====================================================================
$*
*---
*crdno    name   type
5220000   rc-pr  sngljun
*
*crdno  from    to    area  floss  rloss  flag
5220101  520010000  525000000  0.0  0.    0.    100
*
*crdno  ctl  flowf  flowg  velj
5220201  0  194.1553 194.1553  0. * 319.2105
*
***
*  Inlet pipe to precooler
*
*crdno    name    type
5250000   pr-in   pipe
*
*crdno  no.vols.
5250001   3
*
*crdno  area         vol.no.
5250101  0.5           3
*
*crdno  length         vol.no.
```

```
5250301  3.65          3
*
*crdno  v-ang        vol.no.
5250601  -90.0         3
*
*crdno  rough  dhy      vol.no.
5250801  0.  0.7979       3
*
*crdno    ff  rf      jun.no.
5250901   0.  0.        2
*
*crdno  tlpvbfe        vol.no.
5251001  10010          3
*
*crdno  jefvcahs        jun.no.
5251101  0000000         2
*
*crdno   ebt pressure  temp  qual  vol.no.
5251201    0  2614938. 1219848. 1219848. 1. 0. 1
5251202    0  2613621. 1219651. 1219651. 1. 0. 2
5251203    0  2613715. 1219665. 1219665. 1. 0. 3
*
*crdno  i.c.
5251300  0
*
*crdno  flowf  flowg    velj  jun.no.
5251301  197.139 197.139    0.   1 * 319.2105
5251302  197.187 197.187    0.   2 * 319.2105
*
*crdno  dhy         jun.no
5251401  0.7979  1.0  1.0  1.0    2
*
*---
*crdno    name   type
5280000   pr-inj  sngljun
*
*crdno  from    to    area  floss  rloss  flag
5280101  525010000  530000000  0.0  0.    0.    100
*
*crdno  ctl  flowf  flowg  velj
5280201  0  197.1838 197.1838  0. * 319.2105
*
*======================================================================
$*
5300000  precool  pipe
*----------------------------------------------------------------------
-*
*   no. vols
5300001  20
*   vol area
5300101  28.4  20
*   length
5300301  0.2365  20
*   volume
5300401  0.0  20
*   azim angle
5300501  0.0  20
```

```
*   incl angle
5300601  -90.0  20
*   roughness hyd dia
5300801  4.0e-3  9.924e-3 20
*   kf    kr
5300901  80.0  80.0  19
*   pvbfe
5301001  00000  20
*   fvcahs
5301101  001000  19
*   ebt  press  temp
5301201  0  2615890.  1179799. 1179799. 1. 0. 1
5301202  0  2614262.  1144789. 1144789. 1. 0. 2
5301203  0  2612682.  1114443. 1114443. 1. 0. 3
5301204  0  2611144.  1088112. 1088112. 1. 0. 4
5301205  0  2609642.  1065244. 1065244. 1. 0. 5
5301206  0  2608171.  1045368. 1045368. 1. 0. 6
5301207  0  2606727.  1028078. 1028078. 1. 0. 7
5301208  0  2605307.  1013029. 1013029. 1. 0. 8
5301209  0  2603907.  999923.  999923. 1. 0. 9
5301210  0  2602526.  988503.  988503. 1. 0. 10
5301211  0  2601159.  978549.  978549. 1. 0. 11
5301212  0  2599806.  969869.  969869. 1. 0. 12
5301213  0  2598464.  962299.  962299. 1. 0. 13
5301214  0  2597133.  955695.  955695. 1. 0. 14
5301215  0  2595810.  949934.  949934. 1. 0. 15
5301216  0  2594495.  944906.  944906. 1. 0. 16
5301217  0  2593187.  940519.  940519. 1. 0. 17
5301218  0  2591884.  936692.  936692. 1. 0. 18
5301219  0  2590586.  933352.  933352. 1. 0. 19
5301220  0  2589292.  930439.  930439. 1. 0. 20
*   vel/flow
5301300  0
*   liquid  vapor  int-face
5301301  3.35547  3.35547 0.  1  * 319.2105
5301302  3.25721  3.25721 0.  2  * 319.2105
5301303  3.17212  3.17212 0.  3  * 319.2105
5301304  3.09839  3.09839 0.  4  * 319.2105
5301305  3.03445  3.03445 0.  5  * 319.2105
5301306  2.97898  2.97898 0.  6  * 319.2105
5301307  2.93084  2.93084 0.  7  * 319.2105
5301308  2.88905  2.88905 0.  8  * 319.2105
5301309  2.85277  2.85277 0.  9  * 319.2105
5301310  2.821274  2.821274 0.  10 * 319.2105
5301311  2.79394  2.79394 0.  11 * 319.2105
5301312  2.77023  2.77023 0.  12 * 319.2105
5301313  2.74967  2.74967 0.  13 * 319.2105
5301314  2.73186  2.73186 0.  14 * 319.2105
5301315  2.716445  2.716445 0.  15 * 319.2105
5301316  2.70312  2.70312 0.  16 * 319.2105
5301317  2.691623  2.691623 0.  17 * 319.2105
5301318  2.68172  2.68172 0.  18 * 319.2105
5301319  2.673206  2.673206 0.  19 * 319.2105
*hydro jun diam  beta  intercept slope  jun
5301401  9.924e-3  0.0  1.0  1.0  19
***
```

```
*=====================================================================
$*
*crdno    name   type
5350000   pr-lp  sngljun
*---
*
*crdno  from     to     area  floss  rloss  flag
5350101  530010000  540000000  0.0  0.    0.    100
*
*crdno  ctl  flowf  flowg  velj
5350201  0  31.481  31.481  0. * 319.2105
*
*=====================================================================
$*
***
*  Inlet pipe to low pressure compressor
***
*
*crdno    name   type
5400000    lp-in   pipe
*
*crdno  no.vols.
5400001   3
*
*crdno  area         vol.no.
5400101  2.405          2
5400102  5.983          3
*
*crdno  length         vol.no.
5400301  2.45          2
5400302  2.38          3
*
*crdno  v-ang        vol.no.
5400601  90.0          3
*
*crdno  rough  dhy      vol.no.
5400801  0.5e-5  1.75        2
5400802  0.5e-5  2.76        3
*
*crdno    ff  rf      jun.no.
5400901   0.  0.        2
*
*crdno  tlpvbfe        vol.no.
5401001  10000          3
*
*crdno  jefvcahs        jun.no.
5401101  0000000          1
5401102  0000100          2
*
*crdno   ebt pressure  temp  qual  vol.no.
5401201    0  2586328. 930098. 930098. 1. 0. 1
5401202    0  2586201. 930087. 930087. 1. 0. 2
5401203    0  2587093. 930191. 930191. 1. 0. 3
*
*crdno  i.c.
5401300  0
*
```

```
*crdno  flowf  flowg    velj  jun.no.
5401301  31.4988 31.4988    0.   1 * 319.2105
5401302  31.4997 31.4997    0.   2 * 319.2105
*
*crdno  dhy         jun.no
5401401  1.75    1.0  1.0  1.0    2
*
*
*======================================================================
=======*
*
*  Low pressure compressor
*
*----------------------------------------------------------------------
--------*
5500000  lpcmpr  cprssr
*----------------------------------------------------------------------
--------*
*
*crdno  nj
5500001  2
*   area       length     volume
5500101  0.4762      4.2      0.0
*   azim angle  incl angle  delta z  pvbfe
5500102  0.00     90.0     4.2     00000
*   from  jun area  Kf     Kr  fvcahs
5500108  540010000  0.0  0.0   0.0  001000
*   to    jun area  Kf     Kr  fvcahs
5500109  560000000  0.0  0.0   0.0  001000
*   hyd dia  beta  y-int  slope
5500110  0.0000  0.00  1.00  1.00
5500111  0.0000  0.00  1.00  1.00
*   ebt
5500200  3  4.35e6  377.6
*   vel/flow  liquid  vapor  int-face
5500201  1     0.0   312.0  0.
5500202  1     0.0   312.0  0.
*   id  mtr  vel  trip  rvrs
*5500301  0  -1    0  350  0
5500301  0  -1   -1  350  0
*   rated vel sp ratio  flow  sound  inertia  density
5500302  376.991  1.000  319.21  781.48  2891.44  4.2425
*   mot  coeff-tf2 coeff-tf0 coeff-tf1 coeff-tf3
5500303 0.0  0.0   0.0    0.0    0.0
*   shaft  trip
5500309 600  535
*
5500310 0. 1000. -0.00001
*----------------------------------------------------------------------
$
* performance curves based directly on mit calculations with
* extrapolations to boundary of adjacent curves; pump efficiencies
* performance data tables
*crdno  Rel Spd   nu   *    Speed
5500910 -0.10    3    *    -37.6991
5500911  0.00    4   *    0.0  rad/s
5500912  0.40    11   *    150.7694
```

```
5500913  0.50    14   *    188.4955
5500914  0.60    15   *    226.1946
5500915  0.70    16   *    263.8937
5500916  0.80    15   *    301.5928
5500917  0.90    47   *    339.2919
5500918  1.00    35   *    376.9910
5500919  1.10    36   *    414.6901
5500920  1.20    5   *    452.3892
5500921  1.30    5   *    490.0883
5500922  1.40    4   *    527.7874
5500923  1.50    4   *    565.4865
*    relative  pr  eta pump -10% speed
5501001 -0.1000  0.9000  0.0009  *1.0000  0.0010 * extrapolated
5501002  0.0000  0.8500  0.0009  *0.9701  0.8941 * extrapolated
5501003  0.4216  0.6285  0.0009  *0.9619  0.6641 * extrapolated
*    relative  pr  eta pump 0% speed
5501101 -0.1000  0.9300  0.0009
5501102  0.0000  1.0000  0.0009  *1.0000  0.0010 * extrapolated
5501103  0.3736  0.7347  0.8448  *0.9701  0.8941 * extrapolated
5501104  0.4216  0.7285  0.6275  *0.9619  0.6641 * extrapolated
*    relative  pr  eta pump 40% speed
5501201 -0.1000  0.9500  0.0009
5501202  0.0000  1.1000  0.0009  ****************
5501203  0.3736  0.8171  0.8448  *1.0789  0.8941
5501204  0.3745  0.8164  0.8436  *1.0779  0.8929
5501205  0.3753  0.8158  0.8433  *1.0771  0.8925
5501206  0.3762  0.8149  0.8423  *1.0759  0.8915
5501207  0.3770  0.8141  0.8410  *1.0749  0.8901
5501208  0.3919  0.8006  0.8127  *1.0570  0.8601
5501209  0.4067  0.7868  0.7546  *1.0388  0.7986
5501210  0.4216  0.7728  0.6275  *1.0204  0.6641
5501211  0.4826  0.7157  0.1053  *0.9450  0.1115 * extrapolated
*    relative  pr  eta pump 50% speed
5501301  0.0000  1.3000  0.0009  ****************
5501302  0.3736  0.9769  0.8769  *1.2898  0.9281 * extrapolated
5501303  0.4026  0.9423  0.8752  *1.2442  0.9263
5501304  0.4106  0.9328  0.8747  *1.2316  0.9258
5501305  0.4186  0.9232  0.8734  *1.2189  0.9244
5501306  0.4266  0.9139  0.8717  *1.2066  0.9226
5501307  0.4346  0.9036  0.8703  *1.1930  0.9211
5501308  0.4426  0.8940  0.8688  *1.1804  0.9195
5501309  0.4506  0.8844  0.8657  *1.1677  0.9162
5501310  0.4586  0.8742  0.8613  *1.1542  0.9116
5501311  0.4666  0.8644  0.8562  *1.1413  0.9062
5501312  0.4746  0.8543  0.8499  *1.1279  0.8995
5501313  0.4826  0.8445  0.8422  *1.1150  0.8914
5501314  0.5941  0.7087  0.7363  *0.9357  0.7793 * extrapolated
*    relative  pr  eta pump 60% speed
5501401  0.0000  1.5000  0.0009  ****************
5501402  0.4026  1.1765  0.8643  *1.5533  0.9148 * extrapolated
5501403  0.4613  1.0935  0.8745  *1.4438  0.9255
5501404  0.4723  1.0779  0.8763  *1.4232  0.9275
5501405  0.4834  1.0612  0.8765  *1.4011  0.9277
5501406  0.4945  1.0447  0.8770  *1.3793  0.9282
5501407  0.5055  1.0292  0.8782  *1.3589  0.9295
5501408  0.5166  1.0114  0.8778  *1.3354  0.9290
5501409  0.5277  0.9922  0.8758  *1.3100  0.9269
```

```
5501410  0.5387  0.9745  0.8732  *1.2867  0.9242
5501411  0.5609  0.9373  0.8642  *1.2376  0.9146
5501412  0.5719  0.9188  0.8579  *1.2131  0.9080
5501413  0.5830  0.9003  0.8504  *1.1887  0.9000
5501414  0.5941  0.8813  0.8428  *1.1636  0.8920
5501415  0.7124  0.6786  0.7616  *0.8960  0.8061 * extrapolated
*    relative  pr  eta pump 70% speed
5501501  0.0000  1.7500  0.0009  ****************
5501502  0.4613  1.4193  0.8507  *1.8740  0.9004 * extrapolated
5501503  0.5447  1.2767  0.8723  *1.6857  0.9232
5501504  0.5587  1.2528  0.8759  *1.6541  0.9270
5501505  0.5726  1.2245  0.8781  *1.6168  0.9294
5501506  0.5866  1.1975  0.8785  *1.5811  0.9298
5501507  0.6006  1.1687  0.8798  *1.5430  0.9312
5501508  0.6145  1.1412  0.8796  *1.5067  0.9310
5501509  0.6285  1.1122  0.8778  *1.4684  0.9290
5501510  0.6425  1.0825  0.8753  *1.4292  0.9264
5501511  0.6565  1.0521  0.8716  *1.3891  0.9225
5501512  0.6704  1.0209  0.8684  *1.3479  0.9191
5501513  0.6844  0.9892  0.8625  *1.3061  0.9128
5501514  0.6984  0.9564  0.8532  *1.2628  0.9030
5501515  0.7124  0.9246  0.8413  *1.2208  0.8904
5501516  0.8358  0.6436  0.7359  *0.8498  0.7789 * extrapolated
*    relative  pr  eta pump 80% speed
5501601  0.0000  2.1000  0.0009  ****************
5501602  0.5447  1.7424  0.8600  *2.3005  0.9102 * extrapolated
5501603  0.6638  1.4595  0.8764  *1.9270  0.9276
5501604  0.6810  1.4187  0.8788  *1.8732  0.9301
5501605  0.6982  1.3781  0.8799  *1.8195  0.9313
5501606  0.7154  1.3330  0.8805  *1.7600  0.9319
5501607  0.7326  1.2883  0.8804  *1.7010  0.9318
5501608  0.7498  1.2389  0.8780  *1.6357  0.9293
5501609  0.7670  1.1889  0.8745  *1.5697  0.9256
5501610  0.7842  1.1375  0.8722  *1.5019  0.9231
5501611  0.8014  1.0851  0.8648  *1.4327  0.9153
5501612  0.8186  1.0329  0.8541  *1.3638  0.9040
5501613  0.8358  0.9789  0.8440  *1.2925  0.8933
5501614  0.9702  0.5565  0.7651  *0.7347  0.8098 * extrapolated
5501615  1.2390  -.2883  0.6073  *0.7347  0.8098 * extrapolated
*    relative  pr  eta pump 90% speed
5501701  0.0000  2.4896  0.0009
5501702  0.6900  2.0358  0.8453
5501703  0.7000  2.0112  0.8489
5501704  0.7100  1.9859  0.8521
5501705  0.7200  1.9599  0.8550
5501706  0.7300  1.9334  0.8577
5501707  0.7400  1.9065  0.8600
5501708  0.7500  1.8792  0.8622
5501709  0.7600  1.8516  0.8643
5501710  0.7700  1.8239  0.8663
5501711  0.7800  1.7962  0.8683
5501712  0.7900  1.7685  0.8702
5501713  0.8000  1.7409  0.8722
5501714  0.8100  1.7136  0.8744
5501715  0.8200  1.6863  0.8765
5501716  0.8300  1.6585  0.8785
5501717  0.8400  1.6297  0.8800
```

```
5501718  0.8500  1.5993  0.8810
5501719  0.8600  1.5671  0.8815
5501720  0.8700  1.5331  0.8816
5501721  0.8800  1.4975  0.8812
5501722  0.8900  1.4607  0.8806
5501723  0.9000  1.4230  0.8795
5501724  0.9100  1.3846  0.8782
5501725  0.9200  1.3459  0.8766
5501726  0.9300  1.3070  0.8747
5501727  0.9400  1.2679  0.8724
5501728  0.9500  1.2286  0.8694
5501729  0.9600  1.1887  0.8655
5501730  0.9700  1.1480  0.8606
5501731  0.9800  1.1061  0.8543
5501732  0.9900  1.0633  0.8467
5501733  1.0000  1.0198  0.8381
5501734  1.0100  0.9761  0.8291
5501735  1.0200  0.9324  0.8199
5501736  1.0300  0.8885  0.8104
5501737  1.0400  0.8446  0.8007
5501738  1.0500  0.8006  0.7908
5501739  1.0600  0.7566  0.7808
5501740  1.0700  0.7125  0.7706
5501741  1.0800  0.6684  0.7604
5501742  1.0900  0.6242  0.7500
5501743  1.1000  0.5801  0.7396
5501744  1.1100  0.5359  0.7292
5501745  1.1200  0.4917  0.7188
5501746  1.1300  0.4476  0.7084
5501747  1.2812  1.6396  0.5571
*     relative  pr  eta pump 100% speed
5501801  0.0000  2.8896  0.0009
5501802  0.8100  2.4897  0.8507
5501803  0.8200  2.4586  0.8535
5501804  0.8300  2.4266  0.8561
5501805  0.8400  2.3939  0.8584
5501806  0.8500  2.3605  0.8605
5501807  0.8600  2.3264  0.8624
5501808  0.8700  2.2919  0.8642
5501809  0.8800  2.2570  0.8658
5501810  0.8900  2.2217  0.8673
5501811  0.9000  2.1862  0.8688
5501812  0.9100  2.1505  0.8701
5501813  0.9200  2.1147  0.8715
5501814  0.9300  2.0790  0.8728
5501815  0.9400  2.0434  0.8742
5501816  0.9500  2.0080  0.8756
5501817  0.9600  1.9728  0.8771
5501818  0.9700  1.9373  0.8786
5501819  0.9800  1.9003  0.8798
5501820  0.9900  1.8609  0.8808
5501821  1.0000  1.8188  0.8813
5501822  1.0100  1.7743  0.8814
5501823  1.0200  1.7279  0.8810
5501824  1.0300  1.6800  0.8801
5501825  1.0400  1.6310  0.8789
5501826  1.0500  1.5813  0.8775
```

```
5501827  1.0600  1.5308  0.8759
5501828  1.0700  1.4796  0.8741
5501829  1.0800  1.4273  0.8721
5501830  1.0900  1.3738  0.8697
5501831  1.1000  1.3187  0.8665
5501832  1.1100  1.2613  0.8618
5501833  1.1200  1.2013  0.8552
5501834  1.1300  1.1387  0.8467
5501835  1.2811  0.1272  0.6554
*    relative  pr  eta pump 110% speed
5501901  0.0000  3.2896  0.0009
5501902  0.9500  3.0082  0.8731
5501903  0.9600  2.9685  0.8753
5501904  0.9700  2.9277  0.8773
5501905  0.9800  2.8857  0.8790
5501906  0.9900  2.8425  0.8805
5501907  1.0000  2.7983  0.8818
5501908  1.0100  2.7529  0.8829
5501909  1.0200  2.7064  0.8837
5501910  1.0300  2.6589  0.8844
5501911  1.0400  2.6103  0.8848
5501912  1.0500  2.5607  0.8850
5501913  1.0600  2.5100  0.8851
5501914  1.0700  2.4584  0.8849
5501915  1.0800  2.4057  0.8846
5501916  1.0900  2.3521  0.8840
5501917  1.1000  2.2975  0.8833
5501918  1.1100  2.2420  0.8824
5501919  1.1200  2.1855  0.8813
5501920  1.1300  2.1280  0.8800
5501921  1.1400  2.0694  0.8785
5501922  1.1500  2.0097  0.8767
5501923  1.1600  1.9488  0.8748
5501924  1.1700  1.8866  0.8726
5501925  1.1800  1.8232  0.8701
5501926  1.1900  1.7586  0.8675
5501927  1.2000  1.6930  0.8646
5501928  1.2100  1.6265  0.8616
5501929  1.2200  1.5590  0.8584
5501930  1.2300  1.4908  0.8550
5501931  1.2400  1.4218  0.8515
5501932  1.2500  1.3522  0.8479
5501933  1.2600  1.2821  0.8442
5501934  1.2700  1.2115  0.8403
5501935  1.2800  1.1406  0.8365
5501936  1.3982  0.2778  0.7859
*
*    relative  pr  eta pump 120% speed
5502001  0.0000  3.5000  0.0009  ****************
5502002  0.6000  4.1500  0.2000
5502003  1.0748  3.4847  0.8746  * * extrapolated
5502004  1.3915  1.1814  0.8336  * * extrapolated
5502005  1.4100  0.6000  0.7000
*
*    relative  pr  eta pump 130% speed
5502101  0.0000  4.0000  0.0009  ****************
5502102  0.6000  5.0000  0.2000
```

```
5502103  1.2241  3.9712  0.8746  * * extrapolated
5502104  1.5319  1.2322  0.8336  * * extrapolated
5502105  1.5500  0.6000  0.7000
*
*    relative  pr  eta pump 140% speed
5502201  0.0000  4.3000  0.0009  ****************
5502202  0.6000  5.6000  0.2000
5502203  1.3734  4.4577  0.8746  * * extrapolated
5502204  1.6723  1.2830  0.8336  * * extrapolated
*
*    relative  pr  eta pump 150% speed
5502301  0.0000  4.7000  0.0009  ****************
5502302  0.6000  6.0000  0.2000
5502303  1.5227  4.9442  0.8746  * * extrapolated
5502304  1.8127  1.3338  0.8336  * * extrapolated
*
*5500500
*5500501  0.0  376.991
*5500502 1450.  376.991
*=====================================================================
$
*hydro     component name  component type
5600000    lpcout    snglvol
*---------------------------------------------------------------------
$
*hydro    area     length    volume
5600101    4.347      2.45      0.0
*
*hydro   horz angle    vert angle    delta z
5600102    0.0      -90.0      -2.45
*
*hydro    roughness    hyd diam     fe
5600103    0.0      0.0      0
*
*hydro  ebt  pressure  tempe
5600200  0  4357726.  1181832. 1181832. 1.
*=====================================================================
$
*hydro     component name  component type
5650000     lpc-ic      branch
*---------------------------------------------------------------------
$
*   no. juns  vel/flow
5650001  2   0
*hydro    area     length    volume
5650101    4.347      2.45      0.0
*
*hydro   horz angle    vert angle    delta z
5650102    0.0      -90.0     -2.45
*
*hydro    roughness    hyd diam     fe
5650103    0.0      2.353      0
*
*hydro  ebt  pressure  tempe
5650200  0  4357863.  1181846. 1181846. 1.
*   from  to    area  Kf  Kr  efvcahs
5651101  560010000 565000000 0.0   0.0  0.0  0000000
```

```
5652101  565010000 570000000 0.0   0.0  0.0  0000000
*   velf   velg  veli
5651201  12.9294  12.9294 0. * 319.2105
5652201  12.92918 12.92918 0. * 319.2105
*   hyd dia  beta  y-int  slope
5651110  2.353  1.00  1.00  1.00
5652110  2.353  1.00  1.00  1.00
*
*=========================================================================
========*
***
*  570  Inter-cooler
***
5700000  intcool  pipe
*-------------------------------------------------------------------------
--------*
*   no. vols
5700001  20
*   vol area
5700101  28.3  20
*   length
5700301  0.2365  20
*   volume
5700401  0.0  20
*   azim angle
5700501  0.0  20
*   incl angle
5700601  -90.0  20
*   roughness hyd dia
5700801  4.0e-3  9.924e-3 20
*   kf    kr
5700901  130.0  130.0  19
*   pvbfe
5701001  00000  20
*   fvcahs
5701101  001000  19
*   ebt  press  temp
5701201  0  4358364.  1152563. 1152563. 1. 0. 1
5701202  0  4356879.  1126299. 1126299. 1. 0. 2
5701203  0  4355428.  1102891. 1102891. 1. 0. 3
5701204  0  4354008.  1082014. 1082014. 1. 0. 4
5701205  0  4352615.  1063381. 1063381. 1. 0. 5
5701206  0  4351246.  1046744. 1046744. 1. 0. 6
5701207  0  4349898.  1031881. 1031881. 1. 0. 7
5701208  0  4348570.  1018596. 1018596. 1. 0. 8
5701209  0  4347258.  1006716. 1006716. 1. 0. 9
5701210  0  4345962.  996090.  996090. 1. 0. 10
5701211  0  4344678.  986582.  986582. 1. 0. 11
5701212  0  4343408.  978072.  978072. 1. 0. 12
5701213  0  4342148.  970453.  970453. 1. 0. 13
5701214  0  4340898.  963630.  963630. 1. 0. 14
5701215  0  4339656.  957520.  957520. 1. 0. 15
5701216  0  4338423.  952047.  952047. 1. 0. 16
5701217  0  4337196.  947144.  947144. 1. 0. 17
5701218  0  4335976.  942751.  942751. 1. 0. 18
5701219  0  4334760.  938816.  938816. 1. 0. 19
5701220  0  4333550.  935291.  935291. 1. 0. 20
```

```
*   vel/flow
5701300  0
*   liquid  vapor  int-face
5701301  1.936394  1.936394 0.  1  * 319.2105
5701302  1.892748  1.892748 0.  2  * 319.2105
5701303  1.853877  1.853877 0.  3  * 319.2105
5701304  1.81924  1.81924 0.  4  * 319.2105
5701305  1.78836  1.78836 0.  5  * 319.2105
5701306  1.76082  1.76082 0.  6  * 319.2105
5701307  1.736254  1.736254 0.  7  * 319.2105
5701308  1.71433  1.71433 0.  8  * 319.2105
5701309  1.694765  1.694765 0.  9  * 319.2105
5701310  1.6773  1.6773 0.   10 * 319.2105
5701311  1.661713  1.661713 0.  11 * 319.2105
5701312  1.6478  1.6478 0.   12 * 319.2105
5701313  1.635383  1.635383 0.  13 * 319.2105
5701314  1.624304  1.624304 0.  14 * 319.2105
5701315  1.614422  1.614422 0.  15 * 319.2105
5701316  1.60561  1.60561 0.  16 * 319.2105
5701317  1.59776  1.59776 0.  17 * 319.2105
5701318  1.590767  1.590767 0.  18 * 319.2105
5701319  1.584544  1.584544 0.  19 * 319.2105
*hydro jun diam  beta  intercept slope  jun
5701401  9.924e-3  0.0  1.0  1.0  19
***
*
***
* 572  Junction - IC to HPC
*
*crdno    name   type
5720000   ic-hpcj  sngljun
*
*crdno  from    to    area  floss  rloss  flag
5720101  570010000  575000000  0.0  0.0   0.0   00
*
*crdno  ctl  flowf  flowg  velj
5720201  0  89.372  89.372   0. * 319.2105
*
*
*
*======================================================================
========*
***
*  575  Inlet pipe to high pressure compresser
***
*
*crdno    name   type
5750000   ic-hpc   pipe
*
*crdno  no.vols.
5750001   3
*
*crdno  area         vol.no.
5750101  0.5           3
*
*crdno  length          vol.no.
5750301  3.21           3
```

```
*
*crdno  v-ang        vol.no.
5750601  90.0          3
*
*crdno  rough  dhy      vol.no.
5750801  0.5e-5  0.7979       3
*
*crdno    ff  rf       jun.no.
5750901   0.  0.         2
*
*crdno  tlpvbfe        vol.no.
5751001  10000          3
*
*crdno  jefvcahs        jun.no.
5751101  0000000         2
*
*crdno   ebt pressure  temp  qual  vol.no.
5751201    0  4304494. 932850. 932850. 1. 0. 1
5751202    0  4303151. 932810. 932810. 1. 0. 2
5751203    0  4301978. 932785. 932785. 1. 0. 3
*
*crdno  i.c.
5751300  0
*
*crdno  flowf  flowg    velj  jun.no.
5751301  89.7534 89.7534    0.   1 * 319.2105
5751302  89.7788 89.7788    0.   2 * 319.2105
*
*crdno  dhy         jun.no
5751401  0.7979    1.0  1.0  1.0   2
*
*
*======================================================================
=======*
*
*  High pressure compressor
*
*----------------------------------------------------------------------
--------*
5800000  hpcmpr  cprssr
*----------------------------------------------------------------------
--------*
*
*crdno  nj
5800001  2
*   area      length    volume
*3500101  0.50      2.35     0.0
5800101  0.4762      4.2     0.0
*   azim angle  incl angle  delta z  pvbfe
5800102  0.00     90.0     4.2     00000
*   from  jun area  Kf     Kr  fvcahs
5800108  575010000  0.0  0.0   0.0  001000
*   to    jun area  Kf     Kr  fvcahs
5800109  585000000  0.0  0.0   0.0  001000
*   hyd dia  beta  y-int  slope
5800110  0.0000  0.00  1.00  1.00
5800111  0.0000  0.00  1.00  1.00
```

```
*   ebt
5800200  3  7.21e6  378.05
*   vel/flow  liquid  vapor  int-face
5800201  1    0.0   312.0  0.
5800202  1    0.0   312.0  0.
*   id  mtr  vel  trip  rvrs
*5800301  0  -1    0  350  0
5800301  0  -1   -1  350  0
*   rated vel sp ratio  flow  sound  inertia  density
5800302  376.991  1.000  319.21  692.04  2891.44  7.1263
*   mot  coeff-tf2 coeff-tf0 coeff-tf1 coeff-tf3
5800303 0.0  0.0   0.0    0.0   0.0
*   shaft  trip
5800309 600  535
*
5800310 0. 1000. -0.00001
*----------------------------------------------------------------------
$
* performance curves based directly on mit calculations with
* extrapolations to boundary of adjacent curves; pump efficiencies
* performance data tables
*crdno  Rel Spd   nu   *    Speed
5800910 -0.10    3    *    -37.6991
5800911  0.00    4   *    0.0  rad/s
5800912  0.40    11   *    150.7694
5800913  0.50    14   *    188.4955
5800914  0.60    15   *    226.1946
5800915  0.70    16   *    263.8937
5800916  0.80    15   *    301.5928
5800917  0.90    47   *    339.2919
5800918  1.00    35   *    376.9910
5800919  1.10    36   *    414.6901
5800920  1.20    3   *    452.3892
5800921  1.30    3   *    490.0883
5800922  1.40    3   *    527.7874
5800923  1.50    3   *    565.4865
*    relative  pr  eta pump -10% speed
5801001 -0.1000  0.9000  0.0009  *1.0000  0.0010 * extrapolated
5801002  0.0000  0.8500  0.0009  *0.9701  0.8941 * extrapolated
5801003  0.4216  0.6285  0.0009  *0.9619  0.6641 * extrapolated
*    relative  pr  eta pump 0% speed
5801101 -0.1000  0.9300  0.0009
5801102  0.0000  1.0000  0.0009  *1.0000  0.0010 * extrapolated
5801103  0.3736  0.7347  0.8448  *0.9701  0.8941 * extrapolated
5801104  0.4216  0.7285  0.6275  *0.9619  0.6641 * extrapolated
*    relative  pr  eta pump 40% speed
5801201 -0.1000  0.9500  0.0009
5801202  0.0000  1.1000  0.0009  ****************
5801203  0.3736  0.8171  0.8448  *1.0789  0.8941
5801204  0.3745  0.8164  0.8436  *1.0779  0.8929
5801205  0.3753  0.8158  0.8433  *1.0771  0.8925
5801206  0.3762  0.8149  0.8423  *1.0759  0.8915
5801207  0.3770  0.8141  0.8410  *1.0749  0.8901
5801208  0.3919  0.8006  0.8127  *1.0570  0.8601
5801209  0.4067  0.7868  0.7546  *1.0388  0.7986
5801210  0.4216  0.7728  0.6275  *1.0204  0.6641
5801211  0.4826  0.7157  0.1053  *0.9450  0.1115 * extrapolated
```

