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International Agreement Report

Assessment of RELAP5/MOD3.2 With the LSTF Experiment Simulating a Loss of Residual Heat Removal Event During Mid-Loop Operation

Prepared by
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Abstract

The potential for the RELAP5/MOD3.2 code was assessed for the loss of residual heat removal (RHR) event during the mid-loop operation. The predictability of major thermal hydraulic phenomena was evaluated for the long term transient. The results of two typical cases, cold leg opening (CLO) case with water-filled steam generators (SGs) and pressurizer opening (PRO) case with emptied SGs were compared with experimental data conducted at ROSA-IV/LSTF in Japan.

It was found that the code was capable of simulating the system responses to the loss-of-RHR event during the reduced inventory operation. The thermal hydraulic transport process including noncondensable gas behavior was reasonably predicted with an appropriate time setup and CPU time. Overall, the code well predicted the major thermal hydraulic phenomena during the transient.

Executive Summary

Recently, the loss-of-RHR during the reduced inventory operation was of great concern since there have occurred many events associated with it and the potential for the significant risk through the PRA study has been identified. Also, in analytical approach on the issue, it was revealed that there were many difficulties in getting convergence of transient calculation, such as very long computational time and severe flow oscillations in the core region, since the fluid flow and power conditions were very low during the loss-of-RHR event. In particular, it was difficult for the code to calculate the transport process of the mixture gas phase including noncondensable gas. Recently, the USNRC developed the modified version, RELAP5/MOD3.2 code, which incorporates new models and improvements based on the MOD3.1 version to resolve the deficiencies in the code with respect to the analysis of the loss-of-RHR event.

The objective of the present analysis is to assess the potential of the RELAP5/MOD3.2 code in predicting the system behavior following the loss-of-RHR event, and to evaluate the major thermal hydraulic phenomena for a long term transient. To do this, the calculated results are compared with the experiments which were conducted at the ROSA-IV/LSTF in Japan. Two typical geometry conditions considered in the assessment are cold leg opening (CLO) case with water-filled SGs and pressurizer manway opening (PRO) case with emptied SGs. The CLO case was to simulate the geometry conditions during the maintenance of reactor coolant pump and the PRO case was to simulate an open manway on the top of the pressurizer.

The calculation results involved pressure and thermal responses, water level and loop behavior, noncondensable gas behavior and discharged flow through the opening during the long term transient for the both cases. Also, the required CPU time and the estimated system mass errors were discussed in view point of the code performance. The overall conclusions through the present study are as follows:

1) The RELAP5/MOD3.2 code was capable of simulating the system responses to the loss-of-RHR event during the reduced inventory operation. Especially, thermal hydraulic

transport process including noncondensable gas behavior was reasonably predicted with an appropriate time step and CPU time. However, there were some code deficiencies such as an estimation of too large system mass errors and severe flow oscillations in the core region.

2) For the two typical geometry cases, the code predicted well the major phenomena during the long term transient, such as the coolant boiling off in the core, system pressurization, the occurrence of loop seal clearing (LSC), the migration of the noncondensable gas, liquid hold up in pressurizer, core uncovery and so on. Also, the overall trend of system pressures and fluid temperatures and the water level behavior agreed well with the experiment.

3) However, in the CLO case, the heat transfer to the SG secondary side was overestimated due to an excessive condensation on the U-tube wall by a large amount of steam migration toward the SG U-tubes. Thus, the onset of the LSC was a little delayed as compared to the experiment. In the PRO case, the maximum pressure in core upper plenum was overeshot due to an excessive steaming in the core region and the liquid hold up in the pressurizer was also overestimated. Thus, the core heat up initiated much earlier than in the experiment. In view point of safety ensurance, the delay of the LSC, the overestimation of the maximum pressure and the earlier initiation of core heat up could give conservative results since it required earlier operator action following the loss-of-RHR event.

4) Two type of core models were considered for sensitivity study. There were no significant differences between both models, but the multi-dimensional effect on natural circulation flow in the core region was somehow compensated by the two channel core nodalization. Thus, the coolant temperature in the core region was predicted more accurately in case of two channel core model.

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I. Introduction

The Residual Heat Removal (RHR) system is used to operate with the reactor inventory reduced to mid-water level of the primary loop (mid-loop operation) for a maintenance or inspection of components such as steam generator (SG) U-tubes and reactor coolant pump (RCP) during a plant outage in pressurized water reactor (PWR). Recently, the loss-of-RHR was of great concern, since there have occurred many events associated with it and the potential for the significant risk has been identified. The major causes of these events have been found to be a loss of vital ac power, an inadvertent closure of isolation valve in the RHR suction line, and a loss of RHR flow due to air ingestion into the RHR pump. Some of these events resulted in boiling of the reactor vessel coolant and eventually the possibility to uncover the core if the loss of RHR conditions should continue for a long time period [1, 2].

In order to understand thermal hydraulic process following the loss-of-RHR event, analytical studies as well as experimental studies have been performed. In analytic approach, the predictability of the major thermal hydraulic phenomena was evaluated mainly using the best-estimate transient analysis codes such as RELAP5. However, there were many difficulties in calculating the transient process [3, 4], especially in consumption of very long calculational time and occurrence of severe flow oscillations. These problems were found to be due to system configuration of reduced mass inventory under low pressure and existence of noncondensable gas. H. Nakamura et al. [3] performed calculation using the RELAP5/MOD3 v5m5 for the ROSA-IV/LSTF experiment that simulated a loss-of-RHR event during a mid-loop operation after reactor shut-down in a typical Westinghouse type PWR. It was reported that the code predicted well the overall trend of the experimental data, however considerable discrepancies were found in results for phenomena with multi-dimensional effects such as steam migration and natural circulation flow. The analysis also revealed that there were other problems of the code such as a nature of one dimensional code, an overestimation of void fraction and oscillatory flow in core, and difficulty in getting convergence for the gas phase equilibrium. S. Banerjee and Y.A. Hassan [4] also performed the simulation of the loss-of-RHR event during the mid-loop operation using the same code. The calculation results were compared with the same experimental data which were obtained from the ROSA-IV/LSTF in Japan. It was reported that there was good qualitative agreement between the measured and the calculated data, however the calculation were computationally exhaustive and required extreamly small time steps.

The difficulty in calculation has been found to be caused in the transport process of the gas phase, in which steam and noncondensable gases exist simultaneously, especially during severe flow oscillations resulted from the boil off in core. Recently, the USNRC developed the modified version, RELAP5/MOD3.2, which incorporates new models and improvements based on the RELAP5/MOD3.1 version to resolve the deficiencies in the code with respect to the analysis of the loss-of-RHR event. In particular, in this version, the numerical schemes of the code to handle the appearance, transport and disappearance of noncondensable gases in hydrodynamic volumes were upgraded significantly and also the cross flow model was improved by including gravity and wall friction terms.

However, the predictability of the RELAP5/MOD3.2 code on thermal hydraulic phenomena has not been evaluated under the low flow and low pressure conditions. Also, the numerical improvements of the code have not been assessed under the reduced mass inventory operation. Thus, the objective of the present analysis is to assess the potential of the RELAP5/MOD3.2 in predicting the system behavior following the loss-of-RHR event during the mid-loop operation, and to evaluate the major thermal hydraulic phenomena for a long term transient. To do this, the calculated results are compared and evaluated with the experiments which were conducted at the ROSA-IV/LSTF in Japan.

The Chapter II includes a description of the LSTF and experimental conditions and procedures. A code description and modelling of the facility including nodalization and control logics are described in Chapter III. The calculation results are discussed in detail with experimental data in Chapter IV. In particular, the discussion involves an effect of nodalization in the core, consumption of CPU time, an estimated mass error as well as an evaluation of the major phenomena following the loss-of-RHR event. The code run statistics are also described in this chapter. The conclusions obtained through the present study are summarized in Chapter V. Finally, the RELAP5/ MOD3.2 input deck for steady state and transient run are attatched as an Appendix A and B.

II. Experimental Facility and Conditions

II.1. Facility Description

The Large Scale Test Facility (LSTF) of the Rig of Safety Assessment-IV (ROSA-IV) program is a 1/48 volumetrically scaled model of a Westinghouse type 3,423 MWt four loop pressurized water reactor (PWR). Figure 1 shows the overall flow diagram of the LSTF. The facility includes a reactor pressure vessel, two symmetric primary loops and steam generators (SG), pressurizer and ECCS including RHR system. The pressure vessel contains a core with full length fuel of 1,104-rods (3.66 m) simulating rod bundle, a cylindrical downcomer surrounding the core, upper and lower plena, and a upper head. The fuel rods consist of the electrical heated of 1,008 and the unheated of 96. The core bypass region is not simulated. The core power can simulate decay heat up to 14 % of the 1/48-scaled nominal PWR core power. The facility has the same major component elevation as the reference PWR to simulate the natural circulation phenomena and also has large loop pipes to simulate the major two phase phenomena in an actual plant. The four primary loops of the reference PWR were represented by two loops with an equal volume. The hot legs and cold legs were sized to conserve the volume scaling and the ratio of the length to square root of the pipe diameter, $L/D^{0.5}$ for the reference PWR, in expectation that the flow regime transitions in the primary loops can be simulated appropriately by taking this scaling approach. Each primary loop includes an active steam generator (SG) with 141 full height U-tubes and an active reactor coolant pump (RCP).

In measurement systems, more than 2,000 instruments were installed to measure transient parameters which include temperature, pressure, differential pressure and fluid density. The partial pressure of air in gas phase was estimated from the local temperature measurement. Visual observation was also performed using video probes in the SG inlet plenum, horizontal legs and vessel upper plenum. In particular, the onset of steam condensation in the U-tubes was detected by monitoring the condensate flow from the SG U-tubes into the hot leg. The detailed measurement systems such as the installed locations, measuring ranges, estimated accuracy and data acquisition system were described in reference [5].

II.2. Experimental Conditions

In experiment for the simulation of loss-of-RHR event during mid-loop operation, four different cases were performed with different location of the opening on the RCS pressure boundary to simulate typical plant geometry during maintenance [6]; cold leg opening (CLO) case to simulate the plant geometry during the maintenance of the reactor coolant pump, hot leg opening (HLO) case to represent an open manway on the SG inlet plenum and a nozzle dam installed between the opening and the reactor pressure vessel, pressurizer opening (PRO) case to simulate an open manway on the pressurizer, and no-opening (NOO) case for the closed RCS condition. The areas of the opening for each experiment were equivalent to 5 %, 10 % and 33.5 % of cold leg cross area, respectively.

The initial liquid level in the primary loop was set approximately to the centerline of the horizontal legs to simulate a mid-loop operation; the crossover legs were thus filled with liquid. The SG secondary sides were either filled to the normal level with water (above 10 m from the tube sheet) or empty. The core power was 0.6 % (430 kW) of the scaled moninal PWR power and was kept at this value throughout the experiments, to simulate the decay power at approximately one day after the reactor shut-down. The primary coolant temperature was controlled using the RHR system typically at 334 ~ 337 K and 313 ~ 320 K in the hot leg and the cold leg, respectively; the coolant was taken out the nozzles at the bottom of both hot legs, pumped through a simulated RHR heat exchanger and injected into both cold legs through the ECCS nozzles. The initial pressure was atmospheric in both primary and secondary loops with the relief valves on the pressurizer and SGs latched open. The upper portion of the primary and secondary systems and components above the water level was filled with noncondensable gas, an air.

The experiment was initiated by isolating the RHR system from the primary loop and by closing the pressurizer relief valves at the same time. The SG relief valves were left open and no operator action was taken unless the core uncovery started. When the fuel cladding temperature exceeded about 830 K, the CLO case experiment was terminated by injecting manually the ECCS into the cold legs. In PRO case, auxiliary feedwater was injected into the SG in intact loop to reduce the RCS pressure and to terminate the experiment.

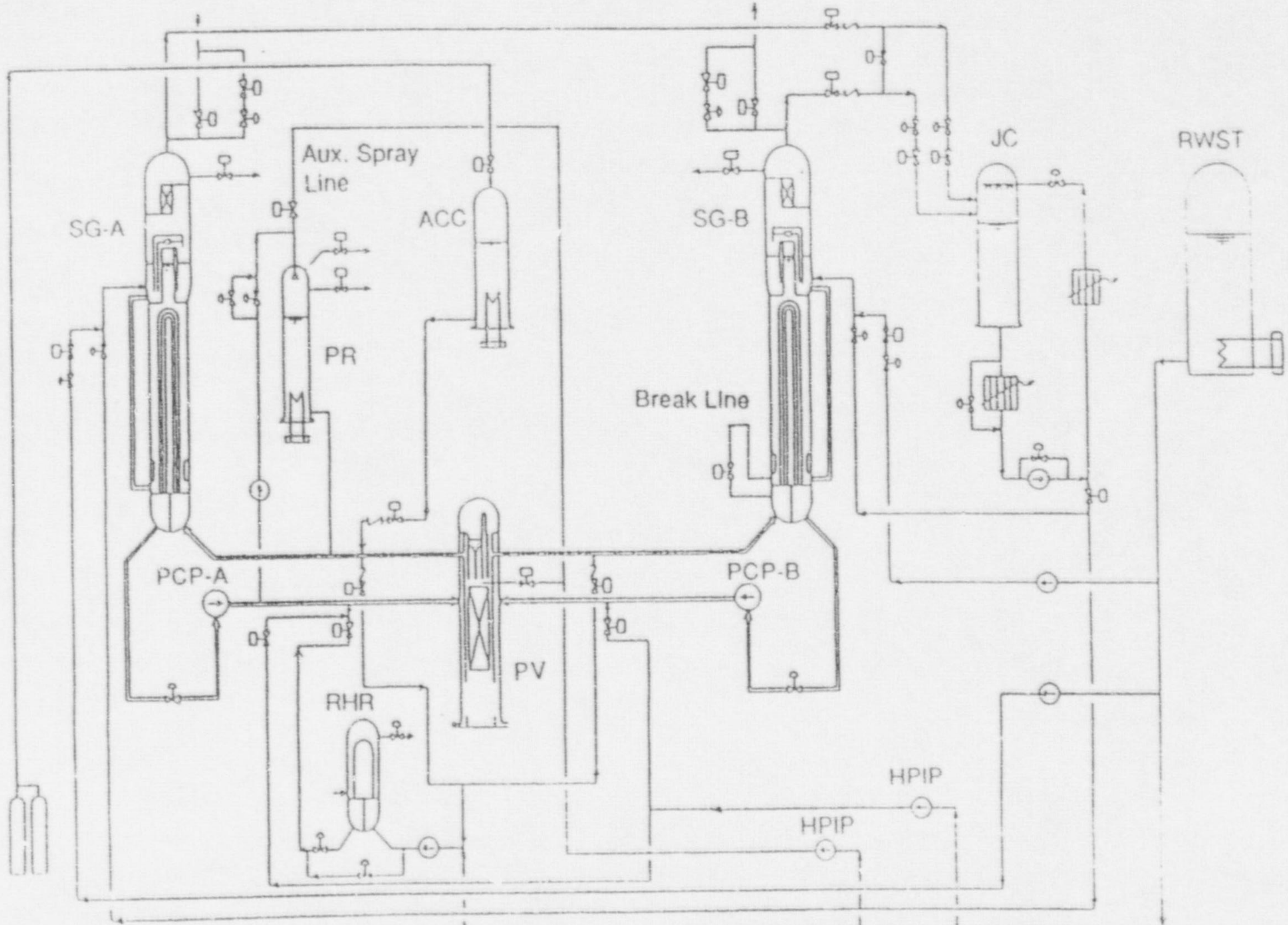


Figure 1 ROSA-IV LSTF Flow Diagram

III. Analysis Code and Modeling

III.1. Code Description

The RELAP5 is internationally well recognized best-estimate system transient analysis code, based on a non-homogeneous and non-equilibrium model for one dimensional two phase flow system [7]. Basically, this code solves six field equations including constitutive models and correlations. It uses a partially implicit numerical scheme to permit economical calculation of system transients. The RELAP5/MOD3.2 version was improved from the RELAP5/MOD3.1. In particular, these improvements include the modification of crossflow model, the numerics to treat with the transport process of noncondensable gases and the new option of the wall condensation in presence of noncondensable gases. In this study on the code assessment for systems behavior following the loss-of-RHR event, the unmodified released code version of the MOD3.2 is used on a main frame computer, DEC workstation 5000/240 with UNIX operating system.

III.2. Modeling Description

Figure 2 shows the nodalization to simulate the LSTF facility with the RELAP5 code. The modeling is based on 179 hydrodynamic volumes connected by 199 junctions and 202 heat structures. In the reactor pressure vessel elements (volumes 100 to 156), the volumes corresponding to the downcomer, the lower plenum and upper plenum, the core, the upper head and the guide thimble channel are defined. The core is modeled as two types of noding schemes as shown in Fig. 3; single channel core is modeled with 12 hydraulic volumes, in which only one serie of heat structures is adopted to simulate the fuel assembly, and two channel core is also modeled as two series channel with 12 volumes and heat structures per each channel connected by crossflow junctions. This arrangement is adopted to assess the multi-dimensional effect such as natural circulation flow in the core region. The power distribution of the two channel core is 60 % for high power channel and 40 % for low power channel. A pipe connection (volume 156) between the upper head (volume 152) and the upper plenum of the reactor vessel (volumes 128 to 140) is introduced to simulate the guide thimble channel path existing in the facility.

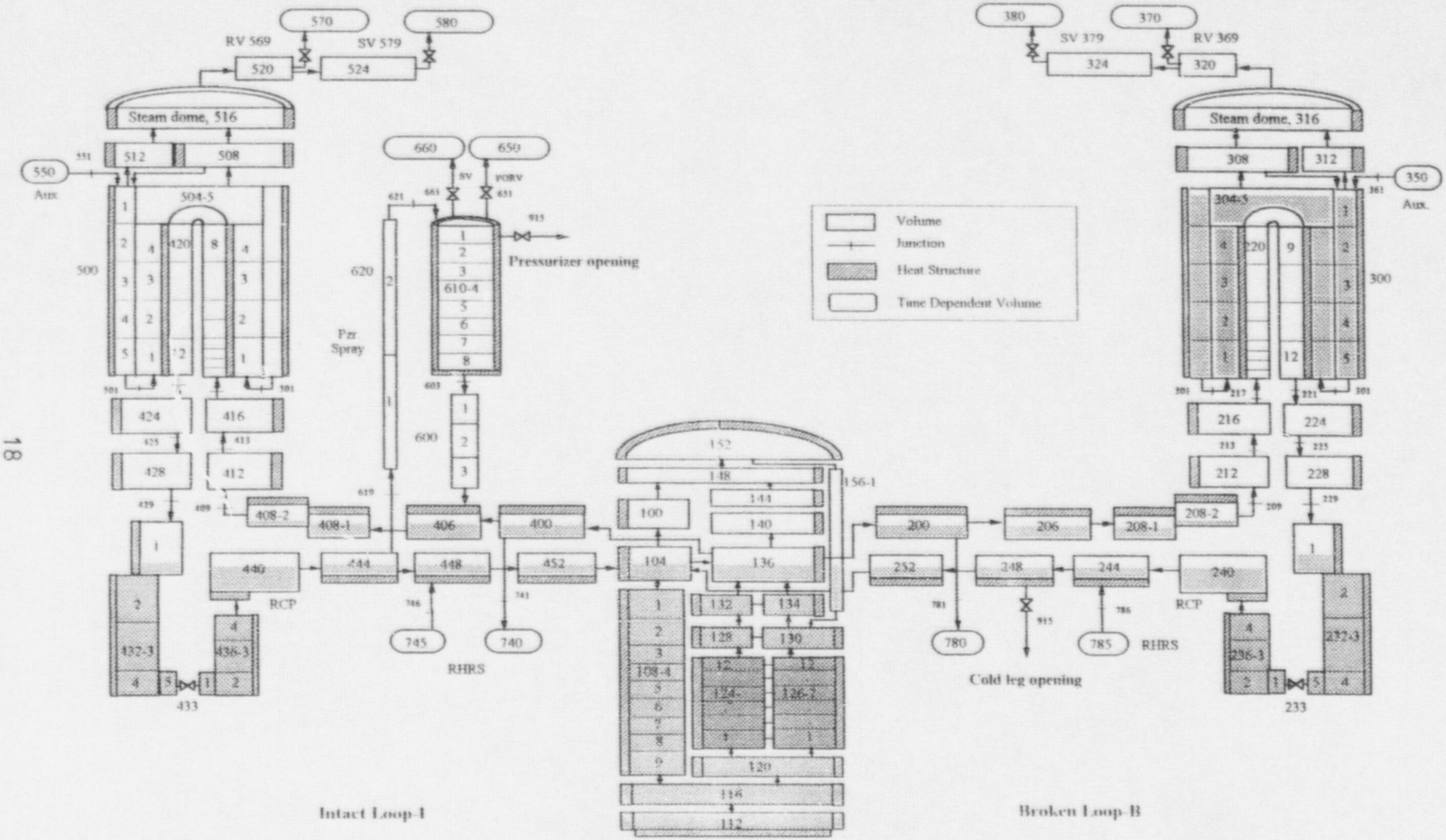
The two loops of the LSTF system are represented by an intact-loop (volumes 400 to 499) and a broken-loop (volumes 200 to 299) in an almost symmetrical way. Each loop consists of a hot leg, SG inlet and outlet plena, SG U-tube channel, loop seal, reactor coolant pump, and a cold leg. In addition, the pressurizer is connected to the hot leg in intact-loop through the surge line elements. The secondary sides of two SGs (volumes 300 to 399 and 500 to 599) are simulated using an identical schematization. They consist of a downcomer, boiling section, steam separator and a steam dome. The auxiliary feedwater lines are modeled by time dependent junctions with imposed flow rates. The relief and safety valves are also connected to the SG steam dome using valve components.

Both SG U-tubes are modeled with 12 volumes. In particular, fine noding scheme was used at the inlet portion of the U-tube, as shown in Fig. 2. which is to accurately simulate the steam migration and condensation phenomena. The RHR system is modeled by time dependent volumes and junctions connected to the hot leg and the cold leg in both intact loop and broken loop.

In this study, two typical cases of the geometrical configurations of the plant are analyzed to assess the code, that is, the cold leg opening (CLO) case with water-filled SGs and pressurizer manway opening (PRO) case with emptied SGs. The openings are modeled by a trip valve and single volume. The opening sizes are equivalent to 5 % and 33.5 % [illegible] leg cross area for CLO case and PRO case, respectively. The openings are located at centerline of the cold legs and at the top of the pressurizer, respectively.

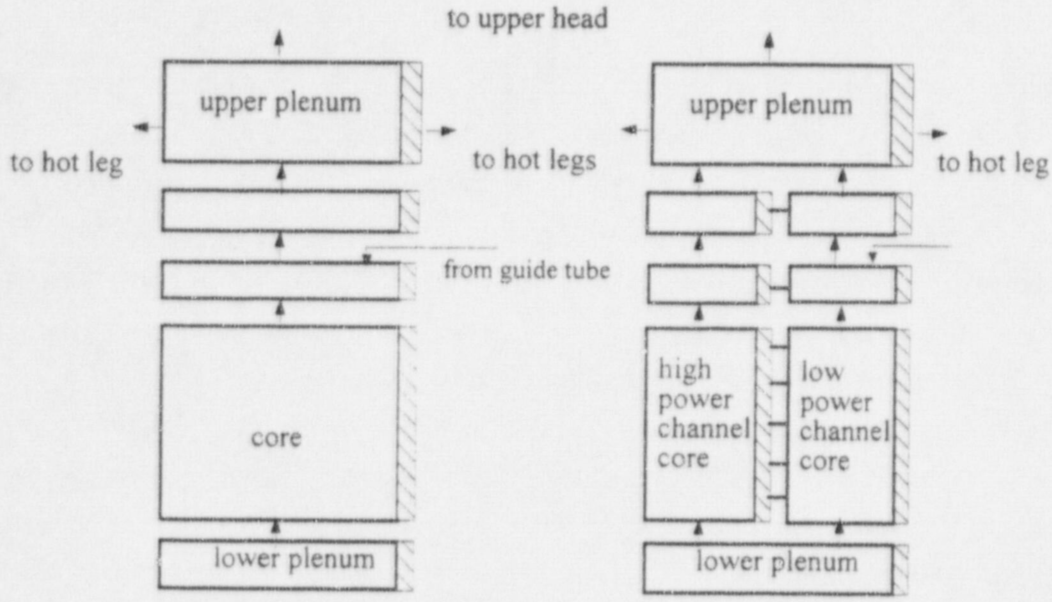
In the noncondensable model of the RELAP5, the steam/noncondensable mixture is assumed to be in thermal equilibrium and the saturation properties of the liquid and steam are assumed to be a function of the partial pressure of the steam. These assumptions intend to force the phasic temperatures and the saturation temperature to the same value. It causes a reduced driving potential for the interfacial mass and heat transfer models. Consequently, low interfacial heat transfer regimes, such as the vertical stratification flow regime, may give heat transfer coefficients that are too low for stable calculation. Under this situation, the RELAP5 user's guide [7] recommends that the vertical stratification model (VSM) should be turned off on a volume basis. According to this guideline, the VSM option was turned off at the volumes in the core.

In addition, the general and specific practices for applying RELAP5 including standard procedures, option selection related to volume and junction, special model applications such as break model and crossflow model, control and trip logics and so on, are used according to the user's guidance. Hence, there are no deviations from the user guidelines described in RELAP5/MOD3 code manual, volume V.



[mdl/COL-NODE.DOC]

Fig. 2 RELAP5 Nodalization of ROSA-IV LSTF for Simulation of a Loss-of-RHR Event during Mid-loop Opeartion



(a) Single Channel Core (b) Two Channel Core

Fig. 3. Core Nodalization for Sensitivity Study

IV. Results and Discussion

IV.1. Initial/Boundary Conditions and Event Description

The initial steady-state conditions were obtained from new transient run up to 1,000 seconds. Transient calculation started with the loss-of-RHR flow at this time. Table 1 shows comparison of initial conditions between the experiment and the calculation and Table 2 represents initial boundary conditions for steady-state and transient runs. The core power was 430 kW to correspond to the decay heat at about 20 hours after the reactor shut-down. SG secondary sides were filled to the normal level with water of room temperature for CLO case and were completely emptied for PRO case. Liquid temperature at inlet of RHR system was 334 ~ 337 K, the outlet liquid temperature was 318 ~ 320 K and the mass flow rate at each loop was 3.0 ~ 3.2 kg/s. The pressurizer and SGs relief valves were opened to remain an atmospheric pressure. The water levels in hot and cold legs were remained at the middle of the loop and an above part of the water was filled with a noncondensable gas, an air. The calculated initial mass inventory in primary side was 2,590 kg for CLO case and 2,686 kg for PRO case. The major calculated parameters of the primary and secondary sides agreed well with the measured values as shown in Table 1.

The transient calculation was initiated by decreasing linearly the RHR flow rate from the initial value to zero for 20 seconds and by opening either the cold leg opening valve for CLO case or the pressurizer opening valve for PRO case. The pressurizer relief and safety valves were closed at the same time. The calculation was attempted up to over 14,000 seconds (about 4 hours) for the CLO case and 9,000 seconds (2.5 hours) for the PRO case until an operator took an action to stop the experiment. The results of calculation were compared with the experimental data obtained in open literature [3, 6, 8]. The origin of the experimental data including the estimated accuracy of the measurement devices and the corresponding RELAP5 parameters are listed in Table 3 and 4 for the CLO case and the PRO case, respectively.

Table 1. Comparison of Initial Conditions

Major Parameters	Experiment; CLO/PRO	RELAP5; CLO/PRO
▪ Core power (kW)	430 / 430	430 / 430
▪ Hot leg temperature (K)	334 / 337	334.1 / 337.1
▪ Cold leg temperature (K)	318 / 320	318.0 / 320.0
▪ Primary pressure (MPa)	0.1013 / 0.1013	0.1013 / 0.1013
▪ Water level at loops (m)	middle of loop	middle of loop
- hot leg void		0.41 / 0.30
- cold leg void		0.51 / 0.21
▪ Secondary pressure (MPa)	0.1013 / 0.1013	0.1013 / 0.1013
▪ Secondary fluid temperature (K)	317 / 317	317.0 / 317.0
▪ Water level in SG (m)	10 / empty	10.08 / empty
▪ Initial coolant inventory (kg)	-	2590 / 2686
▪ RHR flowrate (kg/s)	-	3.2 / 3.0
▪ Noncondensable gas	air / air	air / air

Table 2. Initial Boundary Conditions for Steady-State and Transient Runs

	Steady State	Transient	Remarks
▪ Presurizer Relief valve	open	close	junc-651
▪ Presurizer Safety valve	open	close	junc-661
▪ SG-BL Relief valve	open	open	junc-369
▪ SG-BL Safety valve	open	close	junc-379
▪ SG-IL Relief valve	open	open	junc-569
▪ SG-IL Safety valve	open	close	junc-579
▪ RHRS operation	yes	no	
- suction part			junc-781/741
- discharging part			junc-786/746
▪ Nozzle Dam	no	no	-
▪ Cold leg opening (5 % equivalent break)	no	yes	junc-915
▪ Pressurizer manway opening (33.5 % equivalent break)	no	yes	junc-915

▪ IL: Intact Loop, BL: Broken Loop, SG: Steam Generator, RHRS: Residual Heat Removal System

Table 3 List of Measured and Calculated Parameters for CLO Case

Major Parameters	Origin of Measured Data	Full Scale Accuracy*	Calculated Parameters
▪ Pressure at hot leg-IL	Ref. 3	0.32 FS	p-400010000
▪ Pressure at cold leg-IL	Ref. 3	0.32 FS	p-452010000
▪ DP at crossover leg downside-IL	Ref. 3	0.32 FS	cntrlvar-755
▪ DP at crossover leg upside-IL	Ref. 3	0.32 FS	cntrlvar-753
▪ DP at crossover leg downside-BL	Ref. 3	0.32 FS	cntrlvar-756
▪ DP at crossover leg upside-BL	Ref. 3	0.32 FS	cntrlvar-757
▪ DP at core	Ref. 3	0.32 FS	cntrlvar-761
▪ Core fluid temperature at mid	Ref. 3	0.616 FS	tempf-124060000
▪ Fuel cladding temperature	Ref. 3	0.616 FS	httemp-124101101
▪ Core upper plenum temperature	Ref. 3	0.616 FS	tempf-136010000
▪ Water temperature at hot leg-IL	Ref. 3	0.735 FS	tempf-400010000
▪ Water temperature at cold leg-IL	Ref. 3	0.735 FS	tempf-452010000
▪ Water temperature in SG-BL	Ref. 3	0.777 FS	tempf-304010000
▪ Water temperature in SG-IL	Ref. 3	0.777 FS	tempf-504010000
▪ Gas temp. at SG-IL inlet plenum	Ref. 3	0.735 FS	tempg-416010000
▪ Gas temp. at SG-BL inlet plenum	Ref. 3	0.735 FS	tempg-216010000
▪ Gas temperature in bottom Pzr.	Ref. 3	0.735 FS	tempg-610030000
▪ Gas temperature in upper Pzr.	Ref. 3	0.735 FS	tempg-610080000
▪ Condensate rate at SG-IL U-inlet	unavailable	-	gammaw-420010000
▪ Condensate rate at SG-BL U-inlet	unavailable	-	gammaw-220010000
▪ Collapsed water level in RPV	unavailable	-	cntrlvar 125
▪ Flow rate through cold leg opening	unavailable	-	mflowj-915000000
▪ Flow rate through guide tube	unavailable	-	mflowj-152020000
▪ Void fraction at hot leg-BL	unavailable	-	voidg-200010000
▪ Void fraction at cold leg-BL	unavailable	-	voidg-252010000
▪ Void fraction in core upper plenum	unavailable	-	voidg-136010000
▪ Total noncondensable gas mass	unavailable	-	cntrlvar-930
▪ Noncondensable mass in U-tubes	unavailable	-	cntrlvar-929
▪ Noncondensable mass in RPV	unavailable	-	cntrlvar-880
▪ CPU time	-	N/A	cputime-0
▪ Calculated time step	-	N/A	dt-0
▪ Courant time step	-	N/A	dtcrnt-0
▪ Estimated mass error	-	N/A	emass-0

Table 4 List of Measured and Calculated Parameters for PRO Case

Major Parameters	Origin of Measured Data	Full Scale Accuracy*	Calculated Parameters
▪ Pressure at upper plenum	Ref. 6	0.32 FS	p-136010000
▪ DP at upper plenum	Ref. 6	0.32 FS	cntrlvar-754
▪ DP at core	Ref. 6	0.32 FS	cntrlvar-761
▪ Fuel cladding temperature	Ref. 6	0.616 FS	httemp-124101101
▪ Water temperature at hot leg-IL	Ref. 6	0.735 FS	tempf-400010000
▪ Water temperature at cold leg-IL	Ref. 6	0.735 FS	tempf-452010000
▪ Collapsed water level in Pzr.	Ref. 6	0.32 FS	cntrlvar-126
▪ Collapsed water level in RPV	Ref. 6	0.32 FS	cntrlvar-125
▪ Mixture density at hot leg-IL	Ref. 6	unavailable	rho-400010000
▪ Mixture density at cold leg-IL	Ref. 6	unavailable	rho-452010000
▪ Flow rate through Pzr. opening	unavailable	-	mflowj-915000000
▪ Void fraction at hot leg-IL	unavailable	-	voidg-400010000
▪ Void fraction at cold leg-IL	unavailable	-	voidg-452010000
▪ Void fraction at surge line	unavailable	-	voidg-600020000
▪ Vapor velocity in surge line	unavailable	-	velgj-600020000
▪ Flow regime in surge line	unavailable	-	floreg-600030000
▪ Total noncondensable gas mass	unavailable	-	cntrlvar-930
▪ Noncondensable mass in U-tubes	unavailable	-	cntrlvar-929
▪ Noncondensable mass in Pzr.	unavailable	-	cntrlvar-679
▪ CPU time	-	N/A	cputime-0
▪ Calculated time step	-	N/A	dt-0
▪ Courant time step	-	N/A	dtcrnt-0
▪ Estimated mass error	-	N/A	emass-0

▪ IL: Intact Loop, BL: Broken Loop, RPV: Reactor Pressure Vessel, Pzr: Pressurizer
DP: Differential Pressure, N/A: Not Applicable

* Detailed Information was described in Ref. 5

The overall system behavior during the transient is summarized as follows. First, the coolant in primary side become stagnated due to the loss-of-RHR flow. The coolant temperature in core increases gradually to a saturation value and boiling starts at about 500 seconds after the loss-of-RHR event. The pressure in hot sides such as reactor vessel upper plenum, upper head and hot legs increases due to the boiling in the core and the steam migrates toward SGs and pressurizer through the hot legs. The primary coolant is discharged either through the cold leg opening or through the pressurizer manway opening since the pressure difference is increased due to the steaming. Due to the continuous system pressurization, the loop seal clearing (LSC) occurs in crossover leg for the CLO case. For the PRO case, the liquid is hold up in pressurizer in the primary side. And then the core coolant is redistributed from the core region over the loops. Eventually, core uncovery is caused by the decreased mass inventory in the core region and the core heat up is initiated and the transient is ended at this time. Tables 5 and 6 represent the comparison of the predicted timing of the major events with the experiment for both cases. The detailed discussion of the calculated results is described below section. As a base calculation, tha case of two channel core model in the CLO case and the case of single channel core model in the PRO case are analyzed and discussed.

Table 5. Timing of The Major Phenomena for CLO Case

Major Events (unit : second)	LSTF	RELAP5/MOD3.2
▪ Loss-of-RHR system	1000	1000
▪ Boiling start	1500	1600
▪ Saturation of upper plenum liquid	1590	1790
▪ Steam discharge into upper head	2130	2130
▪ First core heat up start	2950	-
▪ First loop seal clearing (LSC)	3440	3840
▪ Condensate accumulating start	6300	6400
▪ Second loop seal clearing (LSC)	-	9500
▪ Second core heat up start	11920	12000
▪ Termination (ECCS injection)	16800	14000

Table 6. Timing of The Major Phenomena for PRO Case

Major Events (unit : second)	LSTF	RELAP5/MOD3.2
▪ Loss-of-RHR system	1000	1000
▪ Boiling start	1500	1600
▪ Saturation of upper plenum liquid	1600	1800
▪ Reaching maximum pressure	2200	3200
▪ Liquid inflow into pressurizer	2220	2900
▪ Maximum liquid hold up	3600	3700
▪ Stable liquid hold up	3600	4000
▪ Core heat-up start	9400	6400
▪ Termination (Aux. feed injection)	11000	9000

IV.2. Analysis Results for CLO Case

IV.2.1. Pressure Response

Figure 4 shows the pressure behavior in hot and cold legs in intact loop after the loss-of-RHR event, which occurred at 1,000 seconds during the mid-loop operation. At about 1,500 seconds, the liquid in core started to boil and the steam migrated toward the hot legs from the core through core upper plenum. Thus, the pressure in the hot leg started increasing rapidly at about 1,600 seconds. The calculated pressure agreed well with the experiment in the early phase. At about 2,100 seconds, the pressurization rate reduced immediately. This was because a steam flow through guide tubes was established at this time as shown in Fig. 5. The guide tubes were initially submerged under water in upper plenum. As the water level decreased below the guide tube bottom opening due to the boil off, the steam started to be discharged into upper head with large volume.

However, the calculation showed that the pressurization rate was still lower than in the experiment. Such a low pressurization rate resulted in delaying an occurrence of loop seal clearing (LSC). This difference could be explained in association with condensation phenomena on SG U-tubes wall during this phase. Actually in the experiment, the steam condensation was not occurred before the LSC, while in the calculation, a significant amount of steam was condensed at the inlet part of the SG U-tubes. As a result, the pressurization became relatively low during this phase. The condensation phenomena will be further discussed in below section.

With continuously steaming in the core, pressure difference between hot and cold legs increased gradually. Eventually at about 3,740 seconds, when the calculated pressure in the hot leg reached 0.138 MPa which is almost the same value as in the experiment, the LSC occurred in crossover legs. And then the pressure dropped immediately to a little higher value than in the cold leg pressure. The LSC timing was later by 400 seconds than in the experiment, which occurred at 3,440 seconds. This delay, as described above, was due to the low pressurization rate before the LSC, which was caused by an excessive steam condensation on SG inlet U-tubes wall.

Since, as a result of the LSC, the gas flow path was formed from hot leg to cold leg through crossover leg, the steam penetrated the SG U-tubes and began to condense on the entire U-tubes wall. In the experiment, the loop seal was completely cleared in broken loop side and partial LSC in intact loop side. However, in the calculation, it was predicted in the opposite side each other, i.e., complete LSC in the intact loop and partial LSC in the broken loop. In actual, the occurrence location of the complete LSC could be changed, depending on the initial conditions such as water and gas distribution in a loop and power distribution in a core. Anyway, in spite of the difference in occurrence location of the LSC, the overall thermal hydraulic phenomena such as depressurization and condensation was not influenced because of the symmetry in the loop configurations. Figures 6 and 7 show the comparison of differential pressure behavior at downflow and upflow sides of crossover legs. When the LSC occurred, as shown in Fig. 6, the crossover leg was immediately emptied. The calculation well predicted the overall LSC behavior. In the other loop side, the differential pressure was predicted a little high after the LSC, especially in the upflow side, as shown in Fig. 7. This partial LSC resulted in underestimating coolant inventory in the core because an inflow to the core through the cold leg was lower than in the experiment. Figure 8 shows clearly that the core differential pressure was underestimated after the LSC.

