RISK-INFORMED DESIGN CHANGES FOR A PASSIVE COOLING SYSTEM

by

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Submitted to the Department of Nuclear Science and Engineering in
Partial Fulfillment of the Requirements for the Degree of
Master of Science in Nuclear Science and Engineering

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

September 2007

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ABSTRACT

The failure probability of a passive decay heat removal system after a LOCA is evaluated as part of a risk-informed design process for a helium-cooled fast reactor. The system was modeled using RELAP5-3D. The epistemic uncertainties in input parameters as well as the epistemic model uncertainties in the code were assessed and propagated through the model using Latin hypercube sampling. The changes in the design that we investigated reduced the overall failure probability of the system by reducing the impact of the major contributor to the failure probability. Sensitivity analyses led to two unexpected results. First, the key factors affecting the system failure probability are the location of the thermal insulation (inside or outside the hot leg) and the uncertainty in the insulation thermal conductivity. Second, the heat transfer coefficient in the core is not as important as one might expect. Our results show that the heat transfer coefficient in the containment structures is more important. Different methods for sensitivity analysis were applied and gave consistent results.

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ACKNOWLEDGMENT

I am really thankful to my advisor, Prof. Apostolakis, for his guidance, support and advice. Also thanks to Dr Pavel Hejzlar and Professor Driscoll for their helpful assistance.
I would also like to thank those friends who helped me in so many different ways during this wonderful time spent here.
All my gratitude goes to the person without whom this work wouldn't have been possible, thanks for your constant presence, Rossella! Also the greatest thanks to my mom and my dad: I owe you so much! This is for you, my dear little sister, Federica. All my efforts are for you.

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I. INTRODUCTION

Of particular promise in terms of improving the reliability for new nuclear plant designs is the use of passive systems that rely on natural phenomena such as gravity, convection, and conduction. The relevant forces are generally weak and, as a result, passive systems are more sensitive to small changes in their environment [1]than active systems.

The concept of passive function failure has been introduced in [2] as the probability that a system will fail to perform its function, i.e., failure occurs when the "capacity" of the system is exceeded by the "load" imposed on the system. Whenever the load exceeds the capacity the system no longer behaves as expected. The load is represented by a set of measurable parameters of the system (e.g., temperature in the fuel, pressure in the pipes) and the capacity is the limit those parameters should not exceed. Reference [3] outlines a systematic approach to the evaluation of the reliability of a passive system.

There are two major sources of uncertainty affecting our ability to predict the exact values of loads and capacities. The first type of uncertainty is due to the fact that we do not know the exact value of each input parameter. We can only assume a range of values and a corresponding probability distribution. Second, there are uncertainties due to the model we use to simulate the behavior of the system. These uncertainties are related to the inevitable approximations in the constitutive equations, to the numerical solution methods built in the codes, and other computational possible errors [4]. These uncertainties are usually called epistemic uncertainties to distinguish them from the aleatory uncertainties that refer to the random occurrence of events such as loss of coolant accidents (LOCAs) [5].

Probabilistic Safety Assessment (PSA) is a powerful tool that allows us to identify potential accident scenarios and to estimate their probabilities of occurrence over a defined time period. Originally, PSA was primarily used to measure the level of risk associated with an operating facility. More recently, the value of PSA as an important contributor to the design process has been recognized [6-7]. In this paper, PSA is used to guide the designer by comparing different designs and evaluating the risk for each design.

This work presents an example of a risk-informed design change and the evaluation of the failure probability of a passive decay heat removal system after a LOCA including epistemic uncertainties due to both input parameters and the best estimate code used. It also provides the time-dependent reliability of the passive system. In this application, failure limits are fixed values with no uncertainties. We only consider uncertainties on the "loads".

The 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. The computational effort was significant because the complexity of the system required long simulation times (up to 10 hours). The entire system operates as one passive system whose initiation is triggered by the reactor scram after a LOCA. Section II describes the system.

An overview of the methodology is given in Section III. The analysis is presented in Section IV. The reliability evaluation is in Section IV. Finally, conclusions on various aspects of the work and future research suggestions are provided in Section V.

II. GFR SYSTEM DESCRIPTION

II.A. Basic Design

The GFR design that we use [8] consists of a 600 MW_{th} helium-cooled fast reactor core inside the Pressure Vessel (PV), a Brayton power cycle within the Power Conversion Unit (PCU), and two 100% Decay Heat Removal (DHR) loops.

As shown in Figure 1, the PCU has a vertical arrangement and is connected to the reactor vessel through a coaxial duct. The PCU consists of three different kinds of components: the turbine, compressors, and heat exchangers.

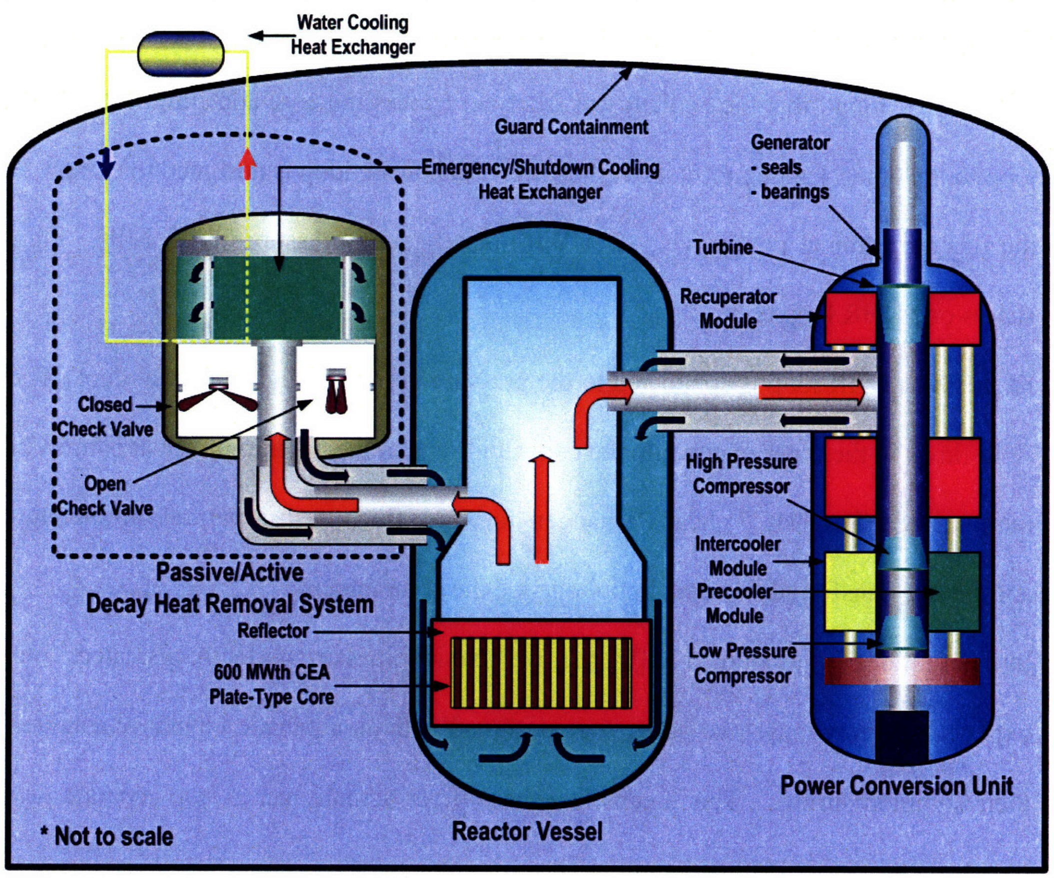

Figure 1 Schematic diagram of GFR systems. Reactor Vessel, PCU and one DHR loop are shown.

The core design is based on a early fully passive Commissariat à l'Energie Atomique (CEA) design [8]; it employs CERCER 70/30 plate type technology in order to reach higher outlet temperatures. The core is designed to have a very low pressure drop to maximize the natural circulation capability.

All these systems are protected by a guard-containment at high design pressure (2 MPa). Since in a LOCA accident scenario the system is depressurized, the high guard-containment pressure is intended to provide sufficient backup pressure to sustain the natural circulation in the DHR loops.

The passive decay heat removal system relies on natural circulation of the gas coolant flowing between the low pressure-drop core and gas/water heat exchangers placed at higher elevation and it does not rely on any active safety systems. The initial design consisted of two 50% DHR loops, working in parallel; this configuration was modified [9] since it was found that the coolant was likely to bypass the core and flow from one DHR loop to the other, leading to fuel overheating. Each DHR loop is designed to extract 2% of the reactor nominal power (i.e., 12 MWth) at a backup pressure of 1.3 MPa. Figure 1 shows one DHR loop only.

Each 100% DHR loop is connected to the pressure vessel through a coaxial duct. The hot fluid flows in the inner duct while the cool fluid runs in the outer duct. Heat is transferred, through the HEATRIC™ heat exchanger, to water flowing in a natural circulating loop and finally transferred to a water pool outside the containment.

In this first design, as studied in [9], the two coaxial pipes are perfectly insulated. We will explain later how these two pipes were designed with an adiabatic boundary condition on their common surface. This means that these pipes actually act as two separate pipes in the ideal case of perfect insulation.