```
*    relative  pr  eta pump 50% speed
5801301  0.0000  1.3000  0.0009  ****************
5801302  0.3736  0.9769  0.8769  *1.2898  0.9281 * extrapolated
5801303  0.4026  0.9423  0.8752  *1.2442  0.9263
5801304  0.4106  0.9328  0.8747  *1.2316  0.9258
5801305  0.4186  0.9232  0.8734  *1.2189  0.9244
5801306  0.4266  0.9139  0.8717  *1.2066  0.9226
5801307  0.4346  0.9036  0.8703  *1.1930  0.9211
5801308  0.4426  0.8940  0.8688  *1.1804  0.9195
5801309  0.4506  0.8844  0.8657  *1.1677  0.9162
5801310  0.4586  0.8742  0.8613  *1.1542  0.9116
5801311  0.4666  0.8644  0.8562  *1.1413  0.9062
5801312  0.4746  0.8543  0.8499  *1.1279  0.8995
5801313  0.4826  0.8445  0.8422  *1.1150  0.8914
5801314  0.5941  0.7087  0.7363  *0.9357  0.7793 * extrapolated
*    relative  pr  eta pump 60% speed
5801401  0.0000  1.5000  0.0009  ****************
5801402  0.4026  1.1765  0.8643  *1.5533  0.9148 * extrapolated
5801403  0.4613  1.0935  0.8745  *1.4438  0.9255
5801404  0.4723  1.0779  0.8763  *1.4232  0.9275
5801405  0.4834  1.0612  0.8765  *1.4011  0.9277
5801406  0.4945  1.0447  0.8770  *1.3793  0.9282
5801407  0.5055  1.0292  0.8782  *1.3589  0.9295
5801408  0.5166  1.0114  0.8778  *1.3354  0.9290
5801409  0.5277  0.9922  0.8758  *1.3100  0.9269
5801410  0.5387  0.9745  0.8732  *1.2867  0.9242
5801411  0.5609  0.9373  0.8642  *1.2376  0.9146
5801412  0.5719  0.9188  0.8579  *1.2131  0.9080
5801413  0.5830  0.9003  0.8504  *1.1887  0.9000
5801414  0.5941  0.8813  0.8428  *1.1636  0.8920
5801415  0.7124  0.6786  0.7616  *0.8960  0.8061 * extrapolated
*    relative  pr  eta pump 70% speed
5801501  0.0000  1.7500  0.0009  ****************
5801502  0.4613  1.4193  0.8507  *1.8740  0.9004 * extrapolated
5801503  0.5447  1.2767  0.8723  *1.6857  0.9232
5801504  0.5587  1.2528  0.8759  *1.6541  0.9270
5801505  0.5726  1.2245  0.8781  *1.6168  0.9294
5801506  0.5866  1.1975  0.8785  *1.5811  0.9298
5801507  0.6006  1.1687  0.8798  *1.5430  0.9312
5801508  0.6145  1.1412  0.8796  *1.5067  0.9310
5801509  0.6285  1.1122  0.8778  *1.4684  0.9290
5801510  0.6425  1.0825  0.8753  *1.4292  0.9264
5801511  0.6565  1.0521  0.8716  *1.3891  0.9225
5801512  0.6704  1.0209  0.8684  *1.3479  0.9191
5801513  0.6844  0.9892  0.8625  *1.3061  0.9128
5801514  0.6984  0.9564  0.8532  *1.2628  0.9030
5801515  0.7124  0.9246  0.8413  *1.2208  0.8904
5801516  0.8358  0.6436  0.7359  *0.8498  0.7789 * extrapolated
*    relative  pr  eta pump 80% speed
5801601  0.0000  2.1000  0.0009  ****************
5801602  0.5447  1.7424  0.8600  *2.3005  0.9102 * extrapolated
5801603  0.6638  1.4595  0.8764  *1.9270  0.9276
5801604  0.6810  1.4187  0.8788  *1.8732  0.9301
5801605  0.6982  1.3781  0.8799  *1.8195  0.9313
5801606  0.7154  1.3330  0.8805  *1.7600  0.9319
5801607  0.7326  1.2883  0.8804  *1.7010  0.9318
5801608  0.7498  1.2389  0.8780  *1.6357  0.9293
```

```
5801609  0.7670  1.1889  0.8745  *1.5697  0.9256
5801610  0.7842  1.1375  0.8722  *1.5019  0.9231
5801611  0.8014  1.0851  0.8648  *1.4327  0.9153
5801612  0.8186  1.0329  0.8541  *1.3638  0.9040
5801613  0.8358  0.9789  0.8440  *1.2925  0.8933
5801614  0.9702  0.5565  0.7651  *0.7347  0.8098 * extrapolated
5801615  1.2390  -.2883  0.6073  *0.7347  0.8098 * extrapolated
*    relative  pr  eta pump 90% speed
5801701  0.0000  2.5000  0.0009
5801702  0.6800  2.0462  0.8453
5801703  0.6900  2.0216  0.8489
5801704  0.7000  1.9963  0.8521
5801705  0.7100  1.9703  0.8550
5801706  0.7200  1.9438  0.8577
5801707  0.7300  1.9169  0.8600
5801708  0.7400  1.8896  0.8622
5801709  0.7500  1.8620  0.8643
5801710  0.7600  1.8343  0.8663
5801711  0.7700  1.8066  0.8683
5801712  0.7800  1.7789  0.8702
5801713  0.7900  1.7513  0.8722
5801714  0.8000  1.7240  0.8744
5801715  0.8100  1.6967  0.8765
5801716  0.8200  1.6689  0.8785
5801717  0.8300  1.6401  0.8800
5801718  0.8400  1.6097  0.8810
5801719  0.8500  1.5775  0.8815
5801720  0.8600  1.5435  0.8816
5801721  0.8700  1.5079  0.8812
5801722  0.8800  1.4711  0.8806
5801723  0.8900  1.4334  0.8795
5801724  0.9000  1.3950  0.8782
5801725  0.9100  1.3563  0.8766
5801726  0.9200  1.3174  0.8747
5801727  0.9300  1.2783  0.8724
5801728  0.9400  1.2390  0.8694
5801729  0.9500  1.1991  0.8655
5801730  0.9600  1.1584  0.8606
5801731  0.9700  1.1165  0.8543
5801732  0.9800  1.0737  0.8467
5801733  0.9900  1.0302  0.8381
5801734  1.0000  0.9865  0.8291
5801735  1.0100  0.9428  0.8199
5801736  1.0200  0.8989  0.8104
5801737  1.0300  0.8550  0.8007
5801738  1.0400  0.8110  0.7908
5801739  1.0500  0.7670  0.7808
5801740  1.0600  0.7229  0.7706
5801741  1.0700  0.6788  0.7604
5801742  1.0800  0.6346  0.7500
5801743  1.0900  0.5905  0.7396
5801744  1.1000  0.5463  0.7292
5801745  1.1100  0.5021  0.7188
5801746  1.1200  0.4580  0.7084
5801747  1.2712  1.6500  0.5571
*    relative  pr  eta pump 100% speed
5801801  0.0000  2.9000  0.0009
```

```
5801802  0.8000  2.5001  0.8507
5801803  0.8100  2.4690  0.8535
5801804  0.8200  2.4370  0.8561
5801805  0.8300  2.4043  0.8584
5801806  0.8400  2.3709  0.8605
5801807  0.8500  2.3368  0.8624
5801808  0.8600  2.3023  0.8642
5801809  0.8700  2.2674  0.8658
5801810  0.8800  2.2321  0.8673
5801811  0.8900  2.1966  0.8688
5801812  0.9000  2.1609  0.8701
5801813  0.9100  2.1251  0.8715
5801814  0.9200  2.0894  0.8728
5801815  0.9300  2.0538  0.8742
5801816  0.9400  2.0184  0.8756
5801817  0.9500  1.9832  0.8771
5801818  0.9600  1.9477  0.8786
5801819  0.9700  1.9107  0.8798
5801820  0.9800  1.8713  0.8808
5801821  0.9900  1.8292  0.8813
5801822  1.0000  1.7847  0.8814
5801823  1.0100  1.7383  0.8810
5801824  1.0200  1.6904  0.8801
5801825  1.0300  1.6414  0.8789
5801826  1.0400  1.5917  0.8775
5801827  1.0500  1.5412  0.8759
5801828  1.0600  1.4900  0.8741
5801829  1.0700  1.4377  0.8721
5801830  1.0800  1.3842  0.8697
5801831  1.0900  1.3291  0.8665
5801832  1.1000  1.2717  0.8618
5801833  1.1100  1.2117  0.8552
5801834  1.1200  1.1491  0.8467
5801835  1.2711  0.1376  0.6554
*    relative  pr  eta pump 110% speed
5801901  0.0000  3.2896  0.0009
5801902  0.9400  3.0186  0.8731
5801903  0.9500  2.9789  0.8753
5801904  0.9600  2.9381  0.8773
5801905  0.9700  2.8961  0.8790
5801906  0.9800  2.8529  0.8805
5801907  0.9900  2.8087  0.8818
5801908  1.0000  2.7633  0.8829
5801909  1.0100  2.7168  0.8837
5801910  1.0200  2.6693  0.8844
5801911  1.0300  2.6207  0.8848
5801912  1.0400  2.5711  0.8850
5801913  1.0500  2.5204  0.8851
5801914  1.0600  2.4688  0.8849
5801915  1.0700  2.4161  0.8846
5801916  1.0800  2.3625  0.8840
5801917  1.0900  2.3079  0.8833
5801918  1.1000  2.2524  0.8824
5801919  1.1100  2.1959  0.8813
5801920  1.1200  2.1384  0.8800
5801921  1.1300  2.0798  0.8785
5801922  1.1400  2.0201  0.8767
```

```
5801923  1.1500  1.9592  0.8748
5801924  1.1600  1.8970  0.8726
5801925  1.1700  1.8336  0.8701
5801926  1.1800  1.7690  0.8675
5801927  1.1900  1.7034  0.8646
5801928  1.2000  1.6369  0.8616
5801929  1.2100  1.5694  0.8584
5801930  1.2200  1.5012  0.8550
5801931  1.2300  1.4322  0.8515
5801932  1.2400  1.3626  0.8479
5801933  1.2500  1.2925  0.8442
5801934  1.2600  1.2219  0.8403
5801935  1.2700  1.1510  0.8365
5801936  1.3882  0.2882  0.7859
*
*    relative  pr  eta pump 120% speed
5802001  0.0000  3.5000  0.0009  ****************
5802002  1.0748  3.4847  0.8746  * * extrapolated
5802003  1.3915  1.1814  0.8336  * * extrapolated
*
*    relative  pr  eta pump 130% speed
5802101  0.0000  4.0000  0.0009  ****************
5802102  1.2241  3.9712  0.8746  * * extrapolated
5802103  1.5319  1.2322  0.8336  * * extrapolated
*
*    relative  pr  eta pump 140% speed
5802201  0.0000  4.3000  0.0009  ****************
5802202  1.3734  4.4577  0.8746  * * extrapolated
5802203  1.6723  1.2830  0.8336  * * extrapolated
*
*    relative  pr  eta pump 150% speed
5802301  0.0000  4.7000  0.0009  ****************
5802302  1.5227  4.9442  0.8746  * * extrapolated
5802303  1.8127  1.3338  0.8336  * * extrapolated
*
*5800500
*5800501  0.0  376.991
*5800502 1450.  376.991
*=======================================================================
$
*hydro     component name  component type
5850000     hpout    snglvol
*-----------------------------------------------------------------------
$
*hydro    area     length    volume
5850101    0.5      1.0      0.0
*
*hydro   horz angle    vert angle    delta z
5850102    0.0      0.0      0.0
*
*hydro    roughness    hyd diam     fe
5850103    0.0      0.0      0
*
*hydro  ebt  pressure  tempe
5850200  0  7210130.  1173657. 1173657. 1.
*=======================================================================
$
```

```
*hydro     component name  component type
5870000    hp-rc      branch
*-----------------------------------------------------------------------
$
*   no. juns  vel/flow
5870001  2   0
*hydro    area     length    volume
5870101    0.5      1.0      0.0
*
*hydro   horz angle    vert angle    delta z
5870102    0.0      0.0      0.0
*
*hydro    roughness    hyd diam     fe
5870103    0.0      0.7979      0
*
*hydro  ebt  pressure  tempe
5870200  0  7209954.  1173663. 1173663. 1.
*   from  to    area  Kf  Kr  efvcahs
5871101  585010000 587000000 0.5   0.0  0.0  0000000
5872101  587010000 590000000 0.0   0.0  0.0  0000000
*   velf   velg  veli
5871201  67.6061  67.6061 0. * 319.2105
5872201  67.6074  67.6074 0. * 319.2104
*   hyd dia  beta  y-int  slope
5871110  0.7979  1.00  1.00  1.00
5872110  0.7979  1.00  1.00  1.00
*
*=======================================================================
$
5900000  rc-hp  pipe
*-----------------------------------------------------------------------
--------*
*   no. vols
5900001  30
*   vol area
5900101  7.32  30
*   length
5900301  0.09384  30
*   volume
5900401  0.0  30
*   azim angle
5900501  0.0  30
*   incl angle
5900601  90.0  30
*   roughness hyd dia
5900801  1.5-4  1.067e-3 30
*   kf    kr
5900901  14.0   14.0  29
*   pvbfe
5901001  00000  30
*   fvcahs
5901101  001000  29
*   ebt
5901201  0  7231182.  1212588. 1212588. 1. 0. 1
5901202  0  7229406.  1250813. 1250813. 1. 0. 2
5901203  0  7227566.  1289093. 1289093. 1. 0. 3
5901204  0  7225664.  1327414. 1327414. 1. 0. 4
```

```
5901205  0  7223700.  1365766. 1365766. 1. 0. 5
5901206  0  7221672.  1404137. 1404137. 1. 0. 6
5901207  0  7219580.  1442517. 1442517. 1. 0. 7
5901208  0  7217424.  1480896. 1480896. 1. 0. 8
5901209  0  7215203.  1519265. 1519265. 1. 0. 9
5901210  0  7212918.  1557615. 1557615. 1. 0. 10
5901211  0  7210568.  1595938. 1595938. 1. 0. 11
5901212  0  7208154.  1634226. 1634226. 1. 0. 12
5901213  0  7205674.  1672471. 1672471. 1. 0. 13
5901214  0  7203128.  1710667. 1710667. 1. 0. 14
5901215  0  7200516.  1748806. 1748806. 1. 0. 15
5901216  0  7197838.  1786883. 1786883. 1. 0. 16
5901217  0  7195095.  1824891. 1824891. 1. 0. 17
5901218  0  7192285.  1862826. 1862826. 1. 0. 18
5901219  0  7189408.  1900682. 1900682. 1. 0. 19
5901220  0  7186466.  1938455. 1938455. 1. 0. 20
5901221  0  7183456.  1976141. 1976141. 1. 0. 21
5901222  0  7180379.  2013735. 2013735. 1. 0. 22
5901223  0  7177236.  2051233. 2051233. 1. 0. 23
5901224  0  7174025.  2088632. 2088632. 1. 0. 24
5901225  0  7170748.  2125927. 2125927. 1. 0. 25
5901226  0  7167402.  2163116. 2163116. 1. 0. 26
5901227  0  7163990.  2200194. 2200194. 1. 0. 27
5901228  0  7160510.  2237160. 2237160. 1. 0. 28
5901229  0  7156964.  2274011. 2274011. 1. 0. 29
5901230  0  7153350.  2310746. 2310746. 1. 0. 30
*   vel/flow
5901300  0
*   liquid  vapor  int-face
5901301  4.76433  4.76433 0.  1  * 319.2104
5901302  4.91561  4.91561 0.  2  * 319.2104
5901303  5.06717  5.06717 0.  3  * 319.2104
5901304  5.21897  5.21897 0.  4  * 319.2104
5901305  5.37095  5.37095 0.  5  * 319.2104
5901306  5.52307  5.52307 0.  6  * 319.2104
5901307  5.6753  5.6753 0.   7  * 319.2105
5901308  5.82761  5.82761 0.  8  * 319.2105
5901309  5.97995  5.97995 0.  9  * 319.2105
5901310  6.1323  6.1323 0.   10 * 319.2105
5901311  6.28462  6.28462 0.  11 * 319.2105
5901312  6.4369  6.4369 0.   12 * 319.2105
5901313  6.58909  6.58909 0.  13 * 319.2105
5901314  6.74117  6.74117 0.  14 * 319.2105
5901315  6.89313  6.89313 0.  15 * 319.2105
5901316  7.04494  7.04494 0.  16 * 319.2105
5901317  7.19658  7.19658 0.  17 * 319.2105
5901318  7.34803  7.34803 0.  18 * 319.2105
5901319  7.49927  7.49927 0.  19 * 319.2105
5901320  7.6503  7.6503 0.   20 * 319.2105
5901321  7.80109  7.80109 0.  21 * 319.2105
5901322  7.95163  7.95163 0.  22 * 319.2105
5901323  8.10192  8.10192 0.  23 * 319.2105
5901324  8.25193  8.25193 0.  24 * 319.2105
5901325  8.40165  8.40165 0.  25 * 319.2105
5901326  8.55108  8.55108 0.  26 * 319.2105
5901327  8.7002  8.7002 0.   27 * 319.2105
5901328  8.84901  8.84901 0.  28 * 319.2105
```

```
5901329  8.9975  8.9975 0.   29 * 319.2105
*hydro jun diam  beta  intercept slope  jun
5901401  1.067e-3  0.0  1.0  1.0  29
*
**    Name  Valve
5910000  bypass  tmdpjun
*          from        to     area   j-flag
5910101  590010000  592000000  0.00  0000000
*      cntrl trp
5910200  1   1005
*
5910201  -0.1 0. 0.  0.
5910202   0.  0. 10. 0.
*
*----------------------------------------------------------
*crdno    name     type
5920000   cprbp2     tmdpvol
*
*crdno   area  lngth  vol  h-a v-ang delz  rgh  dhy  pvbfe
5920101  78.  .9104  0  0  0.  .0  0  1.5  00010
*
*crdno  ebt
5920200  3
*crdno  time  press  temp
5920201  0.0  3e5  740.
*
**    Name  Valve
5930000  RC_Clg  valve
*   from    to    area    kforw  kbackw  j-flag
5930101  590010000  595000000  0.00  0.  0.  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
5930201  1  0.   319.2105  0.0
*   valve-type
5930300  trpvlv
*   trip#  w/v.liq  w/v.vap  w/v.int
5930301  1004
*
*======================================================================
$
*crdno  name  type
5950000  rcoutj  branch
5950001  1   0
5950101  0.5    2.8152  0.0
5950102  0.0    -90.0  -2.8152
5950103  0.0  0.7979   11000
5950200  0   7109896. 2307731. 2307731. 1.
*crdno  from    to    area  floss rloss  flag
*5951101  590010000  595000000  0.0  0.0  0.0  000000
5951101  595010000  597000000  0.0  0.0  0.0  000000
*crdno  flowf  flowg  velj
*5951201  133.8927 133.8927 0. * 319.2105
5951201  134.1854 134.1854 0. * 319.2105
*
*======================================================================
$
*
*
```

```
***
*  597  Hot Duct volume
***
*
*crdno    name   type
5970000   cldduct   pipe
*
*crdno  no.vols.
5970001   4
*
*crdno  area         vol.no.
5970101  1.885          4
*
*crdno  length         vol.no.
5970301  1.85          4
*
*crdno  v-ang        vol.no.
5970601  0.0          4
*
*crdno  rough  dhy      vol.no.
5970801  0.    0.6        4
*
*crdno    ff  rf      jun.no.
5970901   0.  0.        3
*
*crdno  tlpvbfe        vol.no.
5971001  10010          4
*
*crdno  jefvcahs        jun.no.
5971101  0000000         3
*
*crdno   ebt pressure  temp  qual  vol.no.
5971201    0  7149064. 2310600. 2310600. 1. 0. 1
5971202    0  7149072. 2310600. 2310600. 1. 0. 2
5971203    0  7149072. 2310600. 2310600. 1. 0. 3
5971204    0  7149072. 2310600. 2310600. 1. 0. 4
*
*crdno  i.c.
5971300  0
*
*crdno  flowf  flowg    velj  jun.no.
5971301  35.525  35.525    0.   1 * 319.2105
5971302  35.525  35.525    0.   2 * 319.2105
5971303  35.525  35.525    0.   3 * 319.2105
*
*crdno  dhy          jun.no
5971401  0.6   1.0  1.0  1.0    3
*
*
*======================================================================
*
*
*** Bypass Line
*
*======================================================================
**
*
```

```
*
4040000  bypvo21  branch
4040001  1   0
4040101  0.1039  9.144  0.0
4040102  0.0    0.0   0.0
4040103  3.048-7  0.0  11000
4040200  0   7231534.  1175566. 1175566. 1.
4041101  587010002  404010001  0.0  0.0  0.0  000000
4041110  0.0  0.0   1.0  1.0
4041201  -6.90005-7 -6.90005-7 0. * -6.76943-7
*
*
*
4050000  bypsvl2  valve
4050101  404010002  406010001  0.1039
4050102  0.5   0.5    000100
4050103  1.0   1.0    1.0
4050201  1   0.   0.  0. * 0.
4050300  mtrvlv
4050301  481   482    1.0
4050302  0.0   0
*
*
4060000  bypvl22  branch
4060001  1   0
4060101  0.1039  9.144  0.0
4060102  0.0    90.0  4.2
4060103  3.048-7  0.0  11000
4060200  0   3049666. 2494429. 2494429. 1.
4061101  406010002  515010001  0.0  0.0  0.0  000000
4061110  0.0  0.0   1.0  1.0
4061201  -1.244698-9 -1.244698-9 0. * -2.31131-10
*
*
*=======================================================================
*
****
*
*** Source of cooling water for precooler
*
*=======================================================================
**
* 131 Water Source
*
*crdno    name     type
1310000   h2_cd     tmdpvol
*
*crdno   area  lngth  vol  h-a v-ang delz  rgh  dhy  pvbfe
1310101  78.  .9104  0  0  0.   .0  0  1.5  00010
*
*crdno  ebt
1310200  3
*crdno  time  press  temp
1310201  0.0  0.84e6  293.15
*
*
*---
```

```
*crdno    name   type
1320000   hecdj  sngljun
*
*crdno  from     to     area  floss  rloss  flag
1320101  131000000  133000000  0.0  0.    0.    100
*
*crdno  ctl  flowf  flowg  velj
1320201  0  1.490186  1.520952  0. * 1253.5
*
*======================================================================
========*
1330000  prech2o  pipe
*----------------------------------------------------------------------
--------*
*   no. vols
1330001  20
*   vol area
1330101  0.8423  20
*   length
1330301  0.2365  20
*   volume
1330401  0.0  20
*   azim angle
1330501  0.0  20
*   incl angle
1330601  90.0  20
*   roughness hyd dia
1330801  0.0  2.0e-3 20
*   kf    kr
1330901  13.7  13.7  19
*   pvbfe
1331001  00000  20
*   fvcahs
1331101  001000  19
*   ebt  press   temp
1331201  0  834479.   84988.  2576484. 0. 0. 1
1331202  0  811195.   86349.6  2575659. 0. 0. 2
1331203  0  787915.   87917.5  2574782. 0. 0. 3
1331204  0  764650.   89721.8  2573852. 0. 0. 4
1331205  0  741402.   91796.9  2572900. 0. 0. 5
1331206  0  718173.   94182.4  2571848. 0. 0. 6
1331207  0  694965.   96923.8  2570730. 0. 0. 7
1331208  0  671782.   100073.6 2569583. 0. 0. 8
1331209  0  648627.   103692.4 2568406. 0. 0. 9
1331210  0  625502.   107850.  2567196. 0. 0. 10
1331211  0  602412.   112627.  2565952. 0. 0. 11
1331212  0  579360.   118117.  2564672. 0. 0. 12
1331213  0  556350.   124428.4 2563352. 0. 0. 13
1331214  0  533387.   131686.8 2561992. 0. 0. 14
1331215  0  510475.   140038.7 2560586. 0. 0. 15
1331216  0  487618.   149655.  2559134. 0. 0. 16
1331217  0  464821.   160735.3 2557629. 0. 0. 17
1331218  0  442088.   173512.7 2556068. 0. 0. 18
1331219  0  419421.   188262.  2554324. 0. 0. 19
1331220  0  396824.   205304.8 2552454. 0. 0. 20
*   vel/flow
1331300  0
```

```
*   liquid  vapor  int-face
1331301  1.490278  1.538892 0.  1  * 1253.5
1331302  1.490396  1.559857 0.  2  * 1253.5
1331303  1.490533  1.58196 0.  3  * 1253.5
1331304  1.49069  1.60508 0.  4  * 1253.5
1331305  1.490873  1.62915 0.  5  * 1253.5
1331306  1.491085  1.654127 0.  6  * 1253.5
1331307  1.491332  1.679986 0.  7  * 1253.5
1331308  1.491623  1.706704 0.  8  * 1253.5
1331309  1.491964  1.734265 0.  9  * 1253.5
1331310  1.492368  1.762648 0.  10 * 1253.5
1331311  1.492847  1.791832 0.  11 * 1253.5
1331312  1.49342  1.821788 0.  12 * 1253.5
1331313  1.494103  1.85248 0.  13 * 1253.5
1331314  1.494926  1.883866 0.  14 * 1253.5
1331315  1.49592  1.915887 0.  15 * 1253.5
1331316  1.497126  1.92571 0.  16 * 1253.5
1331317  1.498594  1.92763 0.  17 * 1253.5
1331318  1.50039  1.929976 0.  18 * 1253.5
1331319  1.502596  1.93286 0.  19 * 1253.5
*hydro jun diam  beta  intercept slope  jun
1331401  2.0e-3  0.0  1.0  1.0  19
*=====================================================================
$
*
***
* 134  Junction - cooling outlet
*
1340000   coreij  tmdpjun
*crdno  from   to   area  jefvcahs
1340101  133010000  135000000  0.0    000000
1340200  1
1340201  0.0  1.2535e3  0.0  0.0
*
*
*
* 135 Water Sink
*
*crdno    name     type
1350000   hi_cold     tmdpvol
*
*crdno   area  lngth  vol  h-a v-ang delz  rgh  dhy  pvbfe
1350101  78.  .9104  0  0  0.  .0  0  1.5  00010
*
*crdno  ebt
1350200  3
*crdno  time  press    temp
1350201  0.0  0.54e6   325.15
*
*
****
*
*** Source of cooling water for intercooler
*
*
* 141 Water Source
*
```

```
*crdno    name     type
1410000   h2c_cd     tmdpvol
*
*crdno   area  lngth  vol  h-a v-ang delz  rgh  dhy  pvbfe
1410101  78.  .9104  0  0  0.  .0  0  1.5  00010
*
*crdno  ebt
1410200  3
*crdno  time  press  temp
1410201  0.0  0.84e6  293.15
*
*
*---
*crdno    name   type
1420000   hcdj  sngljun
*
*crdno  from    to    area  floss  rloss  flag
1420101  141000000  143000000  0.0  0.    0.    100
*
*crdno  ctl  flowf  flowg  velj
1420201  0  1.62224  1.65259  0. * 985.
*
*=======================================================================
========*
1430000  intch2o  pipe
*-----------------------------------------------------------------------
--------*
*   no. vols
1430001  20
*   vol area
1430101  0.608  20
*   length
1430301  0.2365  20
*   volume
1430401  0.0  20
*   azim angle
1430501  0.0  20
*   incl angle
1430601  90.0  20
*   roughness hyd dia
1430801  0.0  2.0e-3 20
*   kf    kr
1430901  12.   12.  19
*   pvbfe
1431001  00000  20
*   fvcahs
1431101  001000  19
*   ebt  press   temp
1431201  0  833749.   85647.2  2576458. 0. 0. 1
1431202  0  809012.   87706.5  2575581. 0. 0. 2
1431203  0  784296.   90010.2  2574638. 0. 0. 3
1431204  0  759605.   92586.7  2573647. 0. 0. 4
1431205  0  734941.   95467.7  2572631. 0. 0. 5
1431206  0  710307.   98689.  2571472. 0. 0. 6
1431207  0  685704.   102290.8 2570276. 0. 0. 7
1431208  0  661137.   106318.  2569046. 0. 0. 8
1431209  0  636608.   110821.3 2567782. 0. 0. 9
```