Figure 6 also shows that the condensate from the SG U-tube wall started to accumulate in upflow side from about 6,400 seconds. Such a liquid accumulation in the crossover leg resulted in preventing the gas flow from the hot leg toward the cold leg, namely limited the steam condensation on SG U-tube wall, and then the pressure in the hot leg resulted in re-increasing gradually as shown in Fig. 4. The calculated pressure shows a similar behavior to the experiment even though the pressure was slightly overpredicted after 7,000 seconds. The calculation also shows an earlier second LSC at 9,420 seconds than the experiment. It was because the pressure increased a little fast by more accumulation of the condensate in the calculation than in the experiment. Actually, the second LSC in the experiment was induced at 16,800 seconds by the steam condensation on the ECCS coolant injected into the cold legs to terminate the experiment.

In summary, the pressure behavior in the hot leg was reasonably predicted and the pressure behavior in the cold leg excellently agreed with the experiment, even though there were some differences such as the LSC delay and the partial LSC.

IV.2.2. Thermal Response

Figure 9 represents liquid temperatures behavior at inlet, mid-section and outlet of the reactor core with high power. The experimental data are fluid temperatures at mid-section of the core. Following the loss-of-RHR event at 1,000 seconds, coolant in the core became stagnated and the liquid temperature immediately increased. The highest liquid temperature was located first at upper part of the core, however, because of cosine shape of power distribution, the liquid temperature at the mid-height of the core became the highest. After the temperature reached saturation value, the coolant started to boil off and the temperature remained constant. The calculation agreed well with the experiment.

Figure 10 shows liquid temperatures in hot and cold legs in broken loop. They also increased with some delay following the increasing of fluid temperature in the core. After the saturation of steam core upper plenum at about 1,500 seconds, the liquid temperature in the hot leg increased stepwise to the steam temperature in the experiment, and the calculation also showed the similar trend. The experimental data compared in this figure were was measured at the ceiling of the horizontal pipe. It implies that the temperature, which measured after the legs were sufficiently voided, was a steam temperature. Therefore, the measured temperature showed a little difference with the calculated liquid temperature after the LSC.

Figure 11 shows liquid temperatures at the bottom of the SG secondary sides in both loops. The calculated liquid temperature in broken loop SG began to increase earlier than the measured one. It implies that some of the core decay heat was transferred to the SG secondary side in the calculation, while not in the experiment. In other words, a significant amount of steam migrated into SG U-tubes and condensed on the U-tubes wall earlier than in the experiment. Figure 12 shows clearly that the steam had begun to condense on the SG U-tube wall in the broken loop from about 2,000 seconds before the LSC occurred. In actual, the experiment indicated that the flow pattern of the gas phase in the loop was a vertically stratified non-equilibrium flow with separation between air and steam phase. In this situation, the air flow could prevent the steam migration into U-tubes and limit the condensation rate. However, in the calculation, the gas phase was asummed as a thermal equilibrium homogeneous mixture and then the effect of noncondensable gas was underestimated. As a result, the code overestimated the condensation rate, especially in the broken loop occured the LSC.

Figure 11 also indicated that, after the LSC, the calculated liquid temperature in intact loop rapidly increased with higher rate than in the experiment. It implies that the steam condensation concentrated in the inlet part of the U-tube for a short time period. During this phase, there was no condensation at middle and upper part of the U-tubes. Figure 13 shows the liquid temperatures in SG side along the vertical direction. The calculation showed clearly that the temperature started to increase first in the bottom part of the SG secondary side just after the LSC and increased stepwise along the vertical axis. Eventually, all the calculated values reached the same temperature. However, the measured temperatures showed a gradual rise and were nearly flat along the vertical axis [3]. This difference was caused by the one dimensional model of the SG secondary sides in the calculation. In actual, the flow in secondary sides indicated three dimentional natural circulation resulted from the temperature difference. The one dimensional nature as well as the assumption of the homogeneous equilibrium mixture of the gas phase, was well known to be substantial problems in RELAP5/MOD3.2 code. In spite of the one dimensional nature of the code, the calculation showed that the heat transfer into the secondary side from the primary side was accurately predicted.

IV.2.3. Water Level and Loop Behavior

After the coolant in core started to boil off, the water level was decreased by break flow through cold leg opening. Figure 14 shows that the collapsed water level in reactor vessel was decreasing to the active core region with some oscillations. Due to the decreased water level, hot legs and core upper plenum with a mid-water level in the early phase were voided from about 2,000 seconds as shown in Figures 15 and 16. However, the cold legs remained mid-water level before the LSC even with severe void oscillations. This was due to a kind of manometric behavior; because the pressure in hot sides such as the core upper plenum and the hot leg is relatively high to the cold sides such as cold leg and core downcommer, the water level in the cold leg remained high by the compression of the water. When the LSC occurred, the cold legs became completely voided and the collapsed water level in reactor vessel increased immediately by an inflow of the water from the crossover and cold legs.

After the LSC, due to the voided cold legs, the break flow through the cold leg opening became nearly stop. Figure 17 shows clearly that there was no the break flow after the LSC. Although the break flow reduced to zero after the LSC, the core coolant continued boiling and steaming, and was redistributed toward crossover legs by the condensation on the SG U-tube wall. Eventually, the water level in the core reduced enough to initiate a core heat up.

IV.2.4. Core Heat up

In the experiment, since the water level in reactor vessel decreased rapidly by the discharge through cold leg opening before the LSC, the top part of the core was uncovered for a very short time period. This first core heat up occurred locally just on a few number of the fuel rods at top part of the core and the fuel rod surface temperatures reached maximum 600 K. After completion of the LSC, as discussed previous section, the core water level recovered and the fuel rods were quenched. Due to the continuous steaming in the core and steam condensation in SG U-tubes, the reactor vessel coolant was redistributed gradually to the leg sides and then the second core heat up was initiated from 10,920 seconds (182 minutes) following the loss-of-RHR event. The maximum fuel surface temperature exceeded 830 K at 81 minutes after the core uncovery. In the calculation, the first core heat up did not occurred because the core was modeled simple nodes such as an averaged volume. Figure 18 shows comparison of the fuel cladding temperatures at the region of the core. The experiment data were measured at 3.66 m and 3.02 m from the core bottom and the calculated was chosen at 2.90 m from the bottom. As compared with the data at the same height of the core, the calculated core heat up at the middle of the core (below 3.05 m) was initiated earlier by about 1,300 seconds than in the experiment, but the heat up rate well agreed with the experiment. Also, the core heat up at the top of the core (at 3.66 m) started at almost same time, but the heat up rate was a little larger than in the experiment, which was not shown in the figure. It was due to the incorrect void distribution in the core region and underprediction of the core differential pressure, as shown in Fig. 8. When the fuel cladding temperature exceeded 830 K, the experiment was terminated by ECCS injection and the calculation was also ended at this time.

IV.2.5. Gas Phase Behavior

Initially, total mass of noncondensable gas of about 5.25 kg existed in primary system. Due to increasing of steam partial pressure in core upper plenum, the noncondensable gas was migrated along with the steam into the hot legs and SG U-tubes inside. Figure 19 shows the noncondensable gas behavior in each component during the transient. After steaming in the core, it showed clearly that the air inside reactor vessel was completely pushed out at about 2,000 seconds and total air mass rapidly reduced. It implies that the air was discharged through the cold leg opening. However, the air mass inside U-tubes temporally increased before the LSC, because the air migration into SG U-tubes was simultaneously accompanied with the steam transport. The steam condensation inside the U-tube, before the LSC, was discussed above section. When the LSC occurred, the air mass in primary system rapidly decreased, especially inside U-tube, since direct steam flow path was formed from hot leg to cold leg.

In the code, the gas phase was treated as homogeneous mixture of air and steam with thermal equilibrium. With this code model and one dimensional noding nature, it is not easy to accurately predict the gas migration behavior. However, the gas phase temperature is calculated in terms of steam partial pressure and then, from variation of the gas temperatures, existence of steam and steam concentration can be found in a volume. In other words, if the gas temperature in a volume was correctly predicted, then it can be said that an amount of steam in the volume was well predicted qualitatively. Figure 20 shows comparison of gas temperatures in SG inlet plenum. The code predicted well the trend of the experiment. It implies that steam migration into SG U-tube through the hot legs side was appropriately predicted in spite of the limitation of one dimensional code. Also, Figure 21 shows comparison of gas temperatures with elevation inside pressurizer. The calculated gas temperatures had a similar trend to the experiment but they overpredicted a little although the initial steam concentration was slightly high. It implies that a little more steam was migrated to the pressurizer than in the experiment. As a result, it can be said that the steam transport into the hot legs and the pressurizer was reasonably predicted, in spite of some limitations of the RELAP5/MOD3.2 code such as one dimentional nature and assumption of the homogeneous mixture with thermal equilibrium.