In normal operation, the DHR loops are kept closed by check valves that are located between the heat exchanger and the cold leg duct. During normal operation the compressor-driven flow from the main cross duct into the downcomer maintains higher pressure under the check valve keeping it shut and no flow proceeds through the DHR loop. In addition, the helium gas above the check valve is cooler since it is in contact with the water-cooled heat exchanger while the DHR hot leg (on the other side of the check valve), contains hot gas as it is in direct communication with the reactor upper plenum. After a LOCA and following the coastdown of the shaft, the compressor driven flow through the cross-duct stops, the pressure under the check valves is reduced and the check valves open due to a positive pressure differential between the cold and hot DHR legs. Note that the check valves cannot open until the compressor flow stops neither is it desirable to open the check valves before the shaft coasts down to prevent a reversed flow in the DHR loop.

II.B. Accident Scenario

Our transient analysis considers the consequences of a LOCA due to a small break on the cold leg that connects the PV to the PCU. We are interested in the conditional failure probability of the decay heat removal system after the LOCA occurs.

The system must be able to remove the core decay heat during the transient. The main issue is to verify that the backup pressure evolution in time is sufficient to extract the decay heat from the core. This evolution is driven by various parameters, e.g., the coolant heat exchange with the core and the containment structure – a phenomenon that becomes especially important after equilibrium backup pressure is reached.

The LOCA happens when the system is in a steady-state condition; therefore, the initial conditions for the transient analysis come from the steady-state initialization. Figure 2 shows the sequence of events and the resulting fuel temperature.

At time t = 0, the cold leg pipe connecting the PCU to the pressure vessel breaks and the turbine is shut off. Since this is a small break, only a portion of the gas will go through the break into the containment. The other fraction will continue to flow through the downcomer and to cool the core. Although the turbine is off, the shaft will keep turning for a certain time. During the coastdown of the shaft (region A in Figure 2), the PCU is the only cooling system removing decay heat from the core and the fuel temperature decreases due to higher heat removal capacity than power generated after reactor scram. This action lasts for about 10 minutes. In the meantime, the DHR loops are still closed, i.e., the check valves have not opened yet.

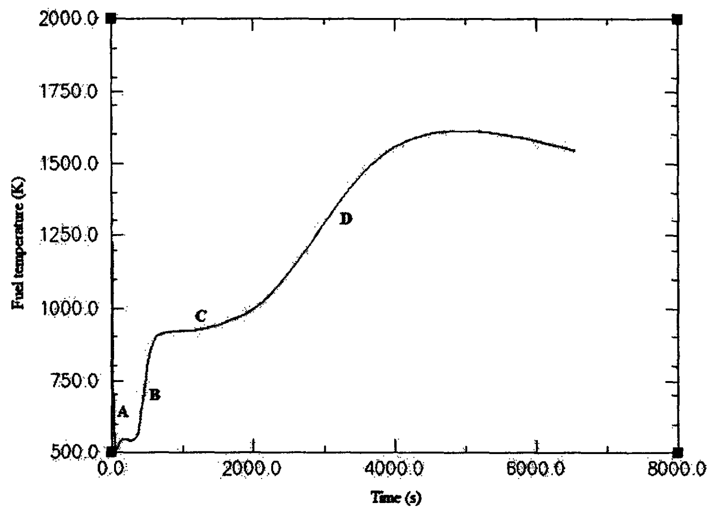

Figure 2 The fuel temperature as the accident scenario unfolds.

Region A corresponds to the shaft sill spinning; region B represnts the time during which the shaft is at a halt and DHR loops haven't opened yet; region C represents the time when DHR system is working; in region D DHR system removes heat at its backup pressure (1.3 MPa)

When the shaft stops, there is no cooling system working and the temperature in the fuel increases (region B). The stopped compressor flow eliminates the negative pressure differential across a check valve causing it to open due to the gravity head difference between the DHR cold and hot legs.

The system has two DHR loops; therefore, there are two check valves, one for each loop. The design is such that, when one valve opens, the other will stay closed and only one loop will be working. This is because the pressure loss through the emergency heat exchanger is significantly smaller than that in the core and one loop becomes a bypass (see

[9] for details) with reverse flow that shuts the check valves in that loop preventing backflow.

After one valve opens, the DHR loop starts removing heat from the core through the natural circulation of the coolant (region C). At first, the cooling system is oversized since it is working at a pressure higher than the backup pressure. Therefore, it is capable to remove almost all of the heat produced in the core, for that reason the fuel temperature has a plateau. As shown in Figure 3, the depressurization process ends in about 50 minutes, reaching the value of about 1.3 MPa. At this point, the outlet coolant temperature keeps rising until it reaches its operating condition (region D in Figure 2). However, the decay heat is below 12 MW_{th} and the system is able to remove that power at this level of backup pressure (see II.A).

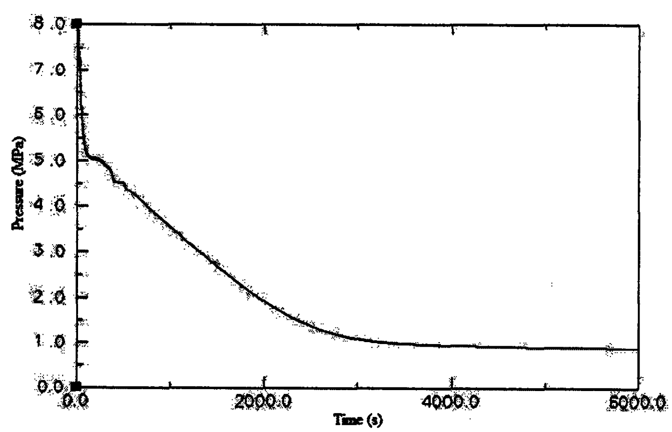

Figure 3 Pressure versus time in the DHR system; the operating condition is reached in about 50 minutes, when the curve reaches its plateau.

II.C. Success Criteria

The failure criterion can be established as a single value target, as a time dependent target, or as an integral value over the mission time [10]. As we stated in Section I, we only consider single-value criteria for the "capacity" of the system. In this case, the maximum fuel temperature should be below 1600 °C (1873.15 K) and the temperature in the DHR steel structure below 850 °C (1123.15 K). The first limit comes from the capability of this type of fuel to prevent significant escape of fission products at temperatures up to 1600 °C*. The second limit is related to the structural resistance of stainless steel used for the DHR hot duct pipes: the inner surface of the hot gas line is in contact with the gas and the duct must withstand the highest coolant temperature. Although probability distributions could be associated with those two limits, we view them as fixed regulatory limits.

II.D. Simulation Code

The RELAP5-3D code [11] was selected to predict the transient response of the GFR to the postulated scenario as well the steady-state performance under nominal conditions.

This code is a best-estimate thermal-hydraulic code developed to perform transient simulations of nuclear reactor cooling systems during postulated accidents. The code models the coupled behavior of the reactor coolant system and the core for LOCAs and operational transients such as anticipated transients without scram, loss of offsite power, loss of feed-water, and loss of flow.

The nodalization of the system in RELAP5-3D is shown in Figure 4. In this diagram, lines represent connections and rectangles represent fluid and structures. Block A represents the Power Conversion Unit; Blocks B1 and B2 are the water secondary loops; Block C is the reactor core; Blocks D1 and D2 are the DHR loops. The check valves connecting the DHR loops to the downcomer are circled. In parallel with the check valves, there are channels to simulate the valve leakages (counter flow).

The importance of including the structures in the simulation has been emphasized in [8]: the structures can store a large amount of energy and this energy is transferred later to the coolant with significant time delay. This is very important in the DHR steel structures; we

* The 1600°C limit was adopted for this study but this innovative GFR uranium carbide plate type fuel with silicon carbide cladding will require irradiation testing before a final limit can be established. The limit pertains to the fuel/cladding plate, but the term fuel limit will be used throughout this paper for simplicity.

will later see that this effect is the major contributor to the overall failure probability of the passive decay heat removal system.

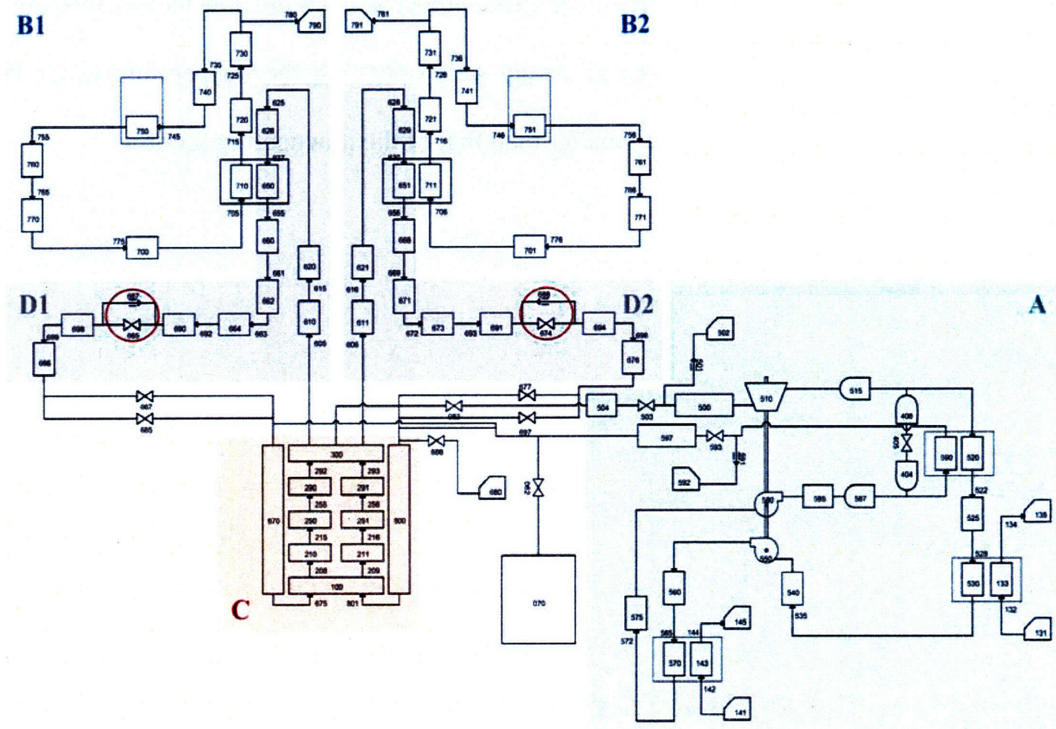

Figure 4 Nodalization of the entire system used in the RELAP5-3D

Also the heat structures in the containment are very important since they absorb heat brought into the containment by the coolant flowing through the break, and so they reduce the backup pressure available to sustain the natural circulation.