```
1431210  0  612120.   115857.5 2566480. 0. 0. 10
1431211  0  587677.   121490.7 2565138. 0. 0. 11
1431212  0  563283.   127793.2 2563754. 0. 0. 12
1431213  0  538940.   134846.4 2562325. 0. 0. 13
1431214  0  514652.   142742.6 2560846. 0. 0. 14
1431215  0  490423.   151586.  2559314. 0. 0. 15
1431216  0  466255.   161494.7 2557725. 0. 0. 16
1431217  0  442152.   172602.3 2556073. 0. 0. 17
1431218  0  418115.5  185061.3 2554218. 0. 0. 18
1431219  0  394148.   199045.3 2552214. 0. 0. 19
1431220  0  370250.   214750.  2550009. 0. 0. 20
*   vel/flow
1431300  0
*   liquid  vapor  int-face
1431301  1.622396  1.67498 0.  1  * 985.
1431302  1.622586  1.69937 0.  2  * 985.
1431303  1.6228  1.725116 0.  3  * 985.
1431304  1.623046  1.752073 0.  4  * 985.
1431305  1.623326  1.78016 0.  5  * 985.
1431306  1.623645  1.809332 0.  6  * 985.
1431307  1.624012  1.839554 0.  7  * 985.
1431308  1.624434  1.8708 0.  8  * 985.
1431309  1.62492  1.903052 0.  9  * 985.
1431310  1.625485  1.93628 0.  10 * 985.
1431311  1.62614  1.970453 0.  11 * 985.
1431312  1.626903  2.00553 0.  12 * 985.
1431313  1.627794  2.04146 0.  13 * 985.
1431314  1.628838  2.07817 0.  14 * 985.
1431315  1.630063  2.09947 0.  15 * 985.
1431316  1.631506  2.101357 0.  16 * 985.
1431317  1.633208  2.103583 0.  17 * 985.
1431318  1.635222  2.106216 0.  18 * 985.
1431319  1.63761  2.10934 0.  19 * 985.
*hydro jun diam  beta  intercept slope  jun
1431401  2.0e-3  0.0  1.0  1.0  19
*=====================================================================
$
*
***
* 144  Junction - cooling outlet
*
1440000   coreij  tmdpjun
*crdno  from   to   area  jefvcahs
1440101  143010000  145000000  0.0    000000
1440200  1
1440201  0.0  0.985e3  0.0  0.0
*
*
*
* 145 Water Sink
*
*crdno    name     type
1450000   hi_cold     tmdpvol
*
*crdno   area  lngth  vol  h-a v-ang delz  rgh  dhy  pvbfe
1450101  78.  .9104  0  0  0.  .0  0  1.5  00010
*
```

```
*crdno  ebt
1450200  3
*crdno  time  press    temp
1450201  0.0  0.54e6   325.15
*
*======================================================================
==
*
*  PCU Model Configuration-Hot Side
*
*======================================================================
==
*-------------------------------------------------------
*  PCU Junction: Reactor Outlet Plenum to PCU Hot Duct
*-------------------------------------------------------
*   name   junction
0820000  RPV-Hdct  valve
*   from    to    area  kforw  kbackw  j-flag
0820101  300010000  504000000  1.606  8.0  1.0  00000200
*   cntrl  w/v.liq  w/v.vap  w/v.int
0820201  0  62.7588  62.7588  0. * 319.2105
*   valve-type
0820300  mtrvlv
*   trip#  w/v.liq  w/v.vap  w/v.int
0820301  527   1003   0.0167   1.0
*
**    Name  Valve
5030000  cprbp2  valve
*   from    to    area    kforw  kbackw  j-flag
5030101  504010000  500000000  0.00  0.  0.  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
5030201  1  0.   0.  0.0
*   valve-type
5030300  trpvlv
*   trip#  w/v.liq  w/v.vap  w/v.int
5030301  1004
*
*-------------------------------------------------------
*
*-------------------------------------------------------
*crdno  name  type
5040000  contnmt  snglvol
*crdno  area  length  vol  h-a v-ang delz  rgh  dhy  pvbfe
5040101  1.606  0.1  0  0  0.  .0  0.  0.  00010   *
*crdno  ebt  press  temp.
5040200  0  7001960. 3442779. 3442779. 1. 0.
*
*-------------------------------------------------------
*  Single Volume: Guard Containment
*-------------------------------------------------------
*crdno  name  type
0700000  contnmt  snglvol
*crdno  area  length  vol  h-a v-ang delz  rgh  dhy  pvbfe
0700101  283.0  10.15  0  0  0.  .0  0.  0.  00010   * 283x66.15
*crdno  ebt  press  temp.
0700200  3  1.0e5  303.15
*-------------------------------------------------------
```

```
*  Single Volume: nossle
*----------------------------------------------------------
*crdno  name  type
*0630000  contnmt  snglvol
*crdno  area  length  vol  h-a v-ang delz  rgh  dhy  pvbfe
*0630101  0.05  0.01  0  0  0.  .0  0.  0.  00010   *
*crdno  ebt  press  temp.
*0630200  3  1.0e5  303.15
*----------------------------------------------------------
*  Single Junction: nossle
*----------------------------------------------------------
**   name   junction
*0640000  tocont  sngljun
*   from   to    area  kforw  kbackw  j-flag
*0640101  063010000  070000000  0.0  0.23  0.23  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
*0640201  0  0. 0. 0. *
*----------------------------------------------------------
*  Valve: PCU to Guard Containment
*----------------------------------------------------------
**    Name  Valve
0620000  PCU-GC  valve
*   from   to    area    kforw  kbackw  j-flag
0620101  597010000  070000000  0.0005  1.0  1.0  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
0620201  1  0.   0.0  0.0
*   valve-type
0620300  trpvlv
*   trip#  w/v.liq  w/v.vap  w/v.int
0620301  522  *CLOSE until 50 secs
*
*---------------------------------------------------
*  083  Junction between PCU and RPV inlet (cold duct)
*---------------------------------------------------
*0830000  pcuhot  tmdpjun
*crdno  from   to   area  jefvcahs
*0830101  597010000  670000000  1.885  000000
*0830200  1  522
*0830201  -1.0  0.0  0.0  0.0
*0830202  0.0  0.0  324.57  0.0
*0830203  1.0  0.0  324.57  0.0
*0830204  50.0  0.0  0.0  0.0
*Note times above are trip tim + given time
*
*
*----------------------------------------------------------
*  PCU Junction: PCU Cold Duct to RPV Downcomer
*----------------------------------------------------------
*   name   junction
9650000  InC-InHP  sngljun
*   from   to    area  kforw  kbackw  j-flag
9650101  597010000  670000000  0.0  0.0  0.0  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
9650201  0  35.525  35.525  0. * 319.2105
*
*----------------------------------------------------------
*  PCU Junction: PCU Cold Duct to RPV Downcomer
```

```
*-------------------------------------------------------
*   name   junction
9660000  InC-InHP  sngljun
*   from    to    area  kforw  kbackw  j-flag
9660101  597010000  800000000  0.0  0.0  0.0  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
9660201  0  35.525  35.525  0. * 319.2105
*
*=====================================================================
==
*
*  Passive DHR DECAY HEAT REMOVAL SYSTEM 1
*
*=====================================================================
==
*
*-------------------------------------------------------
*  Junction: Reactor Outlet Plenum to Passive DHR System Duct
*-------------------------------------------------------
**   name   junction
6050000  opl-hd  sngljun
*   from    to    area  kforw  kbackw  j-flag
6050101  300010000  610000000  0.0  0.23  0.23  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6050201  0  -1.298463-7 -1.298463-7 0. * -4.31083-7
*-------------------------------------------------------
*  Passive DHR Hot Duct  1x50% loop
*-------------------------------------------------------
*   name  pipe/annulus
6100000  hp-hotd  pipe
*   number of volumes
6100001  5
*   area  no of vol
6100101  2.0774  5
*   length  no of vol
6100301  3.8   5
*   volume  no of vol
6100401  0.0   5
*   azi ang  no of vol
6100501  90.    5
*   ver ang  no of vol
6100601  90.   5
*   elev.  no of vol
6100701  3.0   5
*   rough  dhydr.  no of vol
6100801  4.5e-5  1.6264  5
*   kforw  kbackw  no of jun
6100901  0.0875  0.0875   4
*   v-flag  no of vol
6101001  00000  5
*   j-flag  no of jun
6101101  000000  4
*   cntrl  pressure  temperature  *  *  *  no of vol
6101201  0    7058062.  3418188.  3418188. 1. 0.  1
6101202  0    7.058+6  3403438.  3403438. 1. 0.  2
6101203  0    7057949.  3400732.  3400732. 1. 0.  3
6101204  0    7057892.  3401820.  3401820. 1. 0.  4
```

```
6101205  0    7057836.  3411673.  3411673. 1. 0.  5
*   cntrl
6101300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
6101301  -1.256998-7  -1.256998-7 0.  1 * -4.19126-7
6101302  -1.221132-7  -1.221132-7 0.  2 * -4.07489-7
6101303  -1.18709-7  -1.18709-7 0.   3 * -3.96001-7
6101304  -1.156956-7  -1.156956-7 0.  4 * -3.848304-7
*
*-----------------------------------------------------------
*  Junction: HP Hot Duct to HX POD Inlet
*-----------------------------------------------------------
*   name   junction
6150000  hd-hxpin  sngljun
*   from    to    area  kforw  kbackw  j-flag
6150101  610010000  620000000  0.0  0.75  0.75  0000001
*   cntrl  w/v.liq  w/v.vap  w/v.int
6150201  0  -1.158115-7 -1.158115-7 0. * -3.76676-7
*
*-----------------------------------------------------------
*  Passive DHR Heat Exchanger POD Inlet
*-----------------------------------------------------------
*   name   volume
6200000  hp-hxpin  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
6200101  5.4    4.5  0.0  90.  90.  4.5  4.5e-5 1.636  000000  $ 1
*   cntrl  press   temp
6200200  0   7057738.  3488909. 3488909. 1.
*-----------------------------------------------------------
*  Junction: Passive DHR HX POD Inlet to Heat Exchanger Inlet
*-----------------------------------------------------------
*   name   junction
6250000  ihx-hxp  sngljun
*   from    to    area  kforw  kbackw  j-flag
6250101  620010000  626000000  0.0    0.23  0.23  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6250201  0  -3.62896-8  -3.62896-8 0. * -2.489533-7
*
*-----------------------------------------------------------
*  Passive DHR Heat Exchanger Inlet
*-----------------------------------------------------------
*   name   volume
6260000  hp-hxin  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
6260101  2.1276  1.0  0.0  -90.  -90.  -0.5  4.5e-5 0.15  000000  $ 1
*   cntrl  press  temp
6260200  0   7057678.  3388292. 3388292. 1.
*-----------------------------------------------------------
*  Junction: Passive DHR HX Inlet to Heat Exchanger
*-----------------------------------------------------------
*   name   junction
6270000  ihx-hx  sngljun
*   from    to    area  kforw  kbackw  j-flag
6270101  626010000  650000000  0.0  0.23  0.23  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6270201  0  -2.086635-8 -2.086635-8 0. * -2.680236-7
*
```

```
*-----------------------------------------------------------
*  Passive DHR Heat Exchanger
*-----------------------------------------------------------
*   name  pipe/annulus
6500000  hp-hx  pipe
*   number of volumes
6500001  5
*   area  no of vol
6500101  2.1856  5
*   length  no of vol
6500301  0.060  5
*   volume  no of vol
6500401  0.0   5
*   azi ang  no of vol
6500501  -90.  5
*   ver ang  no of vol
6500601  -90.  5
*   elev.  no of vol
6500701  -0.060  5
*   rough  dhydr.  no of vol
6500801  1.e-5  3.055e-3  5
*   kforw  kbackw  no of jun
6500901  0.0   0.0   4
*   v-flag  no of vol
6501001  00000  5
*   j-flag  no of jun
6501101  000000  4
*   cntrl  pressure  temperature  *  *  *  no of vol
6501201  0    7057689.  932251.  932251. 1. 0.  1
6501202  0    7057696.  932245.  932245. 1. 0.  2
6501203  0    7057702.  932240.  932240. 1. 0.  3
6501204  0    7057710.  932236.  932236. 1. 0.  4
6501205  0    7057716.  932233.  932233. 1. 0.  5
*   cntrl
6501300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
6501301  -2.098683-8  -2.098683-8 0.  1 * -2.69573-7
6501302  -2.108813-8  -2.108813-8 0.  2 * -2.708757-7
6501303  -2.11641-8  -2.11641-8 0.  3 * -2.71853-7
6501304  -2.12116-8  -2.12116-8 0.  4 * -2.724644-7
*-----------------------------------------------------------
*  Junction: Passive DHR Heat Exchanger to HX Outlet
*-----------------------------------------------------------
*   name   junction
6550000  hx-ohx  sngljun
*   from   to    area  kforw  kbackw  j-flag
6550101  650010000  660000000  0.0  0.50  0.50  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6550201  0  -4.34546-8 -4.34546-8 0. * -2.737685-7
*
*-----------------------------------------------------------
*  Passive DHR Heat Exchanger Outlet Plenum
*-----------------------------------------------------------
*   name   volume
6600000  hp-outpl  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
6600101  2.1276  1.0  0.0  -90.  -90.  -0.2  4.5e-5 0.15  000000
```

```
*   cntrl  press    temp
6600200  0    7057726.  1896749. 1896749. 1.
*
*---------------------------------------------------------
*  Junction: Passive DHR HX Outlet to Downcomer
*---------------------------------------------------------
*   name   junction
6610000  hp-ohx  sngljun
*   from   to    area  kforw  kbackw  j-flag
6610101  660010000  662000000  0.0  1.0  1.0  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6610201  0  -2.273712-8 -2.273712-8 0. * -2.254984-7
*---------------------------------------------------------
*  Passive DHR Heat Exchanger Outlet Pod
*---------------------------------------------------------
*   name   volume
6620000  hp-outpp  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
6620101  10.995  1.0  0.0  -90.  -90.  -1.0  4.5e-5 2.026  000000  $
*   cntrl  press    temp
6620200  0    7057754.  2344926. 2344926. 1.
*
*---------------------------------------------------------
*  Junction: Passive DHR HX Outlet Pod
*---------------------------------------------------------
*   name   junction
6630000  hp-ohxp  sngljun
*   from   to    area  kforw  kbackw  j-flag
6630101  662010000  664000000  0.0  0.0  0.0  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6630201  0  -4.49314-9  -4.49314-9 0. * -1.282388-7
*
*---------------------------------------------------------
*  Passive DHR  BLOWER volume
*---------------------------------------------------------
*   name   volume
6640000  hp-outpb  snglvol
*   area   length  vol. a.ang.  in.ang. elev.  rough.  hDe  v-flag
6640101  6.1576  3.0  0.0  -90.  -90.  -3.0  4.5e-5  1.4  000000
*   cntrl  press    temp
6640200  0    7057845.  2358240. 2358240. 1.
*
*   name   junction
6920000  hp-ohxp  sngljun
*   from   to    area  kforw  kbackw  j-flag
6920101  664010000  690000000  0.0   0.0  0.0  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6920201  0  -4.67222-9  -4.67222-9 0. * -1.88798-7
*---------------------------------------------------------
*   name   volume
6900000  hp-outpc  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
6900101  6.1576  0.5  0.0  -90.  0.  0.0  0. 1.4  000000
*   cntrl  press    temp
6900200  0    7057892.  1666776. 1666776. 1.
*
*---------------------------------------------------------
```

```
*-----------------------------------------------------------
*   name   junction
6650000  hp-blow  valve
*   from    to     area  kforw  kbackw  j-flag
6650101  690010000  698000000  6.1576 13.46  13.46  00000200
*   cntrl  w/v.liq  w/v.vap  w/v.int
6650201  0  0.     0.  0. * 0.
*   valve-type
6650300  mtrvlv
*   trip#  w/v.liq  w/v.vap  w/v.int
6650301  539   541   0.025   0.0
*--------------------------------------------------------------
**    Name  Valve
6870000  leak1  tmdpjun
*           from         to     area   j-flag
6870101  698000000  690010000  0.00  0000000
*      cntrl trp
6870200  1   541
*
6870201  -0.1 0. 0.  0.
6870202   0.  0. 0.15 0.
*--------------------------------------------------------------
*   name   volume
6980000  hp-outpd  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
6980101  6.1576  0.5  0.0  -90.  0.  0.0  0. 1.4  000000
*   cntrl  press    temp
6980200  0    9623368.  3469112.  3469112. 1.
*   name   junction
6990000  hp-ohxp  sngljun
*   from    to     area  kforw  kbackw  j-flag
6990101  698010000  666000000  0.0   0.0  0.0  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6990201  0  -4.67222-9  -4.67222-9 0. * -1.88798-7
*----------------------------------------------------------
*  Passive DHR Cold leg  1x50% loop
*----------------------------------------------------------
*   name  pipe/annulus
6660000  SCS-CL  pipe
*   number of volumes
6660001  5
*   area  no of vol
6660101  6.1576  5
*   length  no of vol
6660301  3.7   5
*   volume  no of vol
6660401  0.0   5
*   azi ang  no of vol
6660501  -90.  5
*   ver ang  no of vol
6660601  -90.  5
*   elev.  no of vol
6660701  -2.9   5
*   rough  dhydr.  no of vol
6660801  4.5e-5  1.6117  5
*   kforw  kbackw  no of jun
6660901  0.0875  0.0875   4
```

```
*   v-flag  no of vol
6661001  00000  5
*   j-flag  no of jun
6661101  000000  4
*   cntrl  pressure  temperature  *  *  *  no of vol
6661201  0    9644631.  3497396.  3497396. 1. 0.  1
6661202  0    9644697.  3497396.  3497396. 1. 0.  2
6661203  0    9644763.  3497396.  3497396. 1. 0.  3
6661204  0    9644829.  3497396.  3497396. 1. 0.  4
6661205  0    9644895.  3497397.  3497397. 1. 0.  5
*   cntrl
6661300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
6661301  -9.47945-14  -9.47945-14 0.  1 * -2.729385-13
6661302  -1.594003-13 -1.594003-13 0.  2 * -4.58962-13
6661303  -2.3107-13  -2.3107-13 0.  3 * -6.6533-13
6661304  -2.0602-13  -2.0602-13 0.  4 * -5.93211-13
*
*
*-----------------------------------------------------------
*  Junction connecting Passive  Cold Leg to RPV downcomer with valve
(simulates
*-----------------------------------------------------------
*   name   junction
6670000  hp-ohb  valve
*   from    to    area  kforw  kbackw  j-flag
6670101  666010000  670000000  0.0   1.0  1.0  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6670201  0  0.    0.  0. * 0.
*   valve-type
6670300  trpvlv
*   trip#  w/v.liq  w/v.vap  w/v.int
6670301  525  * Close Until end of coastdown
*-----------------------------------------------------------
*  Bypass Junction to simulate leakage of check  check valve
*-----------------------------------------------------------
*   name   junction
6950000  leak_chv  valve
*   from    to    area  kforw  kbackw  j-flag
6950101  666010000  670000000  1.e-9  1.e9  1.e9  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6950201  0  0.    0.  0. * 0.
*   valve-type
6950300  trpvlv
*   trip#  w/v.liq  w/v.vap  w/v.int
6950301  525  * Close Until end of coastdown
*
*=====================================================================
==
*
*  Passive DHR DECAY HEAT REMOVAL SYSTEM 2 (DHR2)
*
*=====================================================================
==
*
*-----------------------------------------------------------
*  Junction: Reactor Outlet Plenum to Passive DHR System Duct (DHR2)
```

```
*-----------------------------------------------------------
*   name   junction
6060000  opl-hd2  sngljun
*   from    to     area  kforw  kbackw  j-flag
6060101  300010000  611000000  0.0  0.23  0.23  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6060201  0  -1.822274-7 -1.822274-7 0. * -6.11274-7
*-----------------------------------------------------------
*  Passive DHR Hot Duct (DHR2)
*-----------------------------------------------------------
*   name  pipe/annulus
6110000  hp-hotd2  pipe
*   number of volumes
6110001  5
*   area  no of vol
6110101  2.0774  5
*   length  no of vol
6110301  3.8   5
*   volume  no of vol
6110401  0.0   5
*   azi ang  no of vol
6110501  90.   5
*   ver ang  no of vol
6110601  90.   5
*   elev.  no of vol
6110701  3.0   5
*   rough  dhydr.  no of vol
6110801  4.5e-5  1.6264  5
*   kforw  kbackw  no of jun
6110901  0.0875  0.0875  4
*   v-flag  no of vol
6111001  00000  5
*   j-flag  no of jun
6111101  000000  4
*   cntrl  pressure  temperature  *  *  *  no of vol
6111201  0   7058062.  3383064.  3383064. 1. 0.  1
6111202  0   7.058+6  3366640.  3366640. 1. 0.  2
6111203  0   7057948.  3341524.  3341524. 1. 0.  3
6111204  0   7057890.  3294012.  3294012. 1. 0.  4
6111205  0   7057830.  3193825.  3193825. 1. 0.  5
*   cntrl
6111300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
6111301  -1.7768-7  -1.7768-7  0.   1 * -5.98928-7
6111302  -1.726138-7 -1.726138-7 0.   2 * -5.86226-7
6111303  -1.6624-7  -1.6624-7  0.   3 * -5.72729-7
6111304  -1.569187-7 -1.569187-7 0.   4 * -5.57591-7
*
*-----------------------------------------------------------
*  Junction: HP Hot Duct to HX POD Inlet (DHR2)
*-----------------------------------------------------------
*   name   junction
6160000  hd-hxpi2  sngljun
*   from   to    area  kforw  kbackw  j-flag
6160101  611010000  621000000  0.0  0.75  0.75  0000001
*   cntrl  w/v.liq  w/v.vap  w/v.int
6160201  0  -1.378557-7 -1.378557-7 0. * -5.37921-7
```

```
*
*------------------------------------------------------------
*  Passive DHR Heat Exchanger POD Inlet (DHR2)
*------------------------------------------------------------
*   name   volume
6210000  hp-hxp2  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
6210101  5.4    4.5  0.0  90.  90.  4.5  4.5e-5  1.636  000000  $ 1
*   cntrl  press    temp
6210200  0    7057717.  2908740. 2908740. 1.
*------------------------------------------------------------
*  Junction: Passive DHR HX POD Inlet to Heat Exchanger Inlet  (DHR2)
*------------------------------------------------------------
*   name   junction
6280000  ihx-hxp2  sngljun
*   from   to    area  kforw  kbackw  j-flag
6280101  621010000  629000000  0.0  0.23  0.23  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6280201  0  -1.570477-8 -1.570477-8 0. * -3.142066-7
*
*------------------------------------------------------------
*  Passive DHR Heat Exchanger Inlet (DHR2)
*------------------------------------------------------------
*   name   volume
6290000  hp-hxin2  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
6290101  2.1276  1.0  0.0  -90.  -90.  -0.5  4.5e-5 0.15  000000  $ 1
*   cntrl  press    temp
6290200  0    7057657.  1164302. 1164302. 1.
*------------------------------------------------------------
*  Junction: Passive DHR HX Inlet to Heat Exchanger  (DHR2)
*------------------------------------------------------------
*   name   junction
6300000  ihx-hx  sngljun
*   from   to    area  kforw  kbackw  j-flag
6300101  629010000  651000000  0.0  0.23  0.23  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6300201  0  -2.589013-8 -2.589013-8 0. * -3.32553-7
*
*------------------------------------------------------------
*  Passive DHR Heat Exchanger (DHR2)
*------------------------------------------------------------
*   name  pipe/annulus
6510000  hp-hx2  pipe
*   number of volumes
6510001  5
*   area  no of vol
6510101  2.1856  5
*   length  no of vol
6510301  0.060  5
*   volume  no of vol
6510401  0.0   5
*   azi ang  no of vol
6510501  -90.  5
*   ver ang  no of vol
6510601  -90.  5
*   elev.  no of vol
```

```
6510701  -0.06  5
*   rough  dhydr.  no of vol
6510801  1.e-5  3.055e-3  5
*   kforw  kbackw  no of jun
6510901  0.0   0.0   4
*   v-flag  no of vol
6511001  00000  5
*   j-flag  no of jun
6511101  000000  4
*   cntrl  pressure  temperature  *  *  *  no of vol
6511201  0    7057684.  932250.  932250. 1. 0.  1
6511202  0    7057690.  932244.  932244. 1. 0.  2
6511203  0    7057698.  932239.  932239. 1. 0.  3
6511204  0    7057704.  932235.  932235. 1. 0.  4
6511205  0    7057711.  932232.  932232. 1. 0.  5
*   cntrl
6511300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
6511301  -2.60233-8  -2.60233-8 0.  1 * -3.34266-7
6511302  -2.612243-8  -2.612243-8 0.  2 * -3.35541-7
6511303  -2.618735-8  -2.618735-8 0.  3 * -3.36377-7
6511304  -2.62204-8  -2.62204-8 0.  4 * -3.368025-7
*-------------------------------------------------------
*  Junction: Passive DHR Heat Exchanger to HX Outlet  (DHR2)
*-------------------------------------------------------
*   name   junction
6560000  hx-ohx2  sngljun
*   from   to    area  kforw  kbackw  j-flag
6560101  651010000  668000000  0.0  0.50  0.50  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6560201  0  -4.44103-8  -4.44103-8 0. * -3.37483-7
*
*-------------------------------------------------------
*  Passive DHR Heat Exchanger Outlet Plenum (DHR2)
*-------------------------------------------------------
*   name   volume
6680000  hp-outp2  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
6680101  2.1276  1.0  0.0  -90.  -90.  -0.2  4.5e-5 0.15  000000
*   cntrl  press    temp
6680200  0    7057722.  1573145. 1573145. 1.
*
*-------------------------------------------------------
*  Junction: Passive DHR HX Outlet to Downcomer  (DHR2)
*-------------------------------------------------------
*   name   junction
6690000  hp-ohx2  sngljun
*   from   to    area  kforw  kbackw  j-flag
6690101  668010000  671000000  0.0  1.0  1.0  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6690201  0  -2.11582-8  -2.11582-8 0. * -3.063706-7
*-------------------------------------------------------
*  Passive DHR Heat Exchanger Outlet Pod (DHR2)
*-------------------------------------------------------
*   name   volume
6710000  hp-outp2  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
```

```
6710101  10.995  1.0  0.0  -90.  -90.  -1.0  4.5e-5 2.026  000000
*   cntrl  press    temp
6710200  0    7057762.  1607285. 1607285. 1.
*
*-------------------------------------------------------
*  Junction: Passive DHR HX Outlet Pod (DHR2)
*-------------------------------------------------------
*   name   junction
6720000  hp-ohxp  sngljun
*   from    to    area  kforw  kbackw  j-flag
6720101  671010000  673000000  0.0   0.0  0.0  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6720201  0  -4.67222-9  -4.67222-9 0. * -1.88798-7
*-------------------------------------------------------
*  Passive DHR  BLOWER (DHR2)
*-------------------------------------------------------
*   name   volume
6730000  hp-outp2  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
6730101  6.1576  3.0  0.0  -90.  -90.  -3.0  4.5e-5 1.4  000000
*   cntrl  press    temp
6730200  0    7057892.  1666776. 1666776. 1.
*
*-------------------------------------------------------
*   name   junction
6930000  hp-ohxp  sngljun
*   from    to    area  kforw  kbackw  j-flag
6930101  673010000  691000000  0.0   0.0  0.0  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6930201  0  -4.67222-9  -4.67222-9 0. * -1.88798-7
*   name   volume
6910000  hp-outpc  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
6910101  6.1576  0.5  0.0  -90.  0.  0.0  0. 1.4  000000
*   cntrl  press    temp
6910200  0    7057892.  1666776. 1666776. 1.
*
*-------------------------------------------------------
*   name   volume
6940000  hp-outpd  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
6940101  6.1576  0.5  0.0  -90.  0.  0.0  0. 1.4  000000
*   cntrl  press    temp
6940200  0    9623368.  3469112.  3469112. 1.
*
*   name   junction
6960000  hp-ohxp  sngljun
*   from    to    area  kforw  kbackw  j-flag
6960101  694010000  676000000  0.0   0.0  0.0  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6960201  0  -4.67222-9  -4.67222-9 0. * -1.88798-7
*-------------------------------------------------------
*  Valve: Passive DHR  Cold Leg Valve junciton to RPV downcomer (DHR2)
*-------------------------------------------------------
**   name  junction
6740000  hp-cl  valve
*   from    to    area  kforw  kbackw  j-flag
```

```
6740101  691010000  694000000  6.1576  13.46  13.46  00000200
*   cntrl  w/v.liq  w/v.vap  w/v.int
6740201  0  0.    0.  0. * 0.
*   valve-type
6740300  mtrvlv
*   trip#  w/v.liq  w/v.vap  w/v.int
6740301  540   542   0.0125   0.0   0
*
*-------------------------------------------------------------
**    Name  Valve
6880000  leak2  tmdpjun
*           from        to      area   j-flag
6880101  694000000  691010000  0.00  0000000
*       cntrl trp
6880200  1   542
*
6880201  -0.1 0. 0.  0.
6880202   0.  0. 0.15 0.
*------------------------------------------------------------
*------------------------------------------------------------
*  Passive DHR Cold leg  1x50% loop (DHR2)
*------------------------------------------------------------
*   name  pipe/annulus
6760000  SCS-CL  pipe
*   number of volumes
6760001  5
*   area  no of vol
6760101  6.1576  5
*   length  no of vol
6760301  3.7   5
*   volume  no of vol
6760401  0.0   5
*   azi ang  no of vol
6760501  -90.  5
*   ver ang  no of vol
6760601  -90.  5
*   elev.  no of vol
6760701  -2.9   5
*   rough  dhydr.  no of vol
6760801  4.5e-5  1.6117  5
*   kforw  kbackw  no of jun
6760901  0.0875  0.0875   4
*   v-flag  no of vol
6761001  00000  5
*   j-flag  no of jun
6761101  000000  4
*   cntrl  pressure  temperature  *  *  *  no of vol
6761201  0    9623368.  3469112.  3469112. 1. 0.  1
6761202  0    9623434.  3469112.  3469112. 1. 0.  2
6761203  0    9623500.  3469112.  3469112. 1. 0.  3
6761204  0    9623566.  3469113.  3469113. 1. 0.  4
6761205  0    9623632.  3469113.  3469113. 1. 0.  5
*   cntrl
6761300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
6761301  -6.67305-15  -6.67305-15 0.  1 * -1.928565-14
6761302  -3.19196-14  -3.19196-14 0.  2 * -9.22514-14
```

```
6761303  -1.173983-13 -1.173983-13 0.  3 * -3.392996-13
6761304  8.44969-14  8.44969-14 0.  4 * 2.44209-13
*
*-----------------------------------------------------------
*  Valve: Passive DHR  Cold Leg Valve junciton to RPV downcomer (DHR2)
*-----------------------------------------------------------
*   name   junction
6770000  hp-ohb2  valve
*   from    to    area  kforw  kbackw  j-flag
6770101  676010000  800000000  0.0   1.0  1.0  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6770201  0  0.    0.  0. * 0.
*   valve-type
6770300  trpvlv
*   trip#  w/v.liq  w/v.vap  w/v.int
6770301  525  * Close Until end of coastdown
*-----------------------------------------------------------
*  Bypass Junction to simulate leakage of check  check valve
*-----------------------------------------------------------
*   name   junction
6970000  leak_chv  valve
*   from    to    area  kforw  kbackw  j-flag
6970101  676010000  800000000  1.e-9  1.e9  1.e9  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
6970201  0  0.    0.  0. * 0.
*   valve-type
6970300  trpvlv
*   trip#  w/v.liq  w/v.vap  w/v.int
6970301  525  * Close Until end of coastdown
*
*==================================================================
==
*
*  Passive DHR DECAY HEAT REMOVAL SYSTEM UHS SYSTEM 1
*
*==================================================================
==
*-----------------------------------------------------------
*  H20 DHR Heat Exchanger Inlet
*-----------------------------------------------------------
*   name   volume
7000000  h2ohxin  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough.  hDe  v-flag
7000101  0.0873  1.0  0.0  90.  90.  0.5  4.5e-5  0.333  000000
*   cntrl  press   temp
7000200  0    1085604.  104058.9 2584130. 0.
*-----------------------------------------------------------
*  Junction: H2O Passive DHR HX Inlet to Heat Exchanger
*-----------------------------------------------------------
*   name   junction
7050000  h2oihxj  sngljun
*   from    to    area  kforw  kbackw  j-flag
7050101  700010000  710000000  0.0  0.23  0.23  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
7050201  0  8.28489-4 8.3558-4  0. * .0721563
*
*-----------------------------------------------------------
```