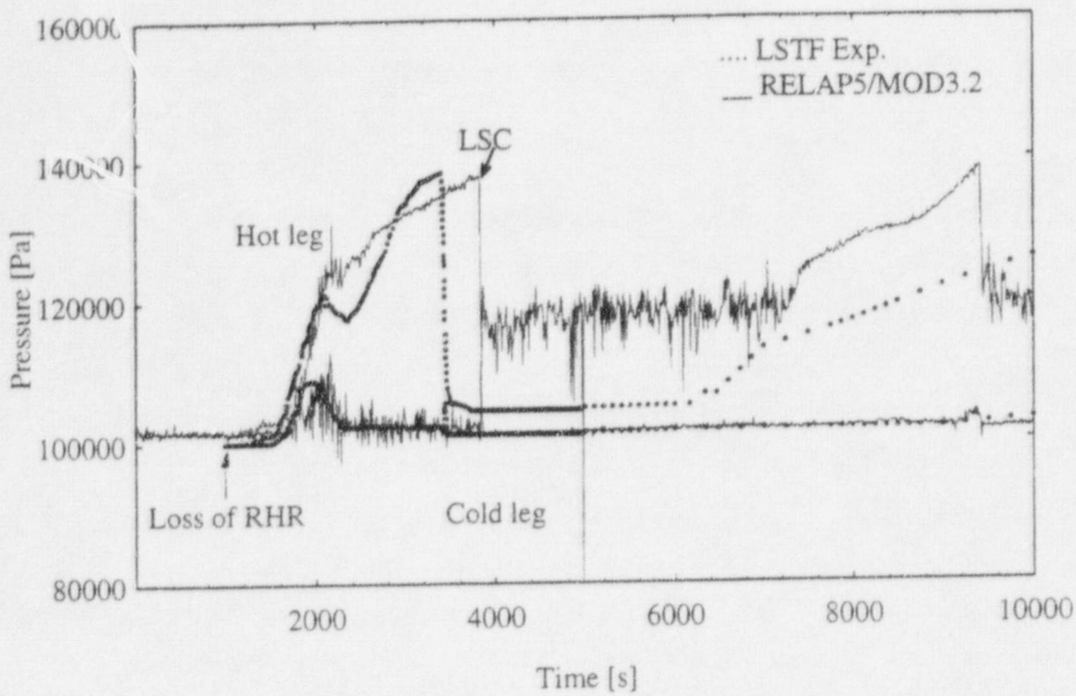


Fig. 4 Comparison of Pressures at Hot and Cold legs in Intact Loop

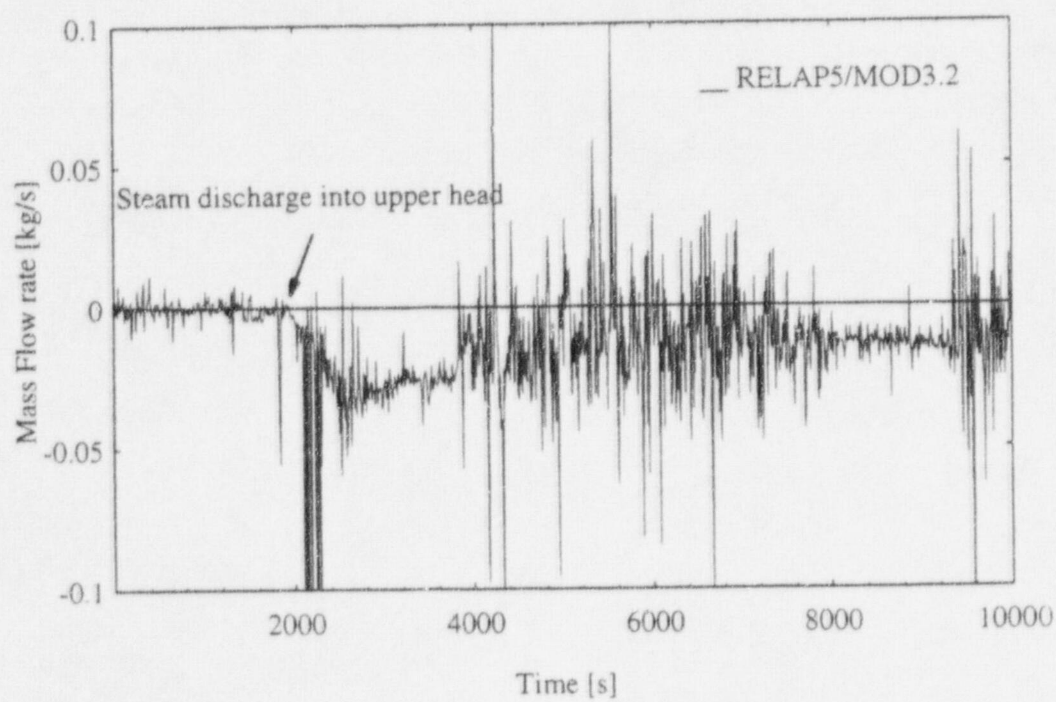


Fig. 5 The Calculated Flow Rate between Guide Tubes and Upper Head

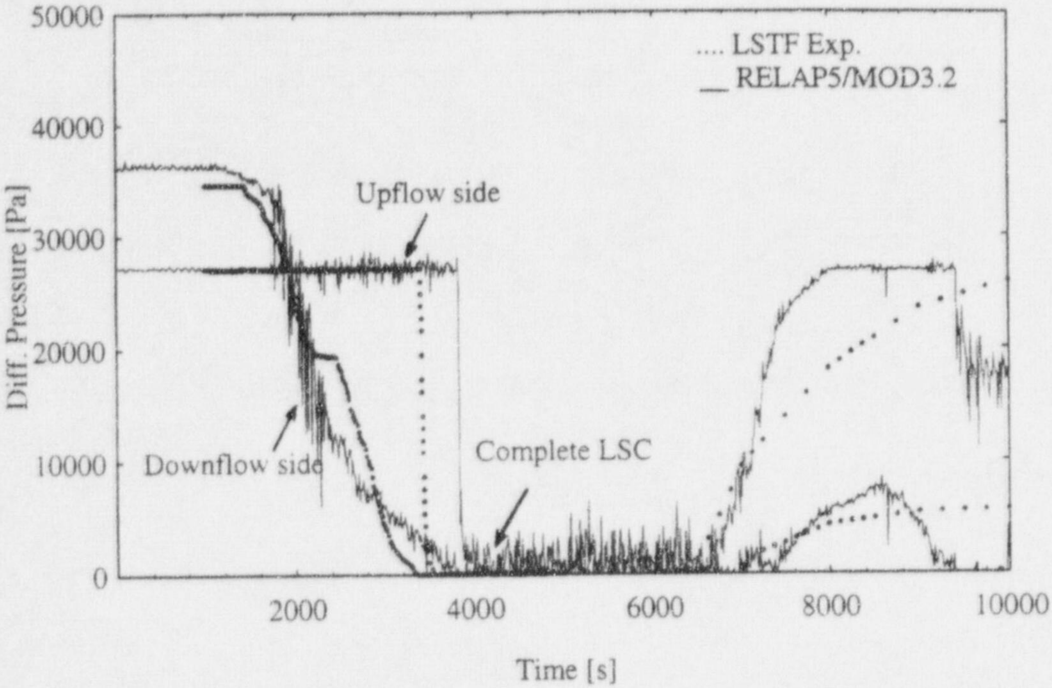


Fig. 6 Comparison of Differential Pressures at Crossover leg in Broken Loop

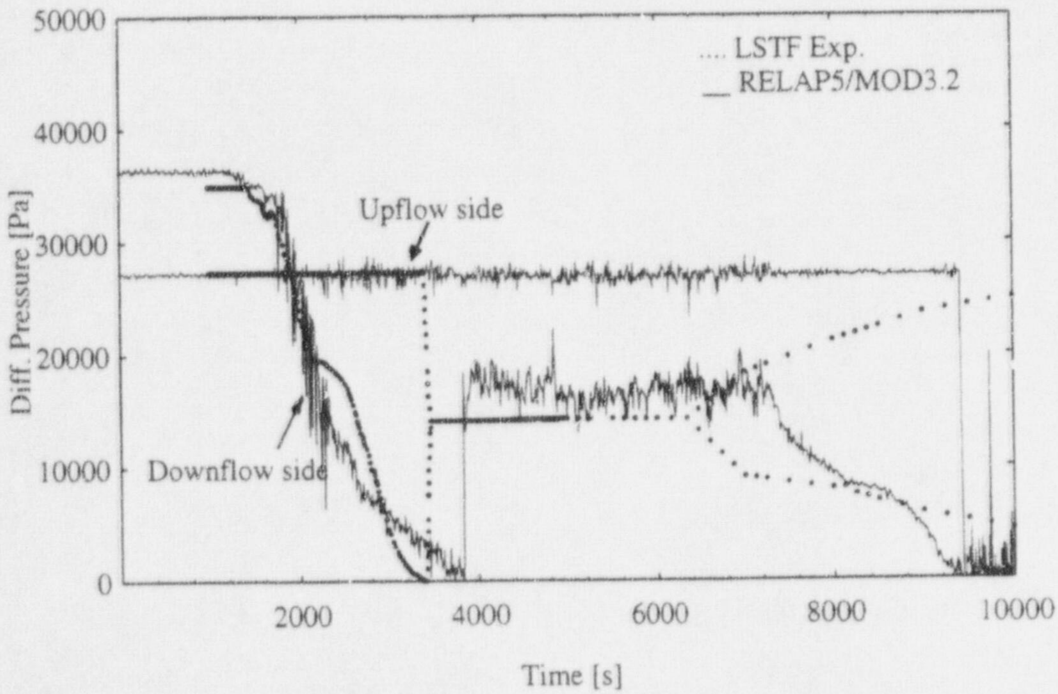


Fig. 7 Comparison of Differential Pressures at Crossover leg in Intact Loop

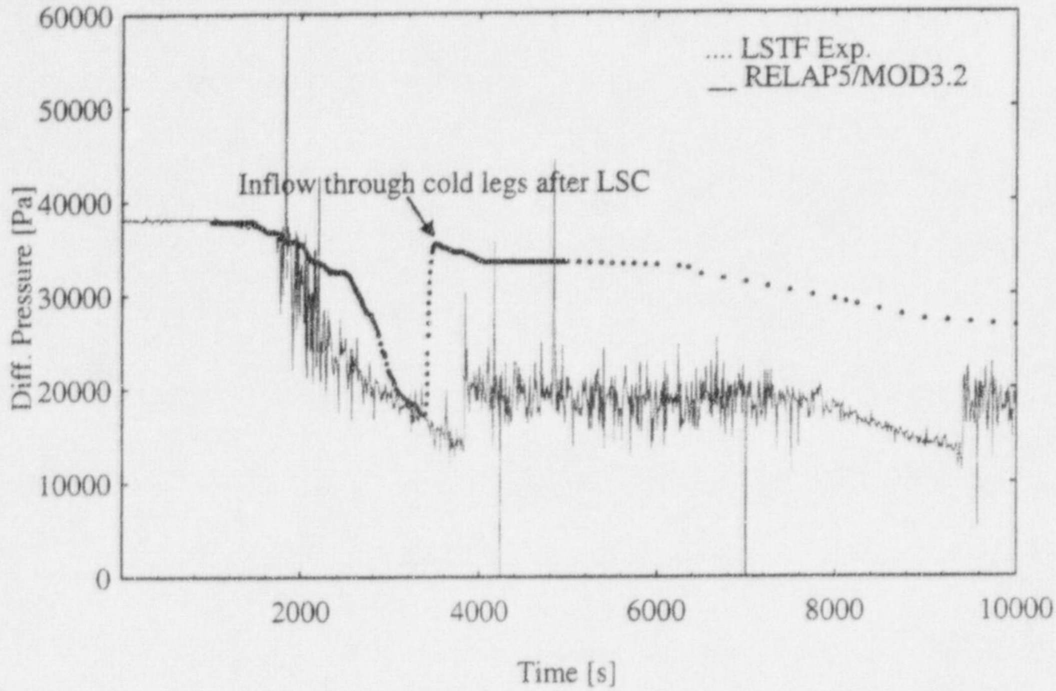


Fig. 8 Comparison of Differential Pressures at Reactor Core

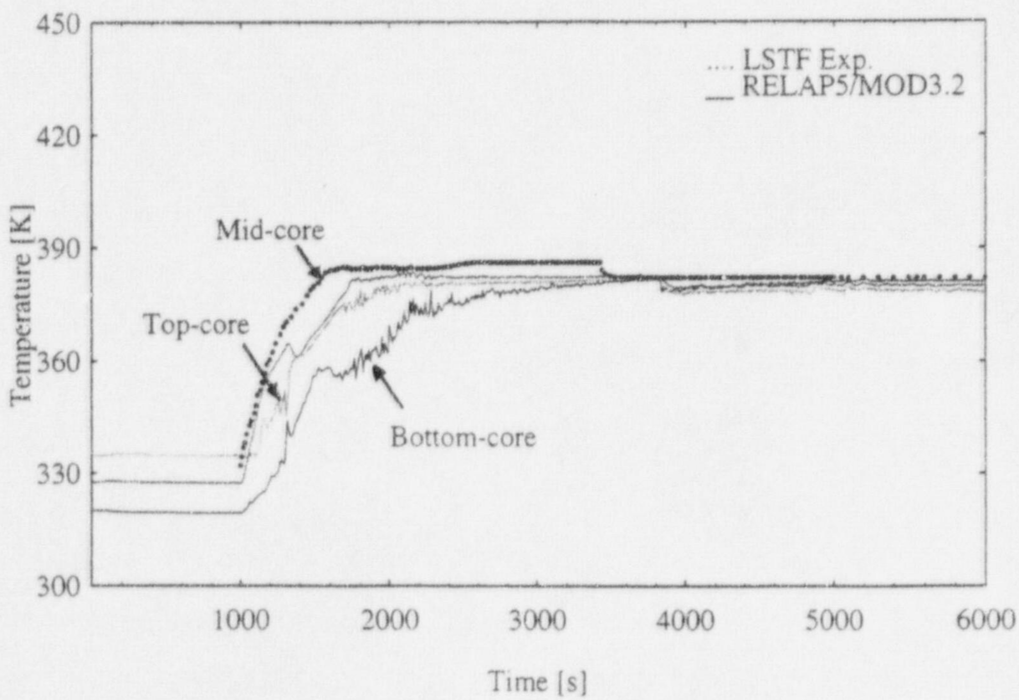


Fig. 9 Comparison of Liquid Temperatures in Core

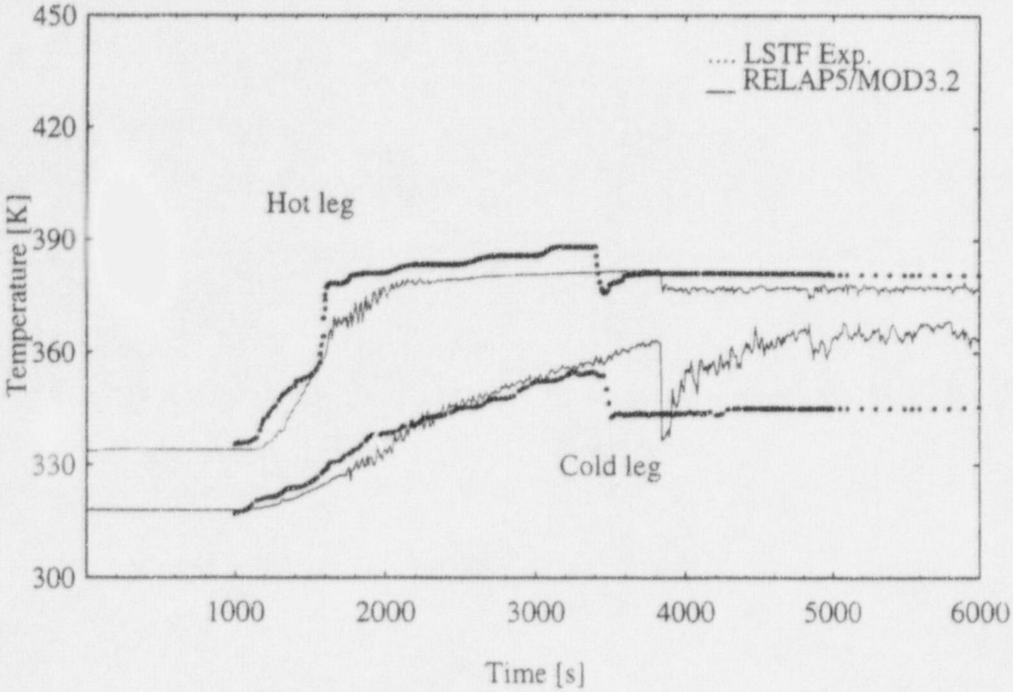


Fig. 10 Comparison of Fluid Temperatures at Hot and Cold legs in Intact Loop

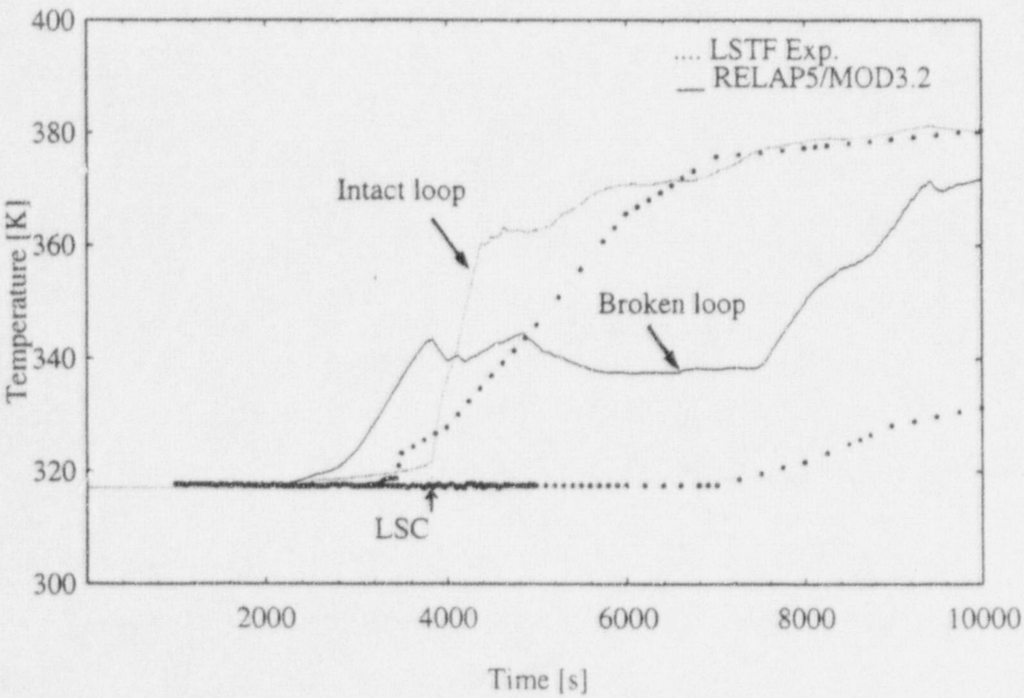


Fig. 11 Comparison of Water Temperatures in SG Secondary Side

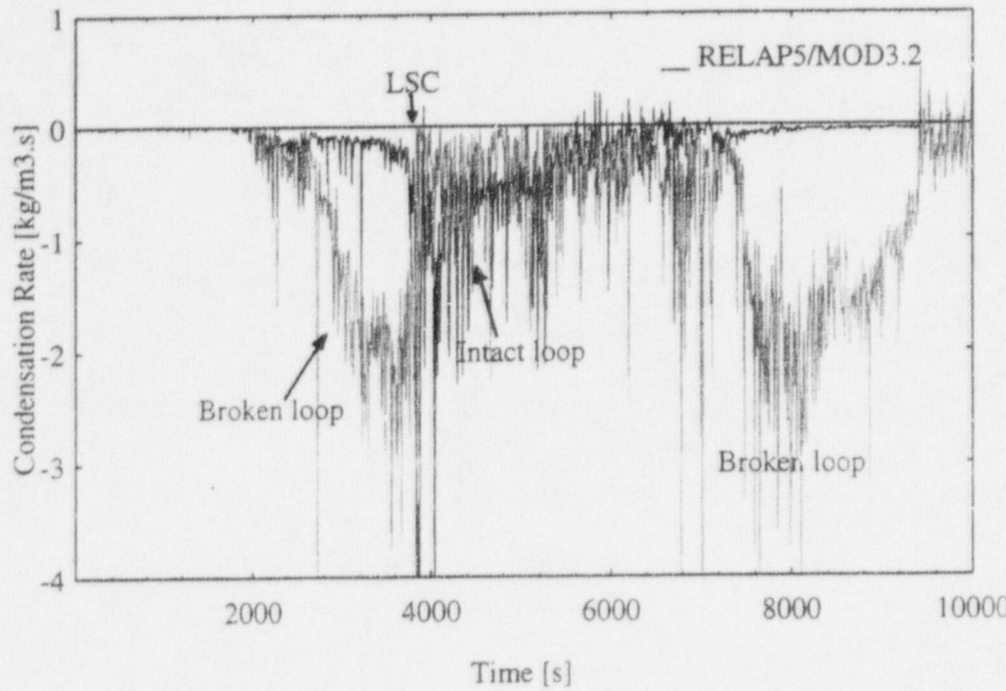


Fig. 12 The Calculated Condensation Rate on SG Inlet U-tube wall

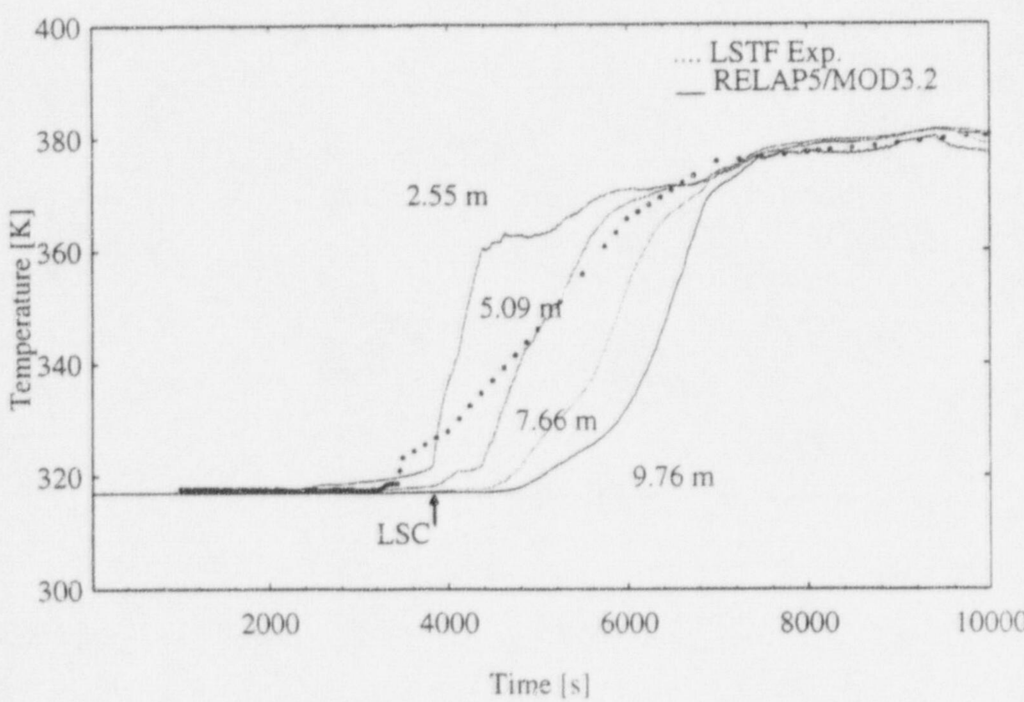


Fig. 13 Comparison of Water Temperatures with Elevation in SG Secondary Side

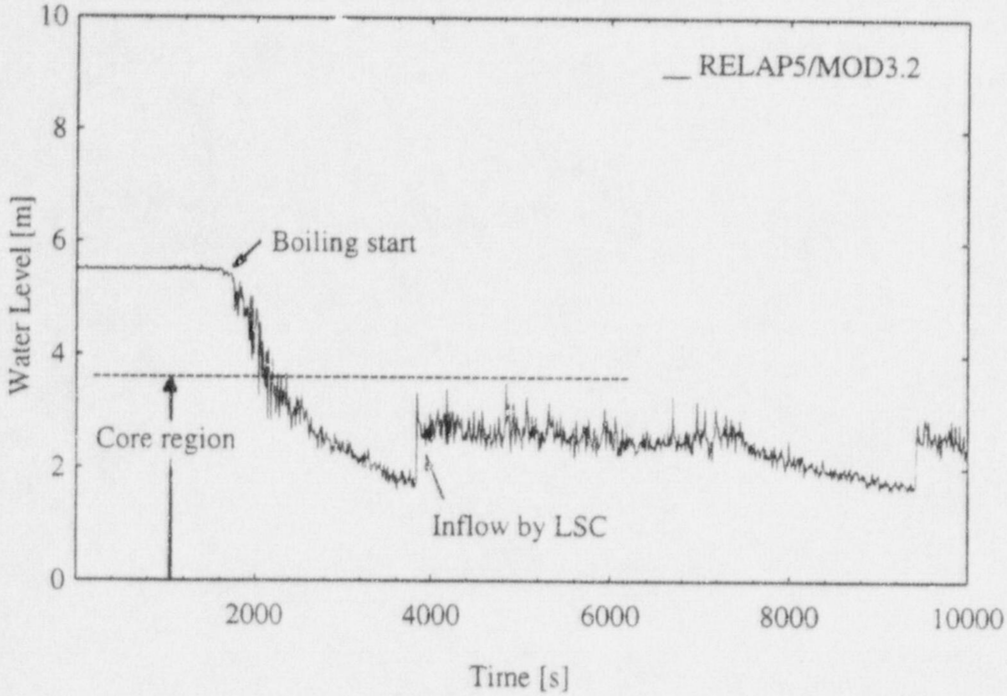


Fig. 14 The Collapsed Water Level in Reactor Pressure Vessel

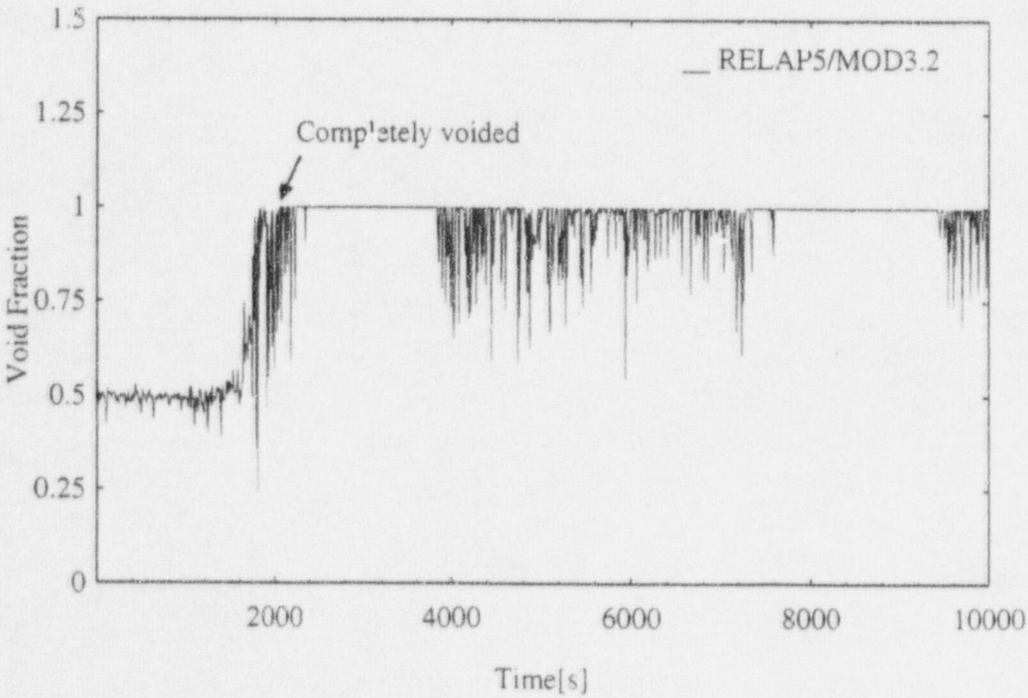


Fig. 15 The Calculated Void Fraction in Core Upper Plenum

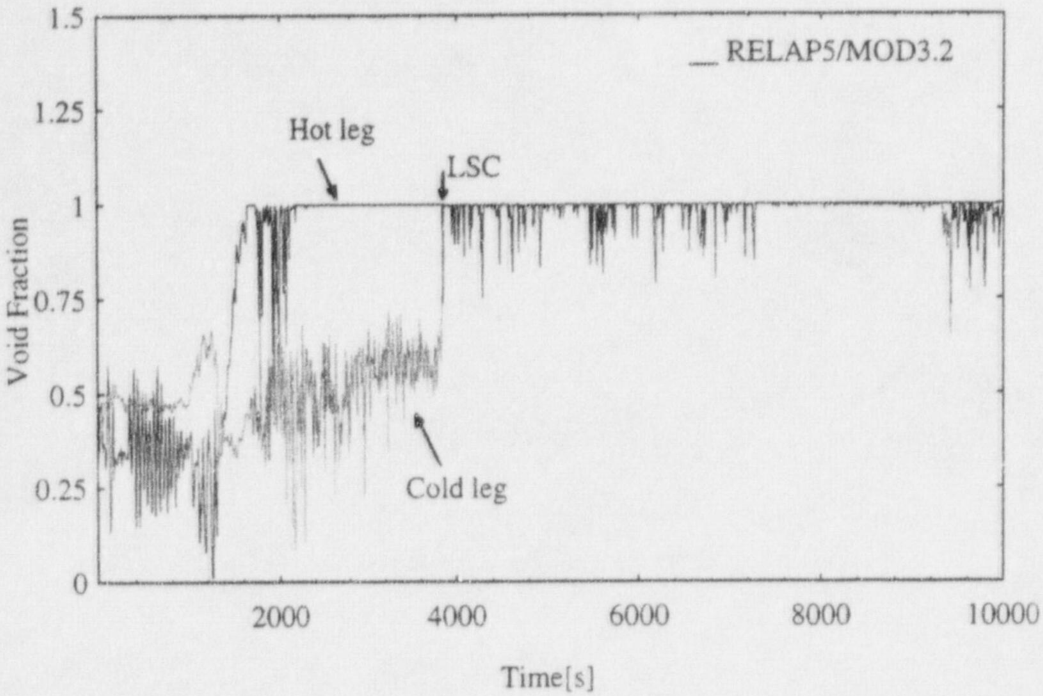


Fig. 16 The Calculated Void Fraction at Hot and Cold legs in Broken Loop

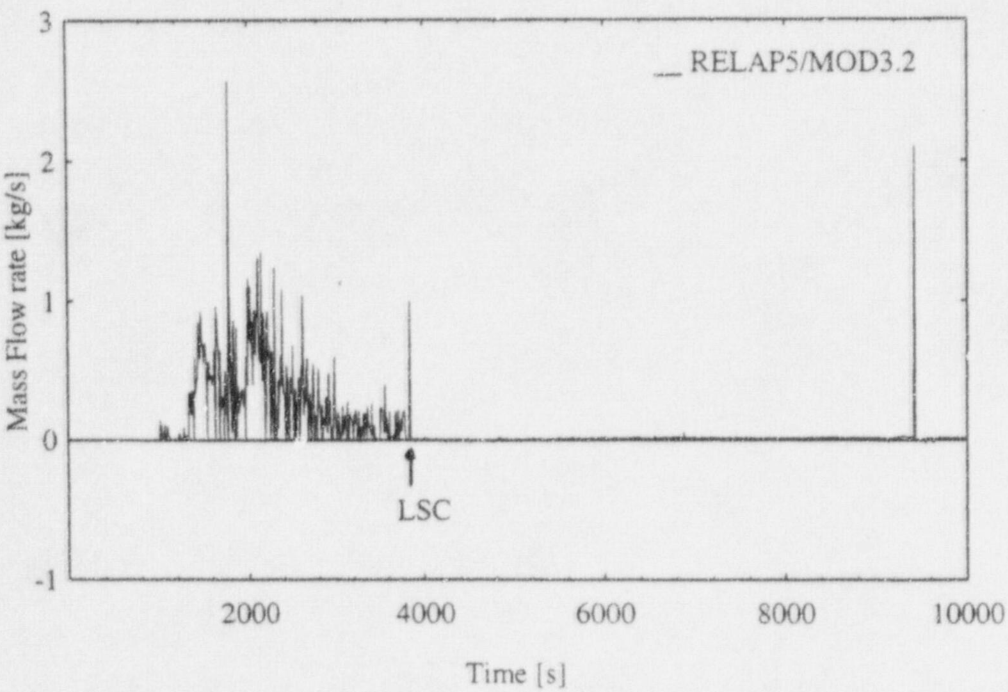


Fig. 17 The Break Flow Rate through the Cold leg Openning

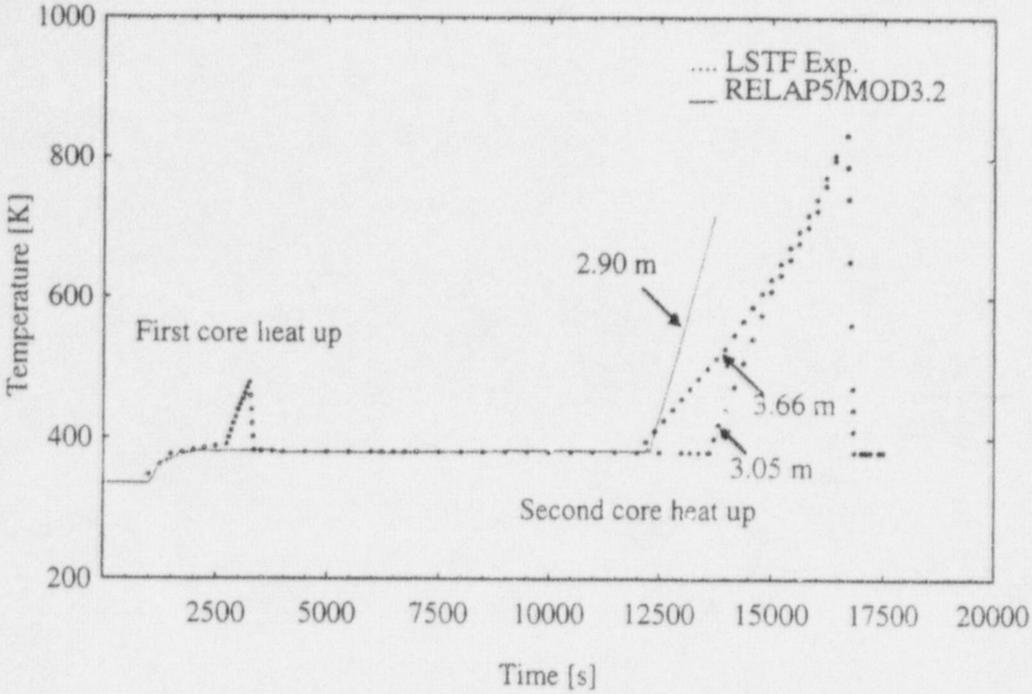


Fig. 18 Comparison of Fuel Cladding Temperatures

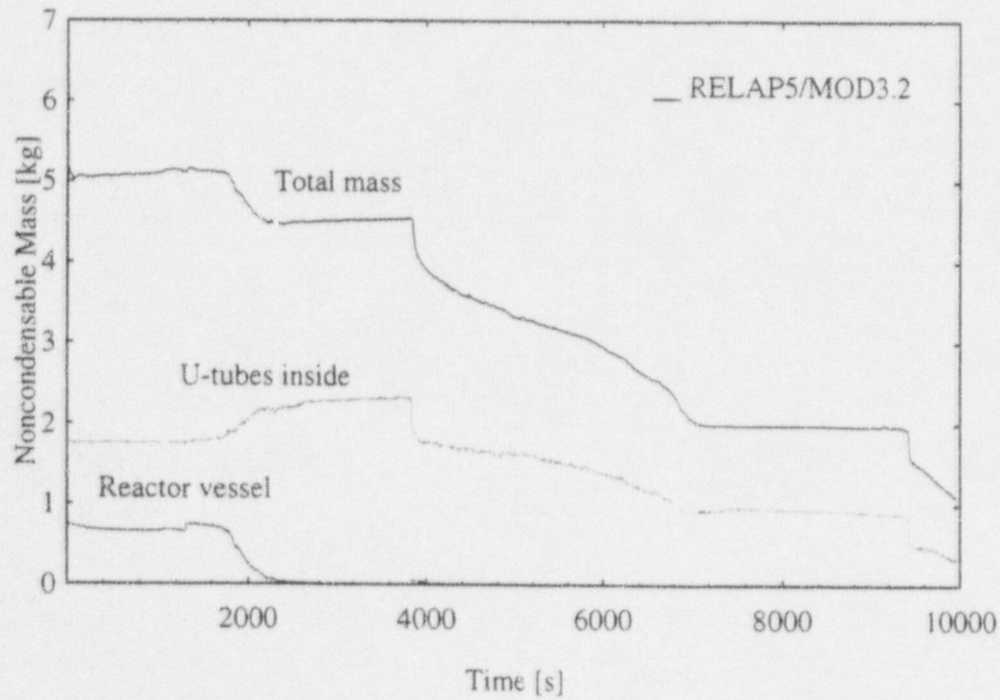


Fig. 19 The Calculated Noncondensable Mass in Primary System

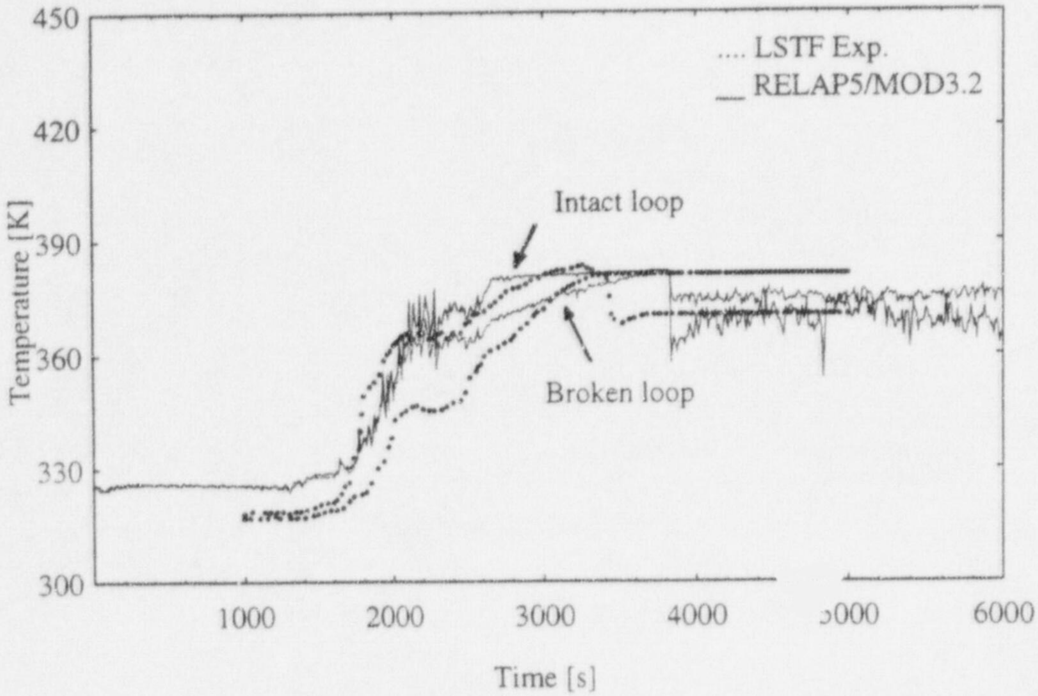


Fig. 20 Comparison of Steam Temperatures at SG Inlet Plenum

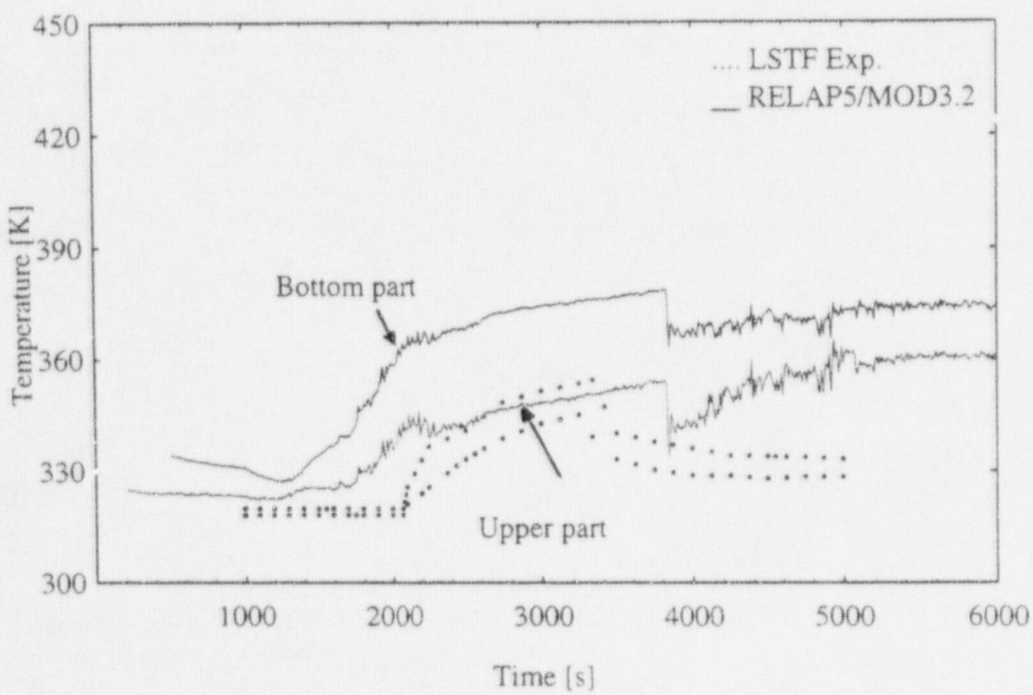


Fig. 21 Comparison of Steam Temperatures in Pressurizer

IV.3. Analysis Results for PRO Case

IV.3.1. Pressure Responses

Since the initial conditions in PRO case were nearly identical to the CLO case, the calculated transient had almost the same behavior until boiling in core was initiated. Due to steaming in the core, pressure in reactor vessel started to increase and core coolant moved into hot leg sides. Figure 22 shows comparison of the pressure behavior in core upper plenum with the experiment after the loss-of-RHR event occurred at 1000 seconds. A starting time of pressure increase and pressurization rate agreed well with the experiment but the maximum pressure was overpredicted a little. This difference was caused by an excessive vaporization in core region and by an overprediction of the water level in hot legs. Figure 23 shows that differential pressure between core bottom and upper plenum was quite underpredicted after the coolant boiling as compared to the experiment. In other words, the void fraction in the core region was overpredicted due to the excessive vaporization and voiding. As a result, the core coolant excessively moved toward hot leg sides by the steam volume expansion. Such an underprediction of the core coolant inventory could be also found in case of CLO calculation as shown in Fig. 8.

Because the hot legs were fully filled with the water for a longer time interval than in the experiment, the steam flow toward pressurizer was prevented by a water blockage in surge line during this period. Thus, the calculated pressure in upper plenum continued increasing for a longer time than in the experiment. As a result, the maximum pressure was overpredicted. When the steam flow path from the upper plenum to the pressurizer opening was formed due to the high pressure difference, the pressure stopped increasing and started to decrease rapidly. After the steam flow was stabilized, the pressure remained nearly constant. In this phase, the calculated agreed well with the experiment. Figure 24 shows that the discharging flow through the pressurizer opening started at about 3200 seconds, resulting in rapidly decreasing the pressure and the stable outflow was formed from about 4000 seconds, resulting in keeping nearly the constant pressure. As a result, since the code unsatisfactorily overpredicted the coolant mass inventory in the hot legs, the surge line and core region, the calculated pressure resulted in overshooting the experiment in the rising phase of the pressure.

IV.3.2. Thermal Responses

Shown in Fig. 25 is comparison of liquid temperatures in hot leg of intact loop with the experiment and Fig. 26 shows fuel cladding temperatures in the eleventh node from bottom among the total of 12 nodes. Due to the loss-of-RHR, the calculated liquid temperatures increased rapidly in the early phase and overshot a little the experiment owing to the overprediction of pressure in reactor vessel. However, after the discharging flow through opening became stabilized from about 4000 seconds, it remained constant saturation temperature, which agreed well with the experiment. Liquid temperature in broken loop also had nearly the same behavior.

As the coolant was discharged through the pressurizer opening, the core coolant mass inventory decreased slowly as shown in Fig. 23. Such decreased core inventory caused an uncovered core and the core heat up, which occurred at 9400 seconds in the experiment. As described above, due to the underprediction of coolant inventory in the reactor vessel, the calculated heat up was initiated earlier by 3000 seconds than in the experiment as shown in Fig. 26. When the fuel cladding temperature exceeded 830 K, auxiliary feedwater was injected into the SG in intact loop to remove the heat energy in the experiment. The calculation also stopped at this fuel cladding temperature.

IV.3.3. Water Level and Loop Behavior

Due to excessively voiding in the core, the large amount of core coolant moved into hot legs and then the water level in the loop rised up to the top part of the hot leg. After filling up the hot leg, the water level in pressurizer started to increase rapidly by liquid insurge through surge line because the manway at the top of the pressurizer was opened. Figure 27 shows comparison of the collapsed water level in the pressurizer with the experiment. The calculated water level started to increase a little later by 600 seconds and were quite overpredicted. As described above, the overshooting of the pressure resulted in the excessive and late rising of the water level. Figure 28 shows that the void fraction in the bottom part of the surge line became zero in the rising phase of pressure, i.e., the surge line was rapidly filled with water as the pressure increased to the maximum value. As a result, the overprediction of the water level in hot legs caused an overshooting of the water level in pressurizer. Even after the surge line was completely being emptied from about 4000 seconds, the calculated water level remained higher value, even though the pressure agreed well with the experiment. Such large water hold up in the pressurizer came from an overprediction of interfacial drag between two phases, because the relative velocities in the pressurizer were calculated very high, although the corresponding experimental data were not available.

Figures 29 and 30 show comparison of calculated mixture density in hot leg and cold leg with those in the experiment. They show clearly that the water level reached to the top part of the hot leg and remained the full level for a longer time period, for over 1000 seconds, even with severe oscillations during this phase. Whereas the experiment shows that the water level in the hot leg rapidly dropped at about 1600 seconds and the hot leg was not fully filled with the water throughout almost transient. As described above, the reason for the overprediction of the water level in the hot legs was the excessive inflow of the core coolant from the reactor vessel. These figures also show that the coolant in the loop was completely emptied at 4000 seconds earlier than in the experiment. Figure 31 also shows that the void fraction at hot legs in broken loop became nearly 1.0 about 4000 seconds when the discharging flow was stabilized. It implies that the discharged mass flow through the opening was overpredicted, but unfortunately the data on the discharged flow rate was not available. Anyway, such an overprediction of the discharged flow rate caused earlier heat up in the core region as shown in Fig. 26.

In this assessment, the surge line pipe was simply modelled 3 horizontal nodes with inclined angle of 30 ~ 40 degree, whereas it has actually complicated geometry. For sensitivity study, a model with 9 horizontal and vertical nodes for the surge line was attempted to assess. However, there were no significant differences in the calculation results. As shown in Fig. 32, the surge line had horizontal stratified flow (HSF) regime in the early phase because the mass flux is very small. The bubbly flow (BF) was intermitently formed from 2200 seconds before the liquid inflow into pressurizer was formed. Because the HSF and BF with void fraction of almost zero prevented the steam flow toward pressurizer opening from the hot legs, the pressure in hot leg side continued to increase until the steam flow was formed by sufficient differential pressure. When the water level in hot leg dropped sufficiently at about 3300 seconds, the gas velocity in the surge line started to increase as shown in Fig. 33. The sufficient gas velocity hold up the water in the pressurizer and the steam generated in the core was stably discharged through pressurizer opening. In the experiment, the measured void fraction, even though the data was not available, showed that the surge line horizontal part was generally steam-filled throughout almost transient and the flow regime might be mist or annular mist flow where liquid is carried away by the gas flow. As a consequence, the code unsatisfactorily predicted the flow pattern in the loop including the surge line, especially in the rising phase of pressure, because of the incorrect prediction of the coolant inventory in the hot legs and the core region. Eventually, the steam flow path through the surge line was established a little later and the liquid hold up and water level in the pressurizer were overpredicted.

IV.3.4. Noncondensable gas behavior

Figure 34 shows noncondensable gas behavior during the transient. The initial total mass of 5.22 kg existed in primary system and decreased rapidly just after the steam flow toward pressurizer opening was formed at about 3400 seconds. The experiment showed that the gas flow in the hot leg was multi-dimensional when the net flow was very small, with air-rich gas stagnating at the pipe bottom and steam flow creeping only the ceiling towards the SG. However, steam condensation did not occur in the SG U-tubes wall since the tubes were still filled with an air and the secondary sides of U-tubes were completely emptied. Thus the rapid change of the air fraction in SG U-tubes was not occurred, whereas it occurred just after the loop seal clearing in the CLO case. It implies that the effect of noncondensable gas was not important in the PRO case because the steam condensation phenomena was not dominant during all the transient.