Check valves are critical hydrodynamic components; one characteristic is that they leak and sometimes they are designed to leak on purpose. As we have already said, this leakage is simulated by imposing connections which are kept open during the steady state; those connections close once check valves open. This effect of prolonged lead during normal operation was not simulated in this study. We assume that a valve starts leaking at the beginning of transient, i.e., each transient is initiated from the identical steady state conditions.

The leakage results in a small reversed coolant flow and in a reversed temperature profile along the loop, which may eventually prevent natural circulation from starting.

During steady state operation, a small backflow proceeds from the downcomer through the heat exchanger and after a prolonged steady state operation the temperature in the riser section of the DHR loop becomes smaller than that of the downcomer section.

III. METHODOLOGY OVERVIEW

The methodology we use to evaluate the reliability of passive systems is consistent with that of [3] and consists of the following steps:

Definition of the system, its mission and failure modes.

Identification of the source of uncertainties (epistemic uncertainties) and the important parameters, including the definition of specific failure criteria.

Quantification of uncertainties by selecting the appropriate distributions for the parameters. In some cases, the amount of data is limited and expert opinion is used.

Propagation of uncertainties via Monte Carlo simulation using a thermal-hydraulic model (e.g., RELAP5-3D).

Sensitivity analysis.

Evaluation of passive system unreliability to be used in the accident sequence analysis.

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IV. ANALYSIS

IV.A. Preliminary Design Evaluation

A first study on the MIT helium-cooled reactor was presented in [9]. From this point on, we will refer to the design presented in that paper as the basic design or the first design.

In that configuration, the dominant failure mode of the system was the structural failure of the DHR loop. A sensitivity analysis showed that check valve leakages were most important. An adiabatic boundary condition between the two coaxial DHR pipes was assumed, meaning that, for the purpose of that study, they were actually separated.

Some improvements to the system were suggested, such as relaxing the perfect insulation assumption between the two pipes by inserting insulation material on the inner side of the hot leg, combined with an increase in containment backup pressure in order to increase the mass flow rate in the DHR loop.

In our first analysis, we modified the design as suggested in the paper (i.e., insertion of insulation material between the hot and cold pipe) to assess whether this change led to a reduction in the failure probability of the passive system. At first, we did not change the backup pressure in the containment since its increase would affect the cost of the plant and this modification would be the last to make.

Figure 5 presents the different geometries we tested. The various simulations will be described and commented in the next sections.

Design A is the configuration of the basic design: the hot gas flows upward and the cold gas flows downward. The outer and inner ducts are connected by stainless steel but a perfect insulation condition was imposed in the RELAP5-3D code.

Design B is the configuration suggested in [9] as a possible improvement to reduce the system failure probability following a LOCA. The insulation material is placed on the inner side of the hot pipe. Its thickness was determined using two criteria: a constraint on the overall dimensions and thermal insulation efficiency.

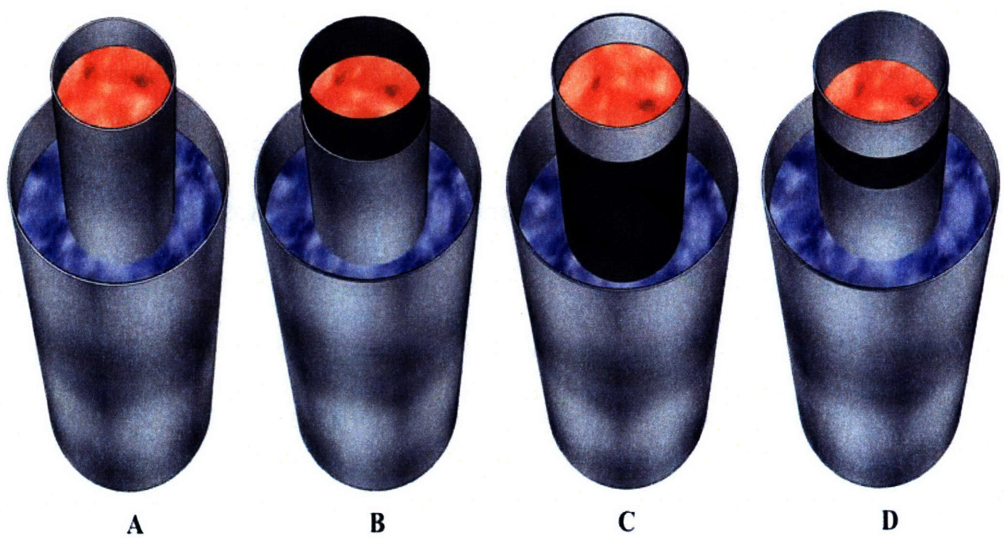

Figure 5 Different configurations for the DHR coaxial pipes; light gray: stainless steel; dark gray: insulation material.

For the second criterion, we evaluated the heat transferred from the fluid to the structure, and calculated the temperature in the steel. Figure 6 shows that the effectiveness of insulation decreases for thicknesses greater than 40 mm. Since this value was also reasonable for the design, we set it as a reference for the insulation thickness.

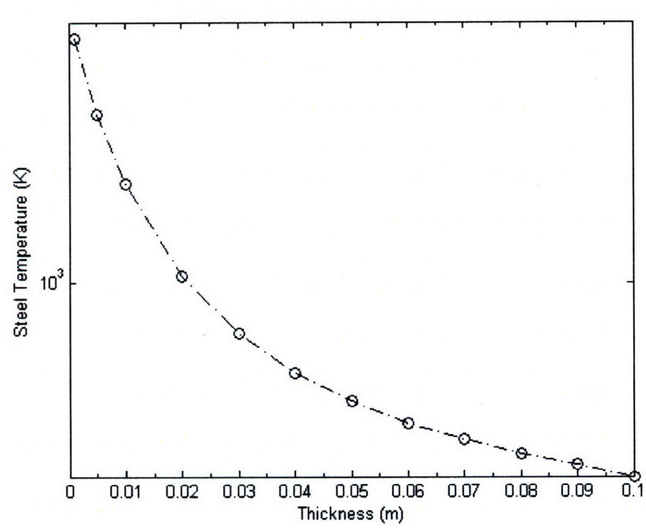

Figure 6 Temperature of stainless steel DHR hot leg pipe is plotted as function of the insulator thickness.

The results given in Figure 7 show that configuration B is worse than the basic configuration: by introducing the thermal insulation between the hot gas and the pipe we reduce the temperature burden on the steel structures but we prevent the gas from transferring heat to the pipe and vice versa.

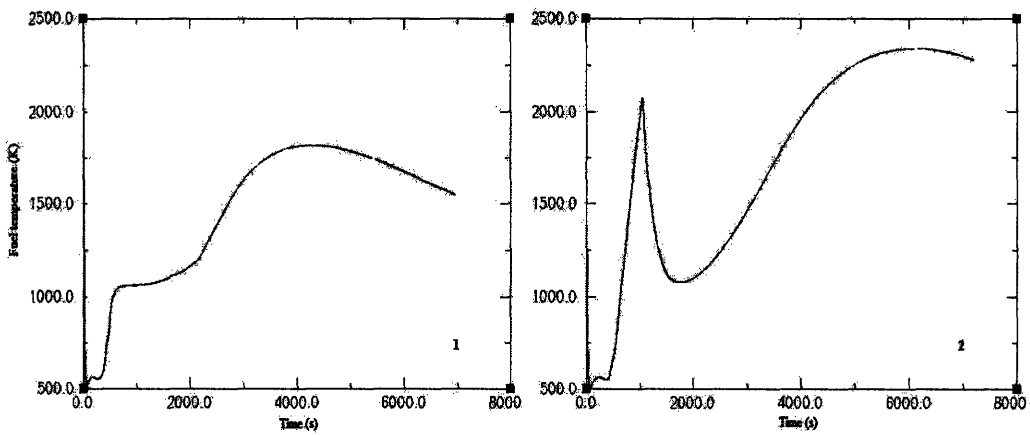

Figure 7 Fuel temperature for design configurations A and B.

The figure on the left corresponds to configuration A and the maximum temperature in the fuel is 1760 K. The figure on the right corresponds to configuration B and the maximum temperature in the fuel is 2250 K.

As discussed in Section II.B, this effect delays the opening of the valves (or may even prevent it) causing a high peak in temperature well above the limit. This is because the hot pipe wall of the hot leg stabilizes the hot-cold leg gas temperature difference necessary to initiate natural circulation. During the transient, a situation can occur in which the hot gas is pushed out of the hot leg and replaced by cooler gas. If the hot pipe wall, which has orders of magnitude higher heat capacity than helium gas is in direct contact with the gas, it can easily heat up gas to high temperature and reestablish desirable density difference between the hot and cold legs. Insulating the hot pipe wall on the inside prevents this rapid heat exchange and results in failure to open the check valve.