```
*  Passive H2O DHR Heat Exchanger
*-----------------------------------------------------------
*   name  pipe/annulus
7100000  h2ohphx  pipe
*   number of volumes
7100001  5
*   area  no of vol
7100101  1.09281  5
*   length  no of vol
7100301  0.060  5
*   volume  no of vol
7100401  0.0   5
*   azi ang  no of vol
7100501  90.   5
*   ver ang  no of vol
7100601  90.   5
*   elev.  no of vol
7100701  0.060  5
*   rough  dhydr.  no of vol
7100801  1.e-5  3.055e-3  5
*   kforw  kbackw  no of jun
7100901  0.0   0.0   4
*   v-flag  no of vol
7101001  00000  5
*   j-flag  no of jun
7101101  000000  4
*   cntrl  pressure  temperature  *  *  *  no of vol
7101201  0    1082864.  104068.4  2584060. 0. 0.  1
7101202  0    1082277.  104073.  2584045. 0. 0.  2
7101203  0    1081690.  104078.7  2584030. 0. 0.  3
7101204  0    1081103.  104085.5  2584014. 0. 0.  4
7101205  0    1080516.  104093.  2.584+6 0. 0.  5
*   cntrl
7101300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
7101301  6.61846-5  6.62321-5  0.   1 * .0721563
7101302  6.61846-5  6.62321-5  0.   2 * .0721563
7101303  6.61846-5  6.62321-5  0.   3 * .0721563
7101304  6.61847-5  6.62322-5  0.   4 * .0721563
*
*-----------------------------------------------------------
*  Junction: H2O Passive DHR Heat Exchanger to HX Outlet
*-----------------------------------------------------------
*   name   junction
7150000  h2hxohx  sngljun
*   from   to    area  kforw  kbackw  j-flag
7150101  710010000  720000000  0.0  1.00  1.00  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
7150201  0  8.28492-4 8.35584-4 0. * .0721563
*
*-----------------------------------------------------------
*  Passive H2O DHR Heat Exchanger Outlet Plenum
*-----------------------------------------------------------
*   name   volume
7200000  h2ooutpl  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
7200101  0.0873  1.0  0.0  90.  90.  0.2  4.5e-5 0.333  000000
```

```
*   cntrl  press    temp
7200200  0    1079244.  104098. 2583967. 0.
*
*-----------------------------------------------------------
*  Junction: H2O DHR Heat Exchanger Outlet Plenum to UHS Duct
*-----------------------------------------------------------
*   name   junction
7250000  h2oplhd  sngljun
*   from    to    area  kforw  kbackw  j-flag
7250101  720010000  730000000  0.0  0.23  0.23  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
7250201  0  8.28492-4  8.35584-4 0. * .0721563
*
*-----------------------------------------------------------
*  Passive DHR Hot Duct
*-----------------------------------------------------------
*   name  pipe/annulus
7300000  h2ohotd  pipe
*   number of volumes
7300001  5
*   area  no of vol
7300101  0.0873  5
*   length  no of vol
7300301  1.6   5
*   volume  no of vol
7300401  0.0   5
*   azi ang  no of vol
7300501  90.   5
*   ver ang  no of vol
7300601  90.   5
*   elev.  no of vol
7300701  1.6   5
*   rough  dhydr.  no of vol
7300801  4.5e-5  0.333  5
*   kforw  kbackw  no of jun
7300901  0.0875  0.0875  4
*   v-flag  no of vol
7301001  00000  5
*   j-flag  no of jun
7301101  000000  4
*   cntrl  pressure  temperature  *  *  *  no of vol
7301201  0   1070439.  104106.3  2583740. 0. 0.  1
7301202  0   1054786.  104114.7  2583334. 0. 0.  2
7301203  0   1039133.  104123.5  2582923. 0. 0.  3
7301204  0   1023479.  104133.1  2582507. 0. 0.  4
7301205  0   1007826.  104160.4  2582086. 3.71865-6 0. 5
*   cntrl
7301300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
7301301  8.28495-4  8.35587-4  0.   1 * .0721562
7301302  8.28501-4  8.35593-4  0.   2 * .0721562
7301303  8.28507-4  8.35599-4  0.   3 * .0721561
7301304  8.28513-4  .00157848  0.   4 * .0721561
*
**-----------------------------------------------------------
**  Junction: Hotleg Duct to surge tank
**-----------------------------------------------------------
```

```
**   name  type
7800000  h2o-surj  sngljun
*   from   to    area  kforw  kbackw  j-flag
7800101  730010000  790000000  0    0.5  0.5  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
7800201  0  -.00146826 -9.44189-7 0. * -4.00458-7
*
*---------------------------------------------------------
**  H2O LOOP surge tank
*---------------------------------------------------------
*   name   volume
7900000  h20surge  tmdpvol
*   area  length  vol. a.ang. in.ang. elev. rough.  hDe  pvbfe
7900101  500.0  10.0  0.0  0.0  0.0  0.  0.00046  7.4  00010
*   cntrl
7900200  003
*      press  temp
7900201  0.0  1.00000e6  473.0
*---------------------------------------------------------
*  Junction: HP Hot Duct to HX Inlet
*---------------------------------------------------------
*   name   junction
7350000  h2ohxpin  sngljun
*   from   to    area  kforw  kbackw  j-flag
7350101  730010000  740000000  0.0  0.75  0.75  0000001
*   cntrl  w/v.liq  w/v.vap  w/v.int
7350201  0  8.28526-4  .02027343 0. * .0721564
*
*---------------------------------------------------------
*  Passive DHR Heat Exchanger Inlet
*---------------------------------------------------------
*   name   volume
7400000  h2ohxin  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough.  hDe  v-flag
7400101  0.0873  1.0  0.0  -90.  -90.  -0.5  4.5e-5  0.333  000000
*   cntrl  press    temp
7400200  0    1002446.  104171.3 2581940. 1.404818-6
*---------------------------------------------------------
*  Junction: Passive DHR HX Inlet to Heat Exchanger
*---------------------------------------------------------
*   name   junction
7450000  h2ohx-h  sngljun
*   from   to    area  kforw  kbackw  j-flag
7450101  740010000  750000000  0.0  0.23  0.23  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
7450201  0  8.28526-4 -.00344602 0. * .0721564
*
*---------------------------------------------------------
*  Passive H2O/UHS  Heat Exchanger
*---------------------------------------------------------
*   name  pipe/annulus
7500000  h2hp-hx  pipe
*   number of volumes
7500001  20
*   area  no of vol
7500101  9.64974e-2  20
*   length  no of vol
```

```
7500301  1.605  20
*   volume  no of vol
7500401  0.0   20
*   azi ang  no of vol
7500501  -90.  20
*   ver ang  no of vol
7500601  0.0   20
*   elev.  no of vol
7500701  0.0   20
*   rough  dhydr.  no of vol
7500801  1.e-5  3.5052e-2  20
*   kforw  kbackw  no of jun
7500901  0.0   0.0    19
*   v-flag  no of vol
7501001  00000  20
*   j-flag  no of jun
7501101  000000  19
*   cntrl  pressure  temperature  *  *  *  no of vol
7501201  0    1004892.  104080.5  2582007. 0. 0.  1
7501202  0    1004892.  104063.  2582007. 0. 0.  2
7501203  0    1004892.  104059.6  2582007. 0. 0.  3
7501204  0    1004891.  104059.  2582007. 0. 0.  4
7501205  0    1004891.  104058.8  2582007. 0. 0.  5
7501206  0    1004891.  104058.8  2582007. 0. 0.  6
7501207  0    1004891.  104058.8  2582007. 0. 0.  7
7501208  0    1004891.  104058.8  2582007. 0. 0.  8
7501209  0    1004891.  104058.8  2582007. 0. 0.  9
7501210  0    1004891.  104058.8  2582007. 0. 0. 10
7501211  0    1004891.  104058.8  2582007. 0. 0. 11
7501212  0    1004891.  104058.8  2582007. 0. 0. 12
7501213  0    1004891.  104058.8  2582007. 0. 0. 13
7501214  0    1004891.  104058.8  2582007. 0. 0. 14
7501215  0    1004891.  104058.8  2582007. 0. 0. 15
7501216  0    1004891.  104058.8  2582007. 0. 0. 16
7501217  0    1004891.  104058.8  2582007. 0. 0. 17
7501218  0    1004891.  104058.8  2582007. 0. 0. 18
7501219  0    1004891.  104058.8  2582007. 0. 0. 19
7501220  0    1004891.  104058.8  2582007. 0. 0. 20
*   cntrl
7501300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
7501301  7.49551-4  7.49551-4  0.   1 * .0721563
7501302  7.4955-4  7.4955-4  0.   2 * .0721563
7501303  7.4955-4  7.4955-4  0.   3 * .0721563
7501304  7.4955-4  7.4955-4  0.   4 * .0721563
7501305  7.4955-4  7.4955-4  0.   5 * .0721563
7501306  7.4955-4  7.4955-4  0.   6 * .0721563
7501307  7.4955-4  7.4955-4  0.   7 * .0721563
7501308  7.4955-4  7.4955-4  0.   8 * .0721563
7501309  7.4955-4  7.4955-4  0.   9 * .0721563
7501310  7.4955-4  7.4955-4  0.   10 * .0721563
7501311  7.4955-4  7.4955-4  0.   11 * .0721563
7501312  7.4955-4  7.4955-4  0.   12 * .0721563
7501313  7.4955-4  7.4955-4  0.   13 * .0721563
7501314  7.4955-4  7.4955-4  0.   14 * .0721563
7501315  7.4955-4  7.4955-4  0.   15 * .0721563
7501316  7.4955-4  7.4955-4  0.   16 * .0721563
```

```
7501317  7.4955-4  7.4955-4  0.   17 * .0721563
7501318  7.4955-4  7.4955-4  0.   18 * .0721563
7501319  7.4955-4  7.4955-4  0.   19 * .0721563
*
*---------------------------------------------------------
*  Junction: H2O/UHS Passive DHR Heat Exchanger to HX Outlet
*---------------------------------------------------------
*   name   junction
7550000  h2hx-ohx  sngljun
*   from   to    area  kforw  kbackw  j-flag
7550101  750010000  760000000  0.0  1.00  1.00  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
7550201  0  8.28518-4  8.28518-4 0. * .0721563
*
*---------------------------------------------------------
*  Passive UHS DHR Heat Exchanger Outlet Plenum
*---------------------------------------------------------
*   name   volume
7600000  h2-outpl  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough.  hDe  v-flag
7600101  0.0873  1.0  0.0  -90.  -90.  -0.5  4.5e-5  0.333  000000
*   cntrl  press    temp
7600200  0    1007337.  104058.8 2582073. 0.
*
*---------------------------------------------------------
*  Junction: Passive DHR HX Outlet to Downcomer
*---------------------------------------------------------
*   name   junction
7650000  hhp-ohx  sngljun
*   from   to    area  kforw  kbackw  j-flag
7650101  760010000  770000000  0.0  1.0  1.0  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
7650201  0  8.28517-4  8.3561-4  0. * .0721563
*---------------------------------------------------------
*  Passive DHR Downcomer
*---------------------------------------------------------
*   name  pipe/annulus
7700000  h2ohotd  pipe
*   number of volumes
7700001  5
*   area  no of vol
7700101  0.0873  5
*   length  no of vol
7700301  1.6   5
*   volume  no of vol
7700401  0.0   5
*   azi ang  no of vol
7700501  -90.  5
*   ver ang  no of vol
7700601  -90.  5
*   elev.  no of vol
7700701  -1.6  5
*   rough  dhydr.  no of vol
7700801  4.5e-5  0.333  5
*   kforw  kbackw  no of jun
7700901  0.0875  0.0875  4
*   v-flag  no of vol
```

```
7701001  00000  5
*   j-flag  no of jun
7701101  000000  4
*   cntrl  pressure  temperature  *  *  *  no of vol
7701201  0    1017609.  104058.8  2582350. 0. 0.  1
7701202  0    1033262.  104058.8  2582768. 0. 0.  2
7701203  0    1048916.  104058.8  2583181. 0. 0.  3
7701204  0    1064569.  104058.8  2583589. 0. 0.  4
7701205  0    1080223.  104058.9  2583992. 0. 0.  5
*   cntrl
7701300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
7701301  8.28514-4  8.35606-4  0.   1 * .0721563
7701302  8.28508-4  8.356-4  0.   2 * .0721563
7701303  8.28502-4  8.35594-4  0.   3 * .0721563
7701304  8.28496-4  8.35589-4  0.   4 * .0721563
*
*-----------------------------------------------------
*  SNGLJ: Passive DHR Cold Duct to Rx Inlet Plenum
*-----------------------------------------------------
*   name   junction
7750000  cd-iplm  sngljun
*   from   to    area  kforw  kbackw  j-flag
7750101  770010000  700000000  0.0  1.0  1.0  0000001
*   cntrl  w/v.liq  w/v.vap  w/v.int
7750201  0  8.2849-4  8.2849-4  0. * .0721563
*
*=====================================================================
==
*
*  Passive DHR DECAY HEAT REMOVAL SYSTEM UHS SYSTEM 2-Water loop
*
*=====================================================================
==
*-----------------------------------------------------
*  H20 DHR Heat Exchanger Inlet (DHR2-Water)
*-----------------------------------------------------
*   name   volume
7010000  h2ohxin  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
7010101  0.0873  1.0  0.0  90.  90.  0.5  4.5e-5 0.333  000000
*   cntrl  press    temp
7010200  0    1085604.  104059. 2584130. 0.
*-----------------------------------------------------
*  Junction: H2O Passive DHR HX Inlet to Heat Exchanger (DHR2-Water)
*-----------------------------------------------------
*   name   junction
7060000  h2oihxj  sngljun
*   from   to    area  kforw  kbackw  j-flag
7060101  701010000  711000000  0.0  0.23  0.23  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
7060201  0  7.98759-4  8.05363-4 0. * .0695671
*
*-----------------------------------------------------
*  Passive H2O DHR Heat Exchanger  (DHR2-Water)
*-----------------------------------------------------
*   name  pipe/annulus
```

```
7110000  h2ohphx  pipe
*   number of volumes
7110001  5
*   area  no of vol
7110101  1.09281  5
*   length  no of vol
7110301  0.060  5
*   volume  no of vol
7110401  0.0   5
*   azi ang  no of vol
7110501  90.   5
*   ver ang  no of vol
7110601  90.   5
*   elev.  no of vol
7110701  0.060  5
*   rough  dhydr.  no of vol
7110801  1.e-5  3.055e-3  5
*   kforw  kbackw  no of jun
7110901  0.0   0.0   4
*   v-flag  no of vol
7111001  00000  5
*   j-flag  no of jun
7111101  000000  4
*   cntrl  pressure  temperature  *  *  *  no of vol
7111201  0    1082864.  104067.  2584060. 0. 0.  1
7111202  0    1082277.  104071.2  2584045. 0. 0.  2
7111203  0    1081690.  104076.7  2584030. 0. 0.  3
7111204  0    1081103.  104083.6  2584014. 0. 0.  4
7111205  0    1080516.  104092.  2.584+6 0. 0.  5
*   cntrl
7111300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
7111301  6.38096-5  6.38538-5  0.   1 * .069567
7111302  6.38096-5  6.38538-5  0.   2 * .069567
7111303  6.38097-5  6.38538-5  0.   3 * .069567
7111304  6.38097-5  6.38538-5  0.   4 * .069567
*
*-----------------------------------------------------------
*  Junction: H2O Passive DHR Heat Exchanger to HX Outlet  (DHR2-Water)
*-----------------------------------------------------------
*   name   junction
7160000  h2hxohx  sngljun
*   from   to    area  kforw  kbackw  j-flag
7160101  711010000  721000000  0.0  1.00  1.00  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
7160201  0  7.98762-4  8.05366-4 0. * .069567
*
*-----------------------------------------------------------
*  Passive H2O DHR Heat Exchanger Outlet Plenum (DHR2-Water)
*-----------------------------------------------------------
*   name   volume
7210000  h2ooutpl  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough.  hDe  v-flag
7210101  0.0873  1.0  0.0  90.  90.  0.2  4.5e-5  0.333  000000  $
*   cntrl  press   temp
7210200  0    1079244.  104097.8 2583967. 0.
*
```

```
*-------------------------------------------------------------
*  Junction: H2O DHR Heat Exchanger Outlet Plenum to UHS Duct (DHR2-
Water)
*-------------------------------------------------------------
*   name   junction
7260000  h2oplhd  sngljun
*   from   to    area  kforw  kbackw  j-flag
7260101  721010000  731000000  0.0  0.23  0.23  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
7260201  0  7.98762-4  8.05366-4 0. * .069567
*
*
*-------------------------------------------------------------
*  Passive DHR Hot Duct (DHR2-Water)
*-------------------------------------------------------------
*   name  pipe/annulus
7310000  h2ohotd  pipe
*   number of volumes
7310001  5
*   area  no of vol
7310101  0.0873  5  $ lumping 2 loops
*   length  no of vol
7310301  1.6   5
*   volume  no of vol
7310401  0.0   5
*   azi ang  no of vol
7310501  90.   5
*   ver ang  no of vol
7310601  90.   5
*   elev.  no of vol
7310701  1.6   5
*   rough  dhydr.  no of vol
7310801  4.5e-5  0.333  5
*   kforw  kbackw  no of jun
7310901  0.0875  0.0875  4
*   v-flag  no of vol
7311001  00000  5
*   j-flag  no of jun
7311101  000000  4
*   cntrl  pressure  temperature  *  *  *  no of vol
7311201  0   1070439.  104108.4  2583740. 0. 0.  1
7311202  0   1054786.  104120.5  2583334. 0. 0.  2
7311203  0   1039133.  104134.  2582923. 0. 0.  3
7311204  0   1023480.  104149.5  2582507. 0. 0.  4
7311205  0   1007826.  104168.6  2582086. 0. 0.  5
*   cntrl
7311300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
7311301  7.98765-4  8.0537-4  0.   1 * .069567
7311302  7.98771-4  8.05375-4  0.   2 * .0695669
7311303  7.98776-4  8.05381-4  0.   3 * .0695668
7311304  7.98782-4  8.05387-4  0.   4 * .0695668
*
**-----------------------------------------------------------
**  Junction: Hotleg Duct to Pressure Controller (DHR2-Water)
**-----------------------------------------------------------
**   name  type
```

```
7810000  htdc-orf  sngljun
*   from    to    area  kforw  kbackw  j-flag
7810101  731010000  791000000  0   0.5  0.5  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
7810201  0  -5.48151-9  -5.4809-9 0. * -4.67351-7
*
*------------------------------------------------------
**  UHS LOOP Pressure Controller  (DHR2-Water)
*------------------------------------------------------
*   name   volume
7910000  h20surge  tmdpvol
*   area  length  vol. a.ang. in.ang. elev. rough.  hDe  pvbfe
7910101  500.0  10.0  0.0  0.0  0.0  0.  0.00046  7.4  00010
*   cntrl
7910200  003
*      press  temp
7910201  0.0  1.00000e6  345.67
*------------------------------------------------------
*  Junction: HP Hot Duct to HX Inlet  (DHR2-Water)
*------------------------------------------------------
*   name   junction
7360000  h2ohxpin  sngljun
*   from    to    area  kforw  kbackw  j-flag
7360101  731010000  741000000  0.0  0.75  0.75  0000001
*   cntrl  w/v.liq  w/v.vap  w/v.int
7360201  0  7.98793-4  7.98793-4 0. * .0695672
*
*------------------------------------------------------
*  Passive DHR Heat Exchanger Inlet (DHR2-Water)
*------------------------------------------------------
*   name   volume
7410000  h2ohxin  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
7410101  0.0873  1.0  0.0  -90.  -90.  -0.5  4.5e-5 0.333  000000  $
*   cntrl  press    temp
7410200  0    1002446.  104180.8 2581940. 0.
*------------------------------------------------------
*  Junction: Passive DHR HX Inlet to Heat Exchanger  (DHR2-Water)
*------------------------------------------------------
*   name   junction
7460000  h2ohx-h  sngljun
*   from    to    area  kforw  kbackw  j-flag
7460101  741010000  751000000  0.0  0.23  0.23  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
7460201  0  7.98795-4  7.98795-4 0. * .0695671
*
*------------------------------------------------------
*  Passive UHS DHR Heat Exchanger  (DHR2-Water)
*------------------------------------------------------
*   name  pipe/annulus
7510000  h2hp-hx  pipe
*   number of volumes
7510001  20
*   area  no of vol
7510101  9.46497e-2  20
*   length  no of vol
7510301  1.605  20
```

```
*   volume  no of vol
7510401  0.0   20
*   azi ang  no of vol
7510501  -90.  20
*   ver ang  no of vol
7510601  0.0   20
*   elev.  no of vol
7510701  0.0   20
*   rough  dhydr.  no of vol
7510801  1.e-5  3.5052e-2 20
*   kforw  kbackw  no of jun
7510901  0.0   0.0   19
*   v-flag  no of vol
7511001  00000  20
*   j-flag  no of jun
7511101  000000  19
*   cntrl  pressure  temperature  *  *  *  no of vol
7511201  0    1004892.  104081.7  2582007. 0. 0.  1
7511202  0    1004892.  104063.2  2582007. 0. 0.  2
7511203  0    1004892.  104059.7  2582007. 0. 0.  3
7511204  0    1004892.  104059.  2582007. 0. 0.  4
7511205  0    1004891.  104058.8  2582007. 0. 0.  5
7511206  0    1004891.  104058.8  2582007. 0. 0.  6
7511207  0    1004891.  104058.8  2582007. 0. 0.  7
7511208  0    1004891.  104058.8  2582007. 0. 0.  8
7511209  0    1004891.  104058.8  2582007. 0. 0.  9
7511210  0    1004891.  104058.8  2582007. 0. 0.  10
7511211  0    1004891.  104058.8  2582007. 0. 0.  11
7511212  0    1004891.  104058.8  2582007. 0. 0.  12
7511213  0    1004891.  104058.8  2582007. 0. 0.  13
7511214  0    1004891.  104058.8  2582007. 0. 0.  14
7511215  0    1004891.  104058.8  2582007. 0. 0.  15
7511216  0    1004891.  104058.8  2582007. 0. 0.  16
7511217  0    1004891.  104058.8  2582007. 0. 0.  17
7511218  0    1004891.  104058.8  2582007. 0. 0.  18
7511219  0    1004891.  104058.8  2582007. 0. 0.  19
7511220  0    1004891.  104058.8  2582007. 0. 0.  20
*   cntrl
7511300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
7511301  7.36762-4  7.36762-4 0.  1 * .0695671
7511302  7.36761-4  7.36761-4 0.  2 * .0695671
7511303  7.3676-4  7.3676-4 0.   3 * .0695671
7511304  7.3676-4  7.3676-4 0.   4 * .0695671
7511305  7.3676-4  7.3676-4 0.   5 * .0695671
7511306  7.3676-4  7.3676-4 0.   6 * .0695671
7511307  7.3676-4  7.3676-4 0.   7 * .0695671
7511308  7.3676-4  7.3676-4 0.   8 * .0695671
7511309  7.3676-4  7.3676-4 0.   9 * .0695671
7511310  7.3676-4  7.3676-4 0.   10 * .0695671
7511311  7.3676-4  7.3676-4 0.   11 * .0695671
7511312  7.3676-4  7.3676-4 0.   12 * .0695671
7511313  7.3676-4  7.3676-4 0.   13 * .0695671
7511314  7.3676-4  7.3676-4 0.   14 * .0695671
7511315  7.3676-4  7.3676-4 0.   15 * .0695671
7511316  7.3676-4  7.3676-4 0.   16 * .0695671
7511317  7.3676-4  7.3676-4 0.   17 * .0695671
```

```
7511318  7.3676-4  7.3676-4 0.   18 * .0695671
7511319  7.3676-4  7.3676-4 0.   19 * .0695671
*
*----------------------------------------------------------
*  Junction: UHS Passive DHR Heat Exchanger to HX Outlet
*----------------------------------------------------------
*   name   junction
7560000  h2hx-ohx  sngljun
*   from   to    area  kforw  kbackw  j-flag
7560101  751010000  761000000  0.0  1.00  1.00  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
7560201  0  7.98788-4  7.98788-4 0. * .0695671
*
*----------------------------------------------------------
*  Passive UHS DHR Heat Exchanger Outlet Plenum
*----------------------------------------------------------
*   name   volume
7610000  h2-outpl  snglvol
*   area   length  vol. a.ang. in.ang. elev. rough. hDe  v-flag
7610101  0.0873  1.0  0.0  -90.  -90.  -0.5  4.5e-5 0.333  000000  $
*   cntrl  press   temp
7610200  0    1007337.  104058.8 2582073. 0.
*
*----------------------------------------------------------
*  Junction: Passive DHR HX Outlet to Downcomer
*----------------------------------------------------------
*   name   junction
7660000  hhp-ohx  sngljun
*   from   to    area  kforw  kbackw  j-flag
7660101  761010000  771000000  0.0  1.0  1.0  0000000
*   cntrl  w/v.liq  w/v.vap  w/v.int
7660201  0  7.98787-4  8.05391-4 0. * .0695671
*----------------------------------------------------------
*  Passive DHR Downcomer
*----------------------------------------------------------
*   name  pipe/annulus
7710000  h2ohotd  pipe
*   number of volumes
7710001  5
*   area  no of vol
7710101  0.0873  5  $ lumping 2 loops
*   length  no of vol
7710301  1.6   5
*   volume  no of vol
7710401  0.0   5
*   azi ang  no of vol
7710501  -90.  5
*   ver ang  no of vol
7710601  -90.  5
*   elev.  no of vol
7710701  -1.6  5
*   rough  dhydr.  no of vol
7710801  4.5e-5  0.333  5
*   kforw  kbackw  no of jun
7710901  0.0875  0.0875  4
*   v-flag  no of vol
7711001  00000  5
```

```
*   j-flag  no of jun
7711101  000000  4
*   cntrl  pressure  temperature  *  *  *  no of vol
7711201  0   1017609.  104058.8  2582350. 0. 0.  1
7711202  0   1033263.  104058.8  2582768. 0. 0.  2
7711203  0   1048916.  104058.8  2583181. 0. 0.  3
7711204  0   1064569.  104058.8  2583589. 0. 0.  4
7711205  0   1080223.  104058.9  2583992. 0. 0.  5
*   cntrl
7711300  0
*   w/v.liq  w/v.vap  w/v.int  no of jun
7711301  7.98783-4  8.05388-4  0.   1 * .0695671
7711302  7.98778-4  8.05382-4  0.   2 * .0695671
7711303  7.98772-4  8.05376-4  0.   3 * .0695671
7711304  7.98766-4  8.05371-4  0.   4 * .0695671
*
*---------------------------------------------------------
*  SNGLJ: Passive DHR Cold Duct to Rx Inlet Plenum
*---------------------------------------------------------
*   name   junction
7760000  cd-iplm  sngljun
*   from    to    area  kforw  kbackw  j-flag
7760101  771010000  701000000  0.0  1.0  1.0  0000001
*   cntrl  w/v.liq  w/v.vap  w/v.int
7760201  0  7.98761-4  7.98761-4 0. * .0695671
*
```

```
*
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
*                  %
*      HEAT STRUCTURE COMPONENTS      %
*                  %
*%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
*
*================================================================
*  RPV Downcomer (Cylinder)         #1     *
*  # Wall thickness: 0.014m             *
*================================================================
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16701000  8  10  2   0  4.0
*    mesh-loc  format-flag
16701100  0   1
*    #-Intvl  R-coord. (radial info.)
16701101  9   4.19
*    comp-#  interval-# (radial info.)
16701201  6   9
*    source  interval-# (radial info.)
16701301  0.0   9
*    initial temperature flag (if flag=0 or -1)
```

```
16701400  -1
*    temp-1 temp-2 temp-3 temp-4 temp-5 temp-6 temp-7 temp-8 temp-9
temp-1
16701401 740.49 740.50 740.50 740.50 740.50 740.50 740.51 740.51 740.51
740.51
16701402 740.50 740.51 740.51 740.51 740.52 740.52 740.52 740.53 740.53
740.53
16701403 740.51 740.52 740.52 740.53 740.53 740.54 740.54 740.54 740.55
740.55
16701404 740.52 740.53 740.54 740.54 740.55 740.56 740.56 740.56 740.57
740.57
16701405 740.53 740.54 740.55 740.56 740.57 740.57 740.58 740.58 740.59
740.59
16701406 740.54 740.55 740.56 740.57 740.58 740.59 740.60 740.60 740.60
740.61
16701407 740.55 740.56 740.58 740.59 740.60 740.61 740.62 740.62 740.62
740.62
16701408 740.56 740.57 740.59 740.60 740.61 740.62 740.63 740.64 740.64
740.64
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
16701501  670010000  10000   160    1    1.05625  8
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
16701601  0    0    0    1    1.05625  8  * Insulate
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
16701701  0    0.   0.   0.    8
*    9-words format option
16701800  0  *This 9-words format excludes the pitch-to-diameter ratio
on 801~
* Add L-B  Dh  HL-f   HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16701801  8.000  0.528125  20.  0.  0.  0.  0.  1.  1
16701802  8.000  1.584375  20.  0.  0.  0.  0.  1.  2
16701803  8.000  2.640625  20.  0.  0.  0.  0.  1.  3
16701804  8.000  3.696875  20.  0.  0.  0.  0.  1.  4
16701805  8.000  4.753125  20.  0.  0.  0.  0.  1.  5
16701806  8.000  5.809375  20.  0.  0.  0.  0.  1.  6
16701807  8.000  6.865625  20.  0.  0.  0.  0.  1.  7
16701808  8.000  7.921875  20.  0.  0.  0.  0.  1.  8
* Add R-B  Dh  HL-f   HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16701901  8.380  0.528125  20.  0.  0.  0.  0.  1.  1
16701902  8.380  1.584375  20.  0.  0.  0.  0.  1.  2
16701903  8.380  2.640625  20.  0.  0.  0.  0.  1.  3
16701904  8.380  3.696875  20.  0.  0.  0.  0.  1.  4
16701905  8.380  4.753125  20.  0.  0.  0.  0.  1.  5
16701906  8.380  5.809375  20.  0.  0.  0.  0.  1.  6
16701907  8.380  6.865625  20.  0.  0.  0.  0.  1.  7
16701908  8.380  7.921875  20.  0.  0.  0.  0.  1.  8
*
*=================================================================
*  RPV Downcomer (Cylinder)        #2   *
*  # Wall thickness: 0.014m          *
*=================================================================
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
18001000  8  10  2   0  4.0
*    mesh-loc  format-flag
18001100  0   1
*    #-Intvl  R-coord. (radial info.)
18001101  9   4.19
```