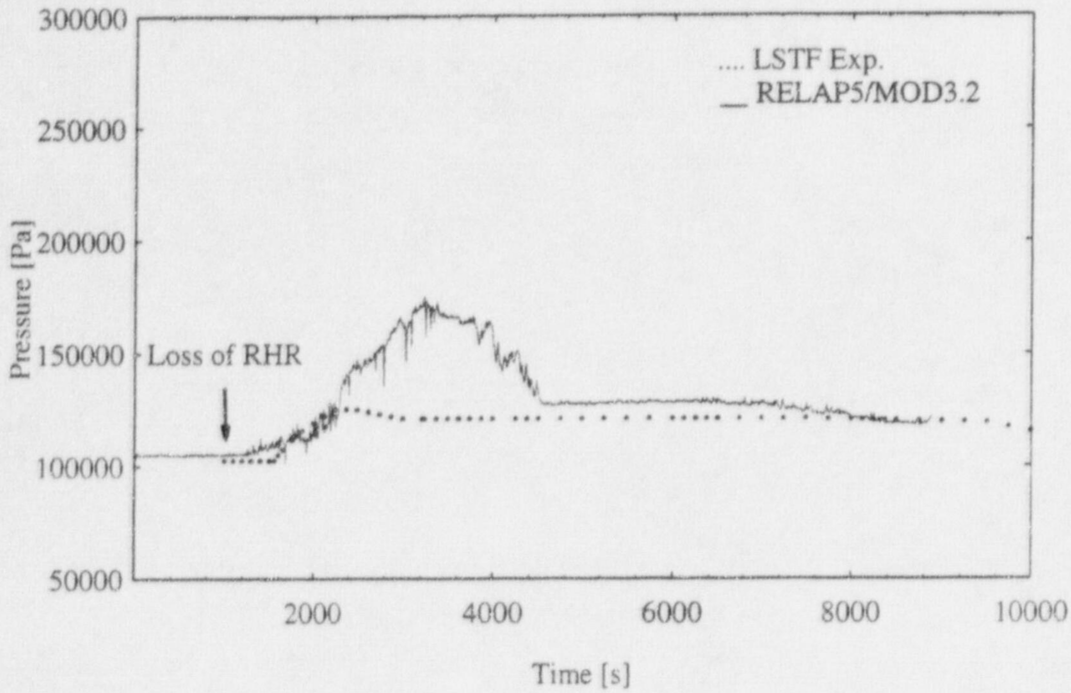


Fig.22 Comparison of Pressures in Core Upper Plenum

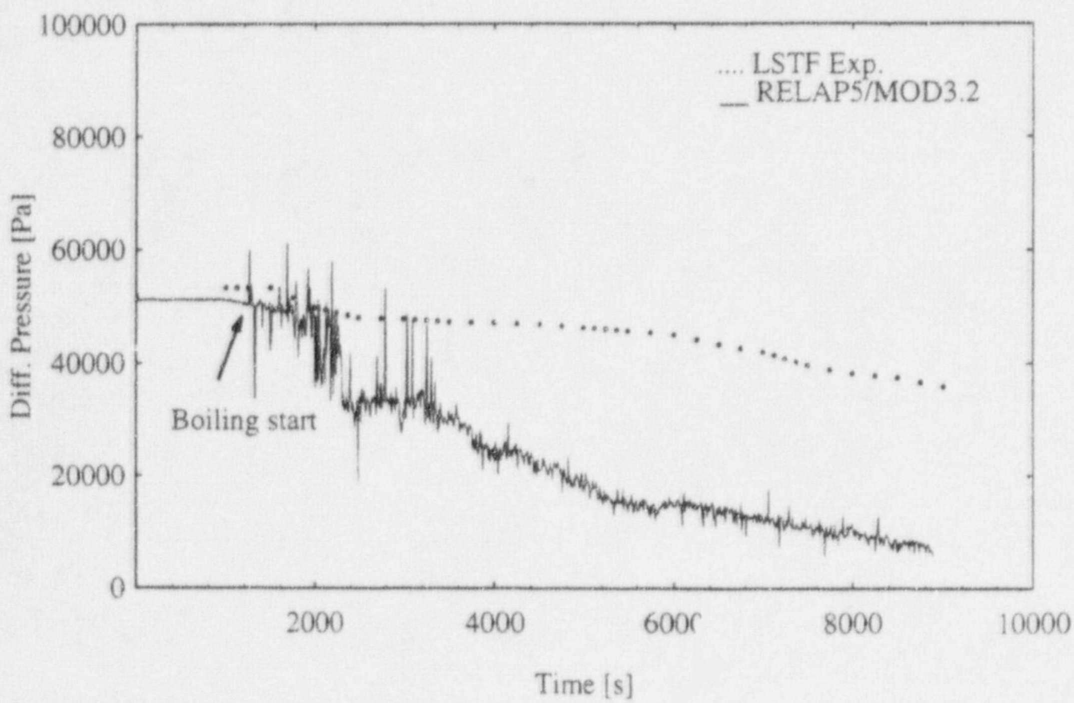


Fig.23 Comparison of Differential Pressures Between Core Bottom and Upper Plenum

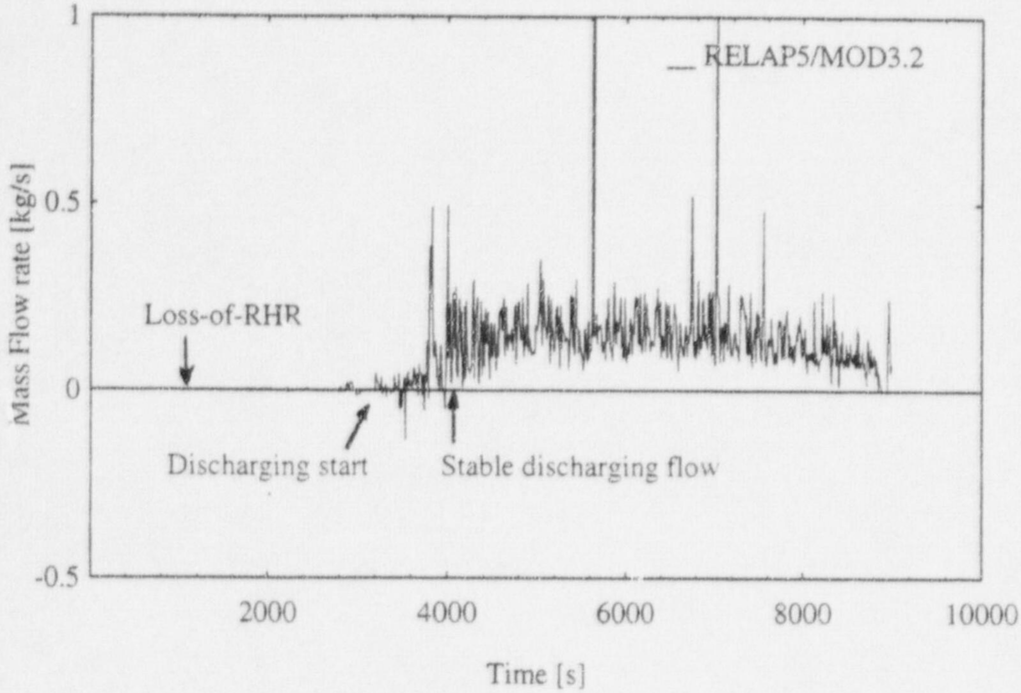


Fig. 24 The Discharged Flow Rate Through Pressurizer Manway Openning

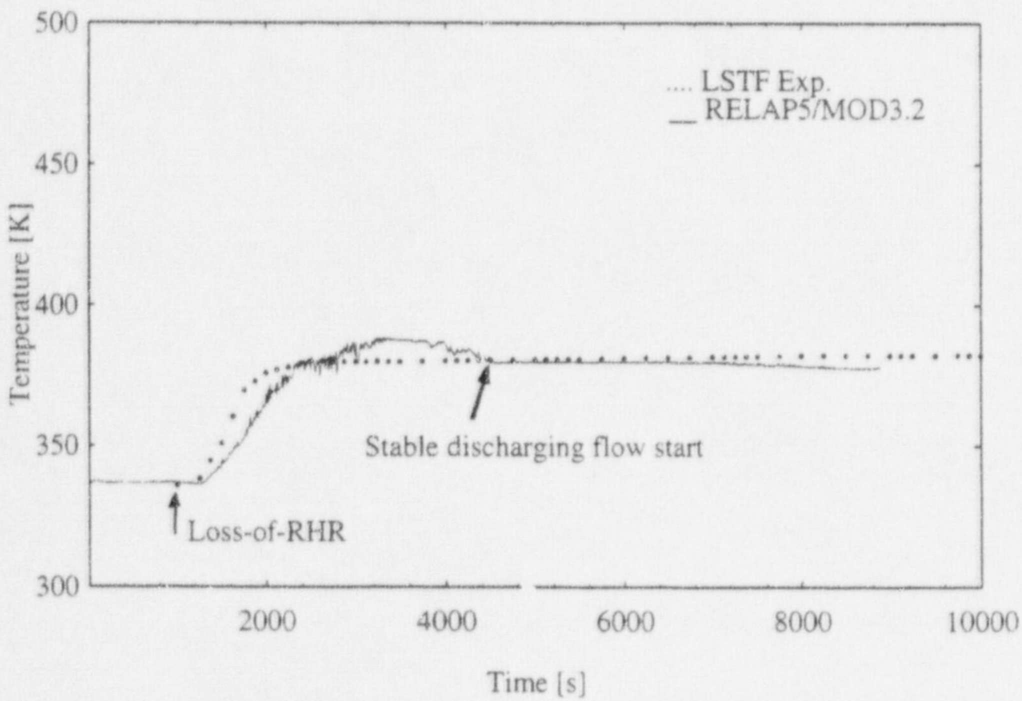


Fig. 25 Comparison of Liquid Temperatures at Hot leg in Intact Loop

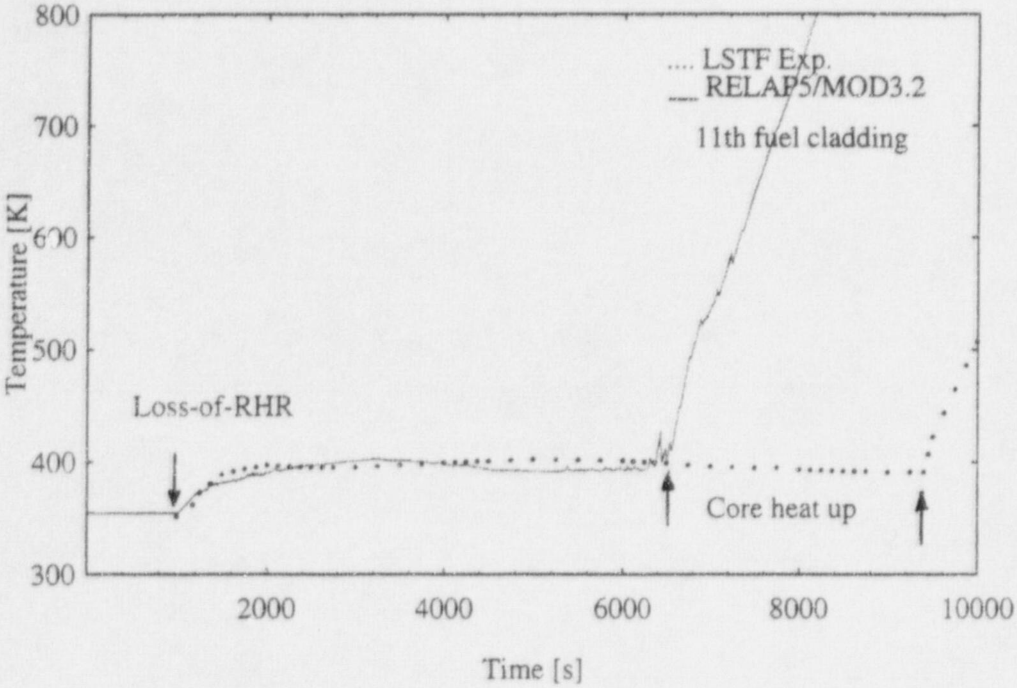


Fig. 26 Comparison of Fuel Cladding Temperatures

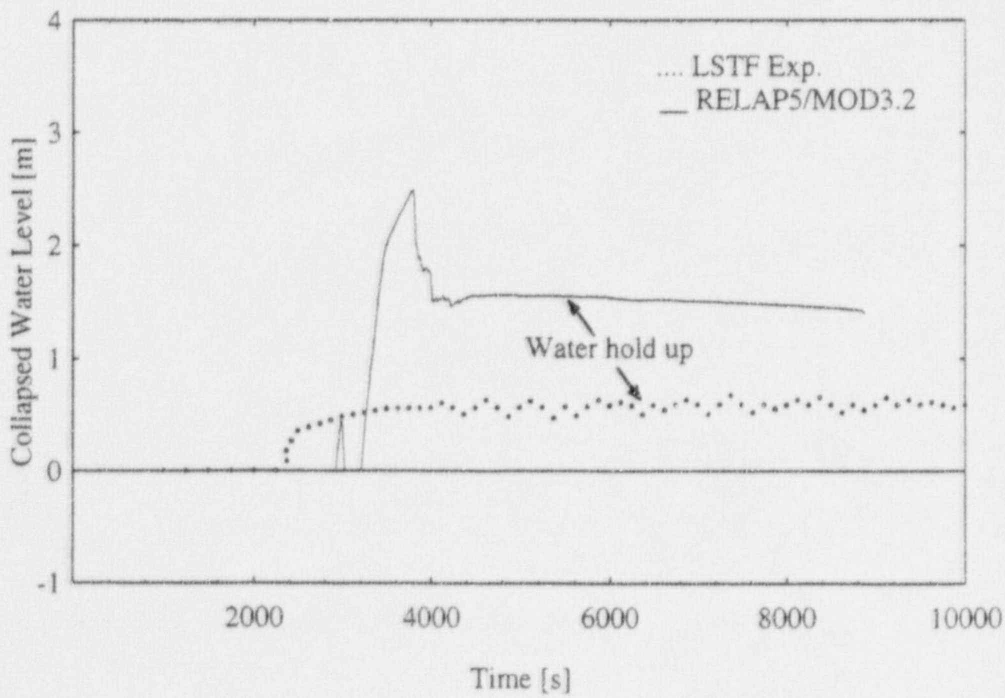


Fig. 27 Comparison of Collapsed Water Levels in Pressurizer

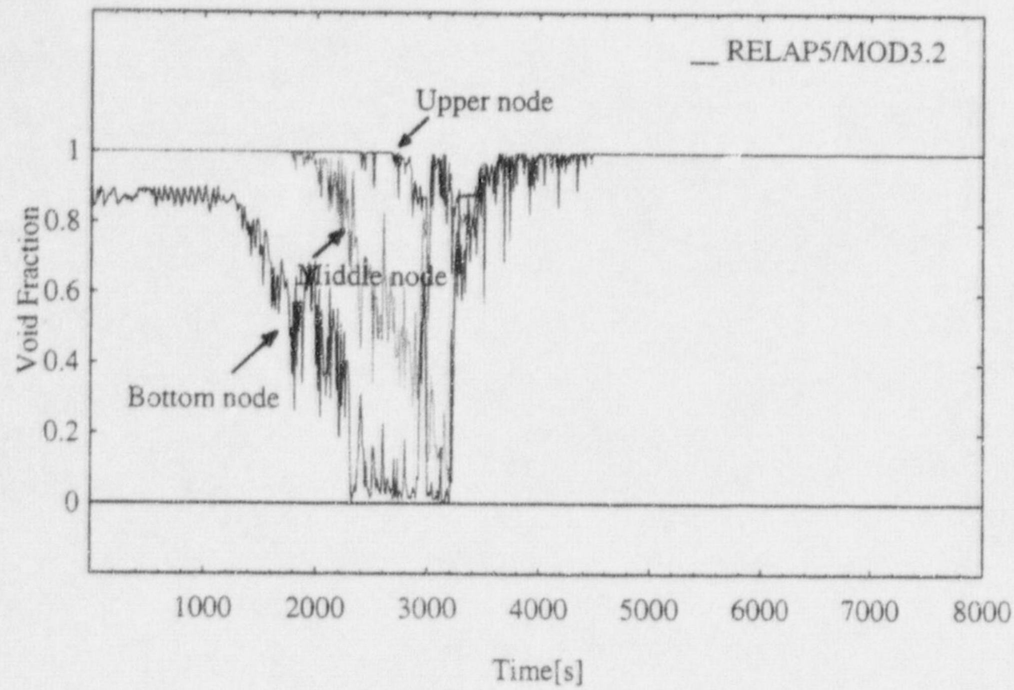


Fig. 28 The Calculated Void Fractions in Surge Line

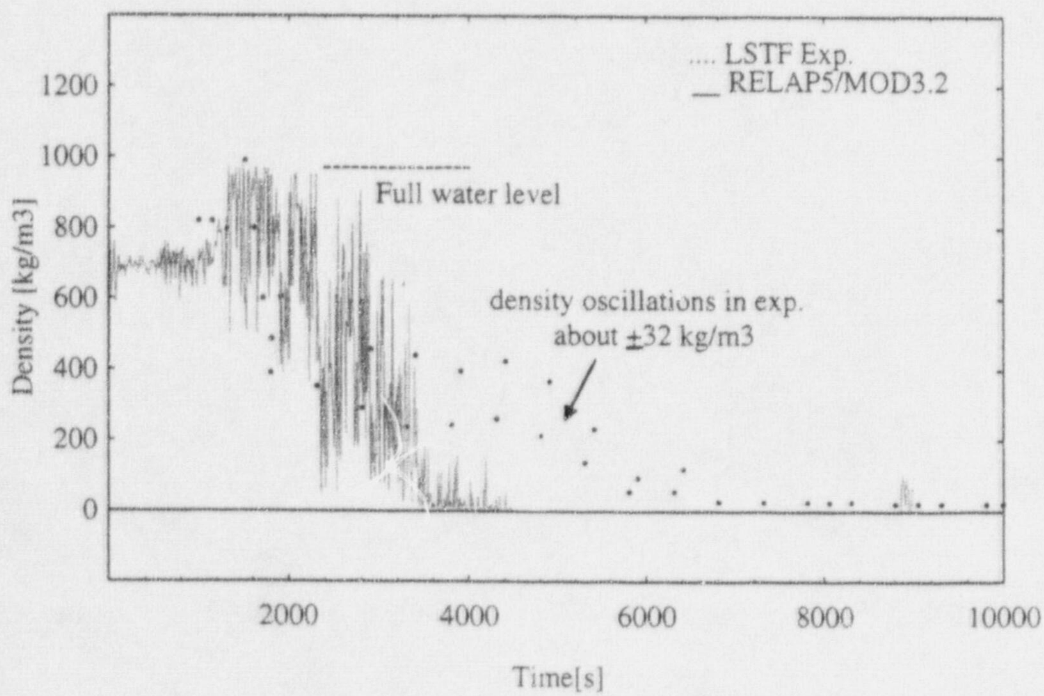


Fig. 29 The Calculated Fluid Density at Hot Leg in Broken Loop

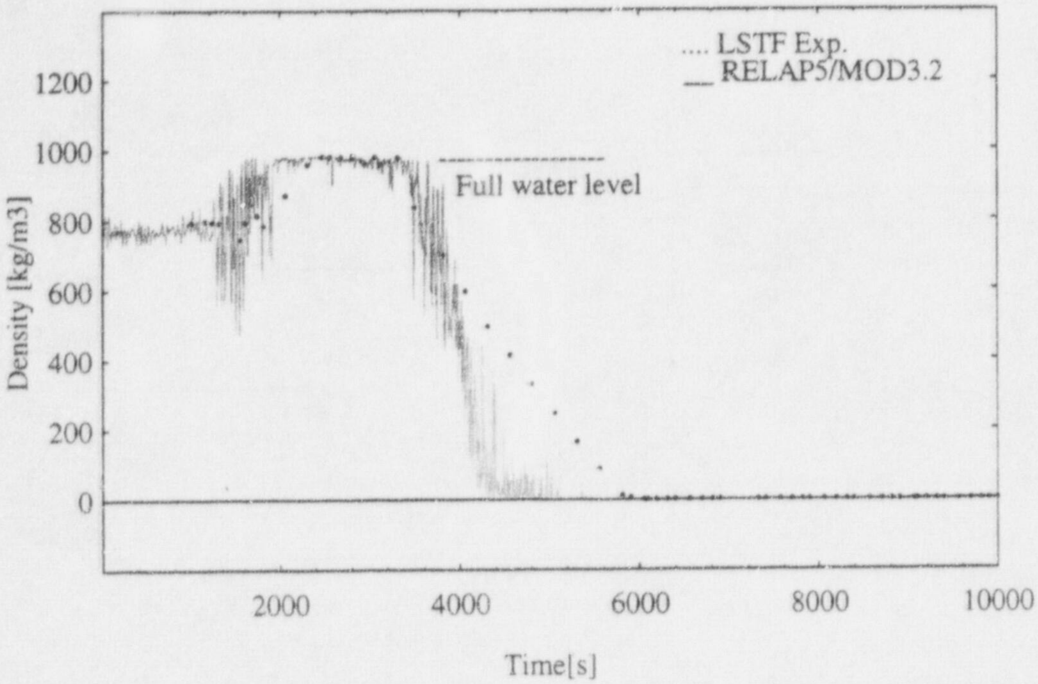


Fig. 30 The Calculated Fluid Density at Cold Leg in Broken Loop

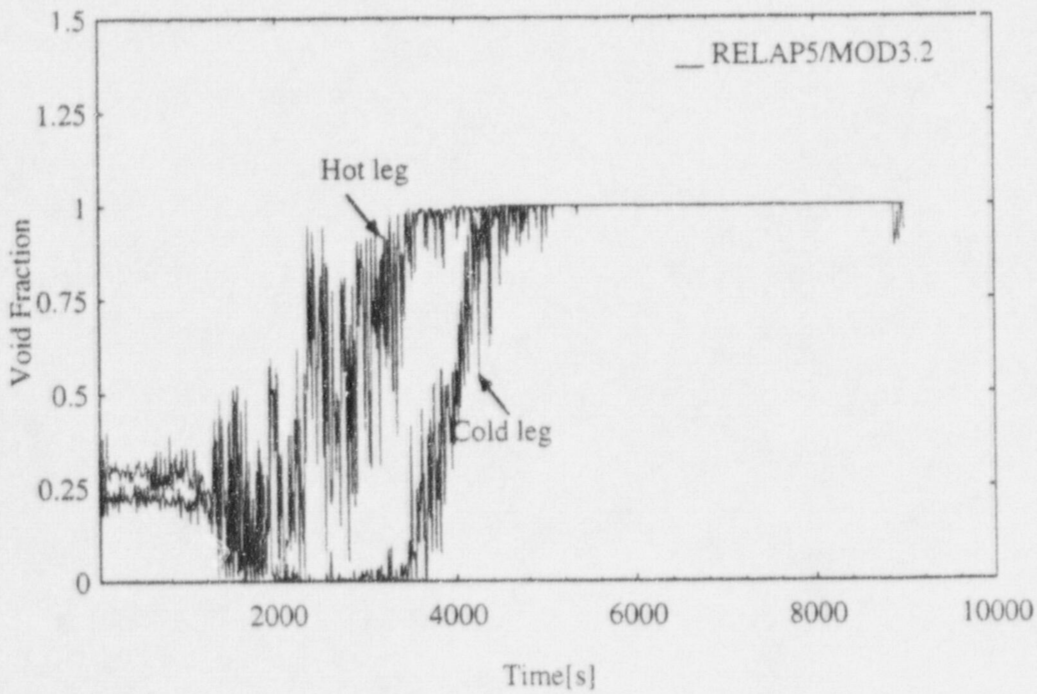


Fig. 31 The Calculated Void Fractions at Hot and Cold legs in Broken Loop

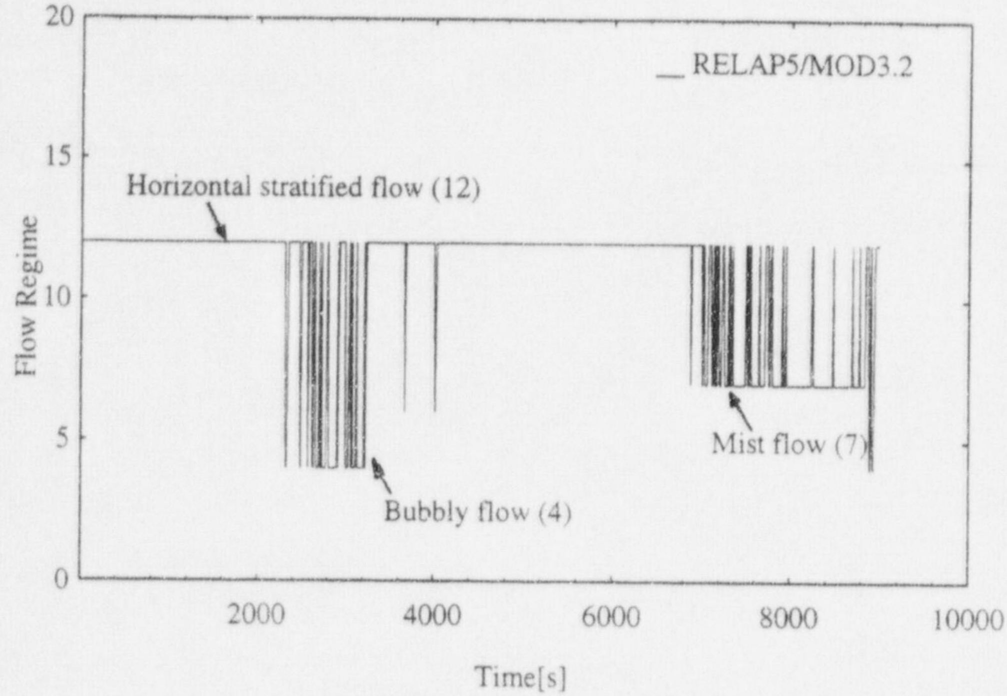


Fig. 32 Flow Regimes in Surge Line

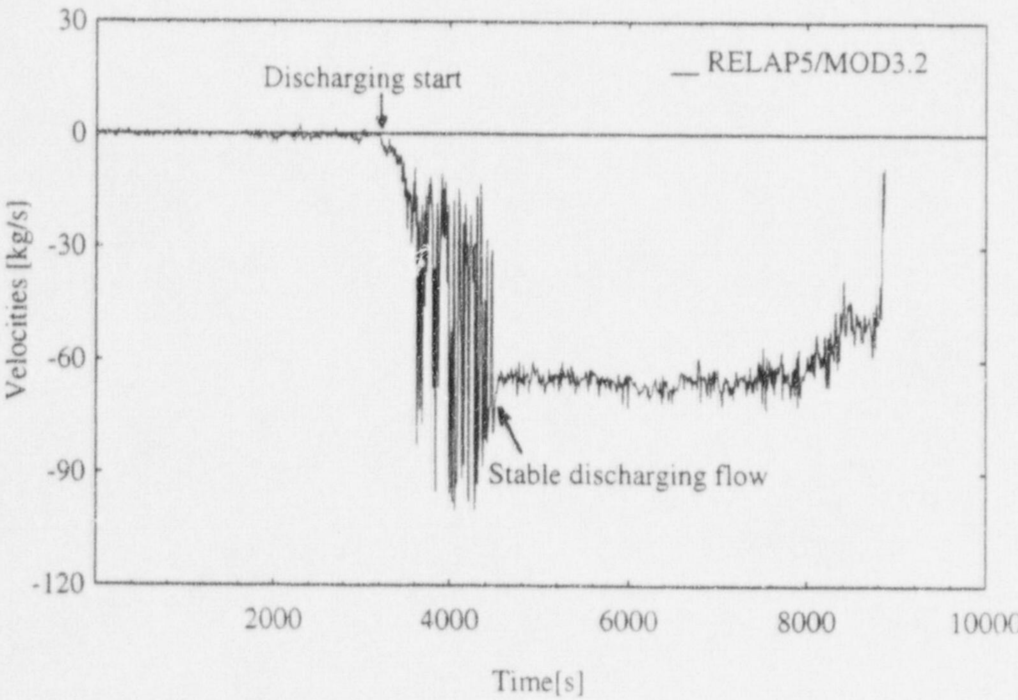


Fig. 33 The Calculated Gas Velocity in Surge Line

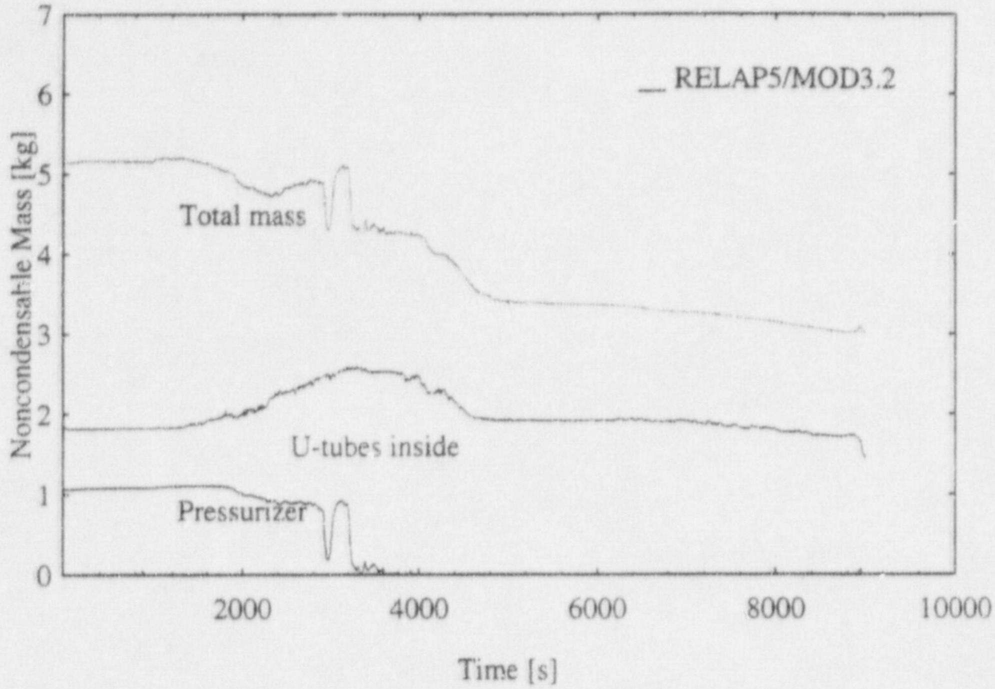


Fig. 34 The Calculated Noncondensable Mass in Primary System

IV.4. Discussion

IV.4.1. CPU time and Mass Error

There have been many difficulties in getting convergence of transient calculation following the loss-of-RHR event during the mid-loop operation. In particular, it was difficult for the code to calculate the ansport process of the mixture gas phase involving noncondensable gas under low flow and low pressure conditions. When the noncondensable gases enter a volume which was filled with steam, the extremely small size of time step was required and the long CPU time was consummed. For example, the calculation performed by H. Nakamura et. al. [3], using the RELAP5/MOD3 v5m5 code on FACOM M-780/20 scalar computer, took CPU time of 37.2 hours to simulate the transient of 3831 seconds. Also, the calculation performed by S. Banerjee et. al. [4] took over 60 hours of CPU time for the same transient of 3040 seconds, even using the CRAY-YMP super-computer. In addition, those calculations were halted at transient time of less than 4000 seconds and eventually the long term system behavior could not be analyzed.

In present calculation using the RELAP5/MOD3.2 version on a DEC station 5000/240, it just took the CPU time of about 6 hours to simulate the transient of 3500 seconds, which is nearly 10 times fast. Table 6 shows comparison of the computational times for the CLO case. Figure 35 shows the required CPU times for the CLO and PRO cases. Transient run started at 1000 seconds and the running was successfully performed without any failure during the transient calculation. The calculated shows that the two channel core model required more CPU time of 1.3 times than the single channel core model, but similar CPU time was required for both cold leg opening (CLO) case and pressurizer opening (PRO) case.

As a result, the present study showed that the MOD3.2 version was capable of simulating the thermal hydraulic processes including noncondensable gases with appropriate time step and CPU time following the loss-of-RHR event during the reduced inventory operation. Even though there were still some flow oscillations, the major phenomena such as a loop seal clearing and a gas migration during the transient were well predicted with appropriate computational speed.

Table 7. Comparison of the Computational Times

Items	Nakamura et. al.[3]	Banerjee et. al. [4]	Present
▪ Code	RELAP5/MOD3/5m5	RELAP5/MOD3/5m5	RELAP5/MOD3.2
▪ Machine	FACOM M-780/20 Scalar computer	CRAY-YMP Super computer	DEC-5000/240 Workstation
▪ Transition time ▪ CUP time	3831 sec. 37.2 hours	3040 sec. 60 hours	3500 sec. 6 hours
▪ Core model ▪ Max. time step ▪ Mass error	two channel N/A N/A	single channle 0.005 sec. N/A	two channel 0.1 sec. 43 kg

In addition to the computational time problem, it has been known that the RELAP5/MOD3 code predicts too large system mass errors during the transient under low power and low flow conditions. In general, this excessive mass error is caused by several situations such as the truncation errors in the linearization procedures, the use of incorrect properties in the numerical scheme, the first appearance of noncondensable gas in a volume and so on. In order to mitigate the mass error in RELAP5/MOD3 code, if the excessive mass error is detected, the time step is repeated at a reduced interval. The system mass error, ε_{srm} is given as nondimensional form as follows:

$$\varepsilon_{srm} = 2\sum_{i=1}^{N}[V_i(\rho_i - \rho_{mi})]^2 / \sum_{i=1}^{N}(V_i\rho_i)^2$$

where ρ_i and ρ_{mi} are the total density of the i-th volume obtained from the state relationship and the mass continuity equation, respectively. The V_i is the element volume and N is the number of the volume.

In present calculation for both cases with two channel core model, the mass error in primary system was estimated about 90 ~ 100 kg, that was nearly 4 % of initial coolant mass inventory for the transient of 2.8 hours. Figure 36 shows the estimated mass errors behavior with the transient time. The mass error was rapidly generated for the early phase of coolant boiling and thereafter it gradually rised. Because the large mass error could significantly reduce the reliability of the calculational data, these mass errors should be reduced to the negligible value. Therefore, a numeric scheme to remove reasonably the mass errors should be considered and developed in the RELAP/MOD3.2 version.

IV.4.2. Effect of Core Nodalization

The nodalization scheme in core is known to have influence on calculation time and thermal hydraulic behavior in primary system [3]. In this assessment, two type of core nodes were considered for a sensitivity study as shown in Fig. 3. As discussed above section, two channel core model required a little more CPU time and caused a little larger mass error than the single channel core model. In addition to the computational time, two channel core model could provide somehow the resolution of the problems resulted from one-dimensional nature of the RELAP5 code such as negligence of natural circulation flow in the core region during the coolant boiling phase. Adversely, it could also give an unrealistic flow behavior such as too fast circulation flows or incorrect flow direction in the core. Figure 37 shows the mass flow rate at mid-core junction for the case of two channel core model. After the loss of RHR event at 1000 seconds, the natural circulation flow was formed during about 700 seconds. Thereafter, there was severe flow oscillations of the vertical and horizontal direction, which did not occurred in the experiment. In case of single channel core model, there was no natural circulation flow but more severe flow oscillations of the vertical direction occurred. These flow oscillations were caused by void oscillations in the core region. The PRO case also showed similar flow oscillations. As a result, it can be stated that the code unsatisfactorily predicted the flow behavior in the core region under low flow and low power conditions.

In spite of the unrealistic flow behavior, the two channel nodalization gave a little more stable flow than the single channel noding and well predicted the coolant mixing in the reactor vessel due to the natural circulation flow. Figure 38 shows the liquid temperatures in core upper plenum for the CLO case. It represents clearly that the two channel core model agreed with the experiment better than the single channel core model. It implies that the multi-dimensional flow characteristic in the core region was compensated by the two channel core nodalization because the fluid in the core was well mixed by the natural circulation flow. Thus, the two channel core predicted a little close to the experiment the major phenomena such as the onset of boiling and the timing of loop seal clearing.

IV.5 Run Statistics

The main computer used in the present calculation was a DEC workstation 5000/240 with UNIX operating system. The required CPU time for the CLO and PRO cases following the loss-of-RHR event was shown in Fig. 35. Figures 39 and 40 show the Courant time limit and advanced time step size with respect to a real transient time for both cases. The maximum time step size was 0.1 second for all the transient and the calculation was runned reasonably with time step below the Courant Limit. For example, the required CPU time to simulate the transient time of 10,000 seconds was 165,222 seconds including 8.7 seconds for input processing for CLO case with two channel core node. The attempted advancement was 228,694 time steps. For the PRO case with single channel core, the required CPU time for the transient of 8,000 seconds was 83,522.7 seconds and the attempted advancement was 153,949 time steps. Therefore, the grind times of both cases can be calculated as follows;

(1) For CLO-Two channel core model case

- CPU time	CPU = 165,222.0 - 8.7 = 165,213.3 sec
- Number of time step	DT = 238,730 - 10,036 = 228,694
- Number of Volume	C = 179

- Transient Real Time RT = 10,000 sec
- Grind Time GT = CPUx1000/(CxDT) = 4.036 CPU msec/vol/step

(2) For PRO-Single channel core model case

- CPU time CPU = 83,522.7 - 8.0 = 83,514.7 sec
- Number of time step DT = 153,949 - 10,059 = 143,890
- Number of Volume C = 158
- Transient Real Time RT = 8,000 sec
- Grind Time GT = CPUx1000/(CxDT) = 3.673 CPU msec/vol/step

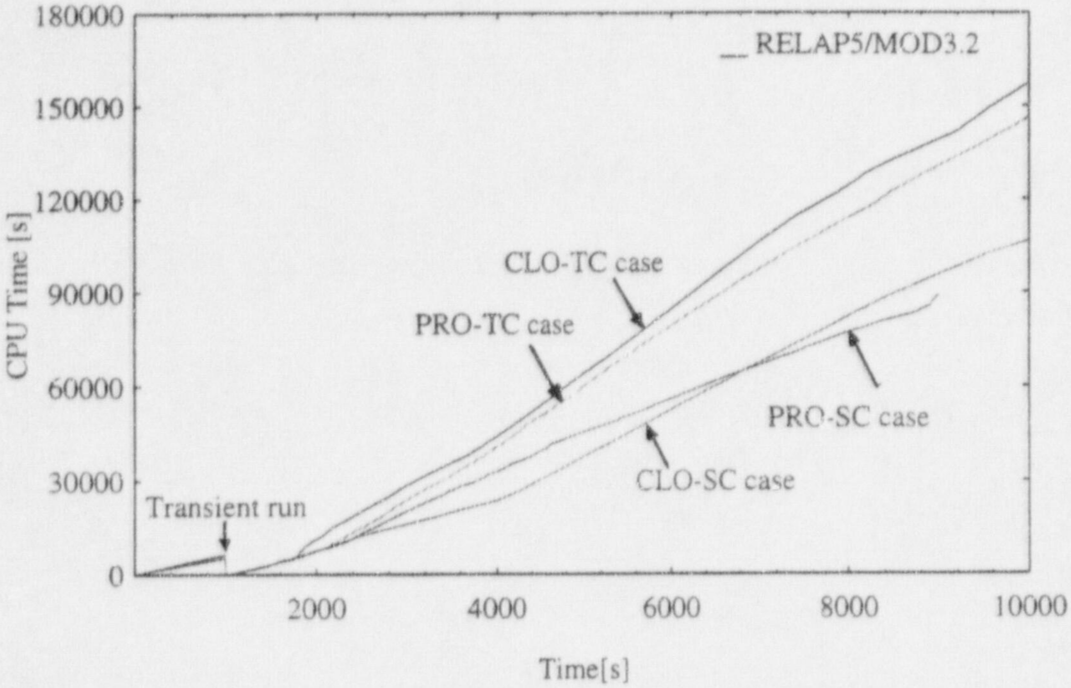


Fig. 35 The CPU Times for CLO and PRO Cases

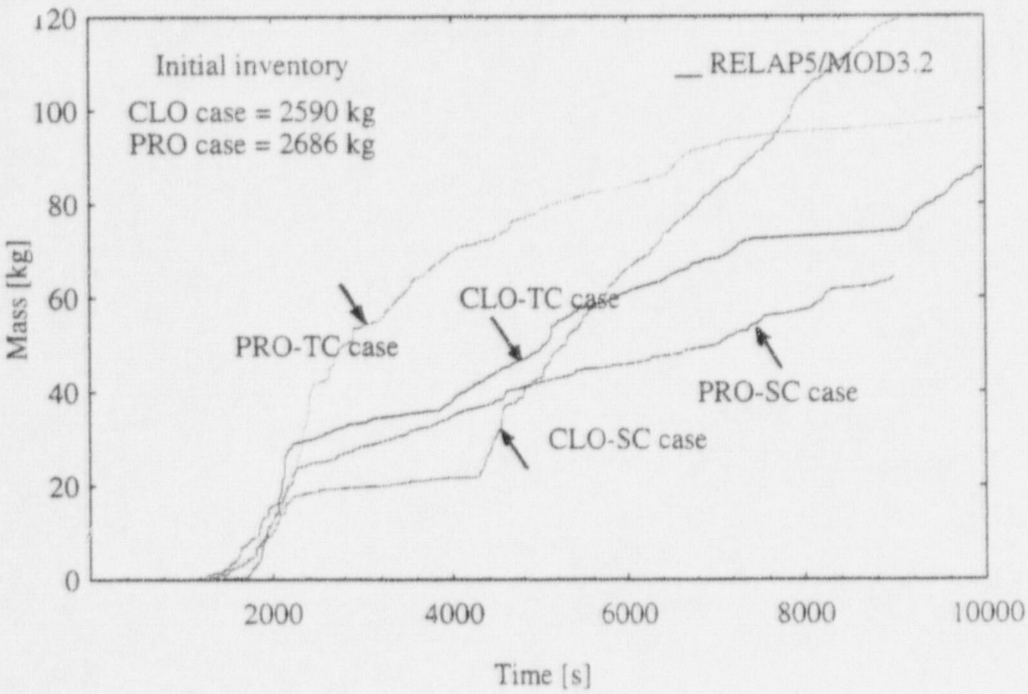


Fig. 36 The Estimated Mass Errors for CLO and PRO Cases

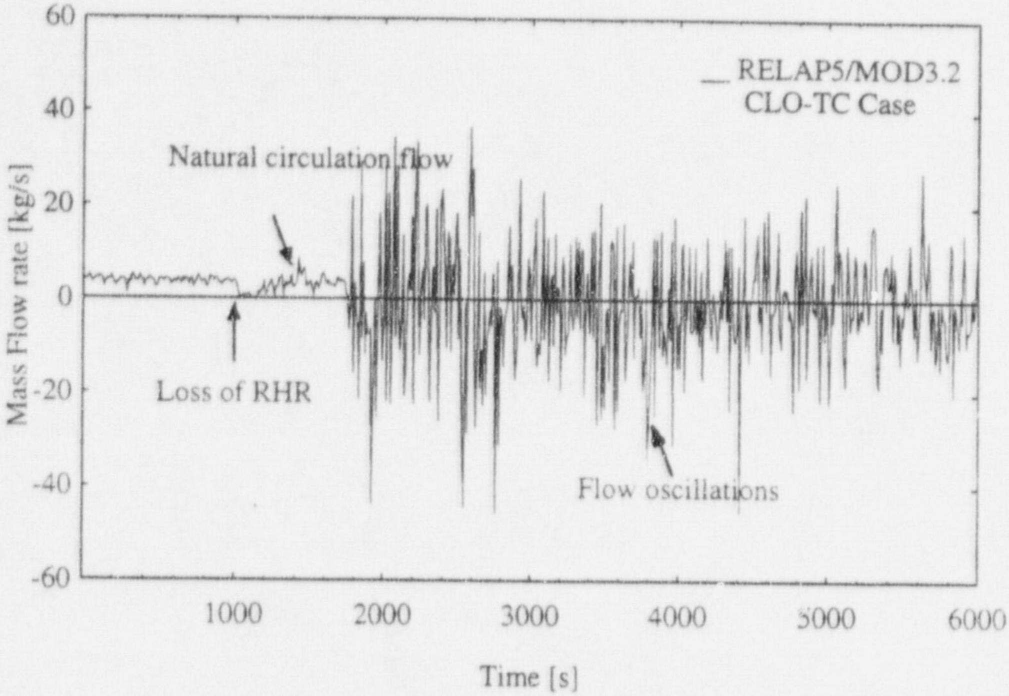


Fig. 37 The Calculated Flow rate at Mid-Core Junction

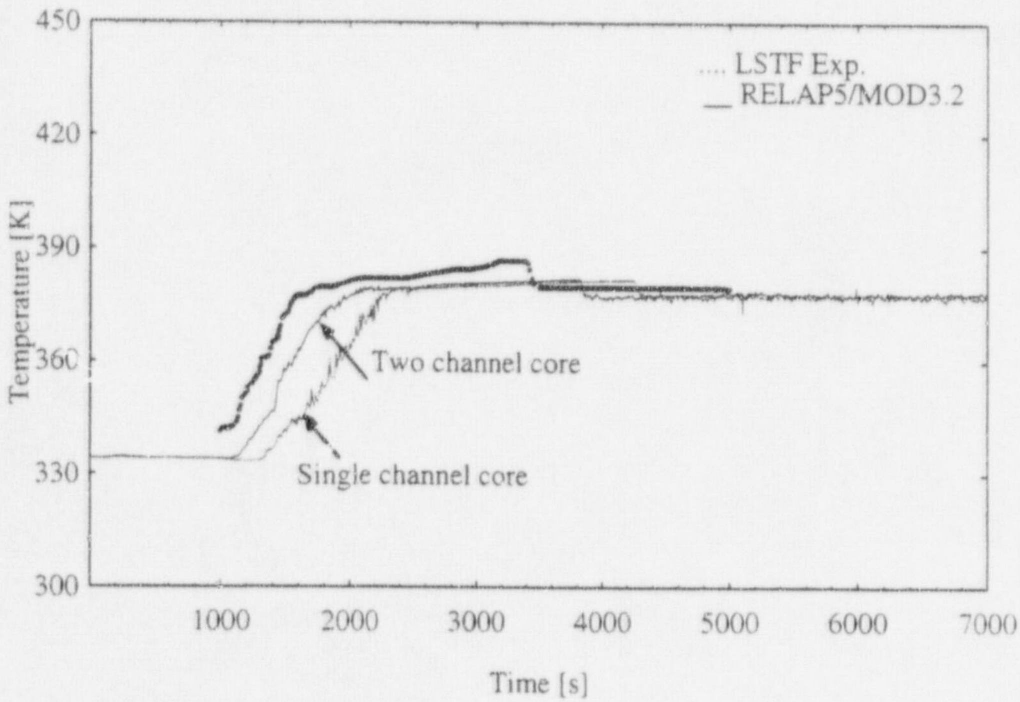


Fig. 38 Comparison of Fluid Temperatures in Core Upper Plenum

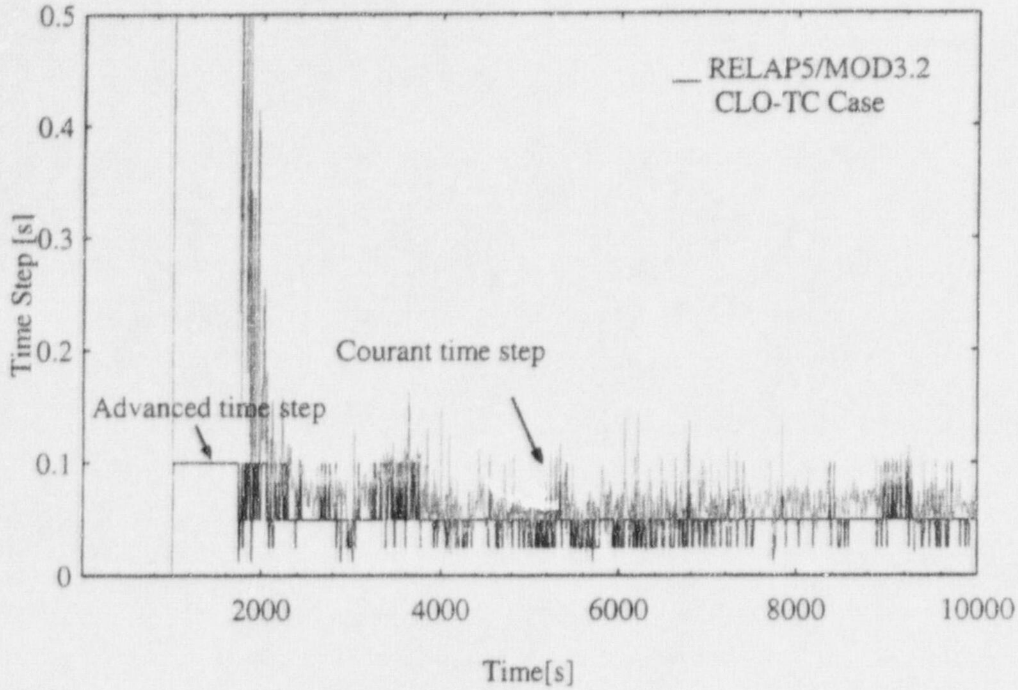


Fig. 39 The Advanced Time Step for CLO Case

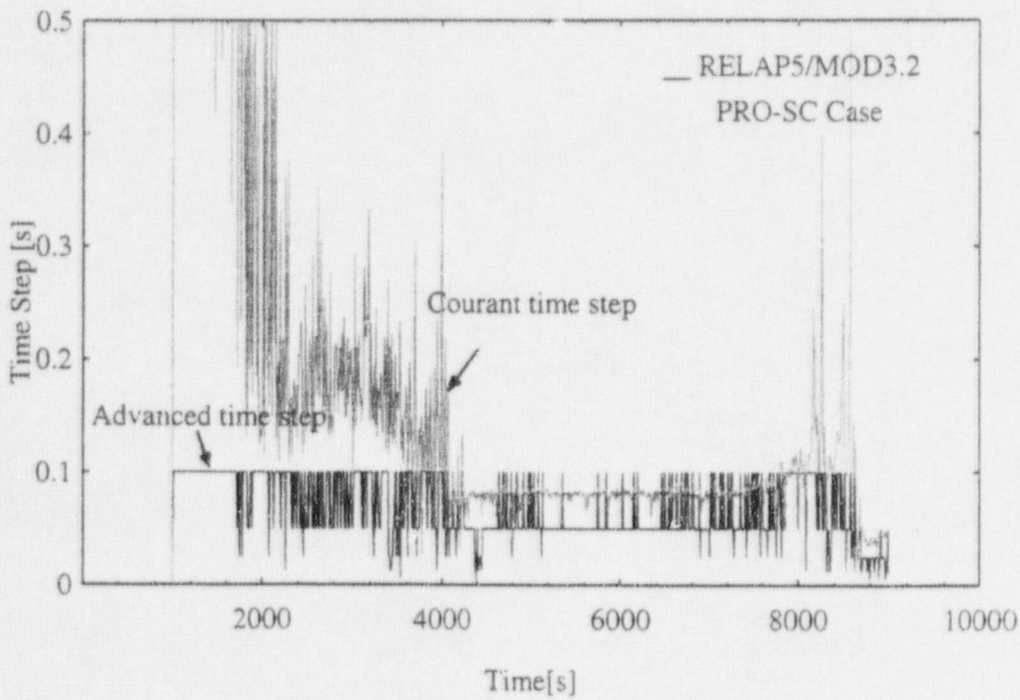


Fig. 40 The Advanced Time Step for PRO Case

V. Conclusions

The potential for the RELAP5/MOD3.2 code was assessed for the loss-of-RHR event during the mid-loop operation and the predictability of major thermal hydraulic phenomena was also evaluated for the long term transient. The calculations were compared with two cases of experiments, cold leg opening (CLO) case with water-filled SGs and pressurizer manway opening (PRO) case with emptied SGs, which were conducted at ROSA-IV/LSTF in Japan. The CLO case was to simulate the geometry conditions during the maintenance of reactor coolant pump and the PRO case was to simulate an open manway on the top of the pressurizer.

1) From the present study, it was found that the RELAP5/MOD3.2 code was capable of simulating the system responses to the loss-of-RHR event during the reduced inventory operation. Especially, thermal hydraulic transport process including noncondensable gas behavior was reasonably predicted with an appropriate time step and CPU time. However, there were some code deficiencies such as an estimation of too large system mass errors and severe flow oscillations in the core region.

2) For the two typical geometry cases, the code predicted well the major phenomena during the long term transient, such as the coolant boiling off in the core, system pressurization, the occurrence of loop seal clearing (LSC), the migration of the noncondensable gas, liquid hold up in pressurizer, core uncovery and so on. Also, the overall trend of system pressures and fluid temperatures and the water level behavior agreed well with the experiment.

3) However, in the CLO case, the heat transfer to the SG secondary side was overestimated due to an excessive condensation on the U-tube wall by a large amount of steam migration toward the SG U-tubes. Thus, the onset of the LSC was a little delayed as compared to the experiment. In the PRO case, the maximum pressure in core upper plenum was overeshot due to an excessive steaming in the core region and the liquid hold up in the pressurizer was also overestimated. Thus, the core heat up

initiated much earlier than in the experiment.

4) Two type of core models were considered for sensitivity study. There were no significant differences between both models, but the multi-dimensional effect on natural circulation flow in the core region was somehow compensated by the two channel core nodalization. Thus, the coolant temperature in the core region was predicted more accurately in case of two channel core model.

References

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[2] U.S. NRC, "Loss of Vital AC Power and the Residual Heat Removal System During Mid-loop Operations at Vogtle Unit 1 on March 20, 1990," NUREG-1410, 1990.

[3] H. Nakamura, J. Katayama and Y. Kukita, "RELAP5 Code Analysis of a ROSA-IV/LSTF Experiment Simulating a Loss of Residual Heat Removal Event during PWR Mid-Loop Operation," Proceeding of the 5th International Topical Meeting on Nuclear Reactor Thermal Hydraulics (NURETH-5), Vol. V, pp. 1333-1340, Salt Lake City, Utah, September 21-24, 1992.

[4] S. Banerjee and Y.A. Hassan, " RELAP5/MOD3 Simulation of the RHR System during Midloop Operation Experiment Conducted at the ROSA-IV Large Scale Test Facility," International Conference on New Trends in Nuclear System Thermohydraulics, pp. 407 - 414, Pisa, Italy, May 30 - June 2, 1994.

[5] ROSA-IV Group, "ROSA-IV Large Scale Test Facility (LSTF) System Description", JAERI-M 84-273, Japan Atomic Energy Research Institute, January, 1985.

[6] H. Nakamura and Y. Kukita, "PWR Thermal-hydraulic Phenomena following Loss of Residual Heat Removal (RHR) during Mid-Loop Operation," International Conference on New Trends in Nuclear System Thermohydraulics, pp 77-86, Pisa, Italy, May 30 - June 2, 1994.

[7] EG&G Idaho, "RELAP5/MOD3 Code Manual: User's Guide and Input Requirements", NUREG/CR-5535, INEL-95/0174, Volume 1-5, August 1995.

[8] G.R. Kimber, "RELAP5/MOD3 Analysis of BETHSY Test 6.9a: Loss of Residual Heat Removal System-Pressurizer Manway Opening," AEA RS 5644, AEA Reactor Services, UK, March 1994.