From this initial analysis, it seems that only an increase in backup pressure would be beneficial to the reliability of the system. However, before considering this option, we tried other configurations which turned out to be more effective for the system.

Design C shows the configuration where insulating material is placed on the outer surface of the hot leg pipe. This arrangement retains the benefit of stabilization of hot leg gas conditions by exposure to hot pipe walls and, in addition, the steel can now transfer some heat to the cool gas coming down in the cold leg pipe, so that the burden on the structure is partially released. On the other hand, the heat transferred to the cooler downcomer reduces slightly the temperature difference between the hot and cold legs decreasing somewhat the DHR loop flow rate. The overall benefit of this design is a reduced fuel temperature by more than 100 K, compared to design A.

Design D is a more realistic representation of the geometry. The insulation material is on the outer surface of the hot pipe but now it is covered by a 2.7 mm stainless steel foil. This foil prevents small particles from being detached and brought along in the loop by the gas causing damage to the structures or occlusions in the core channels. Design D will be analyzed further.

IV.B. Identification of Important Parameters

By important parameters, we refer to those parameters whose values are not known a priori and whose variability affects system performance. We identify them using expert judgment supported by sensitivity analyses. The probability distributions used for these parameters are listed in Table 1. A qualitative discussion of these parameters is given below.

Core roughness

In order to sustain the natural convection, the mass flow rate has to be high enough to remove enough heat from the core. An increase in core roughness results in an increase in the friction factor that eventually leads to a higher pressure drop. Roughness is an important parameter in natural circulation and its uncertainty must be considered. The ceramic plate type core proposed by CEA was chosen since it exhibited the best performance due to its small pressure drop.

Check valve leakage

The valve leakage results in a small reversed coolant flow affecting the temperature profile along the loop, which in turn impacts natural circulation flow and may eventually prevent natural circulation from starting. Experimental data for this parameter are very scarce in the literature, given the few facilities working with hot gas at these temperatures. For this particular parameter, expert opinions become even more important.

Moment of inertia of the shaft

We have already stated that the PCU shaft will keep turning for a certain time. The time the shafts stops determines the moment when DHR system starts running. The higher the moment of inertia, the longer the shaft spins and the later the DHR starts operating. In our study, as we will show later, we excluded this parameter from our analysis. In the next chapter, sensitivity calculations will show how this parameter does not affect the failure probability of the system.

Thermal conductivity

In Section I, we mentioned that in our study we introduced some changes in the geometry and we also introduced new elements. The initial design had coaxial pipes in the DHR loops. The perfect insulation (adiabatic) condition between the hot leg and the cold leg pipes made this configuration to look like separate pipes. To keep the coaxial configuration, we relaxed the adiabatic condition and we introduced some insulation material between the two pipes. The geometrical configuration will be explained in the next section. Here, we only discuss the new parameter we have introduced into our system, the thermal conductivity of the insulation material.

The state of the art [12] of designs for hot gas ducts and their insulations is incomplete with regard to very high temperature performance. The design parameters of the insulation depend strongly on the reactor type. Since the insulating material is in contact with a very hot medium, it has to meet stringent requirements. It must be able to withstand high pressure transients. Damage cannot be repaired because the insulation is installed in areas with difficult access. Ceramic materials seem to be the best option to insulate the hot duct from the cold duct. A range of values was extrapolated to high temperatures [13] and confirmed through expert opinion.

The importance of this parameter lies in the fact that it affects the DHR loop performance significantly. In the adiabatic case, the heat remained entirely in the steel structures of the DHR hot leg. In the present case, the small thermal conductivity of the insulation allows the hot pipe structure to transfer heat to the gas in the cold leg thus reducing the temperature load. This effect is balanced by a negative effect: if the thermal conductivity is too high, the hot gas would transfer heat to the cold gas thereby reducing the temperature differential that drives the natural circulation.

IV.C. MODEL UNCERTAINTY

We have already mentioned that due to unavoidable approximations in the code models, any calculation from a best estimate code, to be meaningful, needs an uncertainty evaluation. These best estimate codes have been developed for pumped circulation systems and their adequacy for natural circulation systems has not been demonstrated. Moreover, many of those best estimate codes have been developed for light water reactor applications and a benchmark comparison with experimental data must be done. Work has been carried out to compare experimental data to numerical predictions from

RELAP5-3D in a gas natural circulation loop [14]. This study shows that the heat transfer correlation for forced convection built in RELAP5-3D does not agree completely with the data. The new correlation developed at MIT demonstrates a better agreement with the data and shows that there is a substantial reduction in the heat transfer coefficient with respect to the previous correlation. This means that the value of the heat transfer coefficient resulting from the RELAP correlation formula, h_{RELAP}, should be adjusted. We do so by multiplying it by a factor ε [5]. This means that the heat transfer coefficient used in our calculations is actually $h = h_{RELAP} \cdot \varepsilon$. In our study, the model uncertainty in the heat transfer coefficient has been translated into an uncertainty in the multiplicative factor ε. The probability distribution of ε is given in Table 1.

Heat transfer coefficient in the core

The heat transfer coefficient is a function of fluid characteristic and system geometry and it is calculated with appropriate correlations. These correlations, built in the RELAP5-3D code, have been corrected with a multiplicative factor. Therefore, the uncertainty in the heat transfer coefficient was put in the multiplicative factor.

Heat transfer coefficient with containment structures

As for the previous parameter, we also use a multiplicative factor to account for uncertainty on the heat transfer to the structures in the containment. This model uncertainty is also justified by the fact that we only have a rough design of containment layout and we lack information about the precise amount of structures.

IV.D. Quantification of Uncertainties

In the previous section, we listed all the parameters considered as important contributors to uncertainty of the final result. Our state of knowledge regarding these uncertainties is expressed by (epistemic) probability density functions that represent parameter variability.

We used lognormal distributions for all parameters, except for the moment of inertia (though this parameter will not be considered in this study, as explained later). Table 1 shows the parameter ranges and corresponding percentiles derived from experts.

Table 1 Probability distributions and ranges for key parameters†.

Parameter	Distribution	Range		Units	Percentiles	
		Low	High		Low	High
Core Roughness	Lognormal	1.00E-05	1.00E-04	[m]	5	85
Check valve leakage (loop 1)	Lognormal	0.05	0.50	[Kg/s]	5	85
Check valve leakage (loop 2)	Lognormal	0.05	0.50	[Kg/s]	5	85
Heat transfer coefficient (structures)	Lognormal	0.50	2.00		20	75
Heat transfer coefficient (core)	Lognormal	0.40	1.60		20	80
Thermal conductivity (insulator)	Lognormal	0.01	0.21	[W/m K]	5	85
Moment of Inertia	Normal	656.88	802.86	[Kg m²]	20	80

Comparing with [9], we have modified the distribution for check valve leakage from an exponential distribution to a lognormal distribution. Since we assume that the valve is normally leaking, an exponential distribution is not satisfactory because it gives the highest probability to the non-leaking condition.

IV.E. Propagation of Uncertainties

We use Monte Carlo simulation to propagate the uncertainties. A drawback of this method is that a large number of calculations is required. In our case, this creates difficulties because each run of RELAP5-3D takes a long time‡.

A method to reduce the number of simulations is to use Latin Hypercube Sampling (LHS) [15]. To generate a sample of size N, the range of each variable x_i, (i = 1… n), is divided into N disjoint intervals of equal probability and one value is selected at random from each interval. The N values obtained for the variable x_i are paired randomly with the N values

† Heat transfer coefficients refer to the multiplicative factors presented in chapter IV.C.

‡ To simulate the performance of the DHR system for a period of 2 hours, it takes up to 10 hours on a Pentium 4, CPU 3.20 GHz, RAM 3.19 GHz 0.99 GB.

of variable x_j. The process is repeated with all the variables to produce N samples, each of size n. By construction, all samples have the same probability.

If we call a realization the result of a simulation (i.e., the temperature as a function of time) with a certain set of parameter values, then failure occurs when a realization exceeds the corresponding limit. Each realization leads to two possible outcomes A: failure or success (A = 1 if it is a failure, A = 0 if it is a success). Therefore, the failure probability FP_N with a sample of size N is given by the following equation:

$$FP_N = \frac{\sum_{i=1}^{N} A(i)}{N} \tag{1}$$

An important issue in LHS is the determination of the number of realizations N. There are no formal rules regarding the sample size. In [16], 12 parameters were studied using a sample of size 500 and 3 parameters were studied with a sample of size 50. In [9], 128 samples were used for 6 parameters. Between these two studies, there is an important difference. In the former, a single value target is defined (i.e., the released dose); therefore, by simulating 500 samples, we obtain the mean and the variance of the target variable we are interested in. On the contrary, in the second case, the target value was considered to be the failure probability of the system and the 128 simulations all together give a point estimate of that target value. This means that in order to obtain complete (1^{st} and 2^{nd} order moments) information about the failure probability of the system, it is required to run multiple samples. Unfortunately, that would be prohibitive in terms of computational times. For this reason, we tried to evaluate the possibility of running smaller samples and repeat these calculations (i.e., the samples) a few times; Table 2 shows the results for the number of failures and the failure probability for different sample sizes.

Table 2 Number of failures for different sample sizes; case 1 refers to Design A (as calculated in Ref. 7); case 2 refers to Design D.

Sample size	# failures case 1	# failures case 2
16	9 56.3%	< 4 21.9%
32	14 43.8%	< 7 19.5%
128	39 30.5%	16 12.5%

This table shows that the failure probability decreases as the sample size increases. In this study, and given the constraint of the long simulation time, the failure probability of the system was obtained by simulating 128 possible realizations for a real time of 7200 s (two hours). In fact, all the failures, if any, occurred in this time window (see also [9]) and there is no need to push further the simulations, as they are very costly in terms of computational time.