```
*    comp-#  interval-# (radial info.)
18001201  6   9
*    source  interval-# (radial info.)
18001301  0.0   9
*    initial temperature flag (if flag=0 or -1)
18001400  -1
*    temp-1 temp-2 temp-3 temp-4 temp-5 temp-6 temp-7 temp-8 temp-9
temp-1
18001401 740.49 740.50 740.50 740.50 740.50 740.50 740.51 740.51 740.51
740.51
18001402 740.50 740.51 740.51 740.51 740.52 740.52 740.52 740.53 740.53
740.53
18001403 740.51 740.52 740.52 740.53 740.53 740.54 740.54 740.54 740.55
740.55
18001404 740.52 740.53 740.54 740.54 740.55 740.56 740.56 740.56 740.57
740.57
18001405 740.53 740.54 740.55 740.56 740.57 740.57 740.58 740.58 740.59
740.59
18001406 740.54 740.55 740.56 740.57 740.58 740.59 740.60 740.60 740.60
740.61
18001407 740.55 740.56 740.58 740.59 740.60 740.61 740.62 740.62 740.62
740.62
18001408 740.56 740.57 740.59 740.60 740.61 740.62 740.63 740.64 740.64
740.64
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
18001501  800010000  10000   160    1    1.05625  8
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
18001601  0    0    0    1    1.05625  8  * Insulate
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
18001701  0    0.   0.   0.    8
*    9-words format option
18001800  0  *This 9-words format excludes the pitch-to-diameter ratio
on 801~
* Add L-B  Dh  HL-f   HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
18001801  8.000  0.528125  20.  0.  0.  0.  0.  1.  1
18001802  8.000  1.584375  20.  0.  0.  0.  0.  1.  2
18001803  8.000  2.640625  20.  0.  0.  0.  0.  1.  3
18001804  8.000  3.696875  20.  0.  0.  0.  0.  1.  4
18001805  8.000  4.753125  20.  0.  0.  0.  0.  1.  5
18001806  8.000  5.809375  20.  0.  0.  0.  0.  1.  6
18001807  8.000  6.865625  20.  0.  0.  0.  0.  1.  7
18001808  8.000  7.921875  20.  0.  0.  0.  0.  1.  8
* Add R-B  Dh  HL-f   HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
18001901  8.380  0.528125  20.  0.  0.  0.  0.  1.  1
18001902  8.380  1.584375  20.  0.  0.  0.  0.  1.  2
18001903  8.380  2.640625  20.  0.  0.  0.  0.  1.  3
18001904  8.380  3.696875  20.  0.  0.  0.  0.  1.  4
18001905  8.380  4.753125  20.  0.  0.  0.  0.  1.  5
18001906  8.380  5.809375  20.  0.  0.  0.  0.  1.  6
18001907  8.380  6.865625  20.  0.  0.  0.  0.  1.  7
18001908  8.380  7.921875  20.  0.  0.  0.  0.  1.  8
*
*=================================================================
*  Inlet Plenum (Cylinder)           *
*  # Wall thickness: 0.004m           *
*=================================================================
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
```

```
11001000  5  5  2   0  0.0
*    mesh-loc  format-flag
11001100  0   1
*    #-Intvl  R-coord. (radial info.)
11001101  4   0.075
*    comp-#  interval-# (radial info.)
11001201  6   4
*    source value  interval-# (radial info.)
11001301  0.0   4
*    initial temperature flag (if flag=0 or -1)
11001400  -1
*    temp-1  temp-2  temp-3  temp-4  temp-5
11001401  740.50  740.50  740.50  740.50  740.50
11001402  740.50  740.50  740.50  740.50  740.50
11001403  740.50  740.50  740.50  740.50  740.50
11001404  740.50  740.50  740.50  740.50  740.50
11001405  740.50  740.50  740.50  740.50  740.50
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
11001501  0    0    0    1    0.2   5  * Insulate
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
11001601  100010000  10000   160    1    0.2   5
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
11001701  0    0.   0.   0.    5
* Add R-B  Dh   HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
11001901  0.150  0.1  20.  0.  0.  0.  0.  1.  1
11001902  0.150  0.3  20.  0.  0.  0.  0.  1.  2
11001903  0.150  0.5  20.  0.  0.  0.  0.  1.  3
11001904  0.150  0.7  20.  0.  0.  0.  0.  1.  4
11001905  0.150  0.9  20.  0.  0.  0.  0.  1.  5
*=============================================================
*  Lower Reflector-Entrance of Core Average Channel (Plate)
*=============================================================
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
12101000  1  3  1   0   0.0
*    mesh-loc  format-flag
12101100  0   1
*    #-Intvl  R-coord. (radial info.)
12101101  2   0.002655
*    comp-#  interval-# (radial info.)
12101201  13   2
*    source value  interval-# (radial info.)
12101301  0.0   2
*    initial temperature flag (if flag=0 or -1)
12101400  -1
*    temp-1  temp-2  temp-3
12101401  740.62  740.62  740.62
* L-B  B.Vol.#  increment  BC option  surf.code  area  NH
12101501  0    0    0    1    439.62  1  * Insulat
* R-B  B.Vol.#  increment  BC option  surf.code  area  NH
12101601  210010000  10000   160    1    439.62  1
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
12101701  0    0.   0.   0.    1
*    9-words format option
* Add R-B  Dh    HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
12101901  0.0127  0.5  20.  0.  0.  0.  0.  1.  1
*
*=============================================================
```

```
*  Lower Reflector-Entrance of Core Hot Channel (Plate)
*==================================================================
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
12111000  1  3  1   0  0.0
*    mesh-loc  format-flag
12111100  0   1
*    #-Intvl  R-coord. (radial info.)
12111101  2   0.002655
*    comp-#  interval-# (radial info.)
12111201  13   2
*    source value  interval-# (radial info.)
12111301  0.0   2
*    initial temperature flag (if flag=0 or -1)
12111400  -1
*    temp-1  temp-2  temp-3
12111401  740.62  740.62  740.62
* L-B  B.Vol.#  increment  BC option  surf.code  area   NH
12111501  0    0    0    1    3.9581195  1  * Insula
* R-B  B.Vol.#  increment  BC option  surf.code  area   NH
12111601  211010000  10000   160    1    3.9581195  1
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
12111701  0    0.   0.   0.    1
* Add R-B  Dh    HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
12111901  0.0127  0.5  20.  0.  0.  0.  0.  1.  1
*
*=====================================================================
==
*  MATRIX CORE HEAT STRUCTURES: Average Channel (Plate)
*=====================================================================
==
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
12501000  8  8  1   0  0.0
*    mesh-loc  format-flag
12501100  0   1
*    #-Intvl  R-coord. (radial info.)
12501101  6   0.002355  * 1/2 fuel plate dimension
12501102  1   0.002655  * coating thickn dimension
*    comp-#  interval-# (radial info.)
12501201  1    6  $ UO2
12501202  -13   7  $ Ferritic SS
*    source  interval-# (radial info.)
12501301  1.0   6
12501302  0.0   7
*    initial temperature flag (if flag=0 or -1)
12501400  -1
*    temp.  mesh point
12501401  934.97  934.24  932.06  928.42  923.33  916.78  908.77
899.31
12501402  1063.8  1062.8  1059.8  1054.8  1047.8  1038.7  1027.7
1014.6
12501403  1172.9  1171.7  1168.1  1162.1  1153.7  1142.9  1129.8
1114.0
12501404  1257.0  1255.8  1251.9  1245.4  1236.4  1224.7  1210.5
1193.4
12501405  1311.0  1309.7  1305.8  1299.4  1290.4  1278.8  1264.6
1247.5
```

```
12501406  1332.3  1331.1  1327.5  1321.6  1313.3  1302.7  1289.6
1273.9
12501407  1321.2  1320.2  1317.2  1312.3  1305.4  1296.5  1285.6
1272.5
12501408  1280.3  1279.6  1277.4  1273.8  1268.9  1262.4  1254.6
1245.1
* L-B  B.Vol.#  increment  BC option  surf.code  surface area  NH
12501501  0    0    0    1    107.159    8
* R-B  B.Vol.#  increment  BC option  surf.code  surface area  NH
12501601  250010000  10000   160    1    107.159    8
** Source  source-type  multiplier DHeat-Left DHeat-Right  NH
$ 1.25 chopped cosine shape  $ He Core
12501701  1000  0.0844607  0.   0.    1
12501702  1000  0.1171673  0.   0.    2
12501703  1000  0.1405377  0.   0.    3
12501704  1000  0.1527072  0.   0.    4
12501705  1000  0.1527072  0.   0.    5
12501706  1000  0.1405377  0.   0.    6
12501707  1000  0.1171673  0.   0.    7
12501708  1000  0.0844607  0.   0.    8
*
12501900  1
* Add R-B  Dh  HL-f   HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
12501901  0.0127 0.121875  20.  0.  0.  0.  0.  1.  0.0  1.1  1.0  1
12501902  0.0127 0.365625  20.  0.  0.  0.  0.  1.  0.0  1.1  1.0  2
12501903  0.0127 0.609375  20.  0.  0.  0.  0.  1.  0.0  1.1  1.0  3
12501904  0.0127 0.853125  20.  0.  0.  0.  0.  1.  0.0  1.1  1.0  4
12501905  0.0127 1.096875  20.  0.  0.  0.  0.  1.  0.0  1.1  1.0  5
12501906  0.0127 1.340625  20.  0.  0.  0.  0.  1.  0.0  1.1  1.0  6
12501907  0.0127 1.584375  20.  0.  0.  0.  0.  1.  0.0  1.1  1.0  7
12501908  0.0127 1.828125  20.  0.  0.  0.  0.  1.  0.0  1.1  1.0  8
*=====================================================================
===*
*  MATRIX CORE HEAT STRUCTURES: Hot Channel (Plate)         *
*=====================================================================
===*
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
12511000  8  8  1   0  0.00
*    mesh-loc  format-flag
12511100  0   1
*    #-Intvl  R-coord. (radial info.)
12511101  6   0.002355  * 1/2 fuel plate dimension
12511102  1   0.002655  * coating thickn dimension
*    comp-#  interval-# (radial info.)
12511201  1    6  $ UO2
12511202  -13   7  $ Ferritic SS
*    source  interval-# (radial info.)
12511301  1.0   6
12511302  0.0   7
*    initial temperature flag (if flag=0 or -1)
12511400  -1
*    temp.  mesh point
12511401  968.50  967.67  965.17  960.99  955.15  947.64  938.45
927.57
12511402  1120.2  1119.0  1115.6  1109.8  1101.7  1091.4  1078.7
1063.6
```

```
12511403  1247.7  1246.4  1242.3  1235.4  1225.8  1213.5  1198.4
1180.3
12511404  1345.6  1344.1  1339.7  1332.3  1322.0  1308.7  1292.4
1272.7
12511405  1407.8  1406.4  1401.9  1394.6  1384.3  1371.0  1354.8
1335.1
12511406  1431.9  1430.6  1426.5  1419.8  1410.3  1398.1  1383.2
1365.1
12511407  1418.6  1417.5  1414.1  1408.5  1400.6  1390.4  1378.0
1362.9
12511408  1371.0  1370.2  1367.8  1363.7  1358.0  1350.6  1341.6
1330.8
* L-B  B.Vol.#  increment  BC option  surf.code  surface area  NH
12511501  0    0    0    1    0.965395   8
* R-B  B.Vol.#  increment  BC option  surf.code  surface area  NH
12511601  251010000  10000   160    1    0.965395   8
** Source  source-type  multiplier DHeat-Left DHeat-Right  NH
$ 1.25 chopped cosine shape  $ He Core
12511701  1000  0.0008750  0.   0.    1
12511702  1000  0.0012139  0.   0.    2
12511703  1000  0.0014560  0.   0.    3
12511704  1000  0.0015821  0.   0.    4
12511705  1000  0.0015821  0.   0.    5
12511706  1000  0.0014560  0.   0.    6
12511707  1000  0.0012139  0.   0.    7
12511708  1000  0.0008750  0.   0.    8
*
12511900  1
* Add R-B  Dh   HL-f   HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
12511901  0.0127 0.121875  20.  0.  0.  0.  0.  1.  0.0  1.1  1.0  1
12511902  0.0127 0.365625  20.  0.  0.  0.  0.  1.  0.0  1.1  1.0  2
12511903  0.0127 0.609375  20.  0.  0.  0.  0.  1.  0.0  1.1  1.0  3
12511904  0.0127 0.853125  20.  0.  0.  0.  0.  1.  0.0  1.1  1.0  4
12511905  0.0127 1.096875  20.  0.  0.  0.  0.  1.  0.0  1.1  1.0  5
12511906  0.0127 1.340625  20.  0.  0.  0.  0.  1.  0.0  1.1  1.0  6
12511907  0.0127 1.584375  20.  0.  0.  0.  0.  1.  0.0  1.1  1.0  7
12511908  0.0127 1.828125  20.  0.  0.  0.  0.  1.  0.0  1.1  1.0  8
*-----------------------------------------------------------*
*  reactor kinetics data           *
*  - ANS 79 Decay Heat Model used         *
*-----------------------------------------------------------*
30000000  point    separabl
30000001  gamma-ac  600.0e6  0.  352.11268  1.0
30000002  ans79-1  200.0
30000011  100  * scram curve
*  Density reactivity feedback
30000501  0.   0.0
30000502  1000.  0.0
*
30000601  100.   0.0
30000602  3000.  0.0
*  Doppler reactivity feedback
*
* Volume weighting factor
*

* For transient calculation, the following data should be used
```

```
* instead of cards 30000801 - 820
* by SIL
*
*30000801  1701001  0  0.02365  -0.000859212
*30000802  1701002  0  0.031328  -0.000859212
*30000803  1701003  0  0.038502  -0.000997298
*30000804  1701004  0  0.045054  -0.000997298
*30000805  1701005  0  0.050881  -0.001072738
*30000806  1701006  0  0.055887  -0.001072738
*30000807  1701007  0  0.059993  -0.001072738
*30000808  1701008  0  0.063131  -0.001253016
*30000809  1701009  0  0.065252  -0.001253016
*30000810  1701010  0  0.066322  -0.001253016
*30000811  1701011  0  0.066322  -0.000722406
*30000812  1701012  0  0.065252  -0.000722406
*30000813  1701013  0  0.063131  -0.000722406
*30000814  1701014  0  0.059993  -0.000784413
*30000815  1701015  0  0.055887  -0.000784413
*30000816  1701016  0  0.050881  -0.000784413
*30000817  1701017  0  0.045054  -0.000746697
*30000818  1701018  0  0.038502  -0.000746697
*30000819  1701019  0  0.031328  -0.00052422
*30000820  1701020  0  0.02365  -0.00052422
*
*-------------------------------------------------------------*
*  scram table              *
*-------------------------------------------------------------*
*
20210000  reac-t    501
20210001  0.0    0.0
20210002  1.98   -0.052667
20210003  2.31   -0.158001
20210004  2.64   -0.421300
20210005  2.97   -0.974300
20210006  3.30   -2.212000
20210007  3.63   -4.371400
20210008  3.96   -5.029700
20210009  4.29   -5.266700
20210010  2.0e20   -5.266700
*
*================================================================
*  Lower Reflector-Entrance of Core Average Channel (Plate)
*================================================================
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
12901000  1  3  1   0  0.0
*    mesh-loc  format-flag
12901100  0   1
*    #-Intvl  R-coord. (radial info.)
12901101  2   0.002655
*    comp-#  interval-# (radial info.)
12901201  13   2
*    source value  interval-# (radial info.)
12901301  0.0   2
*    initial temperature flag (if flag=0 or -1)
12901400  -1
*    temp-1  temp-2  temp-3
12901401  1105.6  1105.6  1105.6
```

```
* L-B  B.Vol.#  increment  BC option  surf.code  area  NH
12901501  0    0    0    1    439.62  1  * Zero hea
* R-B  B.Vol.#  increment  BC option  surf.code  area  NH
12901601  290010000  10000   160    1    439.62  1
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
12901701  0    0.   0.   0.    1
*    9-words format option
* Add R-B  Dh    HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
12901901  0.0127  0.5  20.  0.  0.  0.  0.  1.  1
*
*==============================================================
*  Lower Reflector-Entrance of Core Hot Channel (Plate)
*==============================================================
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
12911000  1  3  1   0  0.0
*    mesh-loc  format-flag
12911100  0   1
*    #-Intvl  R-coord. (radial info.)
12911101  2   0.002655
*    comp-#  interval-# (radial info.)
12911201  13   2
*    source value  interval-# (radial info.)
12911301  0.0   2
*    initial temperature flag (if flag=0 or -1)
12911400  -1
*    temp-1  temp-2  temp-3
12911401  1168.8  1168.8  1168.8
* L-B  B.Vol.#  increment  BC option  surf.code  area   NH
12911501  0    0    0    1    3.9581195  1  * Zero
* R-B  B.Vol.#  increment  BC option  surf.code  area   NH
12911601  291010000  10000   160    1    3.9581195  1
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
12911701  0    0.   0.   0.    1
* Add R-B  Dh    HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
12911901  0.0127  0.5  20.  0.  0.  0.  0.  1.  1
*++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++
*
*************************** STRUCTURE 5201
***************************
* Recuperator -- plate-fin
*===================================================================
$
*ht str ht.strs  m.pts  geom  init  l.coord  refl  b.vol  ax.incr.
15201000  30   3  1  1  0.0    0
*
*    loc  flag
15201100  0   1
*
*   #   r
15201101  2   0.0004572
*
*    compos.  #
15201201  15   2
*
*   source  #
15201301  0.0   2
```

```
*
*    temperature flag
15201400  -1
*
*   temperature #
15201401  742.40  742.29  742.19
15201402  730.64  730.53  730.42
15201403  718.84  718.73  718.62
15201404  707.00  706.89  706.78
15201405  695.13  695.02  694.90
15201406  683.22  683.11  683.00
15201407  671.28  671.17  671.05
15201408  659.31  659.2   659.08
15201409  647.31  647.19  647.07
15201410  635.28  635.16  635.04
15201411  623.21  623.09  622.97
15201412  611.13  611.00  610.88
15201413  599.01  598.89  598.76
15201414  586.87  586.75  586.62
15201415  574.71  574.58  574.46
15201416  562.53  562.4   562.27
15201417  550.33  550.2   550.07
15201418  538.11  537.98  537.84
15201419  525.88  525.74  525.61
15201420  513.63  513.5   513.36
15201421  501.38  501.24  501.1
15201422  489.12  488.98  488.83
15201423  476.85  476.71  476.56
15201424  464.58  464.44  464.29
15201425  452.32  452.17  452.02
15201426  440.05  439.9   439.75
15201427  427.8   427.65  427.49
15201428  415.55  415.4   415.25
15201429  403.33  403.17  403.01
15201430  391.12  390.96  390.8

*
*   vol   inc    type  code   factor  #
15201501  520010000  10000  160   0  2192.0  30
*
*   vol   inc    type  code   factor  #
15201601  590300000 -10000  160   0  2192.0  30
*
*   type  mult  D-lt  D-rt  #  *source
15201701  0    0.0   0.0   0.0   30
*
15201800  1
*    Dhe  LHEf  LHEr LGSf  LGSr Kfwd  Krev  Fboil nclf povd ff  #
15201801 2.7-4  0.047 2.768 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 1
15201802 2.7-4  0.141 2.674 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 2
15201803 2.7-4  0.235 2.581 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 3
15201804 2.7-4  0.328 2.487 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 4
15201805 2.7-4  0.422 2.393 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 5
15201806 2.7-4  0.516 2.299 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 6
15201807 2.7-4  0.610 2.205 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 7
15201808 2.7-4  0.704 2.111 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 8
15201809 2.7-4  0.798 2.018 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 9
```

```
15201810 2.7-4  0.891 1.924 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 10
15201811 2.7-4  0.985 1.830 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 11
15201812 2.7-4  1.079 1.736 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 12
15201813 2.7-4  1.173 1.642 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 13
15201814 2.7-4  1.267 1.548 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 14
15201815 2.7-4  1.361 1.455 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 15
15201816 2.7-4  1.455 1.361 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 16
15201817 2.7-4  1.548 1.267 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 17
15201818 2.7-4  1.642 1.173 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 18
15201819 2.7-4  1.736 1.079 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 19
15201820 2.7-4  1.830 0.985 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 20
15201821 2.7-4  1.924 0.891 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 21
15201822 2.7-4  2.018 0.798 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 22
15201823 2.7-4  2.111 0.704 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 23
15201824 2.7-4  2.205 0.610 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 24
15201825 2.7-4  2.299 0.516 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 25
15201826 2.7-4  2.393 0.422 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 26
15201827 2.7-4  2.487 0.328 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 27
15201828 2.7-4  2.581 0.235 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 28
15201829 2.7-4  2.674 0.141 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 29
15201830 2.7-4  2.768 0.047 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 30
*
15201900  1
*     Dhe  LHEf  LHEr LGSf  LGSr Kfwd  Krev  Fboil nclf povd ff   #
15201901 2.4-4  2.768 0.047 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 1
15201902 2.4-4  2.674 0.141 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 2
15201903 2.4-4  2.581 0.235 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 3
15201904 2.4-4  2.487 0.328 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 4
15201905 2.4-4  2.393 0.422 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 5
15201906 2.4-4  2.299 0.516 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 6
15201907 2.4-4  2.205 0.610 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 7
15201908 2.4-4  2.111 0.704 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 8
15201909 2.4-4  2.018 0.798 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 9
15201910 2.4-4  1.924 0.891 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 10
15201911 2.4-4  1.830 0.985 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 11
15201912 2.4-4  1.736 1.079 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 12
15201913 2.4-4  1.642 1.173 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 13
15201914 2.4-4  1.548 1.267 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 14
15201915 2.4-4  1.455 1.361 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 15
15201916 2.4-4  1.361 1.455 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 16
15201917 2.4-4  1.267 1.548 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 17
15201918 2.4-4  1.173 1.642 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 18
15201919 2.4-4  1.079 1.736 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 19
15201920 2.4-4  0.985 1.830 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 20
15201921 2.4-4  0.891 1.924 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 21
15201922 2.4-4  0.798 2.018 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 22
15201923 2.4-4  0.704 2.111 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 23
15201924 2.4-4  0.610 2.205 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 24
15201925 2.4-4  0.516 2.299 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 25
15201926 2.4-4  0.422 2.393 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 26
15201927 2.4-4  0.328 2.487 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 27
15201928 2.4-4  0.235 2.581 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 28
15201929 2.4-4  0.141 2.674 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 29
15201930 2.4-4  0.047 2.768 10.0 10.0 0.0  0.0  1.0  2.815  1.0 1. 30
*
*
*************************** COMPOSITION 15****************************
```

```
* thermal properties of GA design
* distortion in heatric pche
*=========================================================================$
20101500 tbl/fctn   1   1
*-------------------------------------------------------------------------
20101501    2.232611E+02  1.058900E+01
20101502    2.942611E+02  1.158900E+01
20101503    4.220389E+02  1.383203E+01
20101504    5.331500E+02  1.570122E+01
20101505    6.442611E+02  1.744581E+01
20101506    6.998167E+02  1.831810E+01
20101507    8.109278E+02  2.006268E+01
20101508    8.664833E+02  2.093497E+01
20101509    1.255372E+03  2.990710E+01
20101510    1.922039E+03  2.990710E+01
*
20101551    2.002611E+02  3.143784E+06
20101552    2.942611E+02  3.433784E+06
20101553    9.775944E+02  4.694627E+06
20101554    1.922039E+03  4.694627E+06
*
*
*
**************************** STRUCTURE 5301
****************************
* precooler -- tube/shell hx
*==========================================================================
$
*ht str ht.strs  m.pts  geom  init  l.coord  refl  b.vol  ax.incr.
15301000  20   5  2  1  0.0033  0
*
*    loc  flag
15301100  0   1
*
*   #   r
15301101  4   0.0045
*
*    compos.  #
15301201  16   4
*
*   source  #
15301301  0.0   4
*
*    temperature flag
15301400  -1
*
*   temperature #
15301401  324.69  325.27  325.80  326.30  326.76
15301402  320.35  320.86  321.32  321.75  322.15
15301403  316.58  317.02  317.43  317.80  318.15
15301404  313.31  313.69  314.04  314.37  314.67
15301405  310.46  310.80  311.10  311.38  311.65
15301406  307.99  308.28  308.54  308.79  309.02
15301407  305.83  306.08  306.32  306.53  306.73
15301408  303.95  304.17  304.37  304.56  304.74
15301409  302.32  302.51  302.68  302.85  303.00
15301410  300.89  301.06  301.21  301.35  301.48
```

```
15301411  299.65  299.79  299.92  300.05  300.16
15301412  298.56  298.69  298.80  298.91  299.01
15301413  297.62  297.73  297.83  297.92  298.01
15301414  296.79  296.89  296.98  297.06  297.13
15301415  296.07  296.16  296.23  296.30  296.37
15301416  295.45  295.52  295.59  295.65  295.71
15301417  294.90  294.97  295.02  295.08  295.13
15301418  294.43  294.48  294.53  294.58  294.62
15301419  294.02  294.06  294.11  294.15  294.19
15301420  293.66  293.70  293.74  293.77  293.80

*
*   vol    inc    type  code  factor  #
15301501  133200000 -10000  1   1   35500.   20
*
*   vol    inc    type  code  factor  #
15301601  530010000  10000  1   1   35500.   20
*
*   type  mult  D-lt  D-rt  #  *source
15301701  0    0.0   0.0   0.0   20
*
15301800  1
*    Dhe  LHEf  LHEr LGSf  LGSr Kfwd  Krev  Fboil nclf povd ff  #
15301801 0.003394 4.612 0.118 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  1
15301802 0.003394 4.375 0.355 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  2
15301803 0.003394 4.139 0.591 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  3
15301804 0.003394 3.902 0.828 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  4
15301805 0.003394 3.666 1.064 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  5
15301806 0.003394 3.429 1.301 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  6
15301807 0.003394 3.193 1.537 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  7
15301808 0.003394 2.956 1.774 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  8
15301809 0.003394 2.720 2.010 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  9
15301810 0.003394 2.483 2.247 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  10
15301811 0.003394 2.247 2.483 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  11
15301812 0.003394 2.010 2.720 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  12
15301813 0.003394 1.774 2.956 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  13
15301814 0.003394 1.537 3.193 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  14
15301815 0.003394 1.301 3.429 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  15
15301816 0.003394 1.064 3.666 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  16
15301817 0.003394 0.828 3.902 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  17
15301818 0.003394 0.591 4.139 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  18
15301819 0.003394 0.355 4.375 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  19
15301820 0.003394 0.118 4.612 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  20
*
15301900  1
*    Dhe  LHEf  LHEr LGSf  LGSr Kfwd  Krev  Fboil nclf povd ff  #
15301901 0.003394 0.118 4.612 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  1
15301902 0.003394 0.355 4.375 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  2
15301903 0.003394 0.591 4.139 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  3
15301904 0.003394 0.828 3.902 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  4
15301905 0.003394 1.064 3.666 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  5
15301906 0.003394 1.301 3.429 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  6
15301907 0.003394 1.537 3.193 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  7
15301908 0.003394 1.774 2.956 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  8
15301909 0.003394 2.010 2.720 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  9
15301910 0.003394 2.247 2.483 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  10
15301911 0.003394 2.483 2.247 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  11
```

```
15301912 0.003394 2.720 2.010 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  12
15301913 0.003394 2.956 1.774 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  13
15301914 0.003394 3.193 1.537 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  14
15301915 0.003394 3.429 1.301 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  15
15301916 0.003394 3.666 1.064 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  16
15301917 0.003394 3.902 0.828 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  17
15301918 0.003394 4.139 0.591 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  18
15301919 0.003394 4.375 0.355 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  19
15301920 0.003394 4.612 0.118 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  20
*
*
**************************** COMPOSITION 16***************************
* thermal properties of ss-316 modified to compensate for volume
* distortion in heatric pche
*=====================================================================$
20101600 tbl/fctn   1   1    * ss-316
*---------------------------------------------------------------------
20101601    283.15  13.70
20101602    310.93  14.14
20101603    533.15  17.63
20101604    699.82  20.24
20101605    810.93  21.99
20101606   1088.71  26.35
*
20101651    283.15  3.115e06   * divided by 1.140
20101652    310.93  3.237e06
20101653    533.15  3.733e06
20101654    699.82  3.865e06
20101655    810.93  3.958e06
20101656   1088.71  4.309e06
*
*
**************************** STRUCTURE 5701
****************************
* Inter-cooler -- tube/shell hx
*=====================================================================
$
*ht str ht.strs  m.pts  geom  init  l.coord  refl  b.vol  ax.incr.
15701000  20   5  2  1  0.0033  0
*
*    loc  flag
15701100  0   1
*
*   #   r
15701101  4   0.0045
*
*    compos.  #
15701201  16   4
*
*   source  #
15701301  0.0   4
*
*    temperature flag
15701400  -1
*
*   temperature #
15701401  326.30  326.77  327.19  327.59  327.96
```

```
15701402  322.39  322.81  323.19  323.55  323.87
15701403  318.91  319.28  319.62  319.94  320.23
15701404  315.79  316.13  316.43  316.71  316.98
15701405  313.01  313.31  313.58  313.84  314.07
15701406  310.53  310.80  311.04  311.27  311.48
15701407  308.31  308.55  308.77  308.97  309.16
15701408  306.32  306.54  306.73  306.92  307.09
15701409  304.55  304.74  304.92  305.08  305.23
15701410  302.96  303.13  303.29  303.43  303.57
15701411  301.54  301.69  301.83  301.96  302.08
15701412  300.26  300.40  300.53  300.64  300.75
15701413  299.12  299.25  299.36  299.46  299.56
15701414  298.10  298.21  298.31  298.41  298.50
15701415  297.19  297.29  297.38  297.46  297.54
15701416  296.37  296.46  296.54  296.62  296.69
15701417  295.64  295.72  295.79  295.86  295.92
15701418  294.98  295.06  295.12  295.18  295.24
15701419  294.40  294.46  294.52  294.57  294.62
15701420  293.87  293.93  293.98  294.03  294.07