Appendix A

Input Deck for the Assessment of the Loss-of-RHR Event with the Cold Leg Opening (Steady State and Transient Input Deck)

```
*****************************************************
*                                                   *
*    LSTF Mid-loop : Steady State Input Deck        *
*                    for relap5/mod3.2 Assessment   *
*                                                   *
*    Cold leg Opening Case                          *
*****************************************************
*
100      new     transnt
101      run
102      si    si
105      50.0    100.0
*
110      air
115      1.0
*
120     124010000     0.00     h2o     primary
121     304010000     7.9639   h2o     secnd-b
122     504010000     7.9639   h2o     secnd-i
123     900010000     0.00     h2o     contain
*
*  time step control
*
201     1000.0  1.0e-6    0.1     3     100    10000    10000
*
20800001    pps        610020000
20800002    pps        152010000
20800003    pps        136010000
20800004    pps        420010000
20800005    pps        220010000
20800008    gammaw     420010000
20800009    gammaw     220010000
*
*****************************************************
*     minor edits
*****************************************************
*
301  p           610010000        * pzr pressure
302  p           516010000        * sg-i
303  p           316010000        * sg-b
304  p           452010000        * cold leg-i
305  p           252010000        * cold leg-b
306  p           400010000        * hot leg-i
307  p           200010000        * hot leg-b
308  cntrlvar    124              * core level
309  cntrlvar    125              * vessel level
310  cntrlvar    312              * sg-b level
311  cntrlvar    512              * sg-i level
312  cntrlvar    753              * crossover leg-i up
313  cntrlvar    755              * crossover leg-i down
314  cntrlvar    756              * crossover leg-b down
315  cntrlvar    757              * crossover leg-b up
316  cntrlvar    761              * core dp
317  cntrlvar    763              * upper plemum dp
318  cntrlvar    888              * core power
319  cntrlvar    915              * integrated break flow
320  tempf       124010000        * bottom-core temp.
321  tempf       124020000        *
322  tempf       124030000        *
323  tempf       124040000        *
324  tempf       124050000        *
325  tempf       124060000        * mid-core temperature
326  tempf       124070000        *
327  tempf       124080000        *
328  tempf       124090000        *
329  tempf       124100000        *
330  tempf       124110000        *
331  tempf       124120000        * top-core temperature
332  tempf       136010000        * upper plenum
333  httemp      124100109        * bottom-cladding temp.
334  httemp      124100209        *
335  httemp      124100309        *
336  httemp      124100409        *
337  httemp      124100509        *
338  httemp      124100609        * mid-cladding temp
339  httemp      124100709        *
340  httemp      124100809        *
341  httemp      124100909        *
342  httemp      124101009        *
343  httemp      124101109        *
344  httemp      124101209        * top-cladding temp
345  tempf       200010000        * hot leg-b
346  tempf       206010000        * hot leg-b temperature
347  tempf       208010000        * hot leg-b temperature
348  tempf       216010000        * sg-b inlet plenum
349  tempf       220010000        * sg-b inlet
350  tempf       244010000        * cold leg-b temperature
351  tempf       248010000        * cold leg-b temperature
352  tempf       252010000        * cold leg-b
353  tempf       400010000        * hot leg-i
354  tempf       406010000        * hot leg-i temperature
355  tempf       408010000        * hot leg-i temperature
356  tempf       416010000        * sg-i inlet plenum
357  tempf       420010000        * sg-i inlet
358  tempf       444010000        * cold leg-i temperature
359  tempf       448010000        * cold leg-i temperature
360  tempf       452010000        * cold leg-i
361  tempf       610080000        * pzr bottom
362  tempf       610040000        * pzr middle
363  tempf       610010000        * pzr top
364  voidf       104010000        * vessel inlet void
365  voidf       136010000        * vessel outlet void
366  voidf       200010000        * hot leg void
367  voidf       206010000        *
368  voidf       208010000        *
369  voidf       212010000        * sg-b inlet viod
370  voidf       228010000        * sg-b outlet void
371  voidf       232010000        * cross leg void
372  voidf       232050000        *
373  voidf       236040000        * rcp suction void
374  voidf       244010000        * rcp discharge void
375  voidf       248010000        * cold leg void
376  voidf       252010000        * cold leg void
377  voidf       400010000        * hot leg void
378  voidf       406010000        *
379  voidf       408010000        *
380  voidf       412010000        * sg-i inlet void
381  voidf       428010000        * sg-i outlet void
```

```
382   voidf    432010000      * cross leg void
383   voidf    432050000      *
384   voidf    436040000      * rcp suction void
385   voidf    444010000      * rcp discharge void
386   voidf    448010000      * cold leg void
387   voidf    452010000      * cold leg void
388   mflowj   108040000      * downcommer flowrate
389   mflowj   124060000      * core flowrate
390   mflowj   208010000      * hot leg-b flowrate
391   mflowj   217000000      * sg-b inlet flowrate
392   mflowj   252010000      * cold leg-b flowrate
393   mflowj   408010000      * hot leg-i flowrate
394   mflowj   417000000      * sg-i inlet flowrate
395   mflowj   741000000      * hot leg-i si
396   mflowj   746000000      * cold leg-i si
397   mflowj   781000000      * hot leg-b si
398   mflowj   786000000      * cold leg-b si
399   mflowj   915000000      * break flowrate
*
*************************************************
* variable trips
*************************************************
*
500   time   0   lt   null   0   0.0   n  * false
501   time   0   ge   null   0   0.0   n  * true
536   time   0   ge   null   0   0.0   l  * true
537   time   0   lt   null   0   0.0   l  * false
*
*************************************************
*  Hydrodynamic Components
*************************************************
*  reactor vessel
*************************************************
1000000   inann1    snglvol
1000101   0.0   1.5684   0.13609   0.0  -90.  -1.5684
1000102   4.57e-5   0.106   00
1000200   004   101355.0   321.0   1.0
*
*************************************************
1040000   inann    branch
1040001   4        1
1040101   0.0  0.600  0.05425  0.0  -90.0 -0.600   4.57e-5
1040102   0.106   0001000
1040200   004   101660.0   318.0   0.001
1041101   104000000   100010000   0.0   0.0   0.0   0000
1042101   104010000   108000000   0.0   0.0   0.0   0000
1043101   252020002   104010003  0.03365  0.345  0.345   0101
1044101   452010002   104010004  0.03365  0.345  0.345   0101
1041201   0.001   0.001   0.0
1042201   6.0     0.0     0.0
1043201   3.0     0.0     0.0
1044201   3.0     0.0     0.0
*
*************************************************
1080000   downcmer   annulus
1080001   9
1080101   0.09774   9
1080301   0.6757    1
1080302   0.8670    2
1080303   0.610     8
1080304   1.2588    9
1080601   -90.0     9
1080701   -0.6757   1
1080702   -0.8670   2
1080703   -0.610    8
1080704   -1.2588   9
1080801   4.573e-5   0.106   9
1081001   0001000   9
1081101   0000      8
1081201   003   106580.0   318.7   0.  0.  0.  1
1081202   003   114080.0   319.2   0.  0.  0.  2
1081203   003   121160.0   319.4   0.  0.  0.  3
1081204   003   127010.0   319.6   0.  0.  0.  4
1081205   003   132960.0   319.7   0.  0.  0.  5
1081206   003   138810.0   319.8   0.  0.  0.  6
1081207   003   144760.0   319.8   0.  0.  0   7
1081208   003   150600.0   319.8   0.  0.  0.  8
1081209   003   159660.0   319.8   0.  0.  0.  9
1081300   1
1081301   6.0   0.0   0.0   1
1081302   6.0   0.0   0.0   2
1081303   6.0   0.0   0.0   3
1081304   6.0   0.0   0.0   4
1081305   6.0   0.0   0.0   5
1081306   6.0   0.0   0.0   6
1081307   6.0   0.0   0.0   7
1081308   6.0   0.0   0.0   8
*
*************************************************
1120000   lplovol   snglvol
1120101   0.0  0.626  0.1661  0.0  90.0   0.626   4.57e-5
1120102   0.0104   0001000
1120200   003   173420.0   318.0
*
*************************************************
1160000   lowrplnm   branch
1160001   3          1
1160101   0.0  0.4762  0.0943  0.0  90.0  0.4762   4.57e-5
1160102   0.0104   0001000
1160200   003   168070.0   319.7
1161101   108010000   116010000  0.09774   1.0   1.0   0100
1162101   112010000   116000000  0.23623   0.0   0.0   0000
1163101   116010000   120000000  0.15931   8.34  8.34  0000
1161201   6.0    0.0    0.0
1162201   0.01   0.01   0.0
1163201   6.0    0.0    0.0
1162110   0.0104   1.0   1.0   1.0
1163110   0.0104   1.0   1.0   1.0
*
*************************************************
1200000   corein   branch
1200001   2        1
1200101   0.0  1.2588  0.1821  0.0   90.0  1.2588   4.57e-5
1200102   0.0104   0001000
1200200   003   159590.0   319.7
1201101   120010000   124000000   0.068285   0.85  0.85  0000
1202101   120010000   126000000   0.068285   0.85  0.85  0000
1201201   3.0   0.0   0.0
```

```
1202201    3.0        0.0            0.0
1201110    0.009721        1.0        1.0        1.0
*
****************************************************
1240000    coreh      pipe
1240001    12
1240101    0.0            12
1240301    0.305          12
1240401    0.01828        12
1240601    90.0           12
1240701    0.305          12
1240801    4.57e-5        0.00832   12
1240901    0.68           0.68      11
1241001    0001100        12
1241101    0000           11
1241201    003    152050.0    320.0    0.   0.   0.   1
1241202    003    149060.0    321.0    0.   0.   0.   2
1241203    003    146070.0    322.2    0.   0.   0.   3
1241204    003    143090.0    323.6    0.   0.   0.   4
1241205    003    140100.0    325.8    0.   0.   0.   5
1241206    003    137120.0    327.0    0.   0.   0.   6
1241207    003    134150.0    329.6    0.   0.   0.   7
1241208    003    131280.0    331.0    0.   0.   0.   8
1241209    003    128210.0    332.8    0.   0.   0.   9
1241210    003    125250.0    333.6    0.   0.   0.  10
1241211    003    122380.0    334.0    0.   0.   0.  11
1241212    003    119420.0    334.7    0.   0.   0.  12
1241300    1
1241301    3.0        0.0            0.0          1
1241302    3.0        0.0            0.0          2
1241303    3.0        0.0            0.0          3
1241304    3.0        0.0            0.0          4
1241305    3.0        0.0            0.0          5
1241306    3.0        0.0            0.0          6
1241307    3.0        0.0            0.0          7
1241308    3.0        0.0            0.0          8
1241309    3.0        0.0            0.0          9
1241310    3.0        0.0            0.0         10
1241311    3.0        0.0            0.0         11
1241401    0.00832     1.0       1.0       1.0       11
*
****************************************************
1260000    corel      pipe
1260001    12
1260101    0.0            12
1260301    0.305          12
1260401    0.01828        12
1260601    90.0           12
1260701    0.305          12
1260801    4.57e-5        0.00832   12
1260901    0.68           0.68      11
1261001    0001100        12
1261101    0000           11
1261201    003    152950.0    320.0    0.   0.   0.   1
1261202    003    149960.0    321.0    0.   0.   0.   2
1261203    003    146970.0    322.2    0.   0.   0.   3
1261204    003    143990.0    323.6    0.   0.   0.   4
1261205    003    140000.0    325.8    0.   0.   0.   5
1261206    003    137120.0    327.0    0.   0.   0.   6
1261207    003    134150.0    329.6    0.   0.   0.   7
1261208    003    131180.0    331.0    0.   0.   0.   8
1261209    003    128210.0    332.8    0.   0.   0.   9
1261210    003    125250.0    333.6    0.   0.   0.  10
1261211    003    122380.0    334.0    0.   0.   0.  11
1261212    003    119320.0    334.7    0.   0.   0.  12
1261300    1
1261301    3.0        0.0            0.0          1
1261302    3.0        0.0            0.0          2
1261303    3.0        0.0            0.0          3
1261304    3.0        0.0            0.0          4
1261305    3.0        0.0            0.0          5
1261306    3.0        0.0            0.0          6
1261307    3.0        0.0            0.0          7
1261308    3.0        0.0            0.0          8
1261309    3.0        0.0            0.0          9
1261310    3.0        0.0            0.0         10
1261311    3.0        0.0            0.0         11
1261401    0.00832     1.0       1.0       1.0       11
*
****************************************************
1280000    creoutl    branch
1280001    3          1
1280101    0.0  0.867 0.0680  0.0   90.0  0.867   4.57e-5
1280102    0.0   0001000
1280200    003   114340.0   334.0
1281101    124010000  128000000 0.07627 1.272 1.272 0000
1282101    128010000  132000000 0.08368  0.0  0.0   0000
1283101    128010005  130010006  0.0      0.0  0.0   0003
1281201    3.0      0.0          0.0
1282201    3.0      0.0          0.0
1283201    0.1      0.1          0.0
1281110    0.28097       1.0      1.0      1.0
1282110    0.4063        1.0      1.0      1.0
1283110    0.0           1.0      1.0      1.0
*
****************************************************
1300000    creout2    branch
1300001    3          1
1300101    0.0  0.867 0.0680  0.0  90.0   0.867   4.57e-5
1300102    0.0   0001000
1300200    003   114340.0   334.0
1301101    126010000  130000000 0.07627 1.272 1.272 0000
1302101    130010000  134000000 0.08368  0.0  0.0   0000
1303101    156010000  130010000 0.085679 420. 420.0 0000
1301201    3.0      0.0          0.0
1302201    3.0      0.0          0.0
1303201    -0.1     -0.1         0.0
1301110    0.28097       1.0      1.0      1.0
1302110    0.4063        1.0      1.0      1.0
1303110    0.3078        1.0      1.0      1.0
*
****************************************************
1320000    upplnml        snglvol
1320101    0.0 0.6757 0.0530  0.0  90.0  0.6757   4.57e-5
1320102    0.227   0001000
1320200    003   106970.0   334.0
*
1330000    uppjc          sngljun
```

```
1330101    132010005  134010006   0.0   0.0   0.0  0003
1330201    1      0.1    0.1    0.0
*
1340000    upplnm2        snglvol
1340101    0.0  0.6757  0.0530  0.0  90.0  0.6757  4.57e-5
1340102    0.227   0001000
1340200    C03   106970.0   334.0
*
*************************************************
1360000    upplnm        branch
1360001    5         1
1360101    0.0 0.600  0.09389  0.0  90.0  0.600     4.57e-5
1360102    0.321    0001000
1360200    004    102100.0   334.0    0.001
1361101    136010005 200010001 0.03370 0.265 0.265  0102
1362101    136010006 400010001 0.03370 0.265 0.265  0102
1363101    132010000 136000000 0.07835  0.0  0.0    0000
1364101    134010000 136000000 0.07835  0.0  0.0    0000
1365101    140000000 136010000 0.14305  0.0  0.0    0000
1361201    3.0        0.0       0.0
1362201    3.0        0.0       0.0
1363201    3.0        0.0       0.0
1364201    3.0        0.0       0.0
1365201    -0.01      -0.01     0.0
1363110    0.321      1.0      1.0      1.0
1364110    0.321      1.0      1.0      1.0
1365110    0.321      1.0      1.0      1.0
*
*************************************************
1400000    uptopvol     snglvol
1400101    0.0  0.3674 0.0445 0.0  90.0  0.3674   4.57e-5
1400102    0.321    00
1400200    004    101300.0    333.0    1.0
*
*************************************************
1440000    tophat        snglvol
1440101    0.0  0.897 0.1655  0.0  90.0  0.897      4.57e-5
1440102    0.95    00
1440200    004    101300.0    332.0    1.0
*
*************************************************
1480000    uhmidvol      branch
1480001    2            1
1480101    0.0  0.725  0.1970  0.0  90.0  0.725      4.57e-5
1480102    0.256   00
1480200    004    101300.0    328.0    1.0
1481101    100000000  148000000  9.5e-5  0.0  0.0    0100
1482101    144010000  148000000  0.0    0.0   0.0    0000
1481201    0.01       0.01       0.0
1482201    -0.01      -0.01      0.0
*
*************************************************
1520000    uhtopvol      branch
1520001    2            1
1520101    0.0  0.504  0.1475  0.0  90.0  0.504      4.57e-5
1520102    0.0    00
1520200    004          101300.0    331.0    1.0
1521101    148010000 152000000  0.0    0.0  0.0     0000
1522101    152000000 156000000 0.00199 1.472 1.472 0000
1521201    0.01        0.01        0.0
1522201    0.01        0.01        0.0
*
*************************************************
1560000    gdetub       pipe
1560001    2
1560101    0.0          2
1560201    0.0102       1
1560301    1.9260       1
1560302    1.6431       2
1560401    0.06209      1
1560402    0.06286      2
1560601    -90.0        2
1560701    -1.9260      1
1560702    -1.6431      2
1560801    4.57e-5     0.0      2
1560901    3.34        3.34     1
1561001    01000        2
1561101    0000         1
1561201    004   101300.0    331.0    1.0   0.0     0.0     1
1561202    004   106500.0   334.0    0.0007  0.0    0.0     2
1561300    1
1561301    0.01         0.01       0.0         1
*************************************************
*
1810000    core1     sngljun
1810101    124010005  126010006    0.0   0.0    0.0    0003
1810201    1          0.1          0.1          0.0
*
1820000    core2     sngljun
1820101    124020005  126020006    0.0   0.0    0.0    0003
1820201    1          0.1          0.1          0.0
*
1830000    core3     sngljun
1830101    124030005  126030006    0.0   0.0    0.0    0003
1830201    1          0.1          0.1          0.0
*
1840000    core4     sngljun
1840101    124040005  126040006    0.0  0.0    0.0   0003
1840201    1          0.1          0.1          0.0
*
1850000    core5     sngljun
1850101    124050005  126050006    0.0  0.0    0.0   0003
1850201    1          0.1          0.1          0.0
*
1860000    core6     sngljun
1860101    124060005    126060006    0.0  0.0    0.0   0003
1860201    1          0.1          0.1          0.0
*
1870000    core7     sngljun
1870101    124070005    126070006    0.0  0.0    0.0   0003
1870201    1          0.1          0.1          0.0
*
1880000    core8     sngljun
1880101    124080005    126080006    0.0  0.0    0.0   0003
1880201    1          0.1          0.1          0.0
*
1890000    core9     sngljun
1890101    124090005    126090006    0.0  0.0    0.0   0003
```

```
1890201     1      0.1     0.1     0.0
*
1900000     core10    sngljun
1900101     124100005   126100006    0.0  0.0    0.0    0003
1900201     1      0.1     0.1     0.0
*
1910000     core11    sngljun
1910101     124110005   126110006    0.0  0.0    0.0    0003
1910201     1      0.1     0.1     0.0
*
1920000     core12    sngljun
1920101     124120005   126120006    0.0  0.0    0.0    0003
1920201     1      0.1     0.1     0.0
*
**************************************************
* Broken Loop without pressurizer
**************************************************
*
2000000     nphotleg    snglvol
2000101     0.0337 1.3246  0.0 0.0 0.0 0.0 4.57e-5 0.207  00
2000200     004    102100.0    334.0   0.0010
*
**************************************************
2060000     nphotleg      branch
2060001     2          1
2060101     0.0337 1.3843 0.0 0.0 0.0 0.0 4.57e-5 0.207  00
2060200     004    102100.0     334.0    0.00100
2061101     200010000  206000000  0.0337  0.0 0.0    0000
2062101     206010000  208000000  0.0337  0.0  0.0   0000
2061201     0.1        0.0        0.0
2062201     0.1        0.0        0.0
*
**************************************************
2080000     nphotleg        pipe
2080001     2
2080101     0.0337          2
2080301     0.7043          1
2080302     0.5278          2
2080601     0.0             1
2080602     50.0            2
2080701     0.0             1
2080702     0.4043          2
2080801     4.57e-5  0.207  2
2080901     0.05     0.05   1
2081001     0000000         2
2081101     100000          1
2081201     004   102000.0    334.0    0.00100    0.  0.   1
2081202     004   101500.0    334.0    0.1        0.  0.   2
2081300     1
2081301     0.1   0.0   0.0   1
2081401     0.    0.    0.55     0.785    1
*
**************************************************
2090000     nphotleg     sngljun
2090101     208010000 212000000 0.0337   0.0    0.0   0100
2090201     1        0.0        0.0        0.0
*
**************************************************
2120000     npsgin       snglvol
2120101     0.0  0.706  0.125  0.0  90.0   0.706   4.57e-5
2120102     0.377   0000000
2120200     004    101500.0    334.0    1.0
*
**************************************************
2130000     npsgfbj      sngljun
2130101     212010000  214000000  0.2093  0.0  0.0  0000
2130201     1    0.0    0.0    0.0
*
**************************************************
2140000     npsgfb1        snglvol
2140101     0.0 0.55175   0.11615 0.0 90.0 0.55175   4.57e-5
2140102     0.4474    0000000
2140200     004    101500.0    332.0    1.0
*
**************************************************
2150000     npsgfbj       sngljun
2150101     214010000  216000000  0.2105  0.0  0.0  0000
2150201     1    0.0    0.0    0.0
*
**************************************************
2160000     npsgfb2        snglvol
2160101     0.0   0.55175   0.11615 0.0 90.0 0.55175 4.57e-5
2160102     0.4474    0000000
2160200     004    101500.0    325.0    1.0
*
**************************************************
2170000     npsgin        sngljun
2170101     216010000   220000000   0.0425 0.0   0.0 100100
2170110     0.0    0.0    0.725     1.0
2170201     1      0.0      0.0      0.0
*
**************************************************
2200000     npsgtube      pipe
2200001     12
2200101     0.0425        12
2200301     0.7181        4
2200302     1.2827        6
2200303     2.5654        7
2200304     2.1728        9
2200305     2.5654        11
2200306     2.8724        12
2200601     90.0          8
2200604     -90.0         12
2200701     0.7181        4
2200702     1.2827        6
2200703     2.5654        7
2200704     2.0980        8
2200705     -2.0980       9
2200706     -2.5654       11
2200707     -2.8724       12
2200801     1.524-6       0.0196       12
2200901     0.0           0.0          7
2200902     0.006         0.0          8
2200903     0.006         0.006        9
2200904     0.0           0.006        10
2200905     0.0           0.0          11
2201001     0000000       12
2201101     0000          11
```

```
2201201    004    101480.0   317.0   1.  0.  0.  1
2201202    004    101480.0   317.8   1.  0.  0.  2
2201203    004    101470.0   317.7   1.  0.  0.  3
2201204    004    101460.0   317.6   1.  0.  0.  4
2201205    004    101450.0   317.5   1.  0.  0.  5
2201206    004    101440.0   317.4   1.  0.  0.  6
2201207    004    101420.0   317.3   1.  0.  0.  7
2201208    004    101420.0   317.3   1.  0.  0.  8
2201209    004    101390.0   317.3   1.  0.  0.  9
2201210    0C4    101420.0   317.4   1.  0.  0.  10
2201211    004    101440.0   317.6   1.  0.  0.  11
2201212    004    101470.0   317.0   1.  0.  0.  12
2201300    1
2201301    0.0    0.0    0.0    1
2201302    0.0    0.0    0.0    2
2201303    0.0    0.0    0.0    3
2201304    0.0    0.0    0.0    4
2201305    0.0    0.0    0.0    5
2201306    0.0    0.0    0.0    6
2201307    0.0    0.0    0.0    7
2201308    0.0    0.0    0.0    8
2201309    0.0    0.0    0.0    9
2201310    0.0    0.0    0.0    10
2201311    0.0    0.0    0.0    11
*
****************************************************
2210000    npsgout    sngljun
2210101    220010000  224000000  0.0425  0.0 0.0   0100
2210201    1          0.0    0.0     0.0
*
****************************************************
2240000    npsgfbo    snglvol
2240101    0.0  1.1035  0.2323 0.0 -90.0 -1.1035  4.57e-5
2240102    0.4474   0000000
2240200    004   101400.0   320.0   1.0
*
****************************************************
2250000    npsgfbj    sngljun
2250101    224010000  228000000  0.2093 0.0  0.0  0000
2250201    1    0.0   0.0   0.0
*
****************************************************
2280000    npsgout    snglvol
2280101    0.0  0.706  0.125  0.0 -90.0  -0.706   4.57e-5
2280102    0.377   0000000
2280200    004   101500.0   321.0   1.0
*
****************************************************
2290000    npcrsleg    sngljun
2290101    228010000  232000000  0.0222  0.0 0.0   0100
2290201    1       0.0      0.0      0.0
*
****************************************************
2320000    npcrsleg    pipe
2320001    5
2320101    0.0222   5
2320301    0.516    1
2320302    1.2422   4
2320303    1.1919   5
2320601    -50.0    1
2320602    -90.0    4
2320603    0.0      5
2320701    -0.3953  1
2320702    -1.2422  4
2320703    0.0      5
2320801    4.57e-5  0.1682   5
2320901    0.036    0.036    1
2320902    0.0      0.0      3
2320903    0.065    0.065    4
2321001    0000000  5
2321101    0000     4
2321201    004    101500.0    320.0  0.01     0.  0.   1
2321202    003    107500.0    320.0  0.   0.   0.      2
2321203    003    119600.0    320.0  0.   0.   0.      3
2321204    003    131600.0    320.0  0    0.   0.      4
2321205    003    137600.0    320.0  0.   0.   0.      5
2321300    1
2321301    0.1    0.0     0.0     1
2321302    0.1    0.0     0.0     2
2321303    0.1    0.0     0.0     3
2321304    0.1    0.0     0.0     4
*
****************************************************
2330000    npfcv       valve
2330101    232010000  236000000  0.0222   0.0  0.0  0100
2330201    1          0.0        0.0       0.0
2330300    mtrvlv
2330301    536      537       1.42    1.0   0
*
****************************************************
2360000    npcrslgu    pipe
2360001    4
2360101    0.0222   4
2360301    1.3202   1
2360302    1.1222   2
2360303    1.1417   3
2360304    1.1222   4
2360601    0.0      1
2360602    90.0     4
2360701    0.0      1
2360702    1.1222   4
2360801    4.57e-5  0.1682   4
2360901    0.065    0.065    1
2360902    0.0      0.0      3
2361001    0000000  4
2361101    0000     3
2361201    003    137100.0   320.0  0.  0.  0.  1
2361202    003    132700.0   319.0  0.  0.  0.  2
2361203    003    121800.0   319.0  0.  0.  0.  3
2361204    003    110300.0   319.0  0.  0.  0.  4
2361300    1
2361301    0.1    0.0     0.0     1
2361302    0.1    0.0     0.0     2
2361303    0.1    0.0     0.0     3
*
****************************************************
2400000    nprcpump    pump
2400101    0.0   0.802   0.0235   0.0   90.0   0.351   0
```

```
2400108      236010000  0.0222      0.0     0.0       0000
2400109      244000000  0.0337      0.0525  0.0525    0000
2400200      004      103200.0   319.0   0.0003
2400201      1        0.0      0.0          0.0
2400202      1        0.0      0.0          0.0
2400301      0     0      0      -1     -1    500   0
2400302      188.50     0.0      0.054    10.0    55.2
2400303      0.54       750.0  0.0     0.0     0.0   0.0   0.0
*
* single phase head and torque data from lstf sys.
* description
*
2401100  1 1 0.00  1.36  0.10  1.38  0.24  1.42  0.40  1.41
2401101          0.60  1.32  0.80  1.19  1.00  1.00
2401200  1 2 0.00 -0.97 0.20 -0.68 0.50  -0.20  0.65  0.07
2401201          0.80   0.40  1.00    1.00
2401300  1 3 -1.0 3.20 -0.90 2.80 -0.80 2.46  -0.60  1.94
2401301          -0.40 1.57  -0.20  1.41   0.00  1.36
2401400  1 4 -1.00 3.20 -0.80 2.76 -0.60 2.41 -0.40  2.09
2401401          -0.20  1.81   0.00  1.58
2401500  1  5  0.00    0.00  1.00  0.00
2401600  1  6  0.00    0.00  1.00  0.00
2401700  1  7  -1.00  0.00  0.00  0.00
2401800  1  8  -1.00  0.00  0.00  0.00
*
*  torque data
*
2401900  2 1 0.00  0.36  0.12  0.38  0.20  0.44  0.30  0.58
2401901          0.50   0.73  0.70  0.81  1.00  1.00
2402000  2 2 0.00 -1.26  0.10 -0.88 0.30 -0.31 0.50    0.09
2402001          0.65   0.30  0.86  0.63  1.00   1.00
2402100  2 3 -1.00 2.40 -0.85 1.70 -0.65 1.12  -0.50  0.84
2402101          -0.40    0.69 -0.20  0.59   0.00  0.36
2402200  2 4 -1.00 2.40 -0.80 2.12 -0.60 1.80 -0.30 1.32
2402201          0.00  0.80
2402300  2  5   0.00  0.00    1.00  0.00
2402400  2  6   0.00  0.00    1.00  0.00
2402500  2  7  -1.00  0.00    0.00  0.00
2402600  2  8  -1.00  0.00    0.00  0.00
*
*  two phase multiplier tables for head of rc pump 240
*
2403000      0        0.0   0.0
2403001               0.10  0.0
2403002               0.15  0.05
2403003               0.24  0.80
2403004               0.30  0.96
2403005               0.40  0.98
2403006               0.60  0.97
2403007               0.80  0.90
2403008               0.90  0.80
2403009               0.96  0.50
2403010               1.00  0.0
*
*  two phase multiplier tables for torque of rc pump 240
*
2403100      0        0.0   0.0
2403101               1.0   0.0
*
* two-phase diff curves from r5 built-in data
* head difference curves
*
2404100 1 1 0.00  0.00  0.10  0.83  0.20  1.09  0.50  1.02
2404101         0.70  1.01  0.90  0.94  1.00  1.00
2404200 1 2 0.00  0.00  0.10 -0.40  0.20  0.00  0.30  0.10
2404201         0.40 0.21  0.80  0.67  0.90  0.80  1.00  1.00
2404300 1 3 -1.0 -1.16 -0.90 -1.24 -0.80 -1.77 -0.70 -2.36
2404301      -0.60 -2.79 -0.50 -2.91 -0.40 -2.67 -0.25 -1.69
2404302         -0.10  -0.50   0.00   0.00
2404400 1 4 -1.0 -1.16 -0.90 -0.78 -0.80 -0.50 -0.70 -0.31
2404401       -0.60 -0.17 -0.50 -0.08 -0.35 0.00 -0.20  0.05
2404402          -0.10    0.08   0.00   0.11
2404500  1  5   0.00  0.00  1.00  0.00
2404600  1  6   0.00  0.00  1.00  0.00
2404700  1  7  -1.00  0.00  0.00  0.00
2404800  1  8  -1.00  0.00  0.00  0.00
*
*  torque difference curves
*
2404900  2  1  0.0  0.0  0.0  0.0
2405000  2  2  0.0  0.0  0.0  0.0
2405100  2  3  0.0  0.0  0.0  0.0
2405200  2  4  0.0  0.0  0.0  0.0
2405300  2  5  0.0  0.0  0.0  0.0
2405400  2  6  0.0  0.0  0.0  0.0
2405500  2  7  0.0  0.0  0.0  0.0
2405600  2  8  0.0  0.0  0.0  0.0
*
*****************************************************
2440000      npcolleg     branch
2440001      1            1
2440101      0.0337 0.7348 0.0 0.0 0.0 0.0 4.57e-5 0.207   00
2440200      004    101500.0    319.0    0.00040
2441101      244010000  248000000  0.0337   0.0 0.0    0000
2441201      3.0        0.0          0.0
*
*****************************************************
2480000      npcolleg     branch
2480001      1            1
2480101      0.0337 0.9429 0.0 0.0 0.0 0.0 4.57e-5 0.207   00
2480200      004    101500.0    319.0    0.0004
2481101      248010000  252000000  0.0337 0.0  0.0    0000
2481201      3.0        0.0          0.0
*
*****************************************************
2520000      npcolleg        pipe
2520001      2
2520101      0.0337             2
2520301      0.9752             2
2520601      0.0                2
2520701      0.0                2
2520801      4.57e-5  0.207   2
2521001      00                 2
2521101      0000               1
2521201      004    101500.0    318.0    0.0004    0.  0.  1
2521202      004    101500.0    318.0    0.0004    0.  0.  2
2521300      1
2521301      3.0       0.0          0.0         1
```

```
*
****************************************************
*  Secondary side for the broken loop
****************************************************
*
3000000   npstgdcm   annulus
3000001   5
3000101   0.0        1
3000102   0.0296     4
3000103   0.0        5
3000201   0.0        3
3000202   0.005281   4
3000301   2.8965     1
3000302   2.0980     2
3000303   2.5654     4
3000304   3.4395     5
3000401   0.3228     1
3000402   0.0        4
3000403   0.1302     5
3000501   0.0        5
3000601   -90.0      5
3000701   -2.0223    1
3000702   -2.0980    2
3000703   -2.5654    4
3000704   -2.5464    5
3000801   4.57e-5   0.3689   1
3000802   4.57e-5   0.0971   4
3000803   4.57e-5   0.0801   5
3000901   0.0       0.0      4
3001001   0001000    5
3001101   0000       3
3001102   0100       4
3001201   004   104900.0   317.   0.001   0.   0.   1
3001202   003   117300.0   317.   0.0   0    0.   2
3001203   003   139800.0   317.   0.0   0    0.   3
3001204   003   164400.0   317.   0.0   0.   0.   4
3001205   003   188000.0   317.   0.0   0.   0.   5
3001300   1
3001301   0.0   0.0   0.0   1
3001302   0.0   0.0   0.0   2
3001303   0.0   0.0   0.0   3
3001304   0.0   0.0   0.0   4
*
****************************************************
3010000   npstgdcm   sngljun
3010101   300010000   304000000   0.0   100.0   100.0   0000
3010201   1   0.0   0.0   0.0
*
****************************************************
3040000   blsteamg   pipe
3040001   5
3040101   0.2293     3
3040102   0.0        5
3040201   0.2293     2
3040202   0.2323     3
3040203   0.3138     4
3040301   2.5464     1
3040302   2.5654     3
3040303   2.0980     4
3040304   2.0223     5
3040401   0.0        3
3040402   0.4951     4
3040403   0.7979     5
3040501   0.0        5
3040601   90.0       5
3040701   2.5464     1
3040702   2.5654     3
3040703   2.0980     4
3040704   2.0223     5
3040801   4.57e-5   0.036   4
3040802   4.57e-5   0.219   5
3040901   1.435     1.435   4
3041001   0000000    5
3041101   0000       4
3041201   003   187000.0   317.0   0.0   0.0   0.0   1
3041202   003   162200.0   317.0   0.0   0.0   0.0   2
3041203   003   137200.0   317.0   0.0   0.0   0.0   3
3041204   003   114500.0   317.0   0.0   0.0   0.0   4
3041205   004   102800.0   317.0   0.1   0.0   0.0   5
3041300   1
3041301   0.0   0.0   0.0   1
3041302   0.0   0.0   0.0   2
3041303   0.0   0.0   0.0   3
3041304   0.0   0.0   0.0   4
3041401   0.036    1.0   1.0   1.0   3
3041402   0.1258   1.0   1.0   1.0   4
*
****************************************************
3080000   npsepar   separatr
3080001   3   1
3080101   0.0   2.120   0.572   0.0   90.0   2.120   4.57e-5
3080102   0.2134   00
3080200   004   101400.0   317.0   0.5
3081101   308010002   316010001   0.0615   0.0   0.0   0100   0.2
3082101   308010001   300010001   0.03964   100.   100.   0000   0.15
3083101   304050002   308010001   0.1986   0.0   0.0   0000
3081201   0.0   0.0   0.0
3082201   0.0   0.0   0.0
3083201   0.0   0.0   0.0
*
****************************************************
3120000   npsgspbp   branch
3120001   2   1
3120101   0.0   2.120   0.6288   0.0   90.0   2.120   4.57e-5
3120102   0.1242   00
3120200   004   101400.0   317.0   0.5
3121101   300000000   312000000   0.3164   0.0   0.0   0000
3122101   312010000   316000000   0.0392   1.5   1.5   0000
3121201   0.0   0.0   0.0
3122201   0.0   0.0   0.0
*
****************************************************
3160000   stmdome   snglvol
3160101   0.0   3.7778   2.0288   0.0   90.0   7778   4.57e-5
3160102   0.7696   00
3160200   004   101360.0   317.0   1.0
*
****************************************************
```

```
*    blsg  steam  line
**************************************************
3200000    blstmln1      branch
3200001    2             1
3200101    0.0286   5.286  0.0    0.0    0.0    0.0    4.57e-5
3200102    0.1909    00
3200200    004    101300.0    317.0    1.0
3201101    316010000  320000000  0.0286    0.0  0.0    0100
3202101    320010000  324000000  0.0286    0.0  0.0    0000
3201201    0.0          0.0          0.0
3202201    0.0          0.0          0.0
*
**************************************************
3240000    blstmln2     snglvol
3240101    0.0286    9.9213  0.0    0.0    0.0    0.0    4.57e-5
3240102    0.1909    00
3240200    004    101300.0    317.0       1.0
*
**************************************************
* secondary relief and safety valves, intact loop
**************************************************
*
3690000    blsgrv       valve
3690101    320010000   370000000  2.96e-4  0.0149  0.0    0120
3690201    0           0.0          0.0          0.0
3690300    trpvlv
3690301    501
*
**************************************************
3700000    contain       tmdpvol
3700101    1.0e+8    10.0    0.0   0.0   0.0   0.0   0.0   0.0    00
3700200    004
3700201    0.0    1.01325e+5    300.0       1.0
*
**************************************************
3790000    blsgsv       valve
3790101    324010000   380000000  0.00195  0.00055  0.0   0120
3790201    0            0.0          0.0          0.0
3790300    trpvlv
3790301    501
*
**************************************************
3800000    contain       tmdpvol
3800101    1.0e+8   10.0   0.0   0.0   0.0   0.0   0.0    0.0    00
3800200    004
3800201    0.0    1.01325e+5    300.0       1.0
*
**************************************************
*  Intact Loop with pressurizer
**************************************************
*
4000000     wphotleg     snglvol
4000101     0.0337  1.3246  0.0   0.0  0.0  0.0  4.57e-5  0.207   00
4000200     004    102100.0      334.0    0.00100
*
**************************************************
4060000        wphotleg         branch
4060001        3                1
4060101        0.0337  1.3843  0.0  0.0  0.0  0.0  4.57e-5  0.207   00
4060200      004     102100.0     334.0     0.00100
4061101      400010000   406000000   0.0337   0.0    0.0  0000
4062101      406010000   408000000   0.0337   0.0    0.0  0000
4063101      600030002   406010003   0.00352  1.0    0.5  0001
4061201      0.01           0.0           0.0
4062201      0.01           0.0           0.0
4063201      0.0            0.0           0.0
*
**************************************************
4080000      wphotleg          pipe
4080001      2
4080101      0.0337             2
4080301      0.7043             1
4080302      0.5278             2
4080601      0.0                1
4080602      50.0               2
4080701      0.0                1
4080702      0.4043             2
4080801      4.57e-5   0.207    2
4080901      0.05      0.05     1
4081001      0000000            2
4081101      100000             1
4081201      004     101500.0     334.0     0.00100     0.   0   1
4081202      004     101500.0     334.0     0.1         0.   0.  2
4081300      1
4081301      0.1    0.0    0.0                  1
4081401      0.     0.     0.55     0.785       1
*
**************************************************
4090000      wphotleg       sngljun
4090101      408010000   412000000   0.0337   0.0   0.0   0100
4090201      1            0.0           0.0          0.0
*
**************************************************
4120000      wpsgin         snglvol
4120101      0.0  0.706   0.125   0.0   90.0    0.706    4.57e-5
4120102      0.377    0000000
4120200      004     101500.0    334.0     1.0
*
**************************************************
4130000      wpsgfbj        sngljun
4130101      412010000   414000000   0.2093   0.0  0.0    0000
4130201      1    0.0    0.0    0.0
*
**************************************************
4140000      wpsgfb1         snglvol
4140101      0.0   0.55175   0.11615  0.0  90.0  0.55175  4.57e-5
4140102      0.4474    0000000
4140200      004    101500.0    330.0     1.0
*
**************************************************
4150000      wpsgfbj        sngljun
4150101      414010000   416000000   0.2105   0.0   0.0   0000
4150201      1    0.0    0.0    0.0
*
**************************************************
4160000      wpsgfb2         snglvol
4160101      0.0  0.55175   0.11615  0.0  90.0  0.55175   4.57e-5
4160102      0.4474    0000000
```

```
4160200     004    101500.0    325.0    1.0
*
*************************************************
4170000     npsgin        sngljun
4170101     416010000   420000000   0.0425   0.0 0.0  100100
4170110     0.      0.      0.725      1.
4170201     1    0.0     0.0     0.0
*
*************************************************
4200000     wpsgtube     pipe
4200001     12
4200101     0.0425          12
4200301     0.7181          4
4200302     1.2827          6
4200303     2.5654          7
4200304     2.1728          9
4200305     2.5654          11
4200306     2.8724          12
4200601     90.0            8
4200604     -90.0           12
4200701     0.7181          4
4200702     1.2827          6
4200703     2.5654          7
4200704     2.0980          8
4200705     -2.0980         9
4200706     -2.5654         11
4200707     -2.8724         12
4200801     1.524-6         0.0196          12
4200901     0.0             0.0             7
4200902     0.006           0.0             8
4200903     0.006           0.006           9
4200904     0.0             0.006           10
4200905     0.0             0.0             11
4201001     0000000         12
4201101     0000            11
4201201     004         101490.0     317.0     1.   0.   0.   1
4201202     004         101480.0     317.8     1.   0.   0.   2
4201203     004         101470.0     317.7     1.   0.   0.   3
4201204     004         101470.0     317.6     1.   0.   0.   4
4201205     004         101460.0     317.5     1.   0.   0.   5
4201206     004         101450.0     317.4     1.   0.   0.   6
4201207     004         101420.0     317.3     1.   0.   0.   7
4201208     004         101400.0     317.3     1.   0.   0.   8
4201209     004         101400.0     317.3     1.   0.   0.   9
4201210     004         101420.0     317.4     1.   0.   0.   10
4201211     004         101450.0     317.6     1.   0.   0.   11
4201212     004         101490.0     317.0     1.   0.   0.   12
4201300     1
4201301     0.0       0.0        0.0         1
4201302     0.0       0.0        0.0         2
4201303     0.0       0.0        0.0         3
4201304     0.0       0.0        0.0         4
4201305     0.0       0.0        0.0         5
4201306     0.0       0.0        0.0         6
4201307     0.0       0.0        0.0         7
4201308     0.0       0.0        0.0         8
4201309     0.0       0.0        0.0         9
4201310     0.0       0.0        0.0         10
4201311     0.0       0.0        0.0         11
*
*************************************************
4210000     wpsgout       sngljun
4210101     420010000   424000000   0.0425   0.0 0.0    0100
4210201     1               0.0      0.0         0.0
*
*************************************************
4240000     wpsgfbo       snglvol
4240101     0.0   1.1035  0.2323  0.0  -90.0  -1.1035     4.57e-5
4240102     0.4474     0000000
4240200     004     101500.0     320.0     1.0
*
*************************************************
4250000     wpsgfbj        sngljun
4250101     424010000    428000000    0.2093  0.0   0.0     0000
4250201     1      0.0     0.0    0.0
*
*************************************************
4280000     wpsgout        snglvol
4280101     0.0   0.706  0.125   0.0   -90.0   -0.706     4.57e-5
4280102     0.377    0000000
4280200     004     101500.0     320.0     1.0
*
*************************************************
4290000     wpcrsleg      sngljun
4290101     428010000    432000000    0.0222  0.0  0.0       0100
4290201     1          0.0         0.0         0.0
*
*************************************************
4320000     wpcrsleg       pipe
4320001     5
4320101     0.0222     5
4320301     0.516      1
4320302     1.2422     4
4320303     1.1919     5
4320601     -50.0      1
4320602     -90.0      4
4320603     0.0        5
4320701     -0.3953    1
4320702     -1.2422    4
4320703     0.0        5
4320801     4.57e-5    0.1682      5
4320901     0.036      0.036       1
4320902     0.0        0.0         3
4320903     0.065      0.065       4
4321001     0000000    5
4321101     0000       4
4321201     004       101500.0      320.0   0.01     0.    0.    1
4321202     003       107500.0      320.0   0.       0.    0.    2
4321203     003       119200.0      320.0   0.       0.    0.    3
4321204     003       131600.0      320.0   0.       0.    0.    4
4321205     003       137600.0      320.0   0.       0.    0.    5
4321300     1
4321301     0.1       0.0          0.0          1
4321302     0.1       0.0          0.0          2
4321303     0.1       0.0          0.0          3
4321304     0.1       0.0          0.0          4
*
*************************************************
```

```
4330000   wpfcv      valve
4330101   432010000  436000000  0.0222   0.0  0.0   0100
4330201   1          0.0        0.0      0.0
4330300   mtrvlv
4330301   536        537        1.42   1.0    0
*
***************************************************
4360000   wpcrslgu   pipe
4360001   4
4360101   0.0222   4
4360301   1.3202   1
4360302   1.1222   2
4360303   1.1417   3
4360304   1.1222   4
4360601   0.0      1
4360602   90.0     4
4360701   0.0      1
4360702   1.1222   4
4360801   4.57e-5   0.1682   4
4360901   0.065     0.065    1
4360902   0.0       0.0      3
4361001   0000000   4
4361101   0000      3
4361201   003       137200.0   319.6  0.  0.  0.  1
4361202   003       132600.0   319.4  0.  0.  0.  2
4361203   003       121900.0   319.0  0.  0.  0.  3
4361204   003       110000.0   319.0  0.  0.  0.  4
4361300   1
4361301   0.1    0.0     0.0     1
4361302   0.1    0.0     0.0     2
4361303   0.1    0.0     0.0     3
*
***************************************************
4400000   wprcpump   pump
4400101   0.0   0.802   0.0235   0.0   90.0   0.351   0