We mention here that a high number of simulations are important not only to the evaluation of the failure probability but also to the derivation of more detailed information about the combinations of parameter values that may lead to failure. Moreover large samples are necessary when the probability functions used to model each parameter have long tails. In our case, distribution tails are short enough to justify our sample sizes.

We now give the reasons why we will not consider the moment of inertia in the calculations. We performed a sensitivity analysis using a traditional method for sensitivity analysis. We varied one parameter at a time, leaving all the other parameters at their mean values and we observed the effects on system performance. The simulations showed that the system was not affected at all by the variability in the moment of inertia. All simulations will be performed with the moment of inertia set at its nominal value (mean value).

We also need to comment on some offsets we found when we used different computers to simulate the system (several computers were used in parallel, given the huge number of simulations required and the long running time per simulation). RELAP5-3D was run on Windows machines; depending on the CPU power and RAM speed, the results may differ significantly from one station to another. In order to use different machines we ran the same case on each one to verify that the output curves were identical for all the machines.

IV.F. RESULTS

The parameter and model uncertainties were propagated through the code, using a sample of size 128. As stated earlier, two failure limits were considered, one for the fuel and one for the DHR structure. The purpose of these calculations was to evaluate possible improvements with respect to the basic design and previous findings on the conditional failure probability of the passive system.

The conditional probability, as presented in Ref. 7, was reviewed and re-evaluated, as some small errors in the geometry had underestimated the failure probability, which we estimated to be not 0.305, as reported in that paper, but above 0.50. This value will be the new point of comparison for the following analysis. In order to assess this estimation, we compared a preliminary calculation using nominal values of the characteristic parameters (e.g., their mean values) that showed that the previous analysis had underestimated the fuel temperature by about 200 K. Estimation using a sample of size 16 confirmed that the failure probability was higher than previously found.

Figure 8 and Figure 9 show the results of system behavior after the insertion of insulating material (Design D). Figure 8 presents the maximum fuel temperature evolution in time; the failure limit is 1873.15 K. There are 9 realizations that lead to system failure due to an excessive temperature in the fuel.

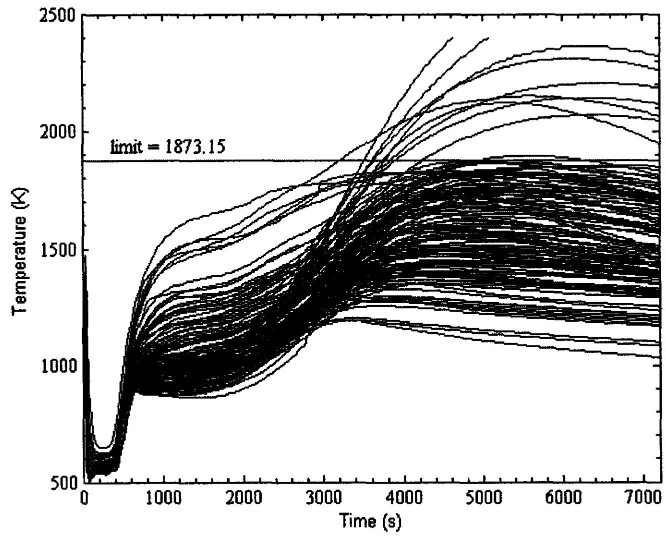

Figure 8 Temperature evolutions in the fuel for 128 samples.

Figure 9 shows the temperature profiles for 128 cases in the steel structure of both DHR loop hot pipes. When we described the system, we mentioned that the DHR system is composed of two 100% loops and only one works while the other remains closed.

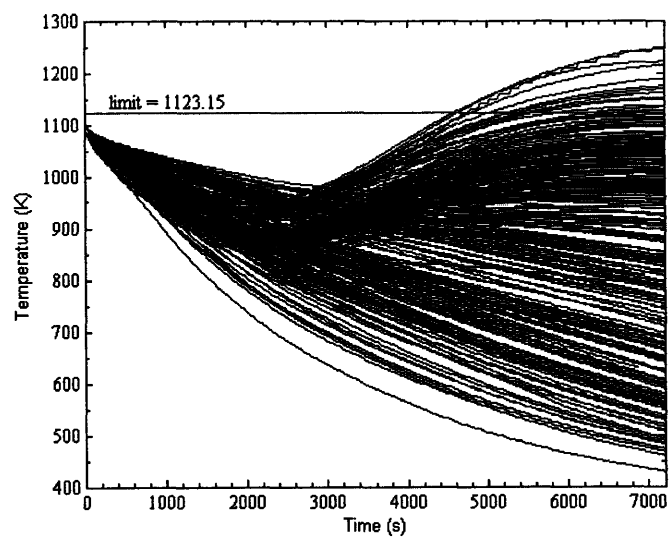

Figure 9 Temperature evolutions in the DHR loop hot pipes for 128 samples.

Consequently, in Figure 9 we actually have 256 curves: the always-decreasing temperature profiles are those for the closed loop, in which the temperature decreases because the hot helium is passing only through the open loop. The curves with a local minimum point (which corresponds to the end of region C in Figure 1) between 2000 and 3000 seconds are the temperature evolutions of the hot leg pipe in the open loop. The failure criterion is 1123.15 K. There are 14 realizations that exceed the limit and lead to structural failure of the DHR pipes.

It can be easily inferred from these two figures that the DHR failures occur later in time than the failures in the fuel. Those realizations that lead to failure because both limit criteria are not met are counted as a single failure; in particular, all failures in the fuel also lead to mechanical failure of the DHR pipe walls and only 7 of the 14 are failures in Figure 9 are failures of the DHR pipes only. This means that the total failure probability, as expressed in equation 1, is:

$$FP_N = \frac{\sum_{i=1}^{N} A(i)}{N} = \frac{9+7}{128} = 0.125$$

This total failure probability confirms that there is an important reduction with respect to the basic design (at least a factor 4) due to the insulation. In addition, if we look closer to the different contributors, we get even more interesting results. In the initial design, the major contributor (at least 66%) to the total failure probability was the structural failure of the DHR pipes, while in the current configuration this contributor is much less important. The new design succeeds in reducing the impact of the previous major failure mode.

IV.G. Sensitivity Analysis

According to [17], the aims of sensitivity analysis are "priority setting, to determine what factor most needs better determination, and to identify the weak links of the assessment chain (those that propagate most variance in the output." Monte Carlo evaluations create a mapping between the inputs and the outputs (y_i, i = 1, 2, the fuel and DHR temperatures). To represent the uncertainty in the output parameter we use the expected value and the variance. These are estimated by the following equations, where *m* is the number of Latin hypercube samples (128):

$$E(y) = \frac{\sum_{i=1}^{m} y_i}{m} \tag{2}$$

$$\mathrm{var}(y) = \frac{\sum_{i=1}^{m} (y_i - E(y))^2}{m-1} \tag{3}$$

The use of the first and second moment to characterize the distribution is very helpful even if some information is lost. The distribution of the maximum temperature in the fuel is presented in Figure 10. The mean and standard deviation of the maximum temperatures both in the fuel and in the DHR structure are as follows:

$E(T_{max}^{fuel}) = 1622.8\,K \qquad std(T_{max}^{fuel}) = 248.9\,K$

$E(T_{max}^{DHR}) = 1105.0\,K \qquad std(T_{max}^{DHR}) = 29.3\,K$

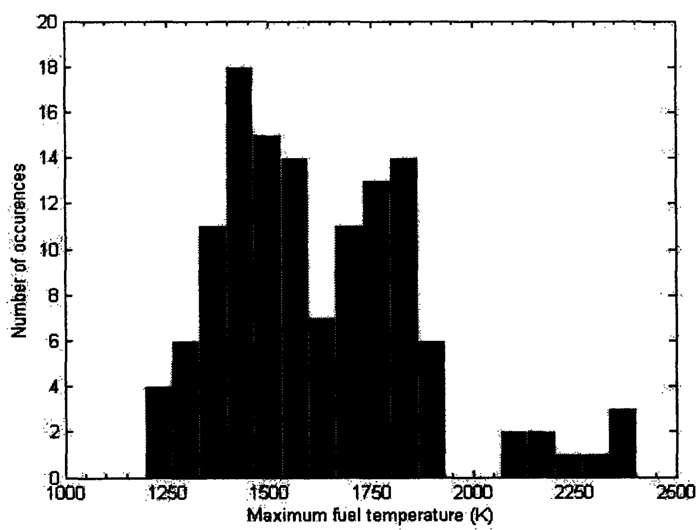

Figure 10 Distribution of the maximum temperatures in the fuel for 128 trials.

We observe that, in the case of maximum fuel temperature, the distribution is quite wide about its mean value, while it is narrower for the maximum DHR temperature distribution. The choice of methods to use in the sensitivity analysis is determined by a number of factors; in our case the most important one was the number of model evaluations we could perform. Since we are using a model that requires long times, we are forced to choose methods that require a relatively low number of model evaluations.