*
*   vol    inc    type  code   factor   #
15701501  143200000 -10000  1   1   32000.   20
*
*   vol    inc    type  code   factor   #
15701601  570010000  10000  1   1   32000.   20
*
*   type  mult  D-lt  D-rt  #  *source
15701701  0    0.0   0.0   0.0   20
*
15701800  1
*    Dhe  LHEf  LHEr LGSf  LGSr Kfwd  Krev  Fboil nclf povd ff   #
15701801 0.003394 4.612 0.118 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  1
15701802 0.003394 4.375 0.355 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  2
15701803 0.003394 4.139 0.591 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  3
15701804 0.003394 3.902 0.828 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  4
15701805 0.003394 3.666 1.064 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  5
15701806 0.003394 3.429 1.301 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  6
15701807 0.003394 3.193 1.537 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  7
15701808 0.003394 2.956 1.774 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  8
15701809 0.003394 2.720 2.010 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  9
15701810 0.003394 2.483 2.247 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  10
15701811 0.003394 2.247 2.483 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  11
15701812 0.003394 2.010 2.720 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  12
15701813 0.003394 1.774 2.956 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  13
15701814 0.003394 1.537 3.193 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  14
15701815 0.003394 1.301 3.429 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  15
15701816 0.003394 1.064 3.666 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  16
15701817 0.003394 0.828 3.902 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  17
15701818 0.003394 0.591 4.139 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  18
15701819 0.003394 0.355 4.375 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  19
15701820 0.003394 0.118 4.612 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  20
*
15701900  1
*    Dhe  LHEf  LHEr LGSf  LGSr Kfwd  Krev  Fboil nclf povd ff   #
15701901 0.003394 0.118 4.612 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  1
15701902 0.003394 0.355 4.375 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  2
```

```
15701903 0.003394 0.591 4.139 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  3
15701904 0.003394 0.828 3.902 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  4
15701905 0.003394 1.064 3.666 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  5
15701906 0.003394 1.301 3.429 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  6
15701907 0.003394 1.537 3.193 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  7
15701908 0.003394 1.774 2.956 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  8
15701909 0.003394 2.010 2.720 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  9
15701910 0.003394 2.247 2.483 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  10
15701911 0.003394 2.483 2.247 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  11
15701912 0.003394 2.720 2.010 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  12
15701913 0.003394 2.956 1.774 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  13
15701914 0.003394 3.193 1.537 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  14
15701915 0.003394 3.429 1.301 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  15
15701916 0.003394 3.666 1.064 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  16
15701917 0.003394 3.902 0.828 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  17
15701918 0.003394 4.139 0.591 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  18
15701919 0.003394 4.375 0.355 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  19
15701920 0.003394 4.612 0.118 10.0 10.0 0.0 0.0 1.0 4.73  1.0 1.1  20
*
*
*======================================================================
===
*  Hot Leg Duct of Passive DHR System 1 (Cylinder):Wall Thickness
(0.027m)
*======================================================================
===
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16101000  5  3  2   0  0.575
*    mesh-loc  format-flag
16101100  0   1
*    #-Intvl  R-coord. (radial info.)
16101101  2   0.585
*    comp-#  interval-# (radial info.)
16101201  6   2
*    source value  interval-# (radial info.)
16101301  0.0   2
*    initial temperature flag (if flag=0 or -1)
16101400  -1
*    temp-1  temp-2  temp-3
16101401  1095.9  1095.9  1095.9
16101402  1091.2  1091.2  1091.2
16101403  1090.3  1090.3  1090.3
16101404  1090.7  1090.7  1090.7
16101405  1093.8  1093.8  1093.8
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
16101501  610010000  10000   160    1    2.60  5
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
16101601  0    0    0    1    2.60  5  * Insulate
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
16101701  0    0.   0.   0.    5
*    9-words format option
16101800  0  *This 9-words format excludes the pitch-to-diameter ratio
on 801~
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16101801  1.150  1.3  20.  0.  0.  0.  0.  1.  1
16101802  1.150  3.9  20.  0.  0.  0.  0.  1.  2
16101803  1.150  6.5  20.  0.  0.  0.  0.  1.  3
```

```
16101804  1.150  9.1  20.  0.  0.  0.  0.  1.  4
16101805  1.150  11.7  20.  0.  0.  0.  0.  1.  5
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16101901  1.170  1.3  20.  0.  0.  0.  0.  1.  1
16101902  1.170  3.9  20.  0.  0.  0.  0.  1.  2
16101903  1.170  6.5  20.  0.  0.  0.  0.  1.  3
16101904  1.170  9.1  20.  0.  0.  0.  0.  1.  4
16101905  1.170  11.7  20.  0.  0.  0.  0.  1.  5
*
*=====================================================================
===
*  Hot Leg Duct of Passive DHR System 2 (Cylinder):Wall Thickness
(0.027m)
*=====================================================================
===
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16111000  5  3  2   0  0.575
*    mesh-loc  format-flag
16111100  0   1
*    #-Intvl  R-coord. (radial info.)
16111101  2   0.585
*    comp-#  interval-# (radial info.)
16111201  6   2
*    source value  interval-# (radial info.)
16111301  0.0   2
*    initial temperature flag (if flag=0 or -1)
16111400  -1
*    temp-1  temp-2  temp-3
16111401  1084.7  1084.7  1084.7
16111402  1079.4  1079.4  1079.4
16111403  1071.3  1071.3  1071.3
16111404  1056.1  1056.1  1056.1
16111405  1023.9  1023.9  1023.9
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
16111501  611010000  10000   160    1    2.60  5
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
16111601  0    0    0    1    2.60  5  * Insulated
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
16111701  0    0.   0.   0.    5
*    9-words format option
16111800  0  *This 9-words format excludes the pitch-to-diameter ratio
on 801~
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16111801  1.150  1.3  20.  0.  0.  0.  0.  1.  1
16111802  1.150  3.9  20.  0.  0.  0.  0.  1.  2
16111803  1.150  6.5  20.  0.  0.  0.  0.  1.  3
16111804  1.150  9.1  20.  0.  0.  0.  0.  1.  4
16111805  1.150  11.7  20.  0.  0.  0.  0.  1.  5
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16111901  1.170  1.3  20.  0.  0.  0.  0.  1.  1
16111902  1.170  3.9  20.  0.  0.  0.  0.  1.  2
16111903  1.170  6.5  20.  0.  0.  0.  0.  1.  3
16111904  1.170  9.1  20.  0.  0.  0.  0.  1.  4
16111905  1.170  11.7  20.  0.  0.  0.  0.  1.  5
*
*=====================================================================
===
```

```
*  HX pod Inlet of Passive DHR System 1 (Cylinder):Wall Thickness
(0.027m)
*==================================================================
===
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16201000  1  3  2   0  0.818
*    mesh-loc  format-flag
16201100  0   1
*    #-Intvl  R-coord. (radial info.)
16201101  2   0.828
*    comp-#  interval-# (radial info.)
16201201  6   2
*    source value  interval-# (radial info.)
16201301  0.0   2
*    initial temperature flag (if flag=0 or -1)
16201400  -1
*    temp-1  temp-2  temp-3
16201401  1118.6  1118.6  1118.6
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
16201501  620010000  10000   160    1    4.50  1
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
16201601  0    0    0    1    4.50  1  * Insulate
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
16201701  0    0.   0.   0.    1
*    9-words format option
16201800  0  *This 9-words format excludes the pitch-to-diameter ratio
on 801~
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16201801  1.636  2.25  20.  0.  0.  0.  0.  1.  1
*
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16201901  1.656  2.25  20.  0.  0.  0.  0.  1.  1
*
*==================================================================
===
*  HX pod Inlet of Passive DHR System 2 (Cylinder):Wall Thickness
(0.027m)
*==================================================================
===
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16211000  1  3  2   0  0.818
*    mesh-loc  format-flag
16211100  0   1
*    #-Intvl  R-coord. (radial info.)
16211101  2   0.828
*    comp-#  interval-# (radial info.)
16211201  6   2
*    source value  interval-# (radial info.)
16211301  0.0   2
*    initial temperature flag (if flag=0 or -1)
16211400  -1
*    temp-1  temp-2  temp-3
16211401  932.43  932.43  932.43
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
16211501  621010000  10000   160    1    4.50  1
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
16211601  0    0    0    1    4.50  1  * Insulate
```

```
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
16211701  0    0.   0.   0.    1
*    9-words format option
16211800  0  *This 9-words format excludes the pitch-to-diameter ratio
on 801~
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16211801  1.636  2.25  20.  0.  0.  0.  0.  1.  1
*
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16211901  1.656  2.25  20.  0.  0.  0.  0.  1.  1
*
*=====================================================================
===
*  HX Inlet of Passive DHR System 1 (Cylinder):Wall Thickness (0.027m)
*=====================================================================
===
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16261000  1  3  2   0  0.075
*    mesh-loc  format-flag
16261100  0   1
*    #-Intvl  R-coord. (radial info.)
16261101  2   0.085
*    comp-#  interval-# (radial info.)
16261201  6   2
*    source value  interval-# (radial info.)
16261301  0.0   2
*    initial temperature flag (if flag=0 or -1)
16261400  -1
*    temp-1  temp-2  temp-3
16261401  1086.5  1086.5  1086.5
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
16261501  626010000  10000   160    1    1.00  1
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
16261601  0    0    0    1    1.00  1  * Insulate
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
16261701  0    0.   0.   0.    1
*    9-words format option
16261800  0  *This 9-words format excludes the pitch-to-diameter ratio
on 801~
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16261801  0.150  0.50  20.  0.  0.  0.  0.  1.  1
*
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16261901  0.170  0.50  20.  0.  0.  0.  0.  1.  1
*
*=====================================================================
===
*  HX Inlet of Passive DHR System 2 (Cylinder):Wall Thickness (0.027m)
*=====================================================================
===
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16291000  1  3  2   0  0.075
*    mesh-loc  format-flag
16291100  0   1
*    #-Intvl  R-coord. (radial info.)
16291101  2   0.085
*    comp-#  interval-# (radial info.)
```

```
16291201  6   2
*    source value  interval-# (radial info.)
16291301  0.0   2
*    initial temperature flag (if flag=0 or -1)
16291400  -1
*    temp-1  temp-2  temp-3
16291401  372.51  372.51  372.51
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
16291501  629010000  10000   160    1    1.00  1
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
16291601  0    0    0    1    1.00  1  * Insulate
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
16291701  0    0.   0.   0.    1
*    9-words format option
16291800  0  *This 9-words format excludes the pitch-to-diameter ratio
on 801~
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16291801  0.150  0.50  20.  0.  0.  0.  0.  1.  1
*
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16291901  0.170  0.50  20.  0.  0.  0.  0.  1.  1
*
*=====================================================================
==
*
*  Passive DHR HEAT EXCHANGER  1
*
*=====================================================================
==
*
*-----------------------------------------------------------
*  Heat Exchanger (model in cylindrical coord)
*-----------------------------------------------------------
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16501000  5  3  1   0  1.5275e-3
*    mesh-loc  format-flag
16501100  0   1
*    #-Intvl  R-coord. (radial info.)
16501101  2   3.0275e-3
*    comp-#  interval-# (radial info.)
16501201  6   2
*    source value  interval-# (radial info.)
16501301  0.0    2
*    initial temperature flag (if flag=0 or -1)
16501400  -1
*    temp.  mesh point  temp.  mesh point
16501401  298.01  298.01  298.01
16501402  298.01  298.01  298.01
16501403  298.01  298.01  298.01
16501404  298.00  298.00  298.00
16501405  298.00  298.00  298.00
* L-B  B.Vol.#  increment  BC option  surf.code  surf area  NH  *H=#of
16501501  650010000  10000   160    1    53.62   5  *139050
* R-B  B.Vol.#  increment  BC option  surf.code  surf area  NH
16501601  710050000  -10000   160    1    53.62   5
*16501601  0    0    1401   1    4171.5  5  *tempera
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
```

```
16501701  0    0.   0.   0.    5
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16501801  3.0550e-3  0.03  20.  0.  0.  0.  0.  1.  1
16501802  3.0550e-3  0.09  20.  0.  0.  0.  0.  1.  2
16501803  3.0550e-3  0.15  20.  0.  0.  0.  0.  1.  3
16501804  3.0550e-3  0.21  20.  0.  0.  0.  0.  1.  4
16501805  3.0550e-3  0.27  20.  0.  0.  0.  0.  1.  5
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16501901  3.0550e-3  0.03  20.  0.  0.  0.  0.  1.  1
16501902  3.0550e-3  0.09  20.  0.  0.  0.  0.  1.  2
16501903  3.0550e-3  0.15  20.  0.  0.  0.  0.  1.  3
16501904  3.0550e-3  0.21  20.  0.  0.  0.  0.  1.  4
16501905  3.0550e-3  0.27  20.  0.  0.  0.  0.  1.  5
*=========================================================================
==
*
*  Passive DHR HEAT EXCHANGER  2
*
*=========================================================================
==
*
*------------------------------------------------------------
*  Heat Exchanger
*------------------------------------------------------------
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16511000  5   3  1   0  1.5275e-3
*    mesh-loc  format-flag
16511100  0   1
*    #-Intvl  R-coord. (radial info.)
16511101  2   3.0275e-3
*    comp-#  interval-# (radial info.)
16511201  6   2
*    source value  interval-# (radial info.)
16511301  0.0    2
*    initial temperature flag (if flag=0 or -1)
16511400  -1
*    temp.  mesh point  temp.  mesh point
16511401  298.01  298.01  298.01
16511402  298.01  298.01  298.01
16511403  298.01  298.01  298.01
16511404  298.00  298.00  298.00
16511405  298.00  298.00  298.00
* L-B  B.Vol.#  increment  BC option  surf.code  surf area  NH
16511501  651010000  10000   160    1    53.62   5
* R-B  B.Vol.#  increment  BC option  surf.code  surf area  NH
16511601  711050000  -10000   160    1    53.62   5
*16511601  0    0    1401   1   4171.5    5  *te
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
16511701  0    0.   0.    0.    5
* Add L-B  Dh    HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil  NH
16511801  3.0550e-3  0.03  20.  0.  0.  0.  0.  1.  1
16511802  3.0550e-3  0.09  20.  0.  0.  0.  0.  1.  2
16511803  3.0550e-3  0.15  20.  0.  0.  0.  0.  1.  3
16511804  3.0550e-3  0.21  20.  0.  0.  0.  0.  1.  4
16511805  3.0550e-3  0.27  20.  0.  0.  0.  0.  1.  5
* Add R-B  Dh    HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil  NH
16511901  3.0550e-3  0.03  20.  0.  0.  0.  0.  1.  1
```

```
16511902  3.0550e-3  0.09  20.  0.  0.  0.  0.  1.  2
16511903  3.0550e-3  0.15  20.  0.  0.  0.  0.  1.  3
16511904  3.0550e-3  0.21  20.  0.  0.  0.  0.  1.  4
16511905  3.0550e-3  0.27  20.  0.  0.  0.  0.  1.  5
*
*=======================================================================
===
*  HX Outlet of Passive DHR System 1 (Cylinder):Wall Thickness (0.027m)
*=======================================================================
===
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16601000  1  3  2   0  0.075
*    mesh-loc  format-flag
16601100  0   1
*    #-Intvl  R-coord. (radial info.)
16601101  2   0.085
*    comp-#  interval-# (radial info.)
16601201  6   2
*    source value  interval-# (radial info.)
16601301  0.0   2
*    initial temperature flag (if flag=0 or -1)
16601400  -1
*    temp-1  temp-2  temp-3
16601401  607.58  607.58  607.58
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
16601501  660010000  10000   160    1    1.00  1
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
16601601  0    0    0    1    1.00  1  * Insulate
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
16601701  0    0.   0.   0.    1
*    9-words format option
16601800  0  *This 9-words format excludes the pitch-to-diameter ratio
on 801~
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16601801  0.150  0.50  20.  0.  0.  0.  0.  1.  1
*
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16601901  0.170  0.50  20.  0.  0.  0.  0.  1.  1
*
*=======================================================================
===
*  HX Outlet of Passive DHR System 2 (Cylinder):Wall Thickness (0.027m)
*=======================================================================
===
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16681000  1  3  2   0  0.075
*    mesh-loc  format-flag
16681100  0   1
*    #-Intvl  R-coord. (radial info.)
16681101  2   0.085
*    comp-#  interval-# (radial info.)
16681201  6   2
*    source value  interval-# (radial info.)
16681301  0.0   2
*    initial temperature flag (if flag=0 or -1)
16681400  -1
*    temp-1  temp-2  temp-3
```

```
16681401  503.73  503.73  503.73
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
16681501  668010000  10000   160    1    1.00  1
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
16681601  0    0    0    1    1.00  1  * Insulate
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
16681701  0    0.   0.   0.    1
*    9-words format option
16681800  0  *This 9-words format excludes the pitch-to-diameter ratio
on 801~
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16681801  0.150  0.50  20.  0.  0.  0.  0.  1.  1
*
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16681901  0.170  0.50  20.  0.  0.  0.  0.  1.  1
*
*====================================================================
===
*  HX Outlet Pod of Passive DHR System 1 (Cylinder):Wall Thickness
(0.027m)
*====================================================================
===
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16621000  1  3  2   0  1.013
*    mesh-loc  format-flag
16621100  0   1
*    #-Intvl  R-coord. (radial info.)
16621101  2   1.023
*    comp-#  interval-# (radial info.)
16621201  6   2
*    source value  interval-# (radial info.)
16621301  0.0   2
*    initial temperature flag (if flag=0 or -1)
16621400  -1
*    temp-1  temp-2  temp-3
16621401  751.45  751.45  751.45
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
16621501  662010000  10000   160    1    1.00  1
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
16621601  0    0    0    1    1.00  1  * Insulate
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
16621701  0    0.   0.   0.    1
*    9-words format option
16621800  0  *This 9-words format excludes the pitch-to-diameter ratio
on 801~
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16621801  2.026  0.50  20.  0.  0.  0.  0.  1.  1
*
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16621901  2.046  0.50  20.  0.  0.  0.  0.  1.  1
*
*====================================================================
===
*  HX Outlet Pod of Passive DHR System 2 (Cylinder):Wall Thickness
(0.027m)
*====================================================================
===
```

```
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16711000  1  3  2  0  1.013
*    mesh-loc  format-flag
16711100  0   1
*    #-Intvl  R-coord. (radial info.)
16711101  2   1.023
*    comp-#  interval-# (radial info.)
16711201  6   2
*    source value  interval-# (radial info.)
16711301  0.0   2
*    initial temperature flag (if flag=0 or -1)
16711400  -1
*    temp-1  temp-2  temp-3
16711401  514.68  514.68  514.68
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
16711501  671010000  10000   160    1    1.00  1
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
16711601  0    0    0    1    1.00  1  * Insulate
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
16711701  0    0.   0.   0.    1
*    9-words format option
16711800  0  *This 9-words format excludes the pitch-to-diameter ratio
on 801~
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16711801  2.026  0.50  20.  0.  0.  0.  0.  1.  1
*
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16711901  2.046  0.50  20.  0.  0.  0.  0.  1.  1
*
*======================================================================
===
*  Blower Volume of Passive DHR System 1 (Cylinder):Wall Thickness
(0.027m)
*======================================================================
===
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16641000  1  3  2  0  0.7
*    mesh-loc  format-flag
16641100  0   1
*    #-Intvl  R-coord. (radial info.)
16641101  2   0.71
*    comp-#  interval-# (radial info.)
16641201  6   2
*    source value  interval-# (radial info.)
16641301  0.0   2
*    initial temperature flag (if flag=0 or -1)
16641400  -1
*    temp-1  temp-2  temp-3
16641401  755.72  755.72  755.72
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
16641501  664010000  10000   160    1    3.00  1
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
16641601  0    0    0    1    3.00  1  * Insulate
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
16641701  0    0.   0.   0.    1
*    9-words format option
```

```
16641800  0  *This 9-words format excludes the pitch-to-diameter ratio
on 801~
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16641801  1.400  1.50  20.  0.  0.  0.  0.  1.  1
*
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16641901  1.420  1.50  20.  0.  0.  0.  0.  1.  1
*
*===================================================================
===
*  Blower Volume of Passive DHR System 2 (Cylinder):Wall Thickness
(0.027m)
*===================================================================
===
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16731000  1  3  2   0  0.7
*    mesh-loc  format-flag
16731100  0   1
*    #-Intvl  R-coord. (radial info.)
16731101  2   0.71
*    comp-#  interval-# (radial info.)
16731201  6   2
*    source value  interval-# (radial info.)
16731301  0.0   2
*    initial temperature flag (if flag=0 or -1)
16731400  -1
*    temp-1  temp-2  temp-3
16731401  533.78  533.78  533.78
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
16731501  673010000  10000   160    1    3.00  1
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
16731601  0    0    0    1    3.00  1  * Insulate
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
16731701  0    0.   0.   0.    1
*    9-words format option
16731800  0  *This 9-words format excludes the pitch-to-diameter ratio
on 801~
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16731801  1.400  1.50  20.  0.  0.  0.  0.  1.  1
*
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16731901  1.420  1.50  20.  0.  0.  0.  0.  1.  1
*
*=============================================================
*  Cold Leg Duct of Passive DHR System 1 (Cylinder)
*=============================================================
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16661000  5  5  2   0  0.76
*    mesh-loc  format-flag
16661100  0   1
*    #-Intvl  R-coord. (radial info.)
16661101  4   0.79
*    comp-#  interval-# (radial info.)
16661201  6   4
*    source value  interval-# (radial info.)
16661301  0.0   4
*    initial temperature flag (if flag=0 or -1)
```

```
16661400  -1
*    temp-1  temp-2  temp-3  temp-4  temp-5
16661401  717.70   717.70   717.70   717.70   717.70
16661402  717.70   717.70   717.70   717.70   717.70
16661403  717.70   717.70   717.70   717.70   717.70
16661404  717.70   717.70   717.70   717.70   717.70
16661405  717.70   717.70   717.70   717.70   717.70
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
16661501  666010000  10000   160    1    12.50  5
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
16661601  0    0    0    1    12.50  5  * Insulate
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
16661701  0    0.   0.   0.    5
*    9-words format option
16661800  0
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16661801  1.520  1.25  20.  0.  0.  0.  0.  1.  1
16661802  1.520  3.75  20.  0.  0.  0.  0.  1.  2
16661803  1.520  6.25  20.  0.  0.  0.  0.  1.  3
16661804  1.520  8.75  20.  0.  0.  0.  0.  1.  4
16661805  1.520  11.25  20.  0.  0.  0.  0.  1.  5
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16661901  1.580  1.25  20.  0.  0.  0.  0.  1.  1
16661902  1.580  3.75  20.  0.  0.  0.  0.  1.  2
16661903  1.580  6.25  20.  0.  0.  0.  0.  1.  3
16661904  1.580  8.75  20.  0.  0.  0.  0.  1.  4
16661905  1.580  11.25  20.  0.  0.  0.  0.  1.  5
*
*=============================================================
*  Cold Leg Duct of Passive DHR System 2 (Cylinder)
*=============================================================
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
16761000  5  5  2   0  0.76
*    mesh-loc  format-flag
16761100  0   1
*    #-Intvl  R-coord. (radial info.)
16761101  4   0.79
*    comp-#  interval-# (radial info.)
16761201  6   4
*    source value  interval-# (radial info.)
16761301  0.0   4
*    initial temperature flag (if flag=0 or -1)
16761400  -1
*    temp-1  temp-2  temp-3  temp-4  temp-5
16761401  717.70   717.70   717.70   717.70   717.70
16761402  717.70   717.70   717.70   717.70   717.70
16761403  717.70   717.70   717.70   717.70   717.70
16761404  717.70   717.70   717.70   717.70   717.70
16761405  717.70   717.70   717.70   717.70   717.70
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
16761501  676010000  10000   160    1    2.50  5
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
16761601  0    0    0    1    2.50  5  * Insulated
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
16761701  0    0.   0.   0.    5
*    9-words format option
16761800  0
```

```
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16761801  1.520  1.25  20.  0.  0.  0.  0.  1.  1
16761802  1.520  3.75  20.  0.  0.  0.  0.  1.  2
16761803  1.520  6.25  20.  0.  0.  0.  0.  1.  3
16761804  1.520  8.75  20.  0.  0.  0.  0.  1.  4
16761805  1.520  11.25  20.  0.  0.  0.  0.  1.  5
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
16761901  1.580  1.25  20.  0.  0.  0.  0.  1.  1
16761902  1.580  3.75  20.  0.  0.  0.  0.  1.  2
16761903  1.580  6.25  20.  0.  0.  0.  0.  1.  3
16761904  1.580  8.75  20.  0.  0.  0.  0.  1.  4
16761905  1.580  11.25  20.  0.  0.  0.  0.  1.  5
*
*=====================================================================
==
*
*  Passive UHS DHR HEAT EXCHANGER  1
*
*=====================================================================
==
*
*-----------------------------------------------------------
*  Heat Exchanger
*-----------------------------------------------------------
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
17501000  20  5  2   0  1.7526e-2
*    mesh-loc  format-flag
17501100  0   1
*    #-Intvl  R-coord. (radial info.)
17501101  4   2.0182e-2
*    comp-#  interval-# (radial info.)
17501201  6   4
*    source value  interval-# (radial info.)
17501301  0.0    4
*    initial temperature flag (if flag=0 or -1)
17501400  -1
*    temp.  mesh point  temp.  mesh point
17501401  298.00  298.00  298.00  298.00  298.00
17501402  298.00  298.00  298.00  298.00  298.00
17501403  298.00  298.00  298.00  298.00  298.00
17501404  298.00  298.00  298.00  298.00  298.00
17501405  298.00  298.00  298.00  298.00  298.00
17501406  298.00  298.00  298.00  298.00  298.00
17501407  298.00  298.00  298.00  298.00  298.00
17501408  298.00  298.00  298.00  298.00  298.00
17501409  298.00  298.00  298.00  298.00  298.00
17501410  298.00  298.00  298.00  298.00  298.00
17501411  298.00  298.00  298.00  298.00  298.00
17501412  298.00  298.00  298.00  298.00  298.00
17501413  298.00  298.00  298.00  298.00  298.00
17501414  298.00  298.00  298.00  298.00  298.00
17501415  298.00  298.00  298.00  298.00  298.00
17501416  298.00  298.00  298.00  298.00  298.00
17501417  298.00  298.00  298.00  298.00  298.00
17501418  298.00  298.00  298.00  298.00  298.00
17501419  298.00  298.00  298.00  298.00  298.00
17501420  298.00  298.00  298.00  298.00  298.00
```

```
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
17501501  750010000  10000   160    1    160.5  20
* R-B  B.Vol.#  increment  BC option  surf.code  Height  NH
17501601  0    0    1401   1   160.5  20  *temperature
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
17501701  0    0.    0.    0.     20
* Add L-B  Dh   HL-f   HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
17501801  3.5052e-2  0.08025e1  20.  0.  0.  0.  0.  1.  1
17501802  3.5052e-2  0.24075e1  20.  0.  0.  0.  0.  1.  2
17501803  3.5052e-2  0.40125e1  20.  0.  0.  0.  0.  1.  3
17501804  3.5052e-2  0.56175e1  20.  0.  0.  0.  0.  1.  4
17501805  3.5052e-2  0.72225e1  20.  0.  0.  0.  0.  1.  5
17501806  3.5052e-2  0.88275e1  20.  0.  0.  0.  0.  1.  6
17501807  3.5052e-2  1.04325e1  20.  0.  0.  0.  0.  1.  7
17501808  3.5052e-2  1.20375e1  20.  0.  0.  0.  0.  1.  8
17501809  3.5052e-2  1.36425e1  20.  0.  0.  0.  0.  1.  9
17501810  3.5052e-2  1.52475e1  20.  0.  0.  0.  0.  1.  10
17501811  3.5052e-2  1.68525e1  20.  0.  0.  0.  0.  1.  11
17501812  3.5052e-2  1.84575e1  20.  0.  0.  0.  0.  1.  12
17501813  3.5052e-2  2.00625e1  20.  0.  0.  0.  0.  1.  13
17501814  3.5052e-2  2.16675e1  20.  0.  0.  0.  0.  1.  14
17501815  3.5052e-2  2.32725e1  20.  0.  0.  0.  0.  1.  15
17501816  3.5052e-2  2.48775e1  20.  0.  0.  0.  0.  1.  16
17501817  3.5052e-2  2.64825e1  20.  0.  0.  0.  0.  1.  17
17501818  3.5052e-2  2.80875e1  20.  0.  0.  0.  0.  1.  18
17501819  3.5052e-2  2.96925e1  20.  0.  0.  0.  0.  1.  19
17501820  3.5052e-2  3.12975e1  20.  0.  0.  0.  0.  1.  20
* Add R-B  Dh  HL-f   HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
17501901  4.0364e-2  0.08025e1  20.  0.  0.  0.  0.  1.  1
17501902  4.0364e-2  0.24075e1  20.  0.  0.  0.  0.  1.  2
17501903  4.0364e-2  0.40125e1  20.  0.  0.  0.  0.  1.  3
17501904  4.0364e-2  0.56175e1  20.  0.  0.  0.  0.  1.  4
17501905  4.0364e-2  0.72225e1  20.  0.  0.  0.  0.  1.  5
17501906  4.0364e-2  0.88275e1  20.  0.  0.  0.  0.  1.  6
17501907  4.0364e-2  1.04325e1  20.  0.  0.  0.  0.  1.  7
17501908  4.0364e-2  1.20375e1  20.  0.  0.  0.  0.  1.  8
17501909  4.0364e-2  1.36425e1  20.  0.  0.  0.  0.  1.  9
17501910  4.0364e-2  1.52475e1  20.  0.  0.  0.  0.  1.  10
17501911  4.0364e-2  1.68525e1  20.  0.  0.  0.  0.  1.  11
17501912  4.0364e-2  1.84575e1  20.  0.  0.  0.  0.  1.  12
17501913  4.0364e-2  2.00625e1  20.  0.  0.  0.  0.  1.  13
17501914  4.0364e-2  2.16675e1  20.  0.  0.  0.  0.  1.  14
17501915  4.0364e-2  2.32725e1  20.  0.  0.  0.  0.  1.  15
17501916  4.0364e-2  2.48775e1  20.  0.  0.  0.  0.  1.  16
17501917  4.0364e-2  2.64825e1  20.  0.  0.  0.  0.  1.  17
17501918  4.0364e-2  2.80875e1  20.  0.  0.  0.  0.  1.  18
17501919  4.0364e-2  2.96925e1  20.  0.  0.  0.  0.  1.  19
17501920  4.0364e-2  3.12975e1  20.  0.  0.  0.  0.  1.  20
*=================================================================
==
*
*  Passive UHS DHR HEAT EXCHANGER  2
*
*=================================================================
==
*
*-----------------------------------------------------
```