4400108   436010000   0.0222    0.0      0.0      0000
4400109   444000000   0.0337    0.0525   0.0525   0000
4400200   004     103200.0   319.0   0.000300
4400201   1       0.0        0.0     0.0
4400202   1       0.0        0.0     0.0
4400301   240   240   240   -1   -1   500   0
4400302   188.5   0.0    .054   10.0   55.2
4400303   0.54   750.0   0.0   0.0   0.0   0.0   0.0
*
***************************************************
4440000   wpcolleg   snglvol
4440101   0.0337 1.1211 0.0 0.0 0.0 0.0 4.57e-5 0.207  00
4440200   004   101500.0   319.0   0.0004
*
***************************************************
4480000   wpcolleg   branch
4480001   2     1
4480101   0.0337 1.1945 0.0 0.0 0.0 0.0 4.57e-5 0.207  00
4480200   004   101500.0   318.0   0.0004
4481101   444010000   448000000   0.0337   0.0  0.0   0000
4482101   448010000   452000000   0.0337   0.0  0.0   0000
4481201   0.1    0.0    0.0
4482201   3.0    0.0    0.0
*
```

```
***************************************************
4520000   wpcolleg   snglvol
4520101   0.0337 1.3125 0.0 0.0 0.0 0.0 4.57e-5 0.207  00
4520200   004   101500.0   318.0   0.0004
*
***************************************************
*  Secondary Loop for the intact loop
***************************************************
*
5000000   wpstgdcm   annulus
5000001   5
5000101   0.0        1
5000102   0.0296     4
5000103   0.0        5
5000201   0.0        3
5000202   0.005281   4
5000301   2.8965     1
5000302   2.0980     2
5000303   2.5654     4
5000304   3.4395     5
5000401   0.3228     1
5000402   0.0        4
5000403   0.1302     5
5000501   0.0        5
5000601   -90.0      5
5000701   -2.0223    1
5000702   -2.0980    2
5000703   -2.5654    4
5000704   -2.5464    5
5000801   4.57e-5   0.3689   1
5000802   4.57e-5   0.0971   4
5000803   4.57e-5   0.0801   5
5000901   0.0       0.0      4
5001001   0001000   5
5001101   0000      3
5001102   0100      4
5001201   004   102600.0   317.   0.001   0.  0.  1
5001202   003   114500.0   317.   0.0   0.  0.  2
5001203   003   137200.0   317.   0.0   0.  0.  3
5001204   003   162100.0   317.   0.0   0.  0.  4
5001205   003   186900.0   317.   0.0   0.  0.  5
5001300   1
5001301   0.0   0.0   0.0   1
5001302   0.0   0.0   0.0   2
5001303   0.0   0.0   0.0   3
5001304   0.0   0.0   0.0   4
*
***************************************************
5010000   wpstgdcm   sngljun
5010101   500010000 504000000  0.0   100.0 100.0   0000
5010201   1    0.0    0.0     0.0
*
***************************************************
*
5040000   wpsteamg   pipe
5040001   5
5040101   0.2293   3
5040102   0.0      5
5040201   0.2293   2
```

```
5040202     0.2323      3
5040203     0.3138      4
5040301     2.5464      1
5040302     2.5654      3
5040303     2.0980      4
5040304     2.0223      5
5040401     0.0         3
5040402     0.4951      4
5040403     0.7979      5
5040501     0.0         5
5040601     90.0        5
5040701     2.5464      1
5040702     2.5654      3
5040703     2.0980      4
5040704     2.0223      5
5040801     4.57e-5     0.036     4
5040802     4.57e-5     0.219     5
5040901     1.435       1.435     4
5041001     0000000     5
5041101     0000        4
5041201     003   187000.0   317.0   0.0     0.0  0.0   1
5041202     003   162100.0   317.0   0.0     0.0  0.0   2
5041203     003   137200.0   317.0   0.0     0.0  0.0   3
5041204     003   114500.0   317.0   0.0     0.0  0.0   4
5041205     004   102800.0   317.0   0.1     0.0  0.0   5
5041300     1
5041301     0.0     0.0      0.0      1
5041302     0.0     0.0      0.0      2
5041303     0.0     0.0      0.0      3
5041304     0.0     0.0      0.0      4
5041401     0.036     1.0     1.0     1.0     3
5041402     0.1258    1.0     1.0     1.0     4
*
**************************************************
5080000    npsepar     separatr
5080001    3    1
5080101    0.0 2.120   0.572   0.0    90.0    2.120    4.57e-5
5080102    0.2134    00
5080200    004    101400.0    317.0    0.5
5081101    508010002  516010001   0.0615 0.0 0.0   0100 0.2
5082101   508010001 500010001 0.03964 100. 100. 0000 0.15
5083101    504050002  508010001   0.1986 0.0  0.0    0000
5081201    0.0        0.0         0.0
5082201    0.0        0.0         0.0
5083201    0.0        0.0         0.0
*
**************************************************
5120000    npsgspbp      branch
5120001    2             1
5120101    0.0  2.120  0.6288  0.0    90.0    2.120    4.57e-5
5120102    0.1242    00
5120200    004    101400.0    317.0    0.5
5121101    500000000  512000000  0.3164  0.0    0.0    0000
5122101    512010000  516000000  0.0392  1.5    1.5    0000
5121201    0.0        0.0        0.0
5122201    0.0        0.0        0.0
*
**************************************************
5160000    stmdome      snglvol
5160101    0.0  3.7778   2.0288   0.0 90.0   3.7778    4.57e-5
5160102    0.7696     00
5160200    004   101300.0    317.0   1.0
*
**************************************************
*    wpsg  steam  line
**************************************************
5200000    ilstmln1     branch
5200001    2            1
5200101    0.0286     5.286   0.0     0.0     0.0     0.0    4.57e-5
5200102    0.1909     00
5200200    004    101300.0    317.0    1.0
5201101    516010000   520000000   0.0286    0.0   0.0    0100
5202101    520010000   524000000   0.0286    0.0   0.0    0000
5201201    0.0         0.0          0.0
5202201    0.0         0.0          0.0
*
**************************************************
5240000    ilstmln2      snglvol
5240101    0.0286     9.9213   0.0     0.0     0.0     0.0    4.57e-5
5240102    0.1909     00
5240200    004    101300.0    317.0    1.0
*
**************************************************
* secondary relief and safety valves, intact loop
**************************************************
*
5690000    ilsgrv      valve
5690101    520010000   570000000   2.96e-4 0.0149 0.0  0120
5690201    0           0.0          0.0         0.0
5690300    trpvlv
5690301    501
*
**************************************************
5700000    contain      tmdpvol
5700101    1.0e+8   10.0   0.0    0.0   0.0   0.0   0.0    0.0    00
5700200    004
5700201    0.0    1.01325e+5    300.0     1.0
*
**************************************************
5790000    blsgsv      valve
5790101    524010000   580000000   0.00195 0.00055 0.0 0120
5790201    0           0.0          0.0          0.0
5790300    trpvlv
5790301    501
*
**************************************************
5800000    contain      tmdpvol
5800101    1.0e+8   10.0   0.0   0.0   0.0   0.0    0.0    0.0    00
5800200    004
5800201    0.0    1.01325e+5    300.0     1.0
*
**************************************************
* pressurizer
**************************************************
*
6000000       prssurgl      pipe
6000001       3
6000101       3.515e-3      3
```

```
6000301    6.7788     1
6000302    9.245      2
6000303    5.4221     3
6000401    0.0        3
6000601    -90.0      3
6000701    -4.4077    1
6000702    -4.995     2
6000703    -2.5768    3
6000801    4.57e-5    0.0669    3
6001001    00         3
6001101    0000       2
6001201    004 101400.0  332.0  1.0  0.0  0.0   1
6001202    004 101500.0  333.0  1.0  0.0  0.0   2
6001203    004 101700.0  334.0  1.0  0.0  0.0   3
6001300    1
6001301    0.0   0.0   0.0   1
6001302    0.0   0.0   0.0   2
*
**************************************************
6030000    prssurgl    sngljun
6030101    610010000   600000000 3.515e-3  0.0 0.0  0100
6030201    1   0.0   0.0   0.0
*
**************************************************
6100000    prsrizer    pipe
6100001    8
6100101    0.0        1
6100102    0.2827     6
6100103    0.2731     8
6100201    0.0        7
6100301    0.201      1
6100302    0.470      3
6100303    0.600      4
6100304    0.682      6
6100305    0.5375     8
6100401    0.0325     1
6100402    0.0        8
6100501    0.0        8
6100601    -90.0      8
6100701    -0.201     1
6100702    -0.470     3
6100703    -0.6       4
6100704    -0.682     6
6100705    -0.5375    8
6100801    4.57e-5    0.3187   1
6100802    4.57e-5    0.600    6
6100803    4.57e-5    0.2949   8
6101001    00         F
6101101    0000       7
6101201    004   101330.0   317.0   1.0   0.0   0.0   1
6101202    004   101330.0   317.0   1.0   0.0   0.0   2
6101203    004   101330.0   318.0   1.0   0.0   0.0   3
6101204    004   101330.0   322.0   1.0   0.0   0.0   4
6101205    004   101330.0   326.0   1.0   0.0   0.0   5
6101206    004   101400.0   329.0   1.0   0.0   0.0   6
6101207    004   101400.0   330.0   1.0   0.0   0.0   7
6101208    004   101400.0   331.0   1.0   0.0   0.0   8
6101300    1
6101301    0.0   0.0   0.0   7
*
**************************************************
6190000    spryin      sngljun
6190101    444010003   620010001  0.0  0.0  0.0    00102
6190201    1   0.0   0.0   0.0
*
**************************************************
6200000    prsspryl    pipe
6200001    2
6200101    3.53e-4        2
6200301    22.43          2
6200601    90.0           2
6200701    8.07975        2
6200801    4.57e-5   0.0    2
6201001    00          2
6201101    0000        1
6201201    004    101500.0   318.0   1.0   0.0   0.0   1
6201202    004    101500.0   318.0   1.0   0.0   0.0   2
6201300    1
6201301    0.0  0.0    0.0        1
*
**************************************************
6210000    prsspryl      sngljun
6210101    620010000  610000000  5.0e-5   0.0 0.0   0100
6210201    1   0.0   0.0   0.0
*
*6210000   prsspryl    tmdpjun
*6210101   620010000   610000000       0.0
*6210200   1           524      p      610010000
*6210201   0.0         0.0      0.0    0.0
*6210202   15.68e6     0.0      0.0    0.0
*6210203   16.03e6     0.98     0.0    0.0
*
**************************************************
6500000    porvout      tmdpvol
6500101    1.0e+1   10.0  0.0  0.0  0.0  0.0  0.0  0   00
6500200    004
6500201    0.0        1.01325e+5       317.0       1.0
*
***************** ********************************
6510000    porv          valve
6510101    610000000 650000000 3.66e-5  0.0251 0.0 0120
6510201    0            0.0        0.0        0.0
6510300    trpvlv
6510301    501
*
**************************************************
6600000    prsfvout      tmdpvol
6600101    1.0e+8  10.0  0.0  0.0  0.0  0.0  0.0   0   00
6600200    004
6600201    0.0        1.01325e+5       317.0       1.0
*
**************************************************
6610000    prsfvalv          valve
6610101    610000000  660000000 1.54e-4 0.2052 0.0 0120
6610201    0            0.0        0.0        0.0
6610300    trpvlv
6610301    501
*
```

```
****************************************************
* rhr system
****************************************************
7800000    rhrscl      tmdpvol
7800101    0.   10.   1000.   0.   0.   0.   0.   0.   00000
7800200    3
7800201    0.0    101325.0    334.0
*
7810000    rsulnl1      tmdpjun
7810101    200010005      780010001        0.006
7810200    1     0
7810201    0.0          3.2    0.0    0.0
7810202    1000.0    3.2    0.0    0.0
*
7850000    rhrsol      tmdpvol
7850101    0.   10.   1000.   0.   0.   0.   0.   0.   00000
7850200    3
7850201    0.0    101325.0    318.0
*
7860000    rsolnl1      tmdpjun
7860101    785010001     244010005        0.006
7860200    1     0
7860201    0.0          3.2    0.0    0.0
7860202    1000.0    3.2    0.0    0.0
*
7400000    rhrsc2      tmdpvol
7400101    0.   10.   1000.   0.   0.   0.   0.   0.   00000
7400200    3
7400201    0.0    101325.0    334.0
*
7410000    rsuln12      tmdpjun
7410101    400010005      740010001        0.006
7410200    1     0
7410201    0.0          3.2    0.0    0.0
7410202    1000.0    3.2    0.0    0.0
*
7450000    rhrso2      tmdpvol
7450101    0.   10.   1000.   0.   0.   0.   0.   0.   00000
7450200    3
7450201    0.0    101325.0    318.0
*
7460000    rsoln12      tmdpjun
7460101    745010001     448010005        0.006
7460200    1     0
7460201    0.0          3.2    0.0    0.0
7460202    1000.0    3.2    0.0    0.0
*
****************************************************
* containment volume for environmental heat losses
****************************************************
9000000    envsink      snglvol
9000101    2000.   100.    0.0   0.0   0.0   0.0   0.0    0    10
9000200    004      1.01325e+5    317.15    1.0
*
9030000    dummy            tmdpvol
9030101    0.0    1.0     10.0   0.0   0.0   0.0   0.0   0.0    00
9030200    004
9030201    0.0    1.01325e+5    317.15    1.0
*
9040000    dumjun        sngljun
9040101    900000000  903000000    0.05   0.0   0.0    1100
9040201    1    0.0    0.0    0.0
*
****************************************************
* break point  - 5% break area
****************************************************
9150000    npcolbrv      valve
9150101    248010006  920010001  1.685e-3  0.  0.0  0100  1.  1.
9150201    0              0.0            0.0            0.0
9150300    trpvlv
9150301    500
*
****************************************************
9200000    npcolleg      tmdpvol
9200101    1.0e+8      10.0  0.0   0.0   0.0   0.0   0.0   0   00
9200200    004
9200201    0.0         1.01325e+5         317.0        1.0
*
****************************************************
* Reactor Vessel Heat Structures
****************************************************
* 100-1; vessel wall above nozzles, below upper head
*          flange
****************************************************
*
11001000     1      7      2      1      0.320
11001100     0      1
11001101     1      0.323
11001102     4      0.476
11001103     1      0.601
11001201     5      1
11001202     6      5
11001203     9      6
11001301     0.0     6
11001400     0
11001401     317.0          7
11001501     100010000        0     101      1      0.823     1
11001601     900010000        0     101      1      0.823     1
11001701     0     0       0       0       1
11001801     0.  10.0   10.0       0.0  0.  0.  0.  1.       1
11001901     0.  10.0   10.0       0.0  0.  0.  0.  1.       1
*
****************************************************
* 104-1; reactor vessel wall below nozzles
****************************************************
*
11041000     12     7      2      1      0.320
11041100     0      1
11041101     1      0.323
11041102     4      0.381
11041103     1      0.506
11041201     5      1
11041202     6      5
11041203     9      6
11041301     0.0     6
11041400     0
11041401     317.0          7
11041501     104010000        0     101      1      0.600     1
```

```
11041502    108010000      0   101    1   0.677    2
11041503    108020000      0   101    1   0.867    3
11041504    108030000  10000   101    1   0.610    9
11041510    108090000      0   101    1   1.2588  10
11041511    112010000      0   101    1   0.445   11
11041512    116010000      0   101    1   0.4762  12
11041601    900010000      0   101    1   0.600    1
11041602    900010000      0   101    1   0.677    2
11041603    900010000      0   101    1   0.867    3
11041604    900010000      0   101    1   0.610    9
11041610    900010000      0   101    1   1.2588  10
11041611    900010000      0   101    1   0.445   11
11041612    900010000      0   101    1   0.4762  12
11041701    0    0    0    0    12
11041801    0. 10.0  10.0    0.0  0. 0. 0. 1.   12
11041901    0. 10.0  10.0    0.0  0. 0. 0. 1.   12
*
**************************************************
* 112-1: vessel bottom and flange
**************************************************
*
11121000    1    7    1    1    0.0
11121100    0    1
11121101    1    0.003
11121102    4    0.724
11121103    1    0.849
11121201    5    1
11121202    6    5
11121203    9    6
11121301    0.0  6
11121400    0
11121401    317.0      7
11121501    112010000    0   101    0   0.686   1
11121601    900010000    0   101    1   0.686   1
11121701    0    0    0    0    1
11121801    0. 10.0  10.0    0.0 0. 0. 0. 1.0    1
11121901    0. 10.0  10.0    0.0 0. 0. 0. 1.0    1
*
**************************************************
*  112-2: heater rods, below heated section
**************************************************
*
11122000    3    4    2    1    0.0
11122100    0    1
11122101    1    0.002
11122102    1    0.00295
11122103    1    0.00375
11122201    3    1
11122202    1    2
11122203    4    3
11122301    0.0  3
11122400    0
11122401    317.0      4
11122501             0    0   0      1   731.2   1
11122502             0    0   0      1   556.2   2
11122503             0    0   0      1   1470.3  3
11122601    112010000     0   101    1   731.2   1
11122602    116010000     0   101    1   556.2   2
11122603    120010000     0   101    1   1470.3  3
11122701    0    0    0    0    3
11122901    0. 10.0   10.0    0.0  0. 0. 0. 1.   3
*
**************************************************
* 120-1: core barrel, channel
**************************************************
*
11201000    18    5    2    1    0.257
11201100    0     1
11201101    4     0.267
11201201    5     4
11201301    0.0   4
11201400    0
11201401    317.0     5
11201501    120010000      0   101    1   1.2588   1
11201502    124010000  10000   101    1   0.305   13
11201503    128010000      0   101    1   0.867   14
11201504    132010000      0   101    1   0.677   15
11201505    136010000      0   101    1   0.600   16
11201506    140010000      0   101    1   0.3674  17
11201507    144010000      0   101    1   0.897   18
11201601    108090000      0   101    1   1.2588   1
11201602    108080000      0   101    1   0.305    2
11201603    108080000      0   101    1   0.305    3
11201604    108070000      0   101    1   0.305    4
11201605    108070000      0   101    1   0.305    5
11201606    108060000      0   101    1   0.305    6
11201607    108060000      0   101    1   0.305    7
11201608    108050000      0   101    1   0.305    8
11201609    108050000      0   101    1   0.305    9
11201610    108040000      0   101    1   0.305   10
11201611    108040000      0   101    1   0.305   11
11201612    108030000      0   101    1   0.305   12
11201613    108030000      0   101    1   0.305   13
11201614    108020000      0   101    1   0.867   14
11201615    108010000      0   101    1   0.677   15
11201616    104010000      0   101    1   0.600   16
11201617    100010000      0   101    1   0.3674  17
11201618    100010000      0   101    1   0.897   18
11201701    0    0    0    0    18
11201801    0. 10.0    10.0    0.0  0.  0.  0.0  1.0   18
11201901    0. 10.0    10.0    0.0  0.  0.  0.0  1.0   18
*
**************************************************
* 124-1: heated section of heater rods in channel
**************************************************
*
11241000    12    9    2    1    0.0
11241100    0     1
11241101    2     0.00200
11241102    2     0.00260
11241103    2     0.00375
11241104    2     0.00475
11241201    7     2
11241202    2     4
11241203    1     6
11241204    4     8
11241301    0.0   2
11241302    1.0   4
```

```
11241303    0.0    8
11241400    0
11241401    317.0          9
11241501             0        0    0    1       162.25       12
11241601    124010000   10000    111   1       162.25       12
11241701    888    0.01575      0.0   0.0   1
11241702    888    0.032925     0.0   0.0   2
11241703    888    0.04815      0.0   0.0   3
11241704    888    0.06045      0.0   0.0   4
11241705    888    0.06915      0.0   0.0   5
11241706    888    0.073575     0.0   0.0   6
11241707    888    0.073575     0.0   0.0   7
11241708    888    0.06915      0.0   0.0   8
11241709    888    0.06045      0.0   0.0   9
11241710    888    0.04815      0.0   0.0   10
11241711    888    0.032925     0.0   0.0   11
11241712    888    0.01575      0.0   0.0   12
11241900    1
11241901    0. 0.1525 3.5075  0. 0. 0. 0. 1.0  3.6 1.1 1.0 1
11241902    0. 0.4575 3.2025  0. 0. 0. 0. 1.0  3.6 1.1 1.0 2
11241903    0. 0.7625 2.8975  0. 0. 0. 0. 1.0  3.6 1.1 1.0 3
11241904    0. 1.0675 2.5925  0. 0. 0. 0. 1.0  3.6 1.1 1.0 4
11241905    0. 1.3725 2.2875  0. 0. 0. 0. 1.0  3.6 1.1 1.0 5
11241906    0. 1.6775 1.9825  0. 0. 0. 0. 1.0  3.6 1.1 1.0 6
11241907    0. 1.9825 1.6775  0. 0. 0. 0. 1.0  3.6 1.1 1.0 7
11241908    0. 2.2875 1.3725  0. 0. 0. 0. 1.0  3.6 1.1 1.0 8
11241909    0. 2.5925 1.0675  0. 0. 0. 0. 1.0  3.6 1.1 1.0 9
11241910    0. 2.8975 0.7625  0. 0. 0. 0. 1.0 3.6 1.1 1.0 10
11241911    0. 3.2025 0.4575  0. 0. 0. 0. 1.0 3.6 1.1 1.0 11
11241912    0. 3.5075 0.1525  0. 0. 0. 0. 1.0 3.6 1.1 1.0 12
*
****************************************************
* 124-2: unheated instrument rods
****************************************************
*
11242000    12     6      2      1      0.0
11242100    0      1
11242101    3      0.00432
11242102    2      0.00612
11242201    1      2
11242202    5      5
11242301    0.0    5
11242400    0
11242401    317.0          6
11242501    0              0      0     1      31.72       12
11242601    124010000   10000   111    1      31.72       12
11242701    0      0         0         0      12
11242900    1
11242901    0.    10.0   10.0  0. 0. 0. 0. 1. 3.6   1.1   1.  12
*
****************************************************
* 124-3: heated section of heater rods in channel
****************************************************
*
11243000    12     9      2      1      0.0
11243100    0      1
11243101    2      0.00200
11243102    2      0.00260
11243103    2      0.00375
11243104    2      0.00475
11243201    7      2
11243202    2      4
11243203    1      6
11243204    4      8
11243301    0.0    2
11243302    1.0    4
11243303    0.0    8
11243400    0
11243401    317.0          9
11243501             0        0    0    1       162.25       12
11243601    126010000   10000    111   1       162.25       12
11243701    888    0.0105       0.0   0.0   1
11243702    888    0.02196      0.0   0.0   2
11243703    888    0.0321       0.0   0.0   3
11243704    888    0.04032      0.0   0.0   4
11243705    888    0.04608      0.0   0.0   5
11243706    888    0.04906      0.0   0.0   6
11243707    888    0.04906      0.0   0.0   7
11243708    888    0.04608      0.0   0.0   8
11243709    888    0.04032      0.0   0.0   9
11243710    888    0.0321       0.0   0.0   10
11243711    888    0.02196      0.0   0.0   11
11243712    888    0.0105       0.0   0.0   12
11243900    1
11243901    0. 0.1525 3.5075  0. 0. 0. 0. 1.0  3.6 1.1 1.0 1
11243902    0. 0.4575 3.2025  0. 0. 0. 0. 1.0  3.6 1.1 1.0 2
11243903    0. 0.7625 2.8975  0. 0. 0. 0. 1.0  3.6 1.1 1.0 3
11243904    0. 1.0675 2.5925  0. 0. 0. 0. 1.0  3.6 1.1 1.0 4
11243905    0. 1.3725 2.2875  0. 0. 0. 0. 1.0  3.6 1.1 1.0 5
11243906    0. 1.6775 1.9825  0. 0. 0. 0. 1.0  3.6 1.1 1.0 6
11243907    0. 1.9825 1.6775  0. 0. 0. 0. 1.0  3.6 1.1 1.0 7
11243908    0. 2.2875 1.3725  0. 0. 0. 0. 1.0  3.6 1.1 1.0 8
11243909    0. 2.5925 1.0675  0. 0. 0. 0. 1.0  3.6 1.1 1.0 9
11243910    0. 2.8975 0.7625  0. 0. 0. 0. 1.0 3.6 1.1 1.0 10
11243911    0. 3.2025 0.4575  0. 0. 0. 0. 1.0 3.6 1.1 1.0 11
11243912    0. 3.5075 0.1525  0. 0. 0. 0. 1.0 3.6 1.1 1.0 12
*
****************************************************
* 128-1: upper plenum internals
****************************************************
*
11281000    1      5      1      1      0.0
11281100    0      1
11281101    4      0.023
11281201    5      4
11281301    0.0    4
11281400    0
11281401    317.0        5
11281501    128010000      0    101     0      0.773     1
11281601    128010000      0    101     0      0.773     1
11281701    0      0      0      0      1
11281801    0. 10.0   10.0 0. 0.0 0. 0. 1.   1
11281901    0. 10.0   10.0 0. 0.0 0. 0. 1.   1
*
****************************************************
* 132-1: guide tubes
****************************************************
*
```

```
11321000   5   4   2   1   0.04405
11321100   0   1
11321101   3   0.04655
11321201   5   3
11321301   0.0   3
11321400   0
11321401   317.0   4
11321501   156020000   0   101   1   5.406   1
11321502   156020000   0   101   1   4.800   2
11321503   156010000   0   101   1   2.939   3
11321504   156010000   0   101   1   7.176   4
11321505   156010000   0   101   1   5.800   5
11321601   132010000   0   101   1   5.406   1
11321602   136010000   0   101   1   4.800   2
11321603   140010000   0   101   1   2.939   3
11321604   144010000   0   101   1   7.176   4
11321605   148010000   0   101   1   5.800   5
11321701   0   0   0   0   5
11321801   0.   10.0   10.0   0. 0.   0.0 0. 1.   5
11321901   0.   10.0   10.0   0. 0.   0.0 0. 1.   5
*
*************************************************
* 144-1: upper core support plate
*************************************************
*
11441000   1   9   1   1   0.0
11441100   0   1
11441101   8   0.304
11441201   5   8
11441301   0.0   8
11441400   0
11441401   317.0   9
11441501   144010000   0   101   0   0.156   1
11441601   140010000   0   101   0   0.156   1
11441701   0   0   0   0   1
11441801   0. 10.0   10.0 0. 0.0 0. 0. 1.   1
11441901   0. 10.0   10.0 0. 0.0 0. 0. 1.   1
*
*************************************************
* 148-1; reactor vessel wall above upper plenum flange
*************************************************
*
11481000   1   7   2   1   0.320
11481100   0   1
11481101   1   0.323
11481102   4   0.522
11481103   1   0.647
11481201   5   1
11481202   6   5
11481203   9   6
11481301   0.0   6
11481400   0
11481401   317.0   7
11481501   148010000   0   101   1   0.404   1
11481601   900010000   0   101   1   0.404   1
11481701   0   0   0   0   1
11481801   0. 10.0   10.0 0. 0.0 0. 0. 1. 1
11481901   0. 10.0   10.0 0. 0.0 0. 0. 1. 1
*
```

```
*************************************************
* 152-1; reactor vessel upper head
*************************************************
*
*
11521000   1   7   3   1   0.320
11521100   0   1
11521101   1   0.324
11521102   4   0.354
11521103   1   0.479
11521201   5   1
11521202   6   5
11521203   9   6
11521301   0.0   6
11521400   0
11521401   317.0   7
11521501   152010000   0   101   1   0.5   1
11521601   900010000   0   101   1   0.5   1
11521701   0   0   0   0   1
11521801   0. 10.0   10.0 0. 0.0 0. 0. 1. 1
11521901   0. 10.0   10.0 0. 0.0 0. 0. 1. 1
*
*************************************************
*        ht str no. 212-1   Loop Heat Structures
*************************************************
*
12121000   2   6   3   1   0.377   0
12121100   0   1
12121101   1   0.380
12121102   2   0.430
12121103   2   0.555
12121201   5   1
12121202   6   3
12121203   9   5
12121301   0.0   5
12121400   0
12121401   317.0   6
12121501   212010000   0   101   1   0.1872   1
12121502   228010000   0   101   1   0.1872   2
12121601   900010000   0   101   1   0.1872   2
12121701   0   0   0   0   2
12121801   0.   10.0   10.0 0.   0.   0.   0.   1.   2
12121901   0.   10.0   10.0 0.   0.   0.   0.   1.   2
*
*************************************************
*      ht str no. 212-2   blsg inlet/outlet plnm walls
*************************************************
12122000   5   6   2   1   0.365   0
12122100   0   1
12122101   1   0.368
12122102   2   0.434
12122103   2   0.559
12122201   5   1
12122202   6   3
12122203   9   5
12122301   0.0   5
12122400   0
12122401   317.0   6
12122501   212010000   0   101   1   0.4237   1
```

```
12122502   228010000  0   101   1   0.4237    2
12122503   214010000  0   101   1   0.55175   3
12122504   216010000  0   101   1   0.55175   4
12122505   224010000  0   101   1   1.1035    5
12122601   900010000  0   101   1   0.4237    2
12122602   900010000  0   101   1   0.55175   4
12122603   900010000  0   101   1   1.1035    5
12122701      0       0      0      0       5
12122801      0.     10.0   10.0   0.  0.  0.  0. 1. 5
12122901      0.     10.0   10.0   0.  0.  0.  0. 1. 5
*
****************************************************
*     ht str no. 220-2   blsg inlet/outlet tube sheet
****************************************************
12202000    2     4    2    1    0.0098    0
12202100    0     1
12202101    3     0.0163
12202201    5     3
12202301    0.0   3
12202400    0
12202401    317.0    4
12202501    220010000   0    101    1    45.40   1
12202502    220080000   0    101    1    45.40   2
12202601    0           0    0      1    45.40   2
12202701    0           0       0        0       2
12202801    0.     10.0    10.0  0. 0. 0.   0.   1.   2
****************************************************
*    ht str no. 220-1 sg in the loop without pressurizer
****************************************************
*
12201000    12     8     2     1     0.00980
12201100    0      1
12201101    7      0.0127
12201201    5      7
12201301    0.0    7
12201400    0
12201401    317.0        8
12201501    220010000  10000    101   1    89.76     4
12201502    220050000  10000    101   1   180.86     6
12201503    220070000      0    101   1   361.72     7
12201504    220080000  10000    101   1   306.36     9
12201505    220100000  10000    101   1   361.72    11
12201506    220120000      0    101   1   359.04    12
12201601    304010000      0    110   1    89.76     4
12201602    304020000      0    110   1   180.86     6
12201603    304030000      0    110   1   361.72     7
12201604    304040000      0    110   1   306.36     9
12201605    304030000 -10000    110   1   361.72    11
12201606    304010000      0    110   1   359.04    12
12201701    0    0    0    0    12
12201801    0. 10.0 10.0  0.0  0.  0.0  0. 1.     12
12201900    1
12201901    0. 10. 10. 0.0  0.  0.0 0. 1.  10.2 1.1 1.0   12
*
****************************************************
*   ht str no. 300-1   blsg external dc pipe to environ
****************************************************
13001000    5     5    2    1    0.0486    0
13001100    0     1
13001101    2     0.0572
13001102    2     0.1572
13001201    5     2
13001202    9     4
13001301    0.0   4
13001401    317.0   5
13001501    300010000   0     101    1     9.0016  1
13001502    300020000   0     101    1     8.3920  2
13001503    300030000   10000 101    1    10.2616  4
13001504    300050000   0     101    1    10.2380  5
13001601    900010000   0     101    1     9.0016  1
13001602    900010000   0     101    1     8.3920  2
13001603    900010000   0     101    1    10.2616  4
13001604    900010000   0     101    1    10.2380  5
13001701     0       0        0        0     5
13001801     0.    10.0    10.0  0.   0.  0.   0.  1.  5
13001901     0.    10.0  10.0    0.   0.  0.   0.  1.  5
*
****************************************************
*      ht str no. 300-2   blsg upper dc to separator
****************************************************
13002000    2     2    2    1    0.2514    0
13002100    0          1
13002101    1          0.2554
13002201    5          1
13002301    0.0        1
13002400    0
13002401    317.0      2
13002501    304050000   0    101    1    0.6461   1
13002502    308010000   0    101    1    2.120    2
13002601    300010000   0    101    1    0.6461   1
13002602    308010000   [illegible]    101    1    2.120    2
13002701      0       0        0        0     2
13002801      0.   10.0   10.0   0.   0.   0.   0.  1.  2
13002901      0.   10.0   10.0   0.   0.   0.   0.  1.  1
13002902      0.   10.0   10.0   0.   0.   0.   0.  1.  2
*
****************************************************
*     ht str no. 300-3   blsg upper sg sheli to environ
****************************************************
*
13003000    4     6    2    1    0.4375    0
13003100       0          1
13003101       1          0.4405
13003102       2          0.4785
13003103       2          0.6035
13003201       5          1
13003202       6          3
13003203       9          5
13003301       0.0        5
13003400       0
13003401       317.0      6
13003501    300010000   0    101    1    0.6461   1
13003502    304050000   0    101    1    1.0104   2
13003503    31201000    0    101    1    2.120    3
13003504    31601000    0    101    1    3.4278   4
13003601    900010000   0    101    1    0.6461   1
13003602    900010000   0    101    1    1.0104   2
13003603    900010000   0    101    1    2.120    3
```

```
13003604   900010000   0    101    1       3.4278   4
13003701       0           0         0       0      4
13003801       0.   10.0   10.0   0.   0.   0.   0.   1.   1
13003802       0.   10.0   10.0   0.   0.   0.   0.   1.   2
13003803       0.   10.0   10.0   0.   0.   0.   0.   1.   3
13003804       0.   10.0   10.0   0.   0.   0.   0.   1.   4
13003901       0.   10.0   10.0   0.   0.   0.   0.   1.   4
*
**************************************************
*     ht str no. 300-4    blsg lower sg dc to boiler
**************************************************
13004000   1      2     2     1     0.345     0
13004100   0            1
13004101   1            0.351
13004201   5            1
13004301   0.0          1
13004400   0
13004401   317.0        2
13004501   304010000    0     101    1       1.0637   1
13004601   300050000    0     101    1       1.0637   1
13004701       0            0          0          0     1
13004801       0.   10.0   10.0   0.   0.   0.   0.   1.   1
13004901       0.   10.0   10.0   0.   0.   0.   0.   1.   1
*
**************************************************
*    ht str no. 300-5    blsg lower sg dc wall to environ
**************************************************
13005000   1       6     2     1     0.370     0
13005100       0               1
13005101       1               0.373
13005102       2               0.405
13005103       2               0.530
13005201       5               1
13005202       6               3
13005203       9               5
13005301       0.0             5
13005400       0
13005401       317.0           6
13005501   300050000   0    101     1       1.2637   1
13005601   900010000   0    101     1       1.2637   1
13005701       0          0           0          0     1
13005801       0.   10.0    10.0   0.   0.   0.   0.    1.   1
13005901       0.   10.0    10.0   0.   0.   0.   0.    1.   1
*
**************************************************
*       ht str no. 304-1    blsg boiler wall to environ
**************************************************
13041000   5       6     2     1     0.347     0
13041100       0            1
13041101       1            0.350
13041102       2            0.380
13041103       2            0.505
13041201       5            1
13041202       6            3
13041203       9            5
13041301       0.0          5
13041400       0
13041401       317.0        6
13041501   304010000   0      101     1      1.2827   1
13041502   304020000   10000   101     1      2.5654   3
13041503   304040000   0       101     1      2.098    4
13041504   304050000   0       101     1      0.3658   5
13041601   900010000   0       101     1      1.2827   1
13041602   900010000   0       101     1      2.5654   3
13041603   900010000   0       101     1      2.098    4
13041604   900010000   0       101     1      0.3658   5
13041701       0             0           0          0     5
13041801       0.    10.0    10.0   0.   0.   0.   0.   1.   4
13041802       0.    10.0    10.0   0.   0.   0.   0.   1.   5
13041901       0.    10.0    10.0   0.   0.   0.   0.   1.   5
*
**************************************************
*     ht str no. 312-1    blsg separator to sep bypass
**************************************************
*
13121000   1       2     2     1     0.2982    0
13121100       0             1
13121101       1             0.3012
13121201       5             1
13121301       0.0           1
13121400       0
13121401       317.0         2
13121501   308010000   0     101     1        1.7886   1
13121601   312010000   0     101     1        1.7886   1
13121701       0          0          0           0     1
13121801       0.    10.0    10.0   0.   0.   0.   0.   1.   1
13121901       0.    10.0    10.0   0.   0.   0.   0.   1.   1
*
**************************************************
*   ht str no. 316-1    blsg hemisph top to environ
**************************************************
13161000   1       6     3     1     0.447     0
13161100       0             1
13161101       1             0.451
13161102       2             0.473
13161103       2             0.598
13161201       5             1
13161202       6             3
13161203       9             5
13161301       0.0           5
13161400       0
13161401       317.0         6
13161501   316010000   0       101      1      0.391   1
13161601   900010000   0       101      1      0.391   1
13161701       0            0          0          0     1
13161801       0.    10.0    10.0    0.   0.   0.   0.   1.   1
13161901       0.    10.0    10.0    0.   0.   0.   0.   1.   1
*
**************************************************
*     primary loop piping heat structures
**************************************************
14001000   6       5     2     1     0.1035    0
14001100       0             1
14001101       2             0.1981
14001102       2             0.3231
14001201       5             2
14001202       9             4
14001301       0.0           4
```

```
14001400      0
14001401      317.0         5
14001501   400010000   0    101    1   1.3246   1
14001502   408010000   0    101    1   0.5968   2
14001503   408020000   0    101    1   0.5278   3
14001504   200010000   0    101    1   1.3246   4
14001505   208010000   0    101    1   0.5968   5
14001506   208020000   0    101    1   0.5278   6
14001601   900010000   0    101    1   1.3246   1
14001602   900010000   0    101    1   0.5968   2
14001603   900010000   0    101    1   0.5278   3
14001604   900010000   0    101    1   1.3246   4
14001605   900010000   0    101    1   0.5968   5
14001606   900010000   0    101    1   0.5278   6
14001701      0          0          0          0   6
14001801      0.   10.0   10.0   0.   0.   0.   0.   1.   6
14001901      0.   10.0   10.0   0.   0.   0.   0.   1.   6
*
**************************************************
*        ht str no. 400-2    il + bl col heat struct
**************************************************
14002000    18    5    2    1    0.0841    0
14002100      0           1
14002101      2           0.1219
14002102      2           0.2469
14002201      5           2
14002202      9           4
14002301      0.0         4
14002400      0
14002401      317.0       5
14002501   432010000   0       101   1   0.516    1
14002502   432020000   10000   101   1   1.2422   4
14002503   432050000   0       101   1   1.1919   5
14002504   436010000   0       101   1   1.1919   6
14002505   436020000   10000   101   1   1.1222   9
14002506   232010000   0       101   1   0.516    10
14002507   232020000   10000   101   1   1.2422   13
14002508   232050000   0       101   1   1.1919   14
14002509   236010000   0       101   1   1.1919   15
14002510   236020000   10000   101   1   1.1222   18
14002601   900010000   0       101   1   0.516    1
14002602   900010000   0       101   1   1.2422   4
14002603   900010000   0       101   1   1.1919   6
14002604   900010000   0       101   1   1.1222   9
14002605   900010000   0       101   1   0.516    10
14002606   900010000   0       101   1   1.2422   13
14002607   900010000   0       101   1   1.1919   15
14002608   900010000   0       101   1   1.1222   18
14002701      0          0          0          0   18
14002801      0.   10.0   10.0   0.   0.   0.   0.   1.   18
14002901      0.   10.0   10.0   0.   0.   0.   0.   1.   18
*
**************************************************
*     ht str no. 400-3    il + bl cl heat struct
**************************************************
14003000    7    5    2    1    0.1035    0
14003100      0           1
14003101      2           0.1937
14003102      2           0.3187
14003201      5           2
14003202      9           4
14003301      0.0         4
14003400      0
14003401      317.0       5
14003501   444010000   0       101   1   1.0562   1
14003502   448010000   0       101   1   1.1067   2
14003503   452010000   0       101   1   1.3125   3
14003504   244010000   0       101   1   0.647    4
14003505   248010000   0       101   1   0.878    5
14003506   252010000   10000   101   1   0.9752   7
14003601   900010000   0       101   1   1.0562   1
14003602   900010000   0       101   1   1.1067   2
14003603   900010000   0       101   1   1.3125   3
14003604   900010000   0       101   1   0.647    4
14003605   900010000   0       101   1   0.878    5
14003606   900010000   0       101   1   0.9752   7
14003701      0          0          0          0   7
14003801      0.   10.0   10.0   0.   0.   0.   0.   1.   7
14003901      0.   10.0   10.0   0.   0.   0.   0.   1.   7
*
**************************************************
*    ht str no. 412-1    ilsg inlet/outlet plnm hemisph
**************************************************
14121000    2    6    3    1    0.377    0
14121100      0           1
14121101      1           0.380
14121102      2           0.430
14121103      2           0.555
14121201      5           1
14121202      6           3
14121203      9           5
14121301      0.0         5
14121400      0
14121401      317.0       6
14121501   412010000   0   101   1   0.1872   1
14121502   428010000   0   101   1   0.1872   2
14121601   900010000   0   101   1   0.1872   2
14121701      0          0          0          0   2
14121801      0.   10.0   10.0   0.   0.   0.   0.   1   2
14121901      0.   10.0   10.0   0.   0.   0.   0.   1   2
*
**************************************************
*        ht str no. 412-2    ilsg inlet/outlet plnm walls
**************************************************
14122000    5    6    2    1    0.365    0
14122100      0           1
14122101      1           0.368
14122102      2           0.434
14122103      2           0.559
14122201      5           1
14122202      6           3
14122203      9           5
14122301      0.0         5
14122400      0
14122401      317.0       6
14122501   412010000   0   101   1   0.4237    1
14122502   428010000   0   101   1   0.4237    2
14122503   414010000   0   101   1   0.55175   3
```

```
14122504   416010000  0   101      1   0.55175  4
14122505   424010000  0   101      1   1.1035   5
14122601   900010000  0   101      1   0.4237   2
14122602   900010000  0   101      1   0.55175  4
14122603   900010000  0   101      1   1.1035   5
14122701      0          0         0          0     5
14122801      0.   10.0    10.0   0.   0.  0.   0.  1.  5
14122901      0.   10.0    10.0   0.   0.  0.   0.  1.  5
*
**************************************************
*       ht str no. 420-1 intact loop sg tubes
**************************************************
*
14201000   12    8    2    1     0.00980
14201100   0     1
14201101   7     0.0127
14201201   5     7
14201301   0.0   7
14201400   0
14201401   317.0       8
14201501   420010000  10000   101   1    89.76     4
14201502   420050000  10000   101   1   180.86     6
14201503   420070000      0   101   1   361.72     7
14201504   420080000  10000   101   1   306.36     9
14201505   420100000  10000   101   1   361.72    11
14201506   420120000      0   101   1   359.04    12
14201601   504010000      0   110   1    89.76     4
14201602   504020000      0   110   1   180.86     6
14201603   504030000      0   110   1   361.72     7
14201604   504040000      0   110   1   306.36     9
14201605   504030000 -10000   110   1   361.72    11
14201606   504010000      0   110   1   359.04    12
14201701   0     0     0     0     12
14201801   0. 10.0  10.0  0.0  0. 0.0  0.  1.    12
14201900   1
14201901   0. 10.0  10.0  0.0  0. 0. 0. 1. 10.2 1.1 1.0  12
*
**************************************************
*      ht str no. 420-2   ilsg inlet/outlet tube sheet
**************************************************
*
14202000   2      4     2     1     0.0098    0
14202100   0            1
14202101   3            0.0163
14202201   5            3
14202301   0.0          3
14202400   0
14202401   317.0        4
14202501   420010000   0      101      1     45.40  1
14202502   420080000   0      101      1     45.40  2
14202601   0           0      0        1     45.40  2
14202701      0          0         0          0     2
14202801      0.    10.0    10.0    0.  0.  0.  0.  1.  2
**************************************************
*     ht str no. 500-1   ilsg external dc pipe to environ
**************************************************
15001000   5      5     2     1     0.0486    0
15001100    0              1
15001101    2              0.0572
15001102    2              0.1572
15001201    5              2
15001202    9              4
15001301    0.0            4
15001401    317.0          5
15001501   500010000   0      101     1      9.0016  1
15001502   500020000   0      101     1      8.3920  2
15001503   500030000   10000  101     1     10.2616  4
15001504   500050000   0      101     1     10.2380  5
15001601   900010000   0      101     1      9.0016  1
15001602   900010000   0      101     1      8.3920  2
15001603   900010000   0      101     1     10.2616  4
15001604   900010000   0      101     1     10.2380  5
15001701      0          0         0          0     5
15001801      0.    10.0    10.0   0.   0.  0.   0.  1.  5
15001901      0.    10.0    10.0   0.   0.  0.   0.  1.  5