We used two types of analysis and four different methods. The first type of analysis is based on a repeated number of simulations. The objective here is to identify the factor which, if fixed at a point value, would result in the greatest reduction in the output uncertainty. Though this method is time consuming, it provides a fairly reliable indication of the relative importance of different parameters. The second type of analysis does not require additional simulations as it is based on the mapping between input factors and output variables calculated in 128 simulations. The first method consists of generating 2D or 3D scatter plots for the pairs (x_{ji}, y_i) or the triplet (x_{ji}, x_{ki}, y_i) with $i = 1, 2 \ldots 128$ and j and k being the indices of given input parameters. Scatter plots offer a qualitative measure of sensitivity. The second method is the entropy or mutual information analysis [18] which addresses the issue of identifying important nonrandom patterns and ranking the association of input-output. The third method is a non-linear regression-based analysis, in which the goal is to identify input variables that have the highest correlation (or partial correlation) with the output of interest. Given the high non-linearity of our system, we were able to reproduce the observed data from 128 trials and the best nonlinear model we could find had a R^2 value of 0.46, which means that it accounts for 46% of the variability in the dependent variable. We did not pursue this method further.

IV.G.1. Parameter Ranking

The method used here is based on repeated simulations where input parameters are fixed one at a time. Our model has 6 input parameters, thus requiring 6 sets of runs. The actual number of sets was 7 since one set of simulations was performed fixing the two check valve leakage parameters at the same value in order to verify any possible relation between these two input factors. The fixed value for each parameter was its mean value. The number of simulations to perform was selected using insights from Table 2. Seven sets of 32 runs were performed.

Table 3 and Table 4 show the results of the analysis and the impact of fixing one parameter at a time on the mean and the variance of the output distributions. The nominal set refers to the case where all the parameters vary according to their distributions. The other cases correspond to the situation where only one parameter (on the left side of the table) is fixed at its mean value.

Table 3 Sensitivity analysis for the maximum cladding temperature; for each set of trials, one parameter is fixed at its mean value.

		Max fuel temperature		
		mean	st. dev.	st. dev. reduction %
	nominal set	1651.17	332.29	
fixed parameters	roughness	1656.21	345.45	104%
	check valve loop 1	1515.06	224.52	68%
	check valve loop 2	1515.13	224.59	68%
	HTC containment	1559.09	180.72	54%
	HTC core	1470.92	208.27	63%
	thermal conductivity	1555.12	156.12	47%
	check valve loops 1&2	1516.06	226.52	68%

The important result from Table 3 is that the parameter whose reduction in uncertainty would reduce the output uncertainty the most is the thermal conductivity of the insulation. The second most important parameter is the heat transfer coefficient in the containment. All the parameters have an impact on the mean maximum temperature. It appears that the roughness is an irrelevant parameter with respect to the output.

Table 4 Sensitivity analysis for the maximum DHR temperature; for each set of trials, one parameter is fixed at its mean value.

		Max DHR temperature		
		mean	st. dev.	st. dev. reduction %
	nominal set	1080.07	41.12	
fixed parameters	roughness	1075.99	42.38	103%
	check valve loop 1	1062.47	33.32	81%
	check valve loop 2	1059.99	33.64	82%
	HTC containment	1053.00	27.90	68%
	HTC core	1058.18	26.89	65%
	thermal conductivity	1059.32	11.79	29%
	check valve loops 1&2	1055.33	35.65	87%

For the maximum DHR temperature we obtain similar results to those for the fuel temperature (Table 4). Again the thermal conductivity uncertainty is the most important contributor to the output uncertainty. It is also clear that the roughness does not contribute to the uncertainty in the maximum DHR temperature.

IV.G.2. Scatter Plots

The simplest qualitative sensitivity analysis consists of generating scatter plots associated with sampled variables. Since this is a visual method, only 2D and 3D plots can be visualized. All of the six variables we considered are independent, therefore we look at scatter plots in which the output variables (i.e., maximum fuel temperature and maximum DHR temperature) are plotted against one (2D plots) or two variables (3D plots). A pattern in the plot means that there is a correlation between the plotted variables whereas little or no pattern means that there is no correlation between the plotted variables.

Figure 11 shows scatter plots for the maximum fuel temperature versus the six input parameters, one at a time.

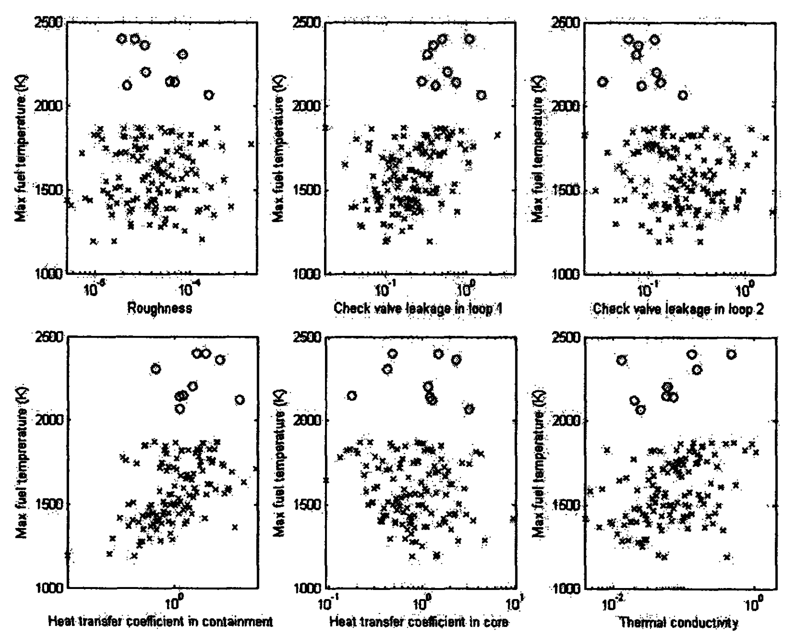

Figure 11 2-D scatter plots for maximum fuel temperature; circles denote failures.

A qualitative evaluation of the plots suggests a possible threshold effect with respect to the heat transfer coefficient in the containment. There are no other clear patterns appearing in the plots. Figure 12 shows a possible threshold effect for the maximum DHR temperature with respect to the heat transfer coefficient in the containment.

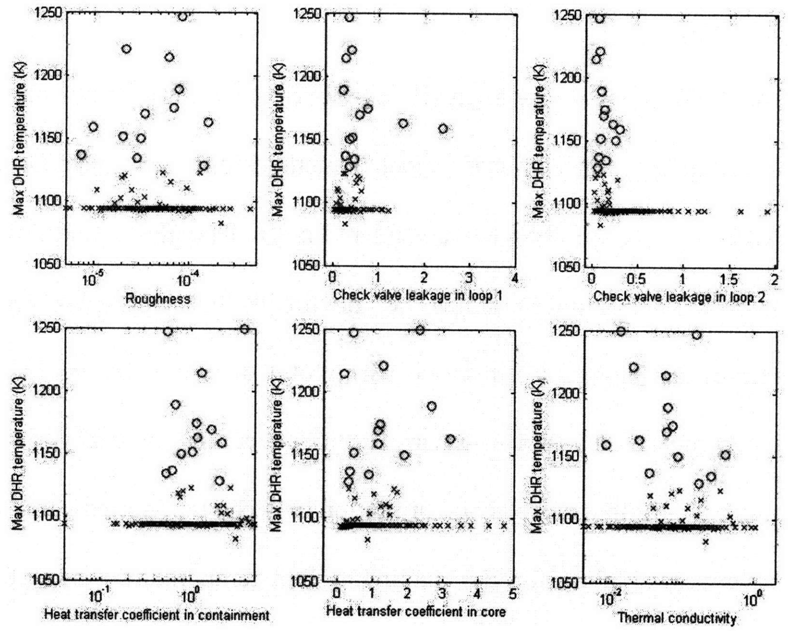

Figure 12 2-D scatter plots for maximum DHR temperature; circles denote failures.

The 3D scatter plots in Figure 13 show the only parameter combinations that exhibit some pattern. The relationship between the two check valves shows that there is a threshold effect between the maximum of the two leakages and the minimum, which confirms what was found in [9].

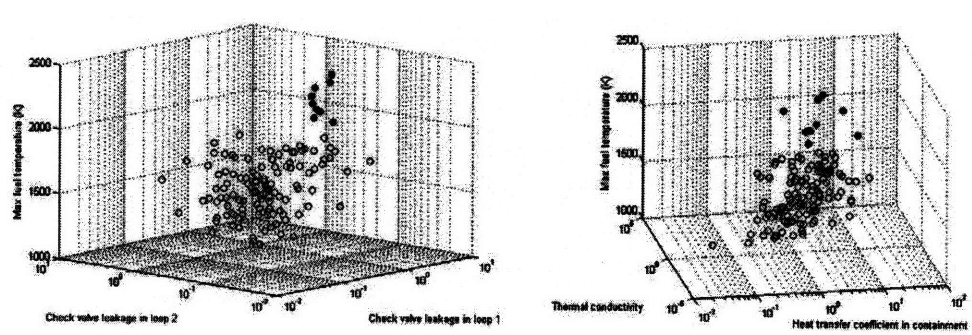

Figure 13 3-D scatter plots for maximum fuel temperature; dark circles denote failures.

The second graph on the right shows a region with low values of the heat transfer coefficient in the containment with no failures and exhibits a possible pattern suggesting a relationship involving these parameters. In the regression section, we will use these parameters to model the system.

Similar plots have been generated for the maximum DHR temperature, though they do not show any particular pattern.

IV.G.3. Entropy Analysis

The entropy-based measure for sensitivity analysis measures the uncertainty reduction in an uncertain output if an uncertain input is perfectly known. Here, the entropy method is combined with a contingency table analysis.

Contingency tables are used to test whether there is any relationship between two or more variables. For the following discussion, we will consider only one output: the maximum fuel temperature. For the second system output (i.e., the maximum DHR temperature), the method works exactly the same.