```
*  Heat Exchanger
*--------------------------------------------------------------
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
17511000  20  5  2   0  1.7526e-2
*    mesh-loc  format-flag
17511100  0   1
*    #-Intvl  R-coord. (radial info.)
17511101  4   2.0182e-2
*    comp-#  interval-# (radial info.)
17511201  6   4
*    source value  interval-# (radial info.)
17511301  0.0    4
*    initial temperature flag (if flag=0 or -1)
17511400  -1
*    temp.  mesh point  temp.  mesh point
17511401  298.00  298.00  298.00  298.00  298.00
17511402  298.00  298.00  298.00  298.00  298.00
17511403  298.00  298.00  298.00  298.00  298.00
17511404  298.00  298.00  298.00  298.00  298.00
17511405  298.00  298.00  298.00  298.00  298.00
17511406  298.00  298.00  298.00  298.00  298.00
17511407  298.00  298.00  298.00  298.00  298.00
17511408  298.00  298.00  298.00  298.00  298.00
17511409  298.00  298.00  298.00  298.00  298.00
17511410  298.00  298.00  298.00  298.00  298.00
17511411  298.00  298.00  298.00  298.00  298.00
17511412  298.00  298.00  298.00  298.00  298.00
17511413  298.00  298.00  298.00  298.00  298.00
17511414  298.00  298.00  298.00  298.00  298.00
17511415  298.00  298.00  298.00  298.00  298.00
17511416  298.00  298.00  298.00  298.00  298.00
17511417  298.00  298.00  298.00  298.00  298.00
17511418  298.00  298.00  298.00  298.00  298.00
17511419  298.00  298.00  298.00  298.00  298.00
17511420  298.00  298.00  298.00  298.00  298.00
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
17511501  751010000  10000   160    1    160.5  20
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
17511601  0    0    1401   1   160.5  20  *temperatu
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
17511701  0    0.   0.   0.    20
* Add L-B  Dh    HL-f  HL-r grid-f  grid-r  grid-kf grid-kr L-Boil NH
17511801  3.5052e-2  0.08025e1  20.  0.  0.  0.  0.  1.  1
17511802  3.5052e-2  0.24075e1  20.  0.  0.  0.  0.  1.  2
17511803  3.5052e-2  0.40125e1  20.  0.  0.  0.  0.  1.  3
17511804  3.5052e-2  0.56175e1  20.  0.  0.  0.  0.  1.  4
17511805  3.5052e-2  0.72225e1  20.  0.  0.  0.  0.  1.  5
17511806  3.5052e-2  0.88275e1  20.  0.  0.  0.  0.  1.  6
17511807  3.5052e-2  1.04325e1  20.  0.  0.  0.  0.  1.  7
17511808  3.5052e-2  1.20375e1  20.  0.  0.  0.  0.  1.  8
17511809  3.5052e-2  1.36425e1  20.  0.  0.  0.  0.  1.  9
17511810  3.5052e-2  1.52475e1  20.  0.  0.  0.  0.  1.  10
17511811  3.5052e-2  1.68525e1  20.  0.  0.  0.  0.  1.  11
17511812  3.5052e-2  1.84575e1  20.  0.  0.  0.  0.  1.  12
17511813  3.5052e-2  2.00625e1  20.  0.  0.  0.  0.  1.  13
17511814  3.5052e-2  2.16675e1  20.  0.  0.  0.  0.  1.  14
17511815  3.5052e-2  2.32725e1  20.  0.  0.  0.  0.  1.  15
```

```
17511816  3.5052e-2  2.48775e1  20.  0.  0.  0.  0.  1.  16
17511817  3.5052e-2  2.64825e1  20.  0.  0.  0.  0.  1.  17
17511818  3.5052e-2  2.80875e1  20.  0.  0.  0.  0.  1.  18
17511819  3.5052e-2  2.96925e1  20.  0.  0.  0.  0.  1.  19
17511820  3.5052e-2  3.12975e1  20.  0.  0.  0.  0.  1.  20
* Add R-B  Dh    HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
17511901  4.0364e-2  0.08025e1  20.  0.  0.  0.  0.  1.  1
17511902  4.0364e-2  0.24075e1  20.  0.  0.  0.  0.  1.  2
17511903  4.0364e-2  0.40125e1  20.  0.  0.  0.  0.  1.  3
17511904  4.0364e-2  0.56175e1  20.  0.  0.  0.  0.  1.  4
17511905  4.0364e-2  0.72225e1  20.  0.  0.  0.  0.  1.  5
17511906  4.0364e-2  0.88275e1  20.  0.  0.  0.  0.  1.  6
17511907  4.0364e-2  1.04325e1  20.  0.  0.  0.  0.  1.  7
17511908  4.0364e-2  1.20375e1  20.  0.  0.  0.  0.  1.  8
17511909  4.0364e-2  1.36425e1  20.  0.  0.  0.  0.  1.  9
17511910  4.0364e-2  1.52475e1  20.  0.  0.  0.  0.  1.  10
17511911  4.0364e-2  1.68525e1  20.  0.  0.  0.  0.  1.  11
17511912  4.0364e-2  1.84575e1  20.  0.  0.  0.  0.  1.  12
17511913  4.0364e-2  2.00625e1  20.  0.  0.  0.  0.  1.  13
17511914  4.0364e-2  2.16675e1  20.  0.  0.  0.  0.  1.  14
17511915  4.0364e-2  2.32725e1  20.  0.  0.  0.  0.  1.  15
17511916  4.0364e-2  2.48775e1  20.  0.  0.  0.  0.  1.  16
17511917  4.0364e-2  2.64825e1  20.  0.  0.  0.  0.  1.  17
17511918  4.0364e-2  2.80875e1  20.  0.  0.  0.  0.  1.  18
17511919  4.0364e-2  2.96925e1  20.  0.  0.  0.  0.  1.  19
17511920  4.0364e-2  3.12975e1  20.  0.  0.  0.  0.  1.  20
*
*-----------------------------------------------------------
* General Table for Surface Temperature of HX
*    time  tempature
20240100  temp
20240101  0.0   298.00
20240102  1.e5  298.00
*
*======================================================================
===
*  Containment Ferrit SS perimeter
*======================================================================
===
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
10701000  1  7  2   0  15.0
*    mesh-loc  format-flag
10701100  0   1
*    #-Intvl  R-coord. (radial info.)
10701101  2   15.025
10701102  4   15.225
*    comp-#  interval-# (radial info.)
10701201  17   2
10701202  6   6
*    source value  interval-# (radial info.)
10701301  0.0   6
*    initial temperature flag (if flag=0 or -1)
10701400  -1
*         temp-1  temp-2  temp-3
10701401  303.15  303.15  303.15  303.15  303.15  303.15  303.15
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
10701501  070010000  10000   160    1    25.0  1
```

```
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
10701601  0    0    0    1    25.0  1  * Insulate
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
10701701  0    0.   0.   0.    1
*
10701800  1  *This 12-words format
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
10701801  0.0  15.  15.  0.  0.  0.  0.  1.  0. 1.1 1.0 1
*
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
10701901  0.0  15.  15.  0.  0.  0.  0.  1.  1
*
*======================================================================
===
*  Containment Concrete floor
*======================================================================
===
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
10702000  1  5  1   0  15.0
*    mesh-loc  format-flag
10702100  0   1
*    #-Intvl  R-coord. (radial info.)
10702101  4   15.5
*    comp-#  interval-# (radial info.)
10702201  14   4
*    source value  interval-# (radial info.)
10702301  0.0   4
*    initial temperature flag (if flag=0 or -1)
10702400  -1
*         temp-1  temp-2  temp-3
10702401  303.15  303.15  303.15  303.15  303.15
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
10702501  070010000  10000   131    0    700.  1
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
10702601  0    0    0    0    700.0  1  * Insulate
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
10702701  0    0.   0.   0.    1
*
10702800  1  *This 12-words format
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
10702801  48.51  15.  15.  0.  0.  0.  0.  1.  0. 1.1 1.0 1
*
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
10702901  48.51  15.  15.  0.  0.  0.  0.  1.  1
*
*======================================================================
===
*  Containment SS stuctures (Thinner ones)
*======================================================================
===
*    #-HS  #-MP  geotype SS-ini L-coord. reflood  bvol-ind axial#
10703000  1  5  1   0  7.5
*    mesh-loc  format-flag
10703100  0   1
*    #-Intvl  R-coord. (radial info.)
10703101  4   7.525
*    comp-#  interval-# (radial info.)
```

```
10703201  4   4
*    source value  interval-# (radial info.)
10703301  0.0   4
*    initial temperature flag (if flag=0 or -1)
10703400  -1
*         temp-1  temp-2  temp-3
10703401  303.15  303.15  303.15  303.15  303.15
* L-B  B.Vol.#  increment  BC option  surf.code  height  NH
10703501  070010000  10000   160    0    700.  1
* R-B  B.Vol.#  increment  BC option  surf.code  height  NH
10703601  0    0    0    0    700.0  1  * Insulate
* Source  source-type  multiplier DHeat-Left DHeat-Right  NH
10703701  0    0.   0.   0.    1
*    9-words format option
10703800  1  *This 12-words format
* Add L-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
10703801  42.79  15.  15.  0.  0.  0.  0.  1.  0. 1.1 1.0 1
*
* Add R-B  Dh  HL-f  HL-r  grid-f  grid-r  grid-kf grid-kr L-Boil NH
10703901  42.79  15.  15.  0.  0.  0.  0.  1.  1
*
*
*++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+
*--------------------------------------------------------
*   h e a t s t r u c t u r e s  p r o p e r t i e s  *
*--------------------------------------------------------
*
20100100  tbl/fctn  1    1  * UO-2
20100200  tbl/fctn  3    1  * gap for average rods
20100300  tbl/fctn  1    1  * zircaloy
20100400  s-steel       * s. steel (default)
20100500  tbl/fctn  1    1  * inconel
20100600  tbl/fctn  1    1  * ferrit SS
20100700  tbl/fctn  1    1  * austenit SS
20100800  tbl/fctn  3    1  * gap for hot rod
20100900  tbl/fctn  1    1  * inconel for energy balance
20101000  tbl/fctn  1    1  * heater (MgO)
*
20101100  tbl/fctn  1    1  * U-TRU-Zr (90:10 weight fraction)
20101200  tbl/fctn  1    1  * UC-SiC (50:50 volume fraction)
20101300  tbl/fctn  1    1  * SiC for the Lower-Upper Reflector
20101400  tbl/fctn  1    1  * Concrete
20101700  tbl/fctn  1    1  * Insulator
*----------------------------------------------------------------
*    fuel  UC
*   temp[k]  lamda[w/m-k]  temp[k]  lamda[w/m-k]
20100101  273.15  21.7   373.15  21.4321
20100102  473.15  21.2364  573.15  21.1129
20100103  673.14  21.0616  773.15  21.0825
20100104  873.15  21.1756  973.15  21.3409
20100105  1073.15  21.384  1173.15  21.532
20100106  1273.15  21.68   1373.15  21.828
20100107  1473.15  21.976  1573.15  22.124
20100108  1673.15  22.272  1773.15  22.42
20100109  1873.15  22.568  1973.15  22.716
20100110  2073.15  22.864  2173.15  23.012
```

```
20100111  2273.15  23.16   2373.15  23.308 *Extrapolated
20100112  2473.15  23.456  2573.15  23.604 *Extrapolated
20100113  2673.15  23.752  2773.15  23.9  *Extrapolated
20100114  2873.15  24.048  2973.15  24.196 *Extrapolated
20100115  3073.15  24.344  3173.15  24.492 *Extrapolated
20100116  3573.15  25.084  4873.15  27.008 *Extrapolated
*-------------------------------------------------------------------
*    gap  gas  average rods
*   gas type  mole fraction
20100201  helium  0.9511
20100202  argon  0.0396
20100203  nitrogen  0.0008
20100204  xenon  0.0076
20100205  krypton  0.0008
*-------------------------------------------------------------------
*    huellrohr  zircaloy
*   temp[k]  lamda[w/m-k]  temp[k]  lamda[w/m-k]
*
20100301  273.15  13.6   373.15  14.1
20100302  473.15  14.8   573.15  15.8
20100303  673.15  16.9   773.15  18.1
20100304  873.15  19.5   973.15  21.1
20100305  1073.15  22.8    1173.15  24.6
20100306  1273.15  26.8    1373.15  29.2
20100307  1473.15  31.7    1573.15  34.4
20100308  1673.15  37.3    1773.15  40.4
20100309  1873.15  43.5    1973.15  46.6
20100309  1873.15  43.5    4973.15  46.6  * test
*-------------------------------------------------------------------
*    inconel
*   temp(k)  lamda(w/m3-k)  temp(k)  lamda(w/m3-k)
20100501  294.3  14.9    366.0   15.7
20100502  477.0  17.5    588.7   19.2
20100503  699.8  20.9    810.9   22.8
20100504  1500.0  22.8
*-------------------------------------------------------------------
*    ferrit
*   temp[k]  lamda[w/m-k]  temp[k]  lamda[w/m-k]
20100601  73.15    44.   373.15  44.   *arbitrarily extended
20100602  473.15   43.   573.15  42.
20100603  673.15   40.   773.15  39.
20100604  873.15   39.   973.15  39.
20100605  1073.15  39.    1173.15  39.
20100605  1073.15  39.    1973.15  39.  *arbitrarily extended
20100606  5000.0   39.
*-------------------------------------------------------------------
*   austenit
*   temp[k]  lamda[w/m-k]  temp[k]  lamda[w/m-k]
20100701  293.15  14.24  413.15  16.7
20100702  523.15  18.6  683.15  18.6
20100703  773.15  20.9  873.15  20.9
20100704  973.15  20.9  2000.   20.9
20100704  973.15  20.9  4000.   20.9  *!test
*-------------------------------------------------------------------
*    gap  gas  hot rod
*   gas type  mole fraction
20100801  helium  0.9079
```

```
20100802  argon  0.0378
20100803  nitrogen  0.0049
20100804  xenon  0.0445
20100805  krypton  0.0050
*-----------------------------------------------------------------
*   Inconel Property Tuning for Energy Balance Factor : 1.55
*
20100901  294.3  23.09    366.0   24.34
20100902  477.0  27.13    588.7   29.76
20100903  699.8  32.39    810.9   35.34
20100904  1500.0  35.34
*
*-----------------------------------------------------------------
*  PZR Heater - MgO (010)
*     temp (k)  thermal conductivity (w/m.k)
20101001  .29320e+03  .81400e+02
20101002  .12732e+04  .10047e+03
20101003  .22532e+04  .11954e+03
*-----------------------------------------------------------------
*  U-TRU-Zr (90:10 weight fraction)
*     temp (k)  thermal conductivity (w/m.k)
20101101  373.   21.16  600.   23.1546
20101102  900.   25.0209  938.  25.2094
20101103  938.01 25.2095  1049.  25.707
20101104  1049.01 25.0707  1132.3  26.0308
*-----------------------------------------------------------------
*  UC-SiC (50:50 volume fraction)
*     temp (k)  thermal conductivity (w/m.k)
20101201  373.   20.9195  600.   20.7434
20101202  900.   20.7767  1200.   20.4998
20101203  1500.   20.3775  1800.   20.2394
20101204  2100.   20.0847  2400.   19.9125
*
*------------------------------------------------------------------
*  SiC
*    temp(k)  lamda(w/m.k)  temp(k)  lamda(w/m.k)
20101301  273.  15.    2400.  15.
*-----------------------------------------------------------------
* Concrete
20101401  1.4
* Insulator
20101701  0.34
*---------------------------------------------------------
*    volumetric heat capacity         *
*---------------------------------------------------------
*   fuel  UC
*    temp[k]  cp[j/m3-k]  temp[k]  cp[j/m3-k]

20100151  273.150  3.536e6   400.   3.536e6 *average
20100152  500.   3.536e6   600.   3.536e6
20100153  700.   3.536e6   800.   3.536e6
20100154  900.   3.536e6   1000.  3.536e6
20100155  1100.  3.536e6   1200.  3.536e6
20100156  1300.  3.536e6   1400.  3.536e6
20100157  1500.  3.536e6   1600.  3.536e6
20100158  1700.  3.536e6   1800.  3.536e6
20100159  1900.  3.536e6   2000.  3.536e6
```

```
20100160  2100.  3.536e6   2200.  3.536e6
20100161  2300.  3.536e6   2400.  3.536e6
20100162  2500.  3.536e6   2600.  3.536e6
20100163  3000.  3.536e6   5000.  3.536e6
*----------------------------------------------------------------
*    gap    gas
*    temp[k]  cp[j/m3-k]  temp[k]  cp[j/m3-k]
20100251  273.15  5.4    3273.15  5.4
*----------------------------------------------------------------
*    huellrohr  zicaloy
*    temp[k]  cp[j/m3-k]  temp[k]  cp[j/m3-k]
20100351  273.15  1.881e6   573.15  2.079e6
20100352  773.15  2.211e6   903.15  2.290e6
20100353  923.15  2.376e6   1083.15  2.376e6
20100354  1103.15  3.630e6   1123.15  4.455e6
20100355  1143.15  4.950e6   1163.15  5.115e6
20100356  1183.15  4.950e6   1203.15  4.455e6
20100357  1213.15  3.360e6   1243.15  2.376e6
20100358  2073.15  2.376e6
20100358  4073.15  2.376e6  *test
*----------------------------------------------------------------
*   inconel
*   temp(k)  cp(j/m3-k)  temp(k)  cp(j/m3-k)
20100551  273.  3.988e6   293.0   3.916e6
20100552  373.  4.169e6   473.0   4.418e6
20100553  573.  4.703e6   673.0   5.095e6
20100554  773.  5.593e6   873.0   6.307e6
20100555  973.  7.482e6    1000.0   7.482e6
20100556 2000.  7.482e6    4000.    7.482e6  *Arbitrary Extended
*----------------------------------------------------------------
*   ferrit
*    temp[k]  cp[j/m3-k]  temp[k]  cp[j/mf-k]
20100651  93.15  3.611e6  373.15  3.847e6  *Arbitrary extended
20100652  473.15  4.082e6  573.15  4.396e6
20100653  673.15  4.788e6  773.15  5.338e6
20100654  2000.  5.338e6  4000.00  5.338e6  *Arbitrary Extended
*----------------------------------------------------------------
*    austenit
*    temp[k]  cp[j/m3-k]  temp[k]  cp[j/m3-k]
20100751  293.15  3.572e6  368.  3.837e6
20100752  478.15  4.102e6  588.15  4.333e6
20100753  698.15  4.465e6  813.15  4.597e6
20100754  873.15  4.465e6  2000.  4.465e6
20100754  873.15  4.465e6  4000.  4.465e6  *test
*----------------------------------------------------------------
*    gap    gas
*    temp[k]  cp[j/m3-k]  temp[k]  cp[j/m3-k]
20100851  273.15  5.4    3273.15  5.4
*-----------------------------------------------------------------
*  Inconel
*   temp(k)  cp(j/m3-k)  temp(k)  cp(j/m3-k)
*
20100951  273.  3.988e6   294.3   3.740e6
20100952  366.5  3.917e6   477.6   4.094e6
20100953  588.8  4.270e6   699.9   4.446e6
20100954  811.0  4.658e6    2000.0   4.658e6
20100955 4000.  4.65836 *Arbitrary Extended
```

```
*-----------------------------------------------------------------
*  PZR Heater - MgO (010)
*     temp (k)  volumetric heat capacity (j/m3.k)
20101051  .293e+03  .2581e+07
20101052  .450e+03  .2835e+07
20101053  .800e+03  .3402e+07
20101054  .112e+04  .3726e+07
20101055  .144e+04  .4050e+07
*-----------------------------------------------------------------
*  U-TRU-Zr (90:10 weight fraction)
*     temp (k)  volumetric heat capacity (j/m3.k)
20101151  373.  2.21306e6  600.  2.58049e6
20101152  900.  3.25756e6  938.  3.35867e6
20101153  938.01 3.03142e6  1049.  2.98995e6
20101154  1049.01 2.71774e6  1132.3  3.05993e6
*-----------------------------------------------------------------
*  UC-SiC (50:50 volume fraction)
*     temp (k)  volumetric heat capacity (j/m3.k)
20101251  373.  2.58160e6  600.  2.74160e6
20101252  900.  3.22160e6  1200.  3.70160e6
20101253  1500.  3.86160e6  1800.  3.95760e6
20101254  2100.  4.02160e6  2400.  4.10160e6
*-----------------------------------------------------------------
*  SiC
*   temp(K) Cp(J/kg-K) temp(K) Cp(J/kg-K)
20101351  273.  500.   600.  600.
20101352  900.  900.  1200.  1200.
20101353  1500.  1300.  1800.  1360.
20101354  2100.  1400.  2400.  1450.
*-----------------------------------------------------------------
* Concrete
20101451  840.
* Insulator
20101751  1050.
*-----------------------------------------------------------
*   power  table
*-----------------------------------------------------------
*20210000  power  503  1.  2775.0e6
*20210001  -1.   1.0
*20210002  0.   0.20267
*20210003  5.   0.12720
*20210004  10.   0.11631
*20210005  20.   0.08037
*20210006  30.   0.06289
*20210007  40.   0.05148
*20210008  50.   0.04565
*20210009  70.   0.04097
*20210010 100.   0.03726
*20210011 150.   0.03448
*20210012 200.   0.03268
*20210013 300.   0.03024
*20210014 400.   0.02862
*20210015 500.   0.02741
*20210016 600.   0.02683
*20210017 800.   0.02486
*20210018 1000.  0.02362
*20210019 1300.  0.02211
```

```
*20210020 1600.  0.02090
*20210021 2000.  0.01960
*20210022 2500.  0.01836
*20210023 3000.  0.01736
*20210024 3500.  0.01657
*20210025 4000.  0.01590
*20210026 4500.  0.01537
*20210027 5000.  0.01490
*20210028 6000.  0.01404
*-----------------------------------------------------------
*   control variables
*-----------------------------------------------------------
*
*  Temperature Drop core
20510100  DeltT  sum  1.0  360. 1
20510101  0.0  -1.0  tempg   100050000
20510102        1.0  tempg   300010000
*
*  Estimated extracted Q (Core)
20510200  EstimQ  mult  5192.4  6.0e8  1
20510201  cntrlvar   101
20510202  mflowj     100040000
*
*  MAX Temperature Cladding: Control variable 103
20510300  max-clad  stdfnctn  1.0  1310.995 1
20510301  max  httemp  251100107  httemp  251100108
20510302       httemp  251100207  httemp  251100208
20510303       httemp  251100307  httemp  251100308
20510304       httemp  251100407  httemp  251100408
20510305       httemp  251100507  httemp  251100508
20510306       httemp  251100607  httemp  251100608
20510307       httemp  251100707  httemp  251100708
20510308       httemp  251100807  httemp  251100808
**  reynolds number (De = 0.0127)
20510800  re-no0  mult  0.0127  2.783415 1
20510801  rhog  250040000  velg  250040000
20510900  re-no  div  1.0  67608.9 1
20510901  viscg  250040000  cntrlvar  108
*
*  MAX Temperature Fuel: Control variable 110
20511000  max-fuel  stdfnctn  1.0  1310.995 1
20511001  max  httemp  251100401  httemp  251100402
20511002       httemp  251100403  httemp  251100404
20511003       httemp  251100501  httemp  251100502
20511004       httemp  251100503  httemp  251100504
20511005       httemp  251100601  httemp  251100602
20511006       httemp  251100603  httemp  251100604
20511007       httemp  251100701  httemp  251100702
20511008       httemp  251100703  httemp  251100704
20511009       httemp  251100801  httemp  251100802
20511010       httemp  251100803  httemp  251100804
*
*  Energy Balance in core 250 and 251
20511100  Core-E  sum  1.0  6.+8  1
20511101  0.0  1.0  q   250010000
20511102   1.0  q   250020000
20511103   1.0  q   250030000
```

```
20511104   1.0  q   250040000
20511105   1.0  q   250050000
20511106   1.0  q   250060000
20511107   1.0  q   250070000
20511108   1.0  q   250080000
20511109   1.0  q   251010000
20511110   1.0  q   251020000
20511111   1.0  q   251030000
20511112   1.0  q   251040000
20511113   1.0  q   251050000
20511114   1.0  q   251060000
20511115   1.0  q   251070000
20511116   1.0  q   251080000
**
*=====================================================================
=====
* Heat loss from the primary wall heat structures
* Hydrodynamic components 100, 210, 211, 290, 291, 610, 611, 666, 676,
670
*=====================================================================
=====
* DHR HX 1 (650): Control varialbe 120
20512000  DhrHX1HS  sum  1.0  .1704288 1
20512001  0.0  1.0  q   650010000
20512002   1.0  q   650020000
20512003   1.0  q   650030000
20512004   1.0  q   650040000
20512005   1.0  q   650050000
*Power generated in the core Control variable 123
20512300  corepowg   sum  1.0  600.0e6 1
20512301   0.0  1.0  htpowg  2501001
20512302   1.0  htpowg  2501002  1.0  htpowg  2501003
20512303   1.0  htpowg  2501004  1.0  htpowg  2501005
20512304   1.0  htpowg  2501006  1.0  htpowg  2501007
20512305   1.0  htpowg  2501008  1.0  htpowg  2511001
20512306   1.0  htpowg  2511002  1.0  htpowg  2511003
20512307   1.0  htpowg  2511004  1.0  htpowg  2511005
20512308   1.0  htpowg  2511006  1.0  htpowg  2511007
20512309   1.0  htpowg  2511008
* DHR HX 2 (651): Control varialbe 125
20512500  DhrHX2HS  sum  1.0  .1704288 1
20512501  0.0  1.0  q   651010000
20512502   1.0  q   651020000
20512503   1.0  q   651030000
20512504   1.0  q   651040000
20512505   1.0  q   651050000
* DHR HX 1 (710): Control varialbe 126
20512600  DhrHX1CS  sum  1.0  .665619 1
20512601  0.0  1.0  q   710010000
20512602   1.0  q   710020000
20512603   1.0  q   710030000
20512604   1.0  q   710040000
20512605   1.0  q   710050000
* DHR HX 2 (711): Control varialbe 127
20512700  DhrHX2CS  sum  1.0  .665619 1 *8.60957-6
20512701  0.0  1.0  q   711010000
20512702   1.0  q   711020000
```

```
20512703   1.0  q   711030000
20512704   1.0  q   711040000
20512705   1.0  q   711050000
* H2O1 (750): Control varialbe 128
20512800  H2O1  sum  1.0  8.10906-6 1
20512801  0.0  1.0  q   750010000
20512802   1.0  q   750020000  1.0  q  750030000
20512803   1.0  q   750040000  1.0  q  750050000
20512804   1.0  q   750060000  1.0  q  750070000
20512805   1.0  q   750080000  1.0  q  750090000
20512806   1.0  q   750100000  1.0  q  750110000
20512807   1.0  q   750120000  1.0  q  750130000
20512808   1.0  q   750140000  1.0  q  750150000
20512809   1.0  q   750160000  1.0  q  750170000
20512810   1.0  q   750180000  1.0  q  750190000
20512811   1.0  q   750200000
* H2O2 (751): Control varialbe 129
20512900  H2O2  sum  1.0  3977.325 1
20512901  0.0  1.0  q   751010000
20512902   1.0  q   751020000  1.0  q  751030000
20512903   1.0  q   751040000  1.0  q  751050000
20512904   1.0  q   751060000  1.0  q  751070000
20512905   1.0  q   751080000  1.0  q  751090000
20512906   1.0  q   751100000  1.0  q  751110000
20512907   1.0  q   751120000  1.0  q  751130000
20512908   1.0  q   751140000  1.0  q  751150000
20512909   1.0  q   751160000  1.0  q  751170000
20512910   1.0  q   751180000  1.0  q  751190000
20512911   1.0  q   751200000
*
20513000   Firder  diffrend  1.0  0.  1
20513001   tempg    251080000
*
20513100   Secder  diffrend  1.0  0.  1
20513101   cntrlvar  130
*
*ctlvar  name  type  factor  init  f c  min  max
20560000  shaft1  shaft  1.0  376.991 1   1  0.1
*
*ctlvar  cv  iner  fric  type   comp  type  comp
20560001  990  729.867  0.0  turbine  510
20560002        cprssr  550
20560003        cprssr  580
20560004        generatr  600
*        iner  fric  trip  discon
20560006  376.991  376.991  1270.95  0.0  360  0
*=================================================================
========*
* added shaft torque from a control variable representing a resistor
bank
*=================================================================
========*
20599000    shftTrq1   function  1.0  1.0  1
20599001  time  0 990
*=================================================================
========*
* Table giving resistor bank torque versus time for 1x shaft
```

```
20299000  reac-t   529
*         time     torque
20299001   0.0      0.
20299002   3.5      -100000.
*======================================================================
========*

$======================================================================
* compute generator torque (N-m) and power (mw)
$======================================================================
*ctlvar  name  type  factor  init  f c  min  max
20560200  gentrq1  sum  1.0   407472.4 1
*
*ctlvar  a0  a1  v1   p1    a2  v2    p2
20560201  0.0  1.0  turtrq  510    1.0  cprtrq  550
20560202   1.0  cprtrq  580
*
*ctlvar  name  type  factor  init  f c  min  max
20560400  genpow1  mult  1.0   153613424. 1
*
*ctlvar  v1   p1   v2    p2
20560401  cntrlvar 600    cntrlvar  602
*
$======================================================================
* compute turbine shaft power in MW
$======================================================================
*ctlvar  name  type  factor  init  f c  min  max
20562000  turpow1  sum  1.e-6  411.063 1 1  1.e-6
*
*ctlvar  a0  a1  v1   p1    a2  v2    p2
20562001  0.0  1.0  turpow  510
*
$======================================================================
==
*control variables to calculate total power transfered in recouperator
*
20503000  rc_hQ1  sum  1.0  -6.00586+8 1
20503001  0.0     1.0 q  520010000  1.0 q  520020000  1.0 q  520030000
20503002  1.0 q  520040000  1.0 q  520050000  1.0 q  520060000  1.0 q
520070000
20503003  1.0 q  520080000  1.0 q  520090000  1.0 q  520100000  1.0 q
520110000
20503004  1.0 q  520120000  1.0 q  520130000  1.0 q  520140000  1.0 q
520150000
20503005  1.0 q  520160000  1.0 q  520170000  1.0 q  520180000  1.0 q
520190000
20503006  1.0 q  520200000  1.0 q  520210000  1.0 q  520220000  1.0 q
520230000
20503007  1.0 q  520240000  1.0 q  520250000  1.0 q  520260000  1.0 q
520270000
20503008  1.0 q  520280000  1.0 q  520290000  1.0 q  520300000
*
20503100  rc_cQ1  sum  1.0  6.00586+8 1
20503101  0.0     1.0 q  590010000  1.0 q  590020000  1.0 q  590030000
20503102  1.0 q  590040000  1.0 q  590050000  1.0 q  590060000  1.0 q
590070000
```