*
**************************************************
*      ht str no. 500-2   ilsg upper dc to separator
**************************************************
15002000   2      2     2     1     0.2514    0
15002100      0               1
15002101      1               0.2554
15002201      5               1
15002301      0.0             1
15002400      0
15002401      317.0           2
15002501   504050000   0      101     1     0.6461  1
15002502   508010000   0      101     1     2.120   2
15002601   500010000   0      101     1     0.6461  1
15002602   508010000   0      101     1     2.120   2
15002701      0          0         0          0     2
15002801      0.    10.0    10.0   0.   0.  0   0.  1.  2
15002901      0.    10.0    10.0   0.   0.  0. 0.   1.  1
15002902      0.    10.0    10.0   0.   0.  0. 0    1   2
*
**************************************************
*       ht str no. 500-3   ilsg upper sg shell to environ
**************************************************
15003000   4      6     2     1     0.4375    0
15003100      0             1
15003101      1             0.4405
15003102      2             0.4785
15003103      2             0.6035
15003201      5             1
15003202      6             3
15003203      9             5
15003301      0.0           5
15003400      0
15003401      317.0         6
15003501   500010000   0    101      1    0.6461  1
15003502   504050000   0    101      1    1.0104  2
15003503   512010000   0    101      1    2.120   3
15003504   516010000   0    101      1    3.4278  4
15003601   900010000   0    101      1    0.6461  1
15003602   900010000   0    101      1    1.0104  2
15003603   900010000   0    101      1    2.120   3
15003604   900010000   0    101      1    3.4278  4
15003701      0          0         0          0     4
```

```
15003801        0.      10.0  10.0    0.    0.  0.   0.  1.   1
15003802        0.      10.0  10.0    0.    0.  0.   0.  1.   2
15003803        0.      10.0  10.0    0.    0.  0.   0.  1.   3
15003804        0.      10.0  10.0    0.    0.  0.   0.  1.   4
15003901        0.      10.0  10.0    0.    0.  0.   0.  1.   4
*
**************************************************
*   ht str no. 500-4   ilsg lower sg dc to boiler
**************************************************
15004000    1       2     2     1      0.345     0
15004100        0            1
15004101        1            0.351
15004201        5            1
15004301        0.0          1
15004400        0
15004401        317.0        2
15004501    504010000   0        101       1       1.0637  1
15004601    500050000   0        101       1       1.0637  1
15004701        0          0           0           0      1
15004801        0.     10.0     10.0    0.   0.   0.   0.  1.  1
15004901        0.     10.0     10.0    0.   0.   0.   0.  1.  1
*
**************************************************
*  ht str no. 500-5   ilsg lower sg dc wall to environ
**************************************************
15005000    1       6     2     1      0.370     0
15005100        0             1
15005101        1             0.373
15005102        2             0.405
15005103        2             0.530
15005201        5             1
15005202        6             3
15005203        9             5
15005301        0.0           5
15005400        0
15005401        317.0         6
15005501    500050000   0        101       1       1.2637  1
15005601    900010000   0        101       1       1.2637  1
15005701        0          0           0           0      1
15005801        0.     10.0     10.0   0.    0.   0.   0.  1.  1
15005901        0.     10.0     10.0   0.    0.   0.   0.  1.  1
*
**************************************************
*       ht str no. 504-1   ilsg boiler wall to environ
**************************************************
15041000    5       6     2     1      0.347     0
15041100       0             1
15041101       1             0.350
15041102       2             0.380
15041103       2             0.505
15041201       5             1
15041202       6             3
15041203       9             5
15041301       0.0           5
15041400       0
15041401       317.0         6
15041501    504010000   0        101       1       1.2827  1
15041502    504020000   10000    101       1       2.5654  3
15041503    504040000   0        101       1       2.098   4
15041504    504050000   0        101       1       0.3658  5
15041601    900010000   0        101       1       1.2827  1
15041602    900010000   0        101       1       2.36[illegible]  3
15041603    900010000   0        101       1       2.098   4
15041604    900010000   0        101       1       0.3658  5
15041701       0          0           0           0      5
15041801       0.     10.0     10.0   0.    0.   0.   0.  1.   4
15041802       0.     10.0     10.0   0.    0.   0.   0.  1.   5
15041901       0.     10.0     10.0   0.    0.   0.   0.  1.   5
*
**************************************************
*       ht str no. 512-1   ilsg separator to sep bypass
**************************************************
15121000    1       2     2     1      0.2982    0
15121100       0             1
15121101       1             0.3012
15121201       5             1
15121301       0.0           1
15121400       0
15121401       317.0         2
15121501    508010000   0        101       1       1.7886  1
15121601    512010000   0        101       1       1.7886  1
15121701       0          0           0           0      1
15121801       0.     10.0     10.0  0.    0.   0.    0.  1.   1
15121901       0.     10.0     10.0  0.    0.   0.    0.  1.   1
*
**************************************************
*       ht str no. 516-1   ilsg hemisph top to environ
**************************************************
15161000    1       6     3     1      0.447     0
15161100       0             1
15161101       1             0.451
15161102       2             0.473
15161103       2             0.598
15161201       5             1
15161202       6             3
15161203       9             5
15161301       0.0           5
15161400       0
15161401       317.0         6
15161501    516010000   0        101       1       0.391   1
15161601    900010000   0        101       1       0.391   1
15161701       0          0           0           0      1
15161801       0.     10.0     10.0    0.   0.   0    0.  1.  1
15161901       0.     10.0     10.0    0.   0.   0.   0   1.  1
*
**************************************************
*      ht str no. 610-1   prizer wall heat struct
**************************************************
16101000    7       6     2     1      0.300     0
16101100       0             1
16101101       1             0.303
16101102       2             0.360
16101103       2             0.485
16101201       5             1
16101202       6             3
16101203       9             5
16101301       0.0           5
16101400       0
```

```
16101401        317.0          6
16101501   610020000   10000   101     1    0.475  2
16101502   610040000   0       101     1    0.600  3
16101503   610050000   10000   101     1    0.682  5
16101504   610070000   10000   101     1    0.5375 7
16101601   900010000   0       101     1    0.475  2
16101602   900010000   0       101     1    0.600  3
16101603   900010000   0       101     1    0.682  5
16101604   900010000   0       101     1    0.5375  7
16101701       0           0           0         0   7
16101801       0    10.0   10.0   0.  0.  0.   0.  1.  5
16101802       0.   10.0   10.0   0.  0.  0.   0.  1.  7
16101901       0.   10.0   10.0   0.  0.  0.   0.  1.  7
*
*****************************************************
*  ht str no. 610-2   prizer top (hemisph) heat struct
*****************************************************
16102000    1     6     3     1     0.323     0
16102100       0             1
16102101       1             0.326
16102102       2             0.383
16102103       2             0.508
16102201       5             1
16102202       6             3
16102203       9             5
16102301       0.0           5
16102400       0
16102401       317.0         5
16102402       317.0         6
16102501   610010000   0      101      1      0.311  1
16102601   900010000   0      101      1      0.311  1
16102701       0           0           0         0   1
16102801       0.   10.0   10.0  0.   0.  0.   0. 1.   1
16102901       0.   10.0   10.0  0.   0.  0.   0. 1.   1
*
*****************************************************
*    ht str no. 610-3   prizer bot (flange) heat struct
*****************************************************
16103000    1     6     1     1     0.0     0
16103100       0             1
16103101       1             0.003
16103102       2             0.8374
16103103       2             0.9624
16103201       5             1
16103202       6             3
16103203       9             5
16103301       0.0           5
16103400       0
16103401       317.0         6
16103501   610080000   0      101      1     0.2731  1
16103601   900010000   0      101      1     0.2731  1
16103701       0          0           0          0   1
16103801       0.   10.0    10.0  0.   0.  0.   0.  1.  1
16103901       0.   10.0    10.0  0.   0.  0.   0.  1.  1
*
*****************************************************
*        Thermal Properties
*****************************************************
*
```

```
20100100     tbl/fctn     1     1   * mgo
20100200     tbl/fctn     1     1   * nicr
20100300     tbl/fctn     1     1   * copper
20100400     tbl/fctn     1     1   * inconel
20100500     tbl/fctn     1     1   * stainless steel
20100600     c-steel                * carbon steel
20100700     tbl/fctn     1     1   * al2o3
20100900     tbl/fctn     1     1   * rockwool insulation
*
*****************************************************
*            thermal conductivity
*****************************************************
*  mgo
*
20100101     293.2    0.814   1273.2   1.047
*
*  nicr heater
*
20100201 293.15 8.78 573.15 11.3 773.15 13.81 1073.15 18.83
20100202 1273.15 22.18 1473.15 25.52   10000.0   25.52
*
*  copper
*
20100301     300.0    383.0
20100302     373.15   379.   473.15   374.   573.15   369.
20100303     673.15   363.   873.15   353.
*
*  inconel 600
*
20100401    200.0    13.0    323.0    14.9
20100402    373.15 15.8 573.15 18.9 873.15 23.8 1173.15 29.3
*
*
*  stainless steel
*
20100501    273.15   12.98   1199.82   25.1   10000.0   25.1
*
*  aluminum oxide
*
20100701    300.0    28.0
20100702   373.15 25.122 473.15 20.935 573.15 16.748 773.15
           12.561
20100703    1073.15   8.374 1473.15   8.374
*
*  rockwool insulation
*
20100901    273.0    0.1192
20100902     311.15   0.1192   422.15   0.1681   533.15   0.2166
20100903     811.15   0.3448
*
*****************************************************
*             volumetric heat capacity
*****************************************************
*  mgo
20100151     293.15   2.88e6   373.15   3.04e6   473.15   3.15e6
20100152     573.15   3.20e6   673.15   3.25e6   773.15   3.29e6
20100153     873.15   3.34e6   973.15   3.44e6 1073.15   3.53e6
20100154    1173.15   3.63e6
*
```

```
* nicr heater
*
20100251    300.0    3.00e+6
20100252    373.15 3.23e+6  573.15 3.62e+6   773.15   4.10e+6
20100253    1073.15 4.61e+6 1173.15 4.73e+6 1273.15 4.95e+6
20100254    1473.15   5.29e+6   10000.0   5.29e+6
*
* copper
*
20100351      3.43e6
*
* inconel 600
*
20100451    300.0    3.50e6     323.0    3.76e6
20100452    373.15 3.94e+6   573.15 4.18e+6 873.15   4.71e+6
20100453    1173.15   5.17e+6
*
* stainless steel
*
20100551  273.15 3.83e+6   366.5   3.83e+6   477.59   4.19e+6
20100552   588.59 4.336e+6 699.82 4.504e+6 810.93 4.639e+6
20100553   922.04 4.773e+6 1144.26 5.076e+6 1366.5 5.376e+6
20100554  1477.59   5.546e+6    10000.0   5.546e+6
*
* aluminum oxide
*
20100751 300.0    3.00e6
20100752 373.15 3.015e+6 473.15 3.482e+6 573.15 3.796e+6
20100753 673.15 3.946e+6 773.15 4.093e+6 873.15 4.239e+6
20100754 973.15 4.384e+6 1073.16 4.373e+6 1173.16 4.529e+6
20100755 1373.16 4.529e+6   1473.16 4.685e+6
*
* rockwool
*
20100951     1.36e-5
*
*****************************************************
* core power
*****************************************************
*
20288800       power       501
20288801          -1.0      0.430e+6
20288802           0.0      0.430e+6
*
*****************************************************
*    Control Systems
*****************************************************
* calculate core collapsed liquid level
*****************************************************
*
20512400   "core lvl"          sum          1.0          3.66     1
20512401       0.0          0.305       voidf        124010000
20512402                    0.305       voidf        124020000
20512403                    0.305       voidf        124030000
20512404                    0.305       voidf        124040000
20512405                    0.305       voidf        124050000
20512406                    0.305       voidf        124060000
20512407                    0.305       voidf        124070000
20512408                    0.305       voidf        124080000
20512409                    0.305       voidf        124090000
20512410                    0.305       voidf        124100000
20512411                    0.305       voidf        124110000
20512412                    0.305       voidf        124120000
*****************************************************
* calculate core collapsed liquid level ---vessel---
*****************************************************
*
20512500   "core lvl"       sum        1.0      5.8027    1
20512501     0.0          0.305       voidf        124010000
20512502                  0.305       voidf        124020000
20512503                  0.305       voidf        124030000
20512504                  0.305       voidf        124040000
20512505                  0.305       voidf        124050000
20512506                  0.305       voidf        124060000
20512507                  0.305       voidf        124070000
20512508                  0.305       voidf        124080000
20512509                  0.305       voidf        124090000
20512510                  0.305       voidf        124100000
20512511                  0.305       voidf        124110000
20512512                  0.305       voidf        124120000
20512513                  0.867       voidf        128010000
20512514                  0.6757      voidf        132010000
20512515                  0.6         voidf        136010000
*
20575100   "dpdoup"        sum        1.0      0.0      1
20575101        0.0          1.0               p    136010000
20575102                    -1.0               p    104010000
*
20575300   "dpe080"        sum        1.0     266000.  1
20575301        0.0          1.0               p    436010000
20575302                    -1.0               p    436040000
*
20575700   "dpe220"        sum        1.0     266000.  1
20575701        0.0          1.0               p    236010000
20575702                    -1.0               p    236040000
*
20575400   "updp"         sum        1.0      0.0      1
20575401        0.0          1.0               p    128010000
20575402                    -1.0               p    136010000
*
20575500   "ildown"        sum        1.0      0.0      1
20575501        0.0         -1.0               p    432010000
20575502                     1.0               p    432050000
*
20575600   "bldown"        sum        1.0      0.0      1
20575601        0.0         -1.0               p    232010000
20575602                     1.0               p    232050000
*
20576000   "dpe290"        sum        1.0      1200.    1
20576001        0.0          1.0               p    120010000
20576002                    -1.0               p    124010000
*
20576100   "dpe300"        sum        1.0      32000.   1
20576101        0.0          1.0               p    124010000
20576102                    -1.0               p    128010[illegible]
*
20576300   "dpe320"        sum        1.0      13000.   1
20576301        0.0          1.0               p    128010000
```

```
20576302                      -1.0            p    140010000
*
****************************************************
* calculate wide range sg liquid levels
****************************************************
*
20531200  "blsglwde"     sum        1.0      8.9221049 1
20531201   0.0    2.5464   voidf    304010000
20531202          2.5654   voidf    304020000
20531203          2.5654   voidf    304030000
20531204          2.0980   voidf    304040000
20531205          2.0223   voidf    304050000
20531206          2.1200   voidf    308010000
20531207          3.7778   voidf    316010000
*
20551200  "ilsglwde"     sum        1.0      8.8904978 1
20551201   0.0    2.5464   voidf    504010000
20551202          2.5654   voidf    504020000
20551203          2.5654   voidf    504030000
20551204          2.0980   voidf    504040000
20551205          2.0223   voidf    504050000
20551206          2.1200   voidf    508010000
20551207          3.7778   voidf    516010000
*
****************************************************
* calculate the noncondensable mass in primary
* system-broken loop
****************************************************
*
20561100   "v-200"     mult     1.0        0.1      1
20561101    tmassv     200010000
20561102    quals      200010000
20561103    quala      200010000
*
20561200   "v-206"     mult     1.0        0.1      1
20561201    tmassv     206010000
20561202    quals      206010000
20561203    quala      206010000
*
20561300   "v-208-1"   mult     1.0        0.1      1
20561301    tmassv     208010000
20561302    quals      208010000
20561303    quala      208010000
20561400   "v-208-2"   mult     1.0        0.1      1
20561401    tmassv     208020000
20561402    quals      208020000
20561403    quala      208020000
*
20562000   "hl-b-nc"   sum      1.0        0.1      1
20562001    0.0     1.0    cntrlvar   611
20562002            1.0    cntrlvar   612
20562003            1.0    cntrlvar   613
20562004            1.0    cntrlvar   614
***
20562100   "v-212"     mult     1.0        0.1      1
20562101    tmassv     212010000
20562102    quals      212010000
20562103    quala      212010000
*
20561900   "v-214"     mult     1.0        0.1      1
20561901    tmassv     214010000
20561902    quals      214010000
20561903    quala      214010000
20562200   "v-216"     mult     1.0        0.1      1
20562201    tmassv     216010000
20562202    quals      216010000
20562203    quala      216010000
*
20562300   "v-220-1"   mult     1.0        0.1      1
20562301    tmassv     220010000
20562302    quals      220010000
20562303    quala      220010000
20562400   "v-220-2"   mult     1.0        0.1      1
20562401    tmassv     220020000
20562402    quals      220020000
20562403    quala      220020000
20562500   "v-220-3"   mult     1.0        0.1      1
20562501    tmassv     220030000
20562502    quals      220030000
20562503    quala      220030000
20562600   "v-220-4"   mult     1.0        0.1      1
20562601    tmassv     220040000
20562602    quals      220040000
20562603    quala      220040000
20562700   "v-220-5"   mult     1.0        0.1      1
20562701    tmassv     220050000
20562702    quals      220050000
20562703    quala      220050000
20562800   "v-220-6"   mult     1.0        0.1      1
20562801    tmassv     220060000
20562802    quals      220060000
20562803    quala      220060000
20562900   "v-220-7"   mult     1.0        0.1      1
20562901    tmassv     220070000
20562902    quals      220070000
20562903    quala      220070000
20563000   "v-220-8"   mult     1.0        0.1      1
20563001    tmassv     220080000
20563002    quals      220080000
20563003    quala      220080000
20563100   "v-220-9"   mult     1.0        0.1      1
20563101    tmassv     220090000
20563102    quals      220090000
20563103    quala      220090000
20563200   "v-220-10"  mult     1.0        0.1      1
20563201    tmassv     220100000
20563202    quals      220100000
20563203    quala      220100000
20563300   "v-220-11"  mult     1.0        0.1      1
20563301    tmassv     220110000
20563302    quals      220110000
20563303    quala      220110000
20563400   "v-220-12"  mult     1.0        0.1      1
20563401    tmassv     220120000
20563402    quals      220120000
20563403    quala      220120000
*
20563500   "v-224"     mult     1.0        0.1      1
```

```
20563501    tmassv     224010000
20563502    quals      224010000
20563503    quala      224010000
*
20563600    "v-228"    mult     1.0        0.1      1
20563601    tmassv     228010000
20563602    quals      228010000
20563603    quala      228010000
*
20563900    "sg-b-t"   sum      1.0        0.1      1
20563901    0.0      1.0      cntrlvar    623
20563902             1.0      cntrlvar    624
20563903             1.0      cntrlvar    625
20563904             1.0      cntrlvar    626
20563905             1.0      cntrlvar    627
20563906             1.0      cntrlvar    628
20563907             1.0      cntrlvar    629
20563908             1.0      cntrlvar    630
20563909             1.0      cntrlvar    631
20563910             1.0      cntrlvar    632
20563911             1.0      cntrlvar    633
20563912             1.0      cntrlvar    634
*
20564000    "sg-b-nc"  sum      1.0        0.1      1
20564001    0.0      1.0      cntrlvar    621
20564002             1.0      cntrlvar    619
20564003             1.0      cntrlvar    622
20564004             1.0      cntrlvar    639
20564005             1.0      cntrlvar    635
20564006             1.0      cntrlvar    636
***
20564100    "v-232-1"  mult     1.0        0.1      1
20564101    tmassv     232010000
20564102    quals      232010000
20564103    quala      232010000
20564200    "v-232-2"  mult     1.0        0.1      1
20564201    tmassv     232020000
20564202    quals      232020000
20564203    quala      232020000
20564300    "v-232-3"  mult     1.0        0.1      1
20564301    tmassv     232030000
20564302    quals      232030000
20564303    quala      232030000
20564400    "v-232-4"  mult     1.0        0.1      1
20564401    tmassv     232040000
20564402    quals      232040000
20564403    quala      232040000
20564500    "v-232-5"  mult     1.0        0.1      1
20564501    tmassv     232050000
20564502    quals      232050000
20564503    quala      232050000
*
20564600    "v-236-1"  mult     1.0        0.1      1
20564601    tmassv     236010000
20564602    quals      236010000
20564603    quala      236010000
20564700    "v-236-2"  mult     1.0        0.1      1
20564701    tmassv     236020000
20564702    quals      236020000
```

```
20564703    quala      236020000
20564800    "v-236-3"  mult     1.0        0.1      1
20564801    tmassv     236030000
20564802    quals      236030000
20564803    quala      236030000
20564900    "v-236-4"  mult     1.0        0.1      1
20564901    tmassv     236040000
20564902    quals      236040000
20564903    quala      236040000
*
20565000    "ol-b-nc"  sum      1.0        0.1      1
20565001    0.0      1.0      cntrlvar    641
20565002             1.0      cntrlvar    642
20565003             1.0      cntrlvar    643
20565004             1.0      cntrlvar    644
20565005             1.0      cntrlvar    645
20565006             1.0      cntrlvar    646
20565007             1.0      cntrlvar    647
20565008             1.0      cntrlvar    648
20565009             1.0      cntrlvar    649
***
20565100    "v-240"    mult     1.0        0.1      1
20565101    tmassv     240010000
20565102    quals      240010000
20565103    quala      240010000
*
20565200    "v-244"    mult     1.0        0.1      1
20565201    tmassv     244010000
20565202    quals      244010000
20565203    quala      244010000
*
20565300    "v-248"    mult     1.0        0.1      1
20565301    tmassv     248010000
20565302    quals      248010000
20565303    quala      248010000
*
20565400    "v-252-1"  mult     1.0        0.1      1
20565401    tmassv     252010000
20565402    quals      252010000
20565403    quala      252010000
20565500    "v-252-2"  mult     1.0        0.1      1
20565501    tmassv     252020000
20565502    quals      252020000
20565503    quala      252020000
*
20566000    "cl-b-nc"  sum      1.0        0.1      1
20566001    0.0      1.0      cntrlvar    651
20566002             1.0      cntrlvar    652
20566003             1.0      cntrlvar    653
20566004             1.0      cntrlvar    654
20566005             1.0      cntrlvar    655
*
*******************************************************
* calculate the noncondensable mass in primary
* system-Intact loop
*******************************************************
*
20581100    "v-400"    mult     1.0        0.1      1
20581101    tmassv     400010000
```

```
20581102    quals      400010000
20581103    quala      400010000
*
20581200    "v-406"    mult      1.0        0.1     1
20581201    tmassv     406010000
20581202    quals      406010000
20581203    quala      406010000
*
20581300    "v-408-1"  mult      1.0        0.1     1
20581301    tmassv     408010000
20581302    quals      408010000
20581303    quala      408010000
20581400    "v-408-2"  mult      1.0        0.1     1
20581401    tmassv     408020000
20581402    quals      408020000
20581403    quala      408020000
*
20582000    "hl-i-nc"  sum       1.0        0.1     1
20582001    0.0        1.0       cntrlvar   811
20582002               1.0       cntrlvar   812
20582003               1.0       cntrlvar   813
20582004               1.0       cntrlvar   814
***
20582100    "v-412"    mult      1.0        0.1     1
20582101    tmassv     412010000
20582102    quals      412010000
20582103    quala      412010000
*
20581900    "v-414"    mult      1.0        0.1     1
20581901    tmassv     414010000
20581902    quals      414010000
20581903    quala      414010000
20582200    "v-416"    mult      1.0        0.1     1
20582201    tmassv     416010000
20582202    quals      416010000
20582203    quala      416010000
*
20582300    "v-420-1"  mult      1.0        0.1     1
20582301    tmassv     420010000
20582302    quals      420010000
20582303    quala      420010000
20582400    "v-420-2"  mult      1.0        0.1     1
20582401    tmassv     420020000
20582402    quals      420020000
20582403    quala      420020000
20582500    "v-420-3"  mult      1.0        0.1     1
20582501    tmassv     420030000
20582502    quals      420030000
20582503    quala      420030000
20582600    "v-420-4"  mult      1.0        0.1     1
20582601    tmassv     420040000
20582602    quals      420040000
20582603    quala      420040000
20582700    "v-420-5"  mult      1.0        0.1     1
20582701    tmassv     420050000
20582702    quals      420050000
20582703    quala      420050000
20582800    "v-420-6"  mult      1.0        0.1     1
20582801    tmassv     420060000
20582802    quals      420060000
20582803    quala      420060000
20582900    "v-420-7"  mult      1.0        0.1     1
20582901    tmassv     420070000
20582902    quals      420070000
20582903    quala      420070000
20583000    "v-420-8"  mult      1.0        0.1     1
20583001    tmassv     420080000
20583002    quals      420080000
20583003    quala      420080000
20583100    "v-420-9"  mult      1.0        0.1     1
20583101    tmassv     420090000
20583102    quals      420090000
20583103    quala      420090000
20583200    "v-420-10" mult      1.0        0.1     1
20583201    tmassv     420100000
20583202    quals      420100000
20583203    quala      420100000
20583300    "v-420-11" mult      1.0        0.1     1
20583301    tmassv     420110000
20583302    quals      420110000
20583303    quala      420110000
20583400    "v-420-12" mult      1.0        0.1     1
20583401    tmassv     420120000
20583402    quals      420120000
20583403    quala      420120000
*
20583500    "v-424"    mult      1.0        0.1     1
20583501    tmassv     424010000
20583502    quals      424010000
20583503    quala      424010000
*
20583600    "v-428"    mult      1.0        1       1
20583601    tmassv     428010000
20583602    quals      428010000
20583603    quala      428010000
*
20583900    "sg-b-tb"  sum       1.0        0.1     1
20583901    0.0        1.0       cntrlvar   823
20583902               1.0       cntrlvar   824
20583903               1.0       cntrlvar   825
20583904               1.0       cntrlvar   826
20583905               1.0       cntrlvar   827
20583906               1.0       cntrlvar   828
20583907               1.0       cntrlvar   829
20583908               1.0       cntrlvar   830
20583909               1.0       cntrlvar   831
20583910               1.0       cntrlvar   832
20583911               1.0       cntrlvar   833
20583912               1.0       cntrlvar   834
*
20584000    "sg-i-nc"  sum       1.0        1       1
20584001    0.0        1.0       cntrlvar   821
20584002               1.0       cntrlvar   819
20584003               1.0       cntrlvar   822
20584004               1.0       cntrlvar   839
20584005               1.0       cntrlvar   835
20584006               1.0       cntrlvar   836
***
```

```
20584100   "v-432-1"   mult   1.0   0.1   1
20584101   tmassv   432010000
20584102   quals    432010000
20584103   quala    432010000
20584200   "v-432-2"   mult   1.0   0.1   1
20584201   tmassv   432020000
20584202   quals    432020000
20584203   quala    432020000
20584300   "v-432-3"   mult   1.0   0.1   1
20584301   tmassv   432030000
20584302   quals    432030000
20584303   quala    432030000
20584400   "v-432-4"   mult   1.0   0.1   1
20584401   tmassv   432040000
20584402   quals    432040000
20584403   quala    432040000
20584500   "v-432-5"   mult   1.0   0.1   1
20584501   tmassv   432050000
20584502   quals    432050000
20584503   quala    432050000
*
20584600   "v-436-1"   mult   1.0   0.1   1
20584601   tmassv   436010000
20584602   quals    436010000
20584603   quala    436010000
20584700   "v-436-2"   mult   1.0   0.1   1
20584701   tmassv   436020000
20584702   quals    436020000
20584703   quala    436020000
20584800   "v-436-3"   mult   1.0   0.1   1
20584801   tmassv   436030000
20584802   quals    436030000
20584803   quala    436030000
20584900   "v-436-4"   mult   1.0   0.1   1
20584901   tmassv   436040000
20584902   quals    436040000
20584903   quala    436040000
*
20585000   "ol-i-nc"   sum   1.0   0.1   1
20585001   0.0   1.0   cntrlvar   841
20585002         1.0   cntrlvar   842
20585003         1.0   cntrlvar   843
20585004         1.0   cntrlvar   844
20585005         1.0   cntrlvar   845
20585006         1.0   cntrlvar   846
20585007         1.0   cntrlvar   847
20585008         1.0   cntrlvar   848
20585009         1.0   cntrlvar   849
***
20585100   "v-440"   mult   1.0   0.1   1
20585101   tmassv   440010000
20585102   quals    440010000
20585103   quala    440010000
*
20585200   "v-444"   mult   1.0   0.1   1
20585201   tmassv   444010000
20585202   quals    444010000
20585203   quala    444010000
*
20585300   "v-448"   mult   1.0   0.1   1
20585301   tmassv   448010000
20585302   quals    448010000
20585303   quala    448010000
*
20585400   "v-452"   mult   1.0   0.1   1
20585401   tmassv   452010000
20585402   quals    452010000
20585403   quala    452010000
*
20586000   "cl-i-nc"   sum   1.0   0.1   1
20586001   0.0   1.0   cntrlvar   851
20586002         1.0   cntrlvar   852
20586003         1.0   cntrlvar   853
20586004         1.0   cntrlvar   854
*
*****************************************************
* calculate the noncondensable mass in primary
* system-pressurizer
*****************************************************
*
20566100   "v-600-1"   mult   1.0   0.1   1
20566101   tmassv   600010000
20566102   quals    600010000
20566103   quala    600010000
20566200   "v-600-2"   mult   1.0   0.1   1
20566201   tmassv   600020000
20566202   quals    600020000
20566203   quala    600020000
20566300   "v-600-3"   mult   1.0   0.1   1
20566301   tmassv   600030000
20566302   quals    600030000
20566303   quala    600030000
*
20566600   "v-610-1"   mult   1.0   0.1   1
20566601   tmassv   610010000
20566602   quals    610010000
20566603   quala    610010000
20566700   "v-610-2"   mult   1.0   0.1   1
20566701   tmassv   610020000
20566702   quals    610020000
20566703   quala    610020000
20566800   "v-610-3"   mult   1.0   0.1   1
20566801   tmassv   610030000
20566802   quals    610030000
20566803   quala    610030000
20566900   "v-610-4"   mult   1.0   0.1   1
20566901   tmassv   610040000
20566902   quals    610040000
20566903   qu[illegible]   610040000
20567000   "v[illegible]-5"   mult   1.0   0.1   1
20567001   tmassv   610050000
20567002   quals    610050000
20567003   quala    610050000
20567100   "v-610-6"   mult   1.0   0.1   1
20567101   tmassv   610060000
20567102   quals    610060000
20567103   quala    610060000
20567200   "v-610-7"   mult   1.0   0.1   1
```

```
20567201   tmassv     610070000
20567202   quals      610070000
20567203   quala      610070000
20567300   "v-610-8"  mult    1.0    0.1    1
20567301   tmassv     610080000
20567302   quals      610080000
20567303   quala      610080000
*
20567400   "v-620-1"  mult    1.0    0.1    1
20567401   tmassv     620010000
20567402   quals      620010000
20567403   quala      620010000
20567500   "v-620-2"  mult    1.0    0.1    1
20567501   tmassv     620020000
20567502   quals      620020000
20567503   quala      620020000
*
20567900   "pzr-nc"   sum     1.0    0.1    1
20567901   0.0     1.0    cntrlvar   666
20567902           1.0    cntrlvar   667
20567903           1.0    cntrlvar   668
20567904           1.0    cntrlvar   669
20567905           1.0    cntrlvar   670
20567906           1.0    cntrlvar   671
20567907           1.0    cntrlvar   672
20567908           1.0    cntrlvar   673
*
20568000   "pzrsp-nc"   sum     1.0    0.1    1
20568001   0.0     1.0    cntrlvar   661
20568002           1.0    cntrlvar   662
20568003           1.0    cntrlvar   663
20568004           1.0    cntrlvar   679
20568005           1.0    cntrlvar   674
20568006           1.0    cntrlvar   675
*
***************************************************
* calculate the noncondensable mass in primary
* system-reactor vessel
***************************************************
*
20586100   "v-100"    mult    1.0    0.1    1
20586101   tmassv     100010000
20586102   quals      100010000
20586103   quala      100010000
*
20586200   "v-104"    mult    1.0    0.1    1
20586201   tmassv     104010000
20586202   quals      104010000
20586203   quala      104010000
*
20586300   "v-108-1"  mult    1.0    0.1    1
20586301   tmassv     108010000
20586302   quals      108010000
20586303   quala      108010000
*
20586400   "v-128"    mult    1.0    0.1    1
20586401   tmassv     128010000
20586402   quals      128010000
20586403   quala      128010000
*
20586500   "v-130"    mult    1.0    0.1    1
20586501   tmassv     130010000
20586502   quals      130010000
20586503   quala      130010000
*
20586600   "v-132"    mult    1.0    0.1    1
20586601   tmassv     132010000
20586602   quals      132010000
20586603   quala      132010000
*
20586700   "v-134"    mult    1.0    0.1    1
20586701   tmassv     134010000
20586702   quals      134010000
20586703   quala      134010000
*
20586800   "v-136"    mult    1.0    0.1    1
20586801   tmassv     136010000
20586802   quals      136010000
20586803   quala      136010000
*
20586900   "v-140"    mult    1.0    0.1    1
20586901   tmassv     140010000
20586902   quals      140010000
20586903   quala      140010000
*
20587000   "v-144"    mult    1.0    0.1    1
20587001   tmassv     144010000
20587002   quals      144010000
20587003   quala      144010000
*
20587100   "v-148"    mult    1.0    0.1    1
20587101   tmassv     148010000
20587102   quals      148010000
20587103   quala      148010000
*
20587200   "v-152"    mult    1.0    0.1    1
20587201   tmassv     152010000
20587202   quals      152010000
20587203   quala      152010000
*
20587300   "v-156-1"  mult    1.0    0.1    1
20587301   tmassv     156010000
20587302   quals      156010000
20587303   quala      156010000
20587400   "v-156-2"  mult    1.0    0.1    1
20587401   tmassv     156020000
20587402   quals      156020000
20587403   quala      156020000
*
20588000   "vesei-nc"   sum     1.0    0.1    1
20588001   0.0     1.0    cntrlvar   861
20588002           1.0    cntrlvar   862
20588003           1.0    cntrlvar   863
20588004           1.0    cntrlvar   864
20588005           1.0    cntrlvar   865
20588006           1.0    cntrlvar   866
20588007           1.0    cntrlvar   867
20588008           1.0    cntrlvar   868
```

```
20588009              1.0     cntrlvar    869
20588010              1.0     cntrlvar    870
20588011              1.0     cntrlvar    871
20588012              1.0     cntrlvar    872
20588013              1.0     cntrlvar    873
20588014              1.0     cntrlvar    874
*
*****************************************************
* total noncondeasable mass in primary system
*****************************************************
*
20593000   "t-nocd-m"    sum       1.0      0.1     1
20593001    0.0       1.0     cntrlvar    620
20593002              1.0     cntrlvar    640
20593003              1.0     cntrlvar    650
20593004              1.0     cntrlvar    660
20593005              1.0     cntrlvar    680
20593006              1.0     cntrlvar    820
20593007              1.0     cntrlvar    840
20593008              1.0     cntrlvar    850
20593009              1.0     cntrlvar    860
20593010              1.0     cntrlvar    880
*
20592900   "u-tubes"    sum       1.0       0.1     1
20592901    0.0       1.0     cntrlvar    639
20592902              1.0     cntrlvar    839
*
*****************************************************
* core power
*****************************************************
*
20588800   "core pow"    function    1.0    0.43e+6    1
20588801    time      0            888
*
*****************************************************
* calculate time-integrated break mass flow
*****************************************************
*
20591500   "int bflo"    integral    1.0     0.00     1
20591501    mflowj      915000000
*
. zzz
```

```
****************************************************
*                                                  *
*   LSTF Mid-loop : Transient Input Deck           *
*                   for relap5/mod3.2 Assessment   *
*                                                  *
*   Cold leg Opening Case                          *
****************************************************
*
100      restart    transnt
101      run
102      si     si
103      10006
105      5.0    10.0
*
201      16000.0    1.0e-12    0.1    3   100    10000    10000
*
20800001   dt          0.0
20800002   dtcrnt      0.0
20800003   systms      1
20800004   sysmer      1
20800005   pps         610020000
20800006   pps         152010000
20800007   pps         136010000
20800008   pps         420010000
20800009   pps         220010000
20800010   gammaw      420010000
20800011   gammaw      220010000
*
****************************************************
*   minor edits
****************************************************
*
301  p          610010000    * pzr pressure
302  p          516010000    * sg-i steam dome pres.
303  p          316010000    * sg-b steam dome pres.
304  p          452010000    * cold leg-i
305  p          252010000    * cold leg-b
306  p          400010000    * hot leg-i
307  p          200010000    * hot leg-b
308  p          248010000    * cold leg-b
309  p          448010000    * cold leg-b
310  p          124010000    * mid-core pressure
311  p          124020000    *
312  p          124030000    *
313  p          124040000    *
314  p          124050000    *
315  mflowj     108040000    * core downcomer flowrate
316  mflowj     124030000    * core flowrate
317  mflowj     136010000    * upper plenum to hl-b
318  mflowj     136020000    * upper plenum to hl-i
319  mflowj     136030000    * upper plenum to up-132
320  mflowj     136040000    * upper plenum to up-140
322  mflowj     208010000    * sg-b inlet flowrate
323  mflowj     252010000    * cold leg-b flowrate
324  mflowj     408010000    * sg-i inlet flowrate
325  mflowj     651000000    * prz. porv flowrate
326  mflowj     915000000    * break flowrate
327  tempf      124010000    *
328  tempf      124020000    *
329  tempf      124030000    * core water temperature
330  tempf      124040000    *
331  tempf      124050000    *
332  sattemp    124060000    * core saturation temp.
333  voidg      124010000    *
334  voidg      124020000    *
335  voidg      124030000    *
336  voidg      124040000    * core void
337  voidg      124050000    *
338  voidg      124060000    *
339  voidf      104010000    * vessel inlet
340  voidf      136010000    * vessel outlet
341  voidf      200010000    * hot leg-b
342  voidf      206010000    *
343  voidf      208010000    *
344  voidf      212010000    * sg-b inlet
345  voidf      228010000    * sg-b outlet
346  voidf      232010000    * cross leg
347  voidf      232050000    *
348  voidf      236040000    * rcp suction
349  voidf      244010000    * rcp discharge
350  voidf      248010000    *
351  voidf      252010000    * cold leg-b
352  voidf      400010000    * hot leg-i
353  voidf      406010000    *
354  voidf      408010000    *
355  voidf      412010000    * sg-i inlet
356  voidf      428010000    * sg-i outlet
357  voidf      432010000    * cross leg
358  voidf      432050000    *
359  voidf      436040000    * rcp suction
360  voidf      444010000    * rcp discharge
361  voidf      448010000    *
362  voidf      452010000    * cold leg-i
363  cputime    0
364  systms     1            * primary system mass
365  sysmer     1            * estimated mass error
*
****************************************************
*    variable trips
****************************************************
*
500  time   0   lt   null  0    0.0      n   * false
501  time   0   ge   null  0    0.0      n   * true
536  time   0   ge   null  0    0.0      l   * true
537  time   0   lt   null  0    0.0      l   * false
555  time   0   ge   null  0    16000.   l * eccs injection
570  time   0   ge   null  0    1000.0   l * rhr flow
*
****************************************************
*  hydrodynamic components
****************************************************
*
3690000    blsgsv      valve
3690101    320010000   370000000  2.96e-4  0.0149  0.0   0120
3690201    0           0.0        0.0      0.0
3690300    trpvlv
3690301    501
*
```

```
3790000   blsgsv     valve
3790101   324010000  380000000 0.00195 0.00055 0.0 0120
3790201   0          0.0        0.0       0.0
3790300   trpvlv
3790301   500
*****************************************************
*
5690000   iisgsv     valve
5690101   520010000  570000000 2.96e-4 0.0149 0.0  0120
5690201   0          0.0        0.0       0.0
5690300   trpvlv
5690301   501
*
5790000   blsgsv     valve
5790101   524C10000  580000000 0.00195 0.00055 0.0 0120
5790201   0          0.0        0.0       0.0
5790300   trpvlv
5790301   500
*****************************************************
*
6510000   porv          valve
6510101   610000000 650000000 3.66e-5   0.0251 0.0 0120
6510201   0     0.0    0.0      0.0
6510300   trpvlv
6510301   500
*
6610000   prsfvalv          valve
6610101   610000000 660000000 1.54e-4 0.2052 0.0   0120
6610201   0       0.0    0.0      0.0
6610300   trpvlv
6610301   500
*
6210000   prsspryl      delete
*****************************************************
*       ecc system                                  *
*****************************************************
*
7410000   rhrou-i     tmdpjun
7410101   400010005   740010001        0.006
7410200   1     570
7410201    0.0      3.2    0.0    0.0
7410202   10.0      1.6    0.0    0.0
7410203   20.0      0.0    0.0    0.0
*
7810000   rhrou-b     tmdpjun
7810101   200010005   780010001        0.006
7810200   1     570
7810201    0.0      3.2    0.0    0.0
7810202   10.0      1.6    0.0    0.0
7810203   20.0      0.0    0.0    0.0
*
7460000   rhrin-i     tmdpjun
7460101   745010001   448010005        0.006
7460200   1     570
7460201    0.0      3.2    0.0    0.0
7460202   10.0      1.6    0.0    0.0
7460203   20.0      0.0    0.0    0.0
*
7860000   rhrin-b     tmdpjun
7860101   785010001   244010005        0.006
7860200   1     570
7860201    0.0      3.2    0.0    0.0
7860202   10.0      1.6    0.0    0.0
7860203   20.0      0.0    0.0    0.0
*
*****************************************************
*  break point  - cold leg 5% break area
*****************************************************
9150000   npcolbrv      sngljun
9150101   248010004 920010001 1.685e-3 0  0  30100 1.0 1.0
9150201   0          0.0        0.0      0.0
*
9200000   npcolleg      tmdpvol
9200101   1.0e+8    10.0   0.0 0.0   0.0   0.0    0.0  0   00
9200200   004
9200201   0.0    1.01325e+5     310.0      1.0
*
*****************************************************
*
. zzz
```