There are k variables x_k (e.g. in our case $k = 1, 2 \ldots 6$) with i possible states and a single output variable y with j possible states. By state, we refer to the intervals in which we divide the range of each variable. For each input variable and the output, we can build a table with i rows and j columns where the matrix elements are integers giving the number of observed events for each combination of row and column. In our study, the input data were grouped into five different states with the same probability (hence $i = 5$ in our case). The output was divided in four possible states.

We give here a few definitions (Ref. 17): N_{ij} is the number of events occurring when x_k assumes its i-th and y assumes its j-th value; $N_{i\cdot}$ is the total number of events for a given i regardless the state of y; $N_{\cdot j}$ is the total number of events for a given j regardless the state of x_k.

We also define three different probabilities: the probability of each element in the contingency table is given by $p_{ij} = N_{ij} / N$; the probability of state x_{ki} is $p_{i\cdot} = N_{i\cdot} / N$; the probability of state y_j is $p_{\cdot j} = N_{\cdot j} / N$.

For both x_k and y, we can define their entropy functions, which give the average information in observing x_k and y. Entropy functions for x_k and y are given in Equation 4.[§] The joint entropy function is given in Equation 5.

$$H(x) = -\sum_i p_{i\cdot} \cdot \ln p_{i\cdot} \quad and \quad H(y) = -\sum_j p_{\cdot j} \cdot \ln p_{\cdot j} \tag{4}$$

$$H(x, y) = -\sum_{i,j} p_{ij} \cdot \ln p_{ij} \tag{5}$$

The mutual information, I(x, y), between x and y measures how knowledge of x would reduce the uncertainty on y.

$$I(x,y) = H(x) + H(y) - H(x,y) = \sum_i \sum_j p_{ij} \cdot \ln \frac{p_{ij}}{p_{i\cdot} p_{\cdot j}} \tag{6}$$

Different indicators are built using the entropy functions and the mutual information function. The first indicator is a quantitative measure called uncertainty coefficient.

$$U(x,y) = 2\frac{I(x,y)}{H(x) + H(y)} \tag{7}$$

U ranges from 0 to 1. A 0 value means that there is no association between the input and the output, while a value of 1 means that knowledge of x completely predicts y.

Another indicator to measure the association between two variables is the R-statistic defined as follows:

$$R(x,y) = \sqrt{1 - \exp(-2I(x,y))} \tag{8}$$

R also ranges from 0 to 1. R is 1 if there is an exact (linear or nonlinear) relationship between x and y; it is zero when x and y are independent.

[§] From now on, we will simply refer to x_k as x

In our study, we built a contingency table for each variable with respect to both the maximum temperature in the fuel and the maximum temperature in the DHR structures. Table 5 gives the values for I(x, y), U(x, y), and R(x, y) where x is an independent input parameter and y is the maximum fuel temperature. All the indicators give the same ranking for the variables. The thermal conductivity of the insulation is the most important parameter followed by the heat transfer coefficient in the containment and check valve leakages. The heat transfer coefficient in the core and roughness are the least important parameters.

Table 5 Indicators of input variable importance with respect to the maximum cladding temperature.

	Max fuel temperature		
	I	U	R
roughness	0.0482	0.0326	0.3030
check valve loop 1	0.1350	0.0916	0.4864
check valve loop 2	0.1063	0.0723	0.4377
HTC containment	0.1118	0.0757	0.4477
HTC core	0.0350	0.0237	0.2601
thermal conductivity	**0.1758**	**0.1190**	**0.5445**

Table 6 Indicators of input variable importance with respect to the maximum cladding temperature.

	Max fuel temperature		
	I	U	R
roughness	0.0482	0.0326	0.3030
check valve loop 1	0.1350	0.0916	0.4864
check valve loop 2	0.1063	0.0723	0.4377
HTC containment	0.1118	0.0757	0.4477
HTC core	0.0350	0.0237	0.2601
thermal conductivity	**0.1758**	**0.1190**	**0.5445**

Table 6 gives the values of I(x, y), U(x, y), and R(x, y) for the second output variable of the system, the maximum DHR temperature. Also in this case, all the indicators give the same ranking for the different parameters, although the most important variables are now the check valve leakages. This is explained by the fact that the temperature in the DHR structures depends a lot on the moment the valves open, which is a function of the leakage. Whereas for the fuel temperature there are three important variables, in this case there is a clear dominance of check valve leakage over the other parameters.

The entropy analysis helps to identify those parameters which affect the most the output uncertainty and gives a ranking of those parameters. Moreover, it is in good agreement with the results from the parameter ranking analysis.

IV.H. RELIABILITY EVALUATION

The reliability of a system is defined as the probability that it will perform its function for a given period of time. In particular, the reliability of a passive system should include two principal aspects: the reliability of components (e.g., valves) and the reliability of the passive function.

We use our results to build the reliability curves for the system. We construct the reliability curve at time t by counting the number of failures before t and dividing it by the total number of simulations. These curves are shown in Figure 14 and Figure 15 for 32 trials and 128 trials, respectively.

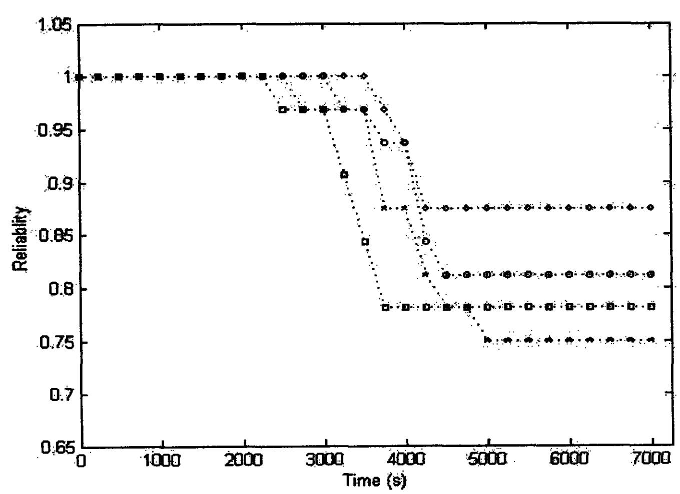

Figure 14 Reliability function; sample size of 32.

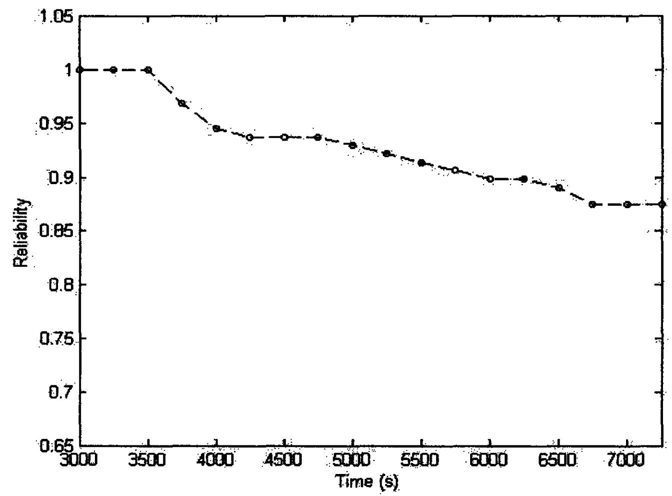

Figure 15 Reliability function for the system; sample size of 128.

For the former, we show multiple curves since multiple sets of 32 trials have been simulated. This gives not only a point estimate on the reliability but also its variability. At t = 7200 s, the average reliability for the first case is R_{32} = 0.805 while the value obtained with 128 trials is R_{128} = 0.875. The agreement between the two cases suggests that a sample of size 32 gives sufficient information for design purposes with the advantage of being less onerous in terms of calculation time.

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V. CONCLUSIONS

The reliability evaluation process provides useful information to the designer when the uncertainty analysis is carried out in parallel with the design. Important parameters and situations are not easy to be foreseen through only mechanistic analysis with nominal values of the parameters. The probabilistic approach allows the designer to have better insights into the behavior of the system.

The changes in the design that we proposed succeeded at both reducing the overall failure probability of the system and reducing the impact of the major contributor to the failure probability; the system performance was affected positively by the insertion of insulation without any increase in the design containment pressure.

Nonetheless, a purely passive GFR system still has a high conditional probability of failure that is difficult to reduce significantly. In our case, we obtained a reduction by roughly a factor of five in the failure probability. However, the conditional probability is still deemed to be high. Therefore, a reliable active system appears to be better suited for this particular application. Our results have led the MIT team to adopt an active DHR as the main mode of decay heat removal for the GFR.

An important issue is the number of simulations required to perform in order to obtain an accurate failure probability. It seems that the number of trials to simulate is very much dependent on the number of input parameters, their distributions (i.e., long tail distributions need a higher number of simulations) and the targeted failure probability. The issue is even more important in the case of complex systems since the computational time may become prohibitive, as it was in our case. A clear understanding of the relationship between the number of trials and the above mentioned parameters is the next step to better support any PRA study.

Sensitivity analysis gave important insights into the system. The first result is identification of the importance of the thermal conductivity of the insulation material in the DHR pipes. The key parameter affecting the failure probability is the uncertainty in the insulation thermal conductivity and the effect of insulation placement. This is also not what a designer would intuitively expect, especially the issue of placement insulation on the inner hot pipe wall. However, there is a physical explanation for that since the insulation affects the driving force for natural flow, which is responsible for ultimate core cooling.

Another insight from the analysis is that the heat transfer coefficient in the core is not as important as a designer would expect. Our results show that the heat transfer coefficient in the containment structures is more important. This is consistent with [1], where it was found that the containment pressure is key parameter driving the system performance and the heat transfer coefficient in the containment structures is an important parameters affecting containment pressure.