```
20503103  1.0 q  590080000  1.0 q  590090000  1.0 q  590100000  1.0 q
590110000
20503104  1.0 q  590120000  1.0 q  590130000  1.0 q  590140000  1.0 q
590150000
20503105  1.0 q  590160000  1.0 q  590170000  1.0 q  590180000  1.0 q
590190000
20503106  1.0 q  590200000  1.0 q  590210000  1.0 q  590220000  1.0 q
590230000
20503107  1.0 q  590240000  1.0 q  590250000  1.0 q  590260000  1.0 q
590270000
20503108  1.0 q  590280000  1.0 q  590290000  1.0 q  590300000
*
$=================================================================
==
*control variables to calculate total power transfered in precooler
*
20503200  pc_hQ1  sum  1.0  -152171632. 1
20503201  0.0     1.0 q  530010000  1.0 q  530020000  1.0 q  530030000
20503202  1.0 q  530040000  1.0 q  530050000  1.0 q  530060000  1.0 q
530070000
20503203  1.0 q  530080000  1.0 q  530090000  1.0 q  530100000  1.0 q
530110000
20503204  1.0 q  530120000  1.0 q  530130000  1.0 q  530140000  1.0 q
530150000
20503205  1.0 q  530160000  1.0 q  530170000  1.0 q  530180000  1.0 q
530190000
20503206  1.0 q  530200000
*
20503300  pc_cQ1  sum  1.0  152171632. 1
20503301  0.0     1.0 q  133010000  1.0 q  133020000  1.0 q  133030000
20503302  1.0 q  133040000  1.0 q  133050000  1.0 q  133060000  1.0 q
133070000
20503303  1.0 q  133080000  1.0 q  133090000  1.0 q  133100000  1.0 q
133110000
20503304  1.0 q  133120000  1.0 q  133130000  1.0 q  133140000  1.0 q
133150000
20503305  1.0 q  133160000  1.0 q  133170000  1.0 q  133180000  1.0 q
133190000
20503306  1.0 q  133200000
*
$=================================================================
==
*control variables to calculate total power transfered in inter-cooler
*
20503400  ic_hQ1  sum  1.0  -128865440. 1
20503401  0.0     1.0 q  570010000  1.0 q  570020000  1.0 q  570030000
20503402  1.0 q  570040000  1.0 q  570050000  1.0 q  570060000  1.0 q
570070000
20503403  1.0 q  570080000  1.0 q  570090000  1.0 q  570100000  1.0 q
570110000
20503404  1.0 q  570120000  1.0 q  570130000  1.0 q  570140000  1.0 q
570150000
20503405  1.0 q  570160000  1.0 q  570170000  1.0 q  570180000  1.0 q
570190000
20503406  1.0 q  570200000
*
20503500  ic_cQ1  sum  1.0  128865440. 1
```

```
20503501  0.0     1.0 q  143010000  1.0 q  143020000  1.0 q  143030000
20503502  1.0 q  143040000  1.0 q  143050000  1.0 q  143060000  1.0 q
143070000
20503503  1.0 q  143080000  1.0 q  143090000  1.0 q  143100000  1.0 q
143110000
20503504  1.0 q  143120000  1.0 q  143130000  1.0 q  143140000  1.0 q
143150000
20503505  1.0 q  143160000  1.0 q  143170000  1.0 q  143180000  1.0 q
143190000
20503506  1.0 q  143200000
*
*
$=================================================================
==
*control variables to calculate total power to compressor
*
*ctlvar  name  type  factor  init  f c  min  max
20503600  qrcl_1 mult  -1.0   130462160. 1
*
*ctlvar  v1   p1   v2    p2
20503601  cprtrq  550    cprvel  550
*
*ctlvar  name  type  factor  init  f c  min  max
20503700  qrch_1  mult  -1.0   126931640. 1
*
*ctlvar  v1   p1   v2    p2
20503701  cprtrq  580    cprvel  580
*
20503800  cpr1  sum  1.0  2.57394+8 1
20503801  0.0  1.0 cntrlvar 036  1.0 cntrlvar 037
*
20503900  cpr1pf sum 1.0 2.4e6 1
20503901  0.0  1.0  p  550010000  -1.0  cprhead 550
*
20504000  Rp1  div  1.0  1.8  1
20504001  cntrlvar 039  p 550010000
*
20504100  cpr2pf sum 1.0 4.5e6 1
20504101  0.0  1.0  p  580010000  -1.0  cprhead 580
*
20504200  Rp2  div  1.0  1.56  1
20504201  cntrlvar 039  p 580010000
.
```

11.3. APPENDIX C: TABLE OF PROPAGATED UNCERTAITY

	Roughness In the core	Valve 674 Leakage	Valve 665 Leakage	Heat Transfer Coefficient in Containment	Heat Transfer Coefficient in Core	Shaft Moment of Inertia
1	7.0266E-05	0.660972906	0.132791381	1.018099269	0.175240146	756.4283936
2	3.17861E-05	0.464606103	0.009216567	0.619031756	1.49147449	908.4799804
3	1.41968E-05	0.189936412	0.446353642	0.518304501	4.089563936	805.6640345
4	0.000165969	0.2247406	1.665210385	3.074084819	1.339039701	774.7889025
5	2.23325E-05	0.110839306	0.363779265	3.883312254	0.543303791	679.3242198
6	8.95976E-05	0.082665107	0.273528511	0.094501105	0.936337946	546.7819977
7	2.53847E-05	0.392584938	0.085119427	1.183833099	0.646817192	653.69233
8	4.4716E-05	0.032207799	0.215695098	1.643178094	0.376749072	723.5864463
9	5.38544E-05	0.607582295	0.156639456	1.772914465	1.793946565	597.3626375
10	7.85191E-05	0.302996778	0.042048843	0.277030229	2.391928364	732.6888426
11	3.85214E-05	0.17446045	0.09064391	4.829592916	0.293658031	703.6532569
12	8.47645E-06	0.140217132	0.220896755	0.42291142	0.864267335	759.3058686
13	5.91768E-05	0.058180793	0.70785134	0.838450117	0.465954267	696.1311388
14	2.84935E-05	0.012386872	0.534292341	2.266994934	1.104884296	823.2713509
15	1.82596E-05	0.337699928	0.348002328	0.745117621	0.761977965	846.9083615
16	0.000123131	0.890796357	0.023758162	1.333115501	0.429398495	633.8352274
17	7.08761E-06	0.066021338	0.127291225	11.24755112	1.596157589	841.0356824
18	1.10777E-05	0.099241677	0.061949683	1.369543295	1.013147351	770.1586118
19	0.000105528	0.529594859	0.189806486	0.948642402	0.727023454	749.8937713

20	4.31121E-05	0.74219072	0.114714985	3.263201796	1.224111492	890.9974519
21	0.000211663	0.03001568	0.069037775	0.210871326	0.676329216	739.7666992
22	1.92448E-05	0.202227439	0.985357812	0.905538264	1.170526951	644.3272329
23	3.40267E-05	0.263548363	0.178068757	0.803267482	3.684155094	626.2864629
24	4.96232E-05	0.498487678	0.238331675	0.468322129	0.095135605	720.8448245
25	0.00014868	0.043266545	0.286472444	2.184673244	0.802686297	807.6559167
26	1.71049E-05	1.190170101	0.512037361	1.487914895	0.242057146	693.869699
27	5.68576E-05	0.001891644	0.593915737	1.121569675	0.409672324	663.102377
28	2.34316E-05	0.422684746	0.321484425	0.347961093	2.105991987	795.8641541
29	3.63424E-05	0.127905542	0.852944013	0.689984288	0.511600116	712.7091911
30	6.49453E-05	0.256755913	0.422403824	2.608512339	0.328936234	684.2025295
31	8.00589E-05	0.158081862	0.017396258	1.921065859	0.574820132	782.6452305
32	2.91641E-05	0.330425174	0.039769783	0.542943227	1.919305918	589.7391975
33	4.68492E-05	0.641145484	0.678139931	0.770016585	0.25968491	812.7976894
34	9.93625E-05	0.80248295	0.911992663	1.061765697	2.910536583	675.4663903
35	8.51434E-05	0.154193833	0.30223248	1.397918526	0.889602906	659.5673134
36	5.12343E-05	0.084045934	0.333844337	0.303841247	0.792966876	825.8242815
37	7.10865E-05	0.480768573	1.230679167	1.908661706	1.247906264	735.2691428
38	0.000111937	0.23343891	0.163818188	0.811362806	0.152467084	766.0256004
39	2.0305E-05	0.136108256	0.490839118	1.721271504	0.397270165	691.1926356
40	9.97261E-06	0.994760314	0.561209485	2.350701033	0.999122583	680.3988408
41	2.17877E-05	0.187909689	0.24745941	3.571845903	0.4874615	698.6515597

42	1.48581E-05	0.244850439	0.183940052	1.239715178	1.684962153	834.5824853
43	4.71902E-05	0.282812486	0.202202188	0.358308616	2.057624559	744.2958614
44	3.09792E-05	0.403472191	0.793651269	6.032402101	0.698321791	753.7330773
45	7.38153E-05	0.060647096	0.629844302	0.71082589	0.956883392	727.6012104
46	0.00020055	0.071397709	0.082152443	2.507926869	1.142414957	919.8463003
47	2.77006E-05	0.104256214	0.153300021	5.406115063	8.141160654	717.6353089
48	3.98161E-05	0.700051648	0.001308486	0.884653856	1.560774312	568.5798634
49	4.62055E-06	0.315619703	0.383399114	1.591284501	0.631478997	649.990263
50	1.61458E-05	0.00693723	0.46147984	1.291044363	2.286157212	620.3083227
51	6.56956E-05	0.17005815	0.231037463	1.54223527	1.041974271	614.5442327
52	6.14829E-05	0.018504666	0.012842897	4.001604887	0.361890083	787.9536835
53	2.61785E-05	0.022433357	0.316280157	0.660842505	0.344565861	764.3418628
54	0.000267854	1.442496364	0.054688522	0.394960618	0.276108579	506.9498172
55	1.24528E-05	0.361764165	0.118231636	0.250464186	0.831776376	709.2587003
56	0.000133637	0.117707471	0.100020368	0.575748717	0.455933376	798.5982391
57	2.46989E-05	0.094621349	0.03588993	2.021533534	1.386404602	640.4817296
58	5.5652E-05	0.049276257	0.258345944	0.605107028	0.212640618	670.8181273
59	1.74366E-05	0.449463712	0.142381726	1.115250099	0.524400738	792.6038844
60	3.79521E-05	0.038705296	0.075183345	0.181204116	0.560520061	740.1853296
61	9.74176E-05	0.272326653	0.106640922	0.484303178	2.635348042	857.0121359
62	4.16683E-05	0.210614439	0.051236791	0.997587303	0.70547236	870.6038543
63	3.56232E-05	0.574585443	0.406903451	2.757981398	0.608032193	776.9877291

64	3.30958E-05	0.374395138	0.028567636	0.443542793	1.406811368	714.4770836
65	2.44393E-05	0.03892315	0.037643374	1.826227042	0.743613759	790.4907116
66	3.26663E-05	0.429736516	0.073220858	2.374057349	0.66304439	762.5381162
67	0.000119456	0.853064915	0.110295296	2.700746814	0.350313969	697.3852592
68	4.24467E-05	0.163285009	0.057242128	0.163381672	0.44344617	667.9643603
69	6.11709E-05	0.182661765	0.194803481	0.323280366	0.289654677	819.3971924
70	1.44549E-05	0.177547568	0.031614643	1.255017446	0.4822816	754.0690469
71	3.96156E-05	0.294931273	0.663103609	0.515879692	0.118911905	810.9794981
72	1.63018E-05	0.292796158	0.396770153	4.520676725	0.756463197	605.3773675
73	9.44872E-05	0.05127336	0.294894594	1.217860942	3.045780555	881.102285
74	1.35938E-05	0.562509747	0.095951235	1.060178579	2.559356379	786.2160539
75	1.56751E-05	0.069275548	0.327920832	2.203124185	0.336998293	750.443934
76	9.2457E-05	0.220260843	0.264218317	0.386888355	0.92479469	771.8319671
77	3.50952E-05	0.321362252	1.155321411	0.787872797	1.950232297	773.9635894
78	5.46275E-05	0.089781232	0.160602313	1.744233057	0.903230525	667.0187805
79	4.80789E-05	0.21184961	0.357060873	1.430553609	0.62257917	726.377878
80	1.19785E-05	0.348104379	0.060423816	1.51025574	1.281580227	901.8600227
81	2.29841E-05	0.078958706	0.066758276	0.921965926	0.549252891	689.3581492
82	5.76447E-05	0.109910569	0.207762362	0.234382257	0.418804468	542.6183457
83	4.8909E-05	0.312370023	0.477193119	2.429644306	0.588941377	779.4032731
84	4.05737E-05	0.387344337	0.828494585	1.564471368	1.629139496	566.0462942
85	9.09296E-06	0.015774464	0.138237619	1.312702309	1.306318855	780.6770487

86	7.22034E-05	0.491041341	0.006652834	1.360475912	0.870487068	646.5550358
87	7.62102E-05	0.405617924	0.018203018	1.464275245	0.217787688	631.2502285
88	8.1427E-06	0.198004657	0.341567074	0.218745727	1.350890534	829.7959148
89	6.33097E-05	1.066584672	0.393328526	3.731597047	1.756550384	736.7537934
90	1.07823E-05	0.063723513	1.027471598	1.087912879	0.600179238	618.2618736
91	3.42523E-05	0.026950605	0.281080473	2.933790801	1.542390549	661.3841643
92	3.00196E-05	0.238012053	0.143020405	0.639826242	1.131315686	723.0224825
93	0.000129871	0.124871384	1.416088806	0.328154832	0.252036602	607.7127042
94	0.000154807	1.640795395	0.174494136	0.698446807	1.458026427	687.2560797
95	5.83034E-05	0.114459764	0.548945478	4.244041273	0.30499423	691.5167995
96	2.08798E-05	0.054269715	0.049615326	0.969358208	0.158179792	745.988633
97	4.6118E-05	0.046090401	0.72803977	0.431048625	0.228051476	719.5882072
98	3.19744E-05	0.123509661	0.378526192	5.066997272	1.194993691	730.2204229
99	0.000109476	0.091293959	0.202069973	0.28116126	2.718226393	828.5424988
100	0.000101622	0.162009876	0.021353242	1.178274754	2.191621088	866.6712278
101	0.000117389	0.197024004	0.089317371	0.632726739	1.862677253	682.3440286
102	1.81686E-05	1.116133243	0.631878624	0.50362288	0.476034599	706.2820555
103	0.000140123	0.3694106	0.123210426	2.116812651	3.350699786	676.6710866
104	2.35482E-05	0.231032974	0.045327924	3.093001052	0.437834921	700.4461747
105	0.000184661	0.00341441	0.011420538	1.036389138	0.951400214	800.1570805
106	0.000350929	0.007558315	0.752383237	2.849447745	1.031748519	840.016604
107	3.66486E-05	0.034792339	0.148018768	1.838354829	1.068334272	704.8611658

108	5.27417E-05	0.267794393	0.166937809	0.722632293	2.239221847	742.5520429
109	2.72498E-05	0.438173699	0.310950321	1.687224992	0.528280225	652.8748077
110	8.64598E-05	0.689489885	0.078987467	0.414106752	0.846720021	638.5343373
111	5.76494E-06	0.720264048	0.567437747	0.954076081	0.388809242	710.7008624
112	2.59569E-05	0.45873879	0.500676834	2.066317956	0.777648147	578.8421024
113	2.89684E-05	0.076801692	0.288628703	3.448935736	0.49654075	803.3525057
114	1.87046E-05	0.014315049	0.432706689	7.888527292	0.653884589	767.0671491
115	2.68496E-05	0.589125745	0.003257401	0.567182096	0.689344201	758.0042827
116	5.1259E-05	0.144203165	0.610120945	0.756656021	0.972753315	862.1368141
117	8.27308E-05	0.622005761	0.252690176	0.893303892	4.6458655	793.8374791
118	3.06792E-05	0.544848006	0.105402894	0.371657756	0.823148669	595.2374457
119	0.000242648	0.100470863	0.232242065	0.463772479	0.372780363	952.8508248
120	2.12095E-05	0.771453316	0.245206874	0.555995609	0.312550768	729.8084907
121	3.77208E-05	0.147013488	0.890147715	0.135454779	1.435246354	627.4004514
122	6.81034E-05	0.248773951	0.027479927	0.86335716	1.078165163	672.4727793
123	4.45943E-05	0.511529166	0.466634545	1.983037627	5.38763593	851.0149522
124	1.27816E-05	0.951530839	0.098224977	0.831457732	1.197266703	747.4191242
125	7.78064E-05	0.132872215	0.221597428	0.675599703	0.566604491	733.6726776
126	6.6777E-05	0.022776219	0.188431304	7.610320216	0.717407639	714.6749388
127	1.97961E-05	0.34663953	0.433029247	1.158006383	1.743479501	816.8852588
128	4.36691E-05	0.276821361	0.131480541	0.594252985	0.197257333	656.443749

11.4. *APPENDIX D: UTILIZED ALGORITHMS*

All algorithms that are present here are for MATLAB® 7.0. They have not been tested on previous versions of the software. They are presented as a series of steps required to finally get the number of failures for each evaluated failures mode. The first algorithm that is presented was used to create the sample offered in Appendix C.

```
function x = LHS(n,v,N,iter)

% x = LHS(n,v,N,iter)
% Creates a Latin Hypercube Sampling x of length n*2^N of v variables
uniformly distributed
% on the interval [0 1] and tries to improve it over iter iterations,
maximizing the minimum
% point-to-point difference.
%
% The resulting vector x can be seen as a composition of LHS samples [0
n], [0
% n*2], ..., [0 n*2^N]
J = 1;
for j=1:iter
    clc;
    j
    J
    X = getsample(n,v,'on',zeros(1,v));
    for i=1:N
        Y = ceil((n*2^i)*X);
        Z = getsample(n*2^i,v,'on',Y);
        X = cat(1,X,Z);
    end
    S = score(X,'maximin');
    if j==1
        s = S;
        x = X;
    elseif (s-S)<0
        s = S;
        J = j;
        x = X;
    end
end
% ------------------------------------------
function x2 = getsample(n,p,dosmooth,except)
for j=1:100
    x = rand(n,p);
    for i=1:p
        x1(:,i) = rank(x(:,i),except(:,i));
    end
    x = x1;
    if isequal(dosmooth,'on')
        x = x - rand(size(x));
```

```
    else
        x = x - 0.5;
    end
    X = x / n;
    S = score(X,'maximin');
    if j==1
        s = S;
        x2 = X;
    elseif (s-S)<0
        s = S;
        x2 = X;
    end
end

function r=rank(x,except)

% Similar to tiedrank, but no adjustment for ties here
[sx, rowidx] = sort(x);
r(rowidx) = 1:length(x);
r = r(:);
for i=1:length(except)
    r = r - except(i);
    r = nonzeros(r);
    r = r + except(i);
end

function s = score(x,crit)
% compute score function, larger is better

if size(x,1)<2
    s = 0;        % score is meaningless with just one point
    return
end

switch(crit)
 case 'correlation'
   % Minimize the sum of between-column squared correlations
   c = corrcoef(x);
   s = -sum(sum(triu(c,1).^2));

 case 'maximin'
   % Maximimize the minimum point-to-point difference
   % Get I and J indexing each pair of points
   [m,p] = size(x);
   pp = (m-1):-1:2;
   I = zeros(m*(m-1)/2,1);
   I(cumsum([1 pp])) = 1;
   I = cumsum(I);
   J = ones(m*(m-1)/2,1);
   J(cumsum(pp)+1) = 2-pp;
   J(1)=2;
   J = cumsum(J);

   % To save space, loop over dimensions
   d = zeros(size(I));
```

```
    for j=1:p
        d = d + (x(I,j)-x(J,j)).^2;
    end
    s = sqrt(min(d));
end
```

The output of this function was then saved in a Matlab® data file called Sample2.mat. The following task is to create the set of RELAP5-3D® input decks corresponding to each realization of the sample. The following algorithm takes the data saved in Sample2.mat and creates each input deck from the nominal case saved on file Final36.i

```
clear
clc

load Sample2;

lookfor = cell(15,1);
lookfor{1} = '2500801 ';
lookfor{2} = '2510801 ';
lookfor{3} = '2100101 ';
lookfor{4} = '2110101 ';
lookfor{5} = '2900101 ';
lookfor{6} = '2910101 ';
lookfor{7} = '6880202 ';
lookfor{8} = '6870202 ';
lookfor{9} = '10701801';
lookfor{10} = '10702801';
lookfor{11} = '10703801';
lookfor{12} = '12501901';
lookfor{13} = '12501902';
lookfor{14} = '12501903';
lookfor{15} = '12501904';
lookfor{16} = '12501905';
lookfor{17} = '12501906';
lookfor{18} = '12501907';
lookfor{19} = '12501908';
lookfor{20} = '12511901';
lookfor{21} = '12511902';
lookfor{22} = '12511903';
lookfor{23} = '12511904';
lookfor{24} = '12511905';
lookfor{25} = '12511906';
lookfor{26} = '12511907';
lookfor{27} = '12511908';
lookfor{28} = '0620101 ';
lookfor{29} = '20560001';

cont = 1;
fon = fopen('Final36.i');

while feof(fon)<1
    C{cont} = fgetl(fon);
    cont = cont + 1;
end
fclose(fon);
```

```
for i=1:256
    fid =
fopen(strcat('[illegible]Trial_',num2str(i),'[illegible]'),'w+');
    for j=1:length(C);
        line = C{j};
        if length(line)>=8;
            switch line(1:8)
                case
{lookfor{1},lookfor{2},lookfor{3},lookfor{4},lookfor{5},...
                        lookfor{6}};
                    value = '1.0e-5 ';
                    line = strcat(line);
                    line = strrep(line, value, sprintf('%0.5g   ',
Sample{2,1}(i)));
                    fprintf(fid,'%s\n',line);
                case lookfor{7};
                    value = '0.15 ';
                    line = strcat(line);
                    line = strrep(line, value, sprintf('%0.5g   ',
Sample{2,2}(i)'));
                    fprintf(fid,'%s\n',line);
                case lookfor{8};
                    value = '0.15 ';
                    line = strcat(line);
                    line = strrep(line, value, sprintf('%0.5g   ',
Sample{2,3}(i)));
                    fprintf(fid,'%s\n',line);
                case {lookfor{9},lookfor{10},lookfor{11}};
                    value = '1.0 ';
                    line = strcat(line);
                    line = strrep(line, value, sprintf('%0.5g   ',
Sample{2,4}(i)));
                    fprintf(fid,'%s\n',line);
                case
{lookfor{12},lookfor{13},lookfor{14},lookfor{15},lookfor{16},...
                        lookfor{17},lookfor{18},lookfor{19}};
                    value = '1.0 ';
                    line = strcat(line);
                    line = strrep(line, value, sprintf('%0.5g   ',
Sample{2,5}(i)));
                    fprintf(fid,'%s\n',line);
                case
{lookfor{20},lookfor{21},lookfor{22},lookfor{23},lookfor{24},...
                        lookfor{25},lookfor{26},lookfor{27}};
                    value = '1.0 ';
                    line = strcat(line);
                    line = strrep(line, value, sprintf('%0.5g   ',
Sample{2,5}(i)));
                    fprintf(fid,'%s\n',line);
                case lookfor{28};
                    value = '1.00 ';
                    line = strcat(line);
                    line = strrep(line, value, sprintf('%0.5g   ',
Sample{2,6}(i)));
                    fprintf(fid,'%s\n',line);
                case lookfor{29};
```

```
                    value = '729.867 ';
                    line = strcat(line);
                    line = strrep(line, value, sprintf('[illegible]',
Sample{2,7}(i)));
                    fprintf(fid,'%s\n',line);
                otherwise
                    fprintf(fid,'%s\n',line);
            end
        else
            fprintf(fid,'%s\n',line);
        end
    end
    fclose(fid);
end
```

Then every case is simulated. After that, the following algorithm imports the data from the simulation output file (e.g. Trial_N.p) to Matlab® environment and saves it into Results.mat as variables called Trial_N.

```
for k=1:128;
    varname = genvarname(['Trial_',num2str(k)]);
    target = ['C:\r5\r3d236le\relap\Thesis\Trial_',num2str(k),'.p'];
    final = ['[' ,varname, ' headings]=cntrlvar(target);'];
    eval([final]);
    save('Results', varname, '-APPEND');
    clear(varname, 'headings');
    k
end
```

The output of function cntrlvar() is a matrix where each column is a vector containing the time evolution of one parameter of the system. The name of the corresponding parameter is saved in the respective element index of vector "headings". The cntrlvar() function is the following:

```
function [cntrl, headings]=cntrlvar(file)

u = 0;
up = 0;
count = 1;
matrix = -1;
flag = 0;


% Calculating number of sections in MINOR EDIT
fid = fopen(file);
while feof(fid)<1
    line = fgetl(fid);
    if length(line)>=12
        if line(1:12) == '  MINOR EDIT'
            flag = flag + 1;
        end
    end
    if flag == 1 & isempty(line)
        flag = 0;
```

```
            break;
        end
        if flag == 1
            if line(1:6) == '1 time'
                up = up + 1;
            end
        end
end
sections = up;
flag = 0;
fclose(fid);


% Calculating number of columns in last section
fid = fopen(file);
flag2 = 0;
up = 0;
while feof(fid)<1
        line = fgetl(fid);
        if length(line)>=12
            if line(1:12) == '  MINOR EDIT'
                flag = 1;
            end
        end
        if flag == 1
            if line(1:6) == '1 time'
                head1 = line;
                head2 = fgetl(fid);
                head3 = fgetl(fid);
                head4 = fgetl(fid);
                up = up + 1;
                flag2 = 1;
            end
            if flag2 == 1;
                head{up*4-3,1} = head1;
                head{up*4-2,1} = head2;
                head{up*4-1,1} = head3;
                head{up*4,1} = head4;
                flag2 = 0;
            end
            if up == sections & flag == 1 &
not(isempty(str2num(line(1:14))))
                leng = length(line);
                flag = 0;
                break;
            end
        end
end
switch leng
        case 27
            lastsecthead = 1;
        case 40
            lastsecthead = 2;
        case 53
            lastsecthead = 3;
        case 66
```

```
            lastsecthead = 4;
        case 79
            lastsecthead = 5;
        case 92
            lastsecthead = 6;
        case 105
            lastsecthead = 7;
        case 118
            lastsecthead = 8;
        case 131
            lastsecthead = 9;
end
headings{1,1} =
cat(2,head{1,1}(1:14),head{2,1}(1:14),head{3,1}(1:14),head{4,1}(1:14));
for i=1:sections-1
    for j=1:9
        headings{1,1+(i*9)-(9-j)} = cat(2,head{i*4-3}(15+13*(j-
1):15+13*j-1),...
            head{i*4-2}(15+13*(j-1):15+13*j-1),...
            head{i*4-1}(15+13*(j-1):15+13*j-1),...
            head{i*4}(15+13*(j-1):15+13*j-1));
    end
end
for i=sections:sections
    for j=1:lastsecthead
        headings{1,1+(i*9)-(9-j)} = cat(2,head{i*4-3}(15+13*(j-
1):15+13*j-1),...
            head{i*4-2}(15+13*(j-1):15+13*j-1),...
            head{i*4-1}(15+13*(j-1):15+13*j-1),...
            head{i*4}(15+13*(j-1):15+13*j-1));
    end
end
flag = 0;
fclose(fid);

% Acquiring data
fid = fopen(file);
while feof(fid)<1
    line = fgetl(fid);
    if length(line)>=12
        if line(1:12) == '  MINOR EDIT'
            flag = 1;
        end
    end
    if isempty(line)
        flag = 0;
    elseif length(line) >= 33
        if line(1:33) == '1RELAP5-3D/ATHENA/SCDAP Ver:2.4.1'
            flag = 0;
        end
    end
    if length(line) >= 7
        if line(1:7) == '0******'
            flag = 0;
        end
    end
    if flag == 1 & line(1:6) == '1 time'
```

```
      u = u + 1;
      if u == sections + 1;
          u = 1;
      end
    end
    if flag == 1 & length(line) > 14 &
not(isempty(str2num(line(1:14))));
        if max(matrix(:,1))<str2num(line(1:14))
            matrix(count,1)  = str2num(line(1:14));
            matrix(count,2)  = str2num(line(15:27));
            matrix(count,3)  = str2num(line(28:40));
            matrix(count,4)  = str2num(line(41:53));
            matrix(count,5)  = str2num(line(54:66));
            matrix(count,6)  = str2num(line(67:79));
            matrix(count,7)  = str2num(line(80:92));
            matrix(count,8)  = str2num(line(93:105));
            matrix(count,9)  = str2num(line(106:118));
            matrix(count,10) = str2num(line(119:131));
            count = count + 1;
        elseif u == sections
            x = find(matrix(:,1) == str2num(line(1:14)));
            y = (u-1)*9 + 2;
            if lastsecthead >= 1
                matrix(x,y)      = str2num(line(15:27));
                if lastsecthead >= 2
                    matrix(x,y+1)  = str2num(line(28:40));
                    if lastsecthead >= 3
                        matrix(x,y+2)  = str2num(line(41:53));
                        if lastsecthead >= 4
                            matrix(x,y+3)  = str2num(line(54:66));
                            if lastsecthead >= 5
                                matrix(x,y+4)  = str2num(line(67:79));
                                if lastsecthead >= 6
                                    matrix(x,y+5)  =
str2num(line(80:92));
                                    if lastsecthead >= 7
                                        matrix(x,y+6)  =
str2num(line(93:105));
                                        if lastsecthead >= 8
                                            matrix(x,y+7)  =
str2num(line(106:118));
                                            if lastsecthead >= 9
                                                matrix(x,y+8)  =
str2num(line(119:131));
                                            end
                                        end
                                    end
                                end
                            end
                        end
                    end
                end
            end
        else
            x = find(matrix(:,1) == str2num(line(1:14)));
            y = (u-1)*9 + 2;
            matrix(x,y)      = str2num(line(15:27));
```

```
                matrix(x,y+1)   = str2num(line(28:40));
                matrix(x,y+2)   = str2num(line(41:53));
                matrix(x,y+3)   = str2num(line(54:66));
                matrix(x,y+4)   = str2num(line(67:79));
                matrix(x,y+5)   = str2num(line(80:92));
                matrix(x,y+6)   = str2num(line(93:105));
                matrix(x,y+7)   = str2num(line(106:118));
                matrix(x,y+8)  = str2num(line(119:131));
            end
        end
end
cntrl = matrix;
fclose(fid);
```

After the data is imported and saved, the analysis starts. The following algorithm tests a certain parameter against a given limit and returns a vector "Failures", with a "0" if a realization was a success or a "1" if it was a failure when compared to the limit. The realization number corresponds to the indices of the "Failures" vector. The algorithm also plots time evolutions of the parameter for all realizations in the sample.

```
Trial = whos('-file','Results','Trial*');
Longitud = length(Trial);
Failures = zeros(128,1);
limit = 1600 % in celcius
for i=1:Longitud;
    load('Results',Trial(i).name);

eval(['plot(',Trial(i).name,'(:,1),max(',Trial(i).name,'(:,78),',Trial(
i).name,'(:,79)))']);
    hold on;
    L = eval(['length(',Trial(i).name,'(:,78))']);
    x =
eval(['max(max(',Trial(i).name,'(200:L,78)),max(',Trial(i).name,'(200:L
,79)))']);
    Name = Trial(i).name;
    if x>(limit+273.15);
        Name = Trial(i).name;
        Index = str2num(Name(7:length(Name)));
        Failures(Index,1) = 1;
    end
    clear(Trial(i).name);
end
```

The complete set of data structures generated by these algorithms provide then the necessary framework for the required further analysis.