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APPENDIX I – NONLINEAR REGRESSION

The clear non-linearity of the model was approached using a nonlinear regression method. The basic idea of nonlinear regression is the same as that of linear regression, which is to find an output to a vector of input variables. The difficulty here lays in the fact that our system doesn't follow any particular functional form. The fitting tool we used estimates the coefficients of the nonlinear regression function using least squares.

From the previous analysis we identified two input parameters to describe the regression model: heat transfer coefficient in the containment and thermal conductivity, as those are the most significant parameters. Therefore the nonlinear function is given by:

$$y_i = f(x_{4i}, x_{6i}, \underline{\beta}) + \varepsilon_i \qquad i = 1, \ldots, n$$

In Equation 11, y_i are the outputs (e.g. maximum temperature), x_4 is the heat transfer coefficient in containment and x_4 is the thermal conductivity.

To assess the adequacy of regression models, the R^2 coefficient plays an important role and it is defined as follows:

$$R^2 = \frac{\sum_i (\hat{y}_i - \bar{y})^2}{\sum_i (y_i - \bar{y})^2}$$

In the formula, $\hat{y}_i$ is the estimate of y_i obtained from the model; those values are compared to the mean value of y. The ratio provides a measure to assess the accordance of the model to the observed data. In case the model reproduces completely the data, R^2 is close to 1. An unsuccessful model has a ratio close to 0.

We tested different model to reproduce the observed data from 128 trials and the best nonlinear model we could find has a R^2 value of 0.46, which means that it accounts for 46% of the variability in the dependent variable.

The low ratio can be explained by the incapability to reproduce the extreme data with very high temperature. However the failure probability (for the only cladding temperature criteria) is close to the observed one: 11 failures in 128 trials instead of 9 failures as observed.

In order to avoid the effects of units, distribution assumptions and nonlinear behavior we also used the technique of rank regression. In this case, data are replaced by their rank and then the nonlinear regression procedure is repeated as we already presented. To determine the rank of each value, the smallest receives rank 1, the next largest has rank 2 and so on. In our case the largest value of each input parameters has rank 128 since we have 128 realizations.

Even in this case we were not able to model the system with good approximation; the best model we could find showed a R^2 value of 0.40. Once again the reason depends on the strongly non linearity of the system we want to model.

APPENDIX II - 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    6000.0    1.0-10  0.0025    23     4000       3200000    3200000
*
*
*
*-------------------------------------------------------
*  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  5.9409e-005   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  5.9409e-005   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  5.9409e-005   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  5.9409e-005   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  5.9409e-005   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  5.9409e-005   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    turbinel     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
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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
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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  0.84206   0.84206   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. 0.311  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  1.546  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. 0.311  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  1.546  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  1.12354   1
12501902  0.0127 0.365625  20.  0.  0.  0.  0.  1.  0.0  1.1  1.12354   2
12501903  0.0127 0.609375  20.  0.  0.  0.  0.  1.  0.0  1.1  1.12354   3
12501904  0.0127 0.853125  20.  0.  0.  0.  0.  1.  0.0  1.1  1.12354   4
12501905  0.0127 1.096875  20.  0.  0.  0.  0.  1.  0.0  1.1  1.12354   5
12501906  0.0127 1.340625  20.  0.  0.  0.  0.  1.  0.0  1.1  1.12354   6
12501907  0.0127 1.584375  20.  0.  0.  0.  0.  1.  0.0  1.1  1.12354   7
```

```
12501908  0.0127 1.828125  20.  0.  0.  0.  0.  1.  0.0  1.1  1.12354   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  1.12354   1
12511902  0.0127 0.365625  20.  0.  0.  0.  0.  1.  0.0  1.1  1.12354   2
12511903  0.0127 0.609375  20.  0.  0.  0.  0.  1.  0.0  1.1  1.12354   3
12511904  0.0127 0.853125  20.  0.  0.  0.  0.  1.  0.0  1.1  1.12354   4
12511905  0.0127 1.096875  20.  0.  0.  0.  0.  1.  0.0  1.1  1.12354   5
12511906  0.0127 1.340625  20.  0.  0.  0.  0.  1.  0.0  1.1  1.12354   6
12511907  0.0127 1.584375  20.  0.  0.  0.  0.  1.  0.0  1.1  1.12354   7
12511908  0.0127 1.828125  20.  0.  0.  0.  0.  1.  0.0  1.1  1.12354   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  7  2   0  0.813
*    mesh-loc  format-flag
16101100  0   1
*    #-Intvl  R-coord. (radial info.)
16101101  2   0.84
16101102  2   0.88
16101103  2   0.8827
*    comp-#  interval-# (radial info.)
16101201  6   2
16101202  17   4
16101203  6   6
*    source value  interval-# (radial info.)
16101301  0.0   6
*    initial temperature flag (if flag=0 or -1)
16101400  -1
*    temp-1  temp-2  temp-3  temp-4  temp-5  temp-6  temp-7
16101401  1095.9  1095.9  1095.9  1095.9  1095.9  1095.9  1095.9
16101402  1091.2  1091.2  1091.2  1091.2  1091.2  1091.2  1091.2
16101403  1090.3  1090.3  1090.3  1090.3  1090.3  1090.3  1090.3
16101404  1090.7  1090.7  1090.7  1090.7  1090.7  1090.7  1090.7
16101405  1093.8  1093.8  1093.8  1093.8  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  666050000 -10000   160    1    2.60  5
*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  1.626  1.3  20.  0.  0.  0.  0.  1.  1
16101802  1.626  3.9  20.  0.  0.  0.  0.  1.  2
16101803  1.626  6.5  20.  0.  0.  0.  0.  1.  3
16101804  1.626  9.1  20.  0.  0.  0.  0.  1.  4
16101805  1.626  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  1.765  1.3  20.  0.  0.  0.  0.  1.  1
16101902  1.765  3.9  20.  0.  0.  0.  0.  1.  2
16101903  1.765  6.5  20.  0.  0.  0.  0.  1.  3
16101904  1.765  9.1  20.  0.  0.  0.  0.  1.  4
16101905  1.765  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  7  2   0  0.813
*    mesh-loc  format-flag
16111100  0   1
*    #-Intvl  R-coord. (radial info.)
16111101  2   0.84
16111102  2   0.88
16111103  2   0.8827
*    comp-#  interval-# (radial info.)
16111201  6   2
16111202  17   4
16111203  6   6
*    source value  interval-# (radial info.)
16111301  0.0   6
*    initial temperature flag (if flag=0 or -1)
16111400  -1
*    temp-1  temp-2  temp-3  temp-4  temp-5  temp-6  temp-7
16111401  1084.7  1084.7  1084.7  1084.7  1084.7  1084.7  1084.7
16111402  1079.4  1079.4  1079.4  1079.4  1079.4  1079.4  1079.4
16111403  1071.3  1071.3  1071.3  1071.3  1071.3  1071.3  1071.3
16111404  1056.1  1056.1  1056.1  1056.1  1056.1  1056.1  1056.1
16111405  1023.9  1023.9  1023.9  1023.9  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  676050000 -10000   160    1    2.60  5
*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  1.626  1.3  20.  0.  0.  0.  0.  1.  1
16111802  1.626  3.9  20.  0.  0.  0.  0.  1.  2
16111803  1.626  6.5  20.  0.  0.  0.  0.  1.  3
16111804  1.626  9.1  20.  0.  0.  0.  0.  1.  4
16111805  1.626  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  1.765  1.3  20.  0.  0.  0.  0.  1.  1
16111902  1.765  3.9  20.  0.  0.  0.  0.  1.  2
16111903  1.765  6.5  20.  0.  0.  0.  0.  1.  3
16111904  1.765  9.1  20.  0.  0.  0.  0.  1.  4
16111905  1.765  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  1.655
*    mesh-loc  format-flag
16661100  0   1
*    #-Intvl  R-coord. (radial info.)
16661101  4   1.685
*    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  3.31  1.25  20.  0.  0.  0.  0.  1.  1
16661802  3.31 3.75  20.  0.  0.  0.  0.  1.  2
16661803  3.31  6.25  20.  0.  0.  0.  0.  1.  3
16661804  3.31  8.75  20.  0.  0.  0.  0.  1.  4
16661805  3.31  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  3.37  1.25  20.  0.  0.  0.  0.  1.  1
16661902  3.37  3.75  20.  0.  0.  0.  0.  1.  2
16661903  3.37  6.25  20.  0.  0.  0.  0.  1.  3
16661904  3.37  8.75  20.  0.  0.  0.  0.  1.  4
16661905  3.37  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  1.655
*    mesh-loc  format-flag
16761100  0   1
*    #-Intvl  R-coord. (radial info.)
16761101  4   1.685
*    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  3.31  1.25  20.  0.  0.  0.  0.  1.  1
16761802  3.31  3.75  20.  0.  0.  0.  0.  1.  2
16761803  3.31  6.25  20.  0.  0.  0.  0.  1.  3
16761804  3.31  8.75  20.  0.  0.  0.  0.  1.  4
16761805  3.31  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  3.37  1.25  20.  0.  0.  0.  0.  1.  1
16761902  3.37  3.75  20.  0.  0.  0.  0.  1.  2
16761903  3.37  6.25  20.  0.  0.  0.  0.  1.  3
16761904  3.37  8.75  20.  0.  0.  0.  0.  1.  4
16761905  3.37  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 1.6383  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 1.6383  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 1.6383  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  0.0737
*-------------------------------------------------------
*     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  729.87   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  genpowl  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  turpowl  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
```