Appendix B

Input Deck for the Assessment of the Loss-of-RHR Event with the Pressurizer Manway Opening (Steady State and Transient Input Deck)

```
****************************************************
*                                                  *
*   LSTF Mid-loop : Steady State Input Deck        *
*                     for relap5/mod3.2 Assessment *
*                                                  *
*   Pressurizer Manway Opening Case                *
****************************************************
*
100     new     transnt
101     run
102     si   si
105     50.0   100.0
*
110     air
115     1.0
*
120     124010000    0.00     h2o     primary
121     304010000    7.9639   h2o     secnd-b
122     504010000    7.9639   h2o     secnd-i
123     900010000    0.00     h2o     contain
*
*  time step control
*
201     1000.0  1.0e-6   0.1    3     100    10000    10000
*
20800001    pps       610020000
20800002    pps       152010000
20800003    pps       136010000
20800004    pps       420010000
20800005    pps       220010000
20800008    gammaw    420010000
20800009    gammaw    220010000
20800010    gammaw    100010000
20800011    gammaw    610040000
*
****************************************************
*    minor edits
****************************************************
*
301  p          610010000     * pzr pressure
302  p          516010000     * sg-i
303  p          316010000     * sg-b
304  p          452010000     * cold leg-i
305  p          252010000     * cold leg-b
306  p          400010000     * hot leg-i
307  p          200010000     * hot leg-b
308  cntrlvar   124           * core level
309  cntrlvar   125           * vessel level
310  cntrlvar   312           * sg-b level
311  cntrlvar   512           * sg-i level
312  cntrlvar   753           * crossover leg-i up
313  cntrlvar   755           * crossover leg-i down
314  cntrlvar   756           * crossover leg-b down
315  cntrlvar   757           * crossover leg-b up
316  cntrlvar   761           * core dp
317  cntrlvar   763           * upper plemum dp
318  cntrlvar   888           * core power
319  cntrlvar   915           * integrated break flowr
320  tempf      124010000     * bottom-core temp.
321  tempf      124020000     *
322  tempf      124030000     *
323  tempf      124040000     *
324  tempf      124050000     *
325  tempf      124060000     * mid-core temperature
326  tempf      124070000     *
327  tempf      124080000     *
328  tempf      124090000     *
329  tempf      124100000     *
330  tempf      124110000     *
331  tempf      124120000     * top-core temperature
332  tempf      136010000     * upper plenum
333  httemp     124100109     * bottom-cladding temp.
334  httemp     124100209     *
335  httemp     124100309     *
336  httemp     124100409     *
337  httemp     124100509     *
338  httemp     124100609     * mid-cladding temp.
339  httemp     124100709     *
340  httemp     124100809     *
341  httemp     124100909     *
342  httemp     124101009     *
343  httemp     124101109     *
344  httemp     124101209     * top-cladding temp.
345  tempf      200010000     * hot leg-b
346  tempf      206010000     * hot leg-b temperature
347  tempf      208010000     * hot leg-b temperature
348  tempf      216010000     * sg-b inlet plenum
349  tempf      220010000     * sg-b inlet
350  tempf      244010000     * cold leg-b temperature
351  tempf      248010000     * cold leg-b temperature
352  tempf      252010000     * cold leg-b
353  tempf      400010000     * hot leg-i
354  tempf      406010000     * hot leg-i temperature
355  tempf      408010000     * hot leg-i temperature
356  tempf      416010000     * sg-i inlet plenum
357  tempf      420010000     * sg-i inlet
358  tempf      444010000     * cold leg-i temperature
359  tempf      448010000     * cold leg-i temperature
360  tempf      452010000     * cold leg-i
361  tempf      610080000     * pzr bottom
362  tempf      610040000     * pzr middle
363  tempf      610010000     * pzr top
364  voidf      104010000     * vessel inlet void
365  voidf      136010000     * vessel outlet void
366  voidf      200010000     * hot leg void
367  voidf      206010000     *
368  voidf      208010000     *
369  voidf      212010000     * sg-b inlet viod
370  voidf      228010000     * sg-b outlet void
371  voidf      232010000     * cross leg void
372  voidf      232050000     *
373  voidf      236040000     * rcp suction void
374  voidf      244010000     * rcp discharge void
375  voidf      248010000     * cold leg void
376  voidf      252010000     * cold leg void
377  voidf      400010000     * hot leg void
378  voidf      406010000     *
379  voidf      408010000     *
```

```
380  voidf   412010000     * sg-i inlet void
381  voidf   428010000     * sg-i outlet void
382  voidf   432010000     * cross leg void
383  voidf   432050000     *
384  voidf   436040000     * rcp suction void
385  voidf   444010000     * rcp discharge void
386  voidf   448010000     * cold leg void
387  voidf   452010000     * cold leg void
388  mflowj  108040000     * core downcommer flow
389  mflowj  124060000     * core flowrate
390  mflowj  208010000     * hot leg-b flowrate
391  mflowj  217000000     * sg-b inlet flowrate
392  mflowj  252010000     * cold leg-b flowrate
393  mflowj  408010000     * hot leg-i flowrate
394  mflowj  417000000     * sg-i inlet flowrate
395  mflowj  741000000     * hot leg-i si
396  mflowj  746000000     * cold leg-i si
397  mflowj  781000000     * hot leg-b si
398  mflowj  786000000     * cold leg-b si
399  mflowj  915000000     * break flowrate
*
****************************************************
* variable trips
****************************************************
*
500  time  0  lt  null  0  0.0  n  * false
501  time  0  ge  null  0  0.0  n  * true
536  time  0  ge  null  0  0.0  l  * true
537  time  0  lt  null  0  0.0  l  * false
*
****************************************************
* Hydrodynamic Components
****************************************************
* reactor vessel
****************************************************
1000000  inannl  snglvol
1000101  0.0  1.5684  0.13609  0.0  -90.  -1.5684
1000102  4.57e-5  0.106  00
1000200  004  102885.0  321.0  1.0
*
****************************************************
1040000  inann  branch
1040001  4  1
1040101  0.0  0.600  0.05425  0.0  -90.0 -0.600  4.57e-5
1040102  0.106  0001000
1040200  004  104309.0  320.0  0.0006
1041101  104000000  100010000  0.0  0.0  0.0  0000
1042101  104010000  108000000  0.0  0.0  0.0  0000
1043101  252020002  104010003  0.03365 0.345 0.345 0101
1044101  452010002  104010004  0.03365 0.345 0.345 0101
1041201  3.7e-3  3.7e-3  0.0
1042201  6.0  0.0  0.0
1043201  3.0  0.0  0.0
1044201  3.0  0.0  0.0
*
****************************************************
1080000  downcmer  annulus
1080001  9
1080101  0.09774  9
1080301  0.6757  1
1080302  0.8670  2
1080303  0.610  8
1080304  1.2588  9
1080601  -90.0  9
1080701  -0.6757  1
1080702  -0.8670  2
1080703  -0.610  8
1080704  -1.2588  9
1080801  4.573e-5  0.106  9
1081001  0001000  9
1081101  0000  8
1081201  003  109060.0  320.7  0.  0.  0.  1
1081202  003  116560.0  320.2  0.  0.  0.  2
1081203  003  123740.0  320.4  0.  0.  0  3
1081204  003  129670.0  320.6  0.  0.  0.  4
1081205  003  135600.0  320.7  0.  0.  0.  5
1081206  003  141530.0  320.8  0.  0.  0.  6
1081207  003  147458.0  320.8  0.  0.  0.  7
1081208  003  153330.0  320.8  0.  0.  0.  8
1081209  003  162460.0  321.0  0.  0.  0  9
1081300  1
1081301  6.0  0.0  0.0  1
1081302  6.0  0.0  0.0  2
1081303  6.0  0.0  0.0  3
1081304  6.0  0.0  0.0  4
1081305  6.0  0.0  0.0  5
1081306  6.0  0.0  0.0  6
1081307  6.0  0.0  0.0  7
1081308  6.0  0.0  0.0  8
*
****************************************************
1120000  lplovol  snglvol
1120101  0.0  0.626 0.1661 0.0  90.0  0.626  4.57e-5
1120102  0.0104  0001000
1120200  [illegible]  176240.0  320.0
*
****************************************************
1160000  lowrplnm  branch
1160001  3  1
1160101  0.0  0.4762 0.0943  0.0 90.0  0.4762  4.57e-5
1160102  0.0104  0001000
1160200  003  170890.0  320.7
1161101  108010000  116010000  0.09774 1.0 1.0  0100
1162101  112010000  116000000  0.23623  0.0 0.0 0000
1163101  116010000  120000000  0.15931 8.34 8.34 0000
1161201  6.0  0.0  0.0
1162201  0.01  0.01  0.0
1163201  6.0  0.0  0.0
1162110  0.0104  1.0  1.0  1.0
1163110  0.0104  1.0  1.0  1.0
*
****************************************************
1200000  corein  branch
1200001  1  1
1200101  0.0  1.2588 0.1821  0.0 90.0  1.2588  4.57e-5
1200102  0.0104  0001000
1200200  003  162470.0  321.1
1201101  120010000  124000000 0.13657  0.85  0.85 0000
```

```
1201201   6.0       0.0          0.0
1201110   0.009721        1.0       1.0       1.0
*
*****************************************************
1240000   core        pipe
1240001   12
1240101   0.0         12
1240301   0.305       12
1240401   0.03656     12
1240601   90.0        12
1240701   0.305       12
1240801   4.57e-5     0.00832   12
1240901   0.68        0.68      11
1241001   0001100     12
1241101   0000        11
1241201   003   154890.0   321.0   0.   0.   0.   1
1241202   003   151940.0   322.0   0.   0.   0.   2
1241203   003   148980.0   324.2   0.   0.   0.   3
1241204   003   146030.0   326.6   0.   0.   0.   4
1241205   003   143080.0   327.8   0.   0.   0.   5
1241206   003   140130.0   330.0   0.   0.   0.   6
1241207   003   137190.0   332.6   0.   0.   0.   7
1241208   003   134250.0   334.0   0.   0.   0.   8
1241209   003   131310.0   335.8   0.   0.   0.   9
1241210   003   128370.0   337.6   0.   0.   0.   10
1241211   003   125440.0   338.0   0.   0.   0.   11
1241212   003   122510.0   338.7   0.   0.   0.   12
1241300   1
1241301   6.0       0.0          0.0       1
1241302   6.0       0.0          0.0       2
1241303   6.0       0.0          0.0       3
1241304   6.0       0.0          0.0       4
1241305   6.0       0.0          0.0       5
1241306   6.0       0.0          0.0       6
1241307   6.0       0.0          0.0       7
1241308   6.0       0.0          0.0       8
1241309   6.0       0.0          0.0       9
1241310   6.0       0.0          0.0       10
1241311   6.0       0.0          0.0       11
1241401   0.00832   1.0       1.0       1.0       11
*
*****************************************************
1280000   creoutl    branch
1280001   3          1
1280101   0.0  0.867  0.1360  0.0  90.0   0.867   4.57e-5
1280102   0.0   0001000
1280200   003   116880.0   337.
1281101   124010000   128000000  0.15255  1.272  1.272  0000
1282101   128010000   132000000  0.16737  0.0    0.0    0000
1283101   156010000   128010000  0.085679 420.   420.   0000
1281201   6.0     0.0        0.0
1282201   6.0     0.0        0.0
1283201   0.1     0.1        0.0
1281110   0.28097      1.0      1.0      1.0
1282110   0.4063       1.0      1.0      1.0
1283110   0.3078       1.0      1.0      1.0
*
*****************************************************
1320000   upplnml        snglvol
1320101   0.0 0.6757 0.1060  0.0  90.0  0.6757   4.57e-5
1320102   0.321   0001000
1320200   003   109480.0   337.0
*****************************************************
*
1340000   upplnm-1      branch
1340001   1           1
1340101   0.0   0.200  0.03130 0.0  90.0  0.200  4.57e-5
1340102   0.321    0001000
1340200   003    105840.0   337.0
1341101   132010000  134000000  0.15669  0.0 0.0  0000
1341201   6.0          0.0        0.0
*
1360000   upplnm-2      branch
1360001   4           1
1360101   0.0   0.200 0.03130   0.0  90.0  0.200    4.57e-5
1360102   0.321    0001000
1360200   004   103440.0   337.0   0.0007
1361101   136010003  400010001 0.03370  .265  .265 0102
1362101   136010005  200010001 0.03370  .265  .265 0102
1363101   134010000  136000000 0.15669  0.0   0.0  0000
1364101   136010000  138000000 0.14305  0.0   0.0  0000
1361201   3.0          0.0        0.0
1362201   3.0          0.0        0.0
1363201   6.0          0.0        0.0
1364201   0.01         0.01       0.0
1363110   0.321     1.0   1.0    1.0
1364110   0.321     1.0   1.0    1.0
*
1380000   upplnm-3      branch
1380001   1           1
1380101   0.0   0.200  0.03130  0.0 90.0  0.200  4.57e-5
1380102   0.321    0001000
1380200   004    103350.0   337.0    1.0
1381101   138010000 140000000 0.14305  0.0   0.0    0000
1381201   0.0          0.0        0.0
*
*****************************************************
1400000    uptopvol     snglvol
1400101    0.0  0.3674 0.0445 0.0 90.0  0.3674    4.57e-5
1400102    0.321    00
1400200    004   103350.0    337.0    1.0
*
*****************************************************
1440000    tophat        snglvol
1440101    0.0  0.897 0.1655  0.0 90.0   0.897   4.57e-5
1440102    0.95     00
1440200    004   102910.0   328.0    1.0
*
*****************************************************
1480000    uhmidvol     branch
1480001    2            1
1480101    0.0  0.725 0.1970  0.0 90.0   0.725    4.57e-5
1480102    0.256   00
1480200    004   102900.0   324.0    1.0
1481101    100000000  148000000   9.5e-5 0.0   0.0  0100
1482101    144010000  148000000   0.0     0.0  0.0  0000
1481201    0.01       0.01       0.0
1482201    -0.01      -0.01      0.0
```

```
*
**************************************************
1520000   uhtopvol   branch
1520001   2          1
1520101   0.0  0.504 0.1475  0.0  90.0  0.504   4.57e-5
1520102   0.0  00
1520200   004   102890.0   327.0   1.0
1521101   148010000  152000000  0.0   0.0  0.0   0000
1522101   152000000 156000000 0.00199 1.472 1.472 0000
1521201   0.01    0.01    0.0
1522201   0.01    0.01    0.0
*
**************************************************
1560000   gdetub    pipe
1560001   2
1560101   0.0       2
1560201   0.0102    1
1560301   1.9260    1
1560302   1.6431    2
1560401   0.06209   1
1560402   0.06286   2
1560601   -90.0     2
1560701   -1.9260   1
1560702   -1.6431   2
1560801   4.57e-5   0.0     2
1560901   3.34      3.34    1
1561001   01000     2
1561101   0000      1
1561201   004  102910.0   326.0   1.0    0.0    0.0   1
1561202   004  107760.0   337.0   0.0006  0.0  0.0   2
1561300   1
1561301   0.01      0.01     0.0      1
*
**************************************************
*  Broken Loop without pressurizer
**************************************************
*
2000000   nphotleg   snglvol
2000101   0.0337 1.3246 0.0 0.0 0.0 0.0 4.57e-5 0.207  00
2000200   004   103650.0   337.0   0.00040
*
**************************************************
2060000   nphotleg     branch
2060001   2          1
2060101   0.0337 1.3843 0.0 0.0 0.0 0.0 4.57e-5 0.207 00
2060200   004   103690.0    338.0   0.00040
2061101   200010000  206000000  0.0337  0.0 0.0  0000
2062101   206010000  208000000  0.0337  0.0 0.0  0000
2061201   0.1       0.0      0.0
2062201   0.1       0.0      0.0
*
**************************************************
2080000   wphotleg      pipe
2080001   2
2080101   0.0337          2
2080301   0.7043          1
2080302   0.5278          2
2080601   0.0             1
2080602   50.0            2
2080701   0.0             1
2080702   0.4043          2
2080801   4.57e-5  0.207  2
2080901   0.05     0.05   1
2081001   0000000         2
2081101   100000          1
2081201   004   103740.0   336.0   0.0004   0.  0.   1
2081202   004   103530.0   336.0   0.1      0.  0.   2
2081300   1
2081301   0.1   0.0   0.0   1
2081401   0.    0.    0.55    0.785    1
*
**************************************************
2090000   nphotleg    sngljun
2090101   208010000  212000000  0.0337  0.0  0.0  0100
2090201   1       0.0        0.0        0.0
*
**************************************************
2120000   npsgin      snglvol
2120101   0.0  0.706  0.125  0.0  90.0   0.706   4.57e-5
2120102   0.377    0000000
2120200   004   103520.0   337.0   1.0
*
**************************************************
2130000   npsgfbj     sngljun
2130101   212010000  216000000  0.2093  0.0 0.0  0000
2130201   1   0.0   0.0   0.0
*
**************************************************
2160000   npsgfb      snglvol
2160101   0.0  1.1035  0.2323 0.0  90.0 1.1035   4.57e-5
2160102   0.4474   0000000
2160200   004   103510.0   330.0   1.0
*
**************************************************
2170000   npsgin      sngljun
2170101   216010000  220000000  0.0425  0.0 0.0 100100
2170110   0.0   0.0   0.725    1.0
2170201   1    0.0    0.0     0.0
*
**************************************************
2200000   npsgtube    pipe
2200001   12
2200101   0.0425      12
2200301   0.7181      4
2200302   1.2827      6
2200303   2.5654      7
2200304   2.1728      9
2200305   2.5654      11
2200306   2.8724      12
2200601   90.0        8
2200604   -90.0       12
2200701   0.7181      4
2200702   1.2827      6
2200703   2.5654      7
2200704   2.0980      8
2200705   -2.0980     9
2200706   -2.5654     11
2200707   -2.8724     12
```

```
2200801     1.524-6     0.0196      12
2200901     0.0         0.0         7
2200902     0.006       0.0         8
2200903     0.006       0.006       9
2200904     0.0         0.006       10
2200905     0.0         0.0         11
2201001     0000000     12
2201101     0000        11
2201201     004     103500.0   317.0   1.  0.  0.  1
2201202     004     103500.0   317.8   1.  0.  0.  2
2201203     004     103490.0   317.7   1.  0.  0.  3
2201204     004     103480.0   317.6   1.  0.  0.  4
2201205     004     103470.0   317.5   1.  0.  0.  5
2201206     004     103460.0   317.4   1.  0.  0.  6
2201207     004     103440.0   317.3   1.  0.  0.  7
2201208     004     103410.0   317.3   1.  0.  0.  8
2201209     004     103410.0   317.3   1.  0.  0.  9
2201210     004     103440.0   317.4   1.  0.  0.  10
2201211     004     103460.0   317.6   1.  0.  0.  11
2201212     004     103490.0   317.0   1.  0.  0.  12
2201300     1
2201301     0.0     0.0     0.0     1
2201302     0.0     0.0     0.0     2
2201303     0.0     0.0     0.0     3
2201304     0.0     0.0     0.0     4
2201305     0.0     0.0     0.0     5
2201306     0.0     0.0     0.0     6
2201307     0.0     0.0     0.0     7
2201308     0.0     0.0     0.0     8
2201309     0.0     0.0     0.0     9
2201310     0.0     0.0     0.0     10
2201311     0.0     0.0     0.0     11
*
****************************************************
2210000     npsgout     sngljun
2210101     220010000  224000000  0.0425 0.0  0.0   0100
2210201     1          0.0   0.0     0.0
*
****************************************************
2240000     npsgfbo     snglvol
2240101     0.0  1.1035  0.2323  0.0  -90.0  -1.1035  4.57e-5
2240102     0.4474   0000000
2240200     004   103510.0   320.0   1.0
*
****************************************************
2250000     npsgfbj     sngljun
2250101     224010000  228000000  0.2093  0.0  0.0  0000
2250201     1      0.0    0.0    0.0
*
****************************************************
2280000     npsgout     snglvol
2280101     0.0  0.706  0.125  0.0  -90.0  -0.706   4.57e-5
2280102     0.377    0000000
2280200     004   103520.0   324.0   1.0
*
****************************************************
2290000     npcrsleg    sngljun
2290101     228010000  232000000  0.0222  0.0  0.0   0100
2290201     1        0.0      0.0      0.0
```

```
*
****************************************************
2320000     npcrsleg    pipe
2320001     5
2320101     0.0222   5
2320301     0.516    1
2320302     1.2422   4
2320303     1.1919   5
2320601     -50.0    1
2320602     -90.0    4
2320603     0.0      5
2320701     -0.3953  1
2320702     -1.2422  4
2320703     0.0      5
2320801     4.57e-5  0.1682   5
2320901     0.036    0.036    1
2320902     0.0      0.0      3
2320903     0.065    0.065    4
2321001     0000000  5
2321101     0000     4
2321201     004     103910.0    320.0  0.005  0.  0.  1
2321202     003     110380.0    320.0  0.  0.  0.     2
2321203     003     122460.0    320.0  0.  0.  0.     3
2321204     003     134540.0    320.0  0.  0.  0.     4
2321205     003     140600.0    320.0  0.  0.  0.     5
2321300     1
2321301     0.1     0.0       0.0      1
2321302     0.1     0.0       0.0      2
2321303     0.1     0.0       0.0      3
2321304     0.1     0.0       0.0      4
*
****************************************************
2330000     npfcv       valve
2330101     232010000  236000000  0.0222  0.0  0.0  0100
2330201     1        0.0       0.0       0.0
2330300     mtrvlv
2330301     536      537       1.42     1.0   0
*
****************************************************
2360000     npcrslgu    pipe
2360001     4
2360101     0.0222   4
2360301     1.3202   1
2360302     1.1222   2
2360303     1.1417   3
2360304     1.1222   4
2360601     0.0      1
2360602     90.0     4
2360701     0.0      1
2360702     1.1222   4
2360801     4.57e-5  0.1682   4
2360901     0.065    0.065    1
2360902     0.0      0.0      3
2361001     0000000  4
2361101     0000     3
2361201     003     140630.0   320.0  0.  0.  0.  1
2361202     003     135220.0   320.0  0.  0.  0.  2
2361203     003     124350.0   320.0  0.  0.  0.  3
2361204     003     113490.0   320.0  0.  0.  0.  4
```

```
2361300     1
2361301     0.1     0.0     0.0     1
2361302     0.1     0.0     0.0     2
2361303     0.1     0.0     0.0     3
*
****************************************************
2400000     nprcpump     pump
2400101     0.0   0.802   0.0235   0.0   90.0   0.351   0
2400108     236010000  0.0222    0.0     0.0      0000
2400109     244000000  0.0337    0.0525  0.0525   0000
2400200     004     106360.0   320.0   0.0001
2400201     1       0.0     0.0         0.0
2400202     1       0.0     0.0         0.0
2400301     0     0     0     -1    -1   500   0
2400302     188.50     0.0     0.054    10.0    55.2
2400303     0.54     750.0   0.0    0.0    0.0   0.0    0.0
*
* single phase head and torque data from lstf sys.
* description
*
2401100  1 1 0.00  1.36  0.10  1.38  0.24  1.42  0.40  1.41
2401101          0.60  1.32  0.80  1.19  1.00  1.00
2401200  1 2 0.00 -0.97 0.20 -0.68 0.50 -0.20  0.65   0.07
2401201          0.80   0.40  1.00   1.00
2401300  1 3 -1.0 3.20 -0.90 2.80 -0.80  2.46  -0.60  1.94
2401301        -0.40 1.57  -0.20  1.41   0.00  1.36
2401400  1 4 -1.00 3.20 -0.80 2.76 -0.60 2.41  -0.40  2.09
2401401        -0.20  1.81   0.00  1.58
2401500  1  5  0.00   0.00  1.00  0.00
2401600  1  6  0.00   0.00  1.00  0.00
2401700  1  7  -1.00  0.00  0.00  0.00
2401800  1  8  -1.00  0.00  0.00  0.00
*
*  torque data
*
2401900  2 1 0.00  0.36  0.12  0.38  0.20  0.44  0.30  0.58
2401901          0.50  0.73  0.70  0.81  1.00  1.00
2402000  2 2 0.00 -1.26 0.10 -0.88 0.30 -0.31  0.50   0.09
2402001          0.65   0.30  0.86   0.63  1.00   1.00
2402100  2 3 -1.00 2.40 -0.85 1.70 -0.65  1.12  -0.50  0.84
2402101         -0.40  0.69  -0.20  0.59   0.00  0.36
2402200  2 4 -1.00 2.40 -0.80 2.12 -0.60  1.80  -0.30  1.32
2402201          0.00  0.80
2402300  2  5  0.00  0.00    1.00  0.00
2402400  2  6  0.00  0.00    1.00  0.00
2402500  2  7  -1.00  0.00  0.00  0.00
2402600  2  8  -1.00  0.00  0.00  0.00
*
*  two phase multiplier tables for head of rc pump 240
*
2403000     0       0.0   0.0
2403001             0.10  0.0
2403002             0.15  0.05
2403003             0.24  0.80
2403004             0.30  0.96
2403005             0.40  0.98
2403006             0.60  0.97
2403007             0.80  0.90
2403008             0.90  0.80
2403009             0.96  0.50
2403010             1.00  0.0
*
*  two phase multiplier tables for torque of rc pump 240
*
2403100     0       0.0   0.0
2403101             1.0   0.0
*
* two-phase diff curves from r5 built-in data
* head difference curves
*
2404100  1 1 0.00  0.00  0.10  0.83  0.20  1.09  0.50  1.02
2404101          0.70  1.01  0.90  0.94  1.00  1.00
2404200  1 2 0.00 0.00  0.10  -0.40  0.20  0.00  0.30  0.10
2404201          0.40 0.21 0.80  0.67  0.90  0.80  1.00  1.00
2404300 1 3 -1.00 -1.16 -0.9 -1.24 -0.80 -1.77 -0.70 -2.36
2404301      -0.60 -2.79 -0.50 -2.91 -0.40 -2.67 -0.25 -1.69
2404302          -0.10  -0.50   0.00   0.00
2404400 1 4 -1.0 -1.16 -0.90 -0.78 -0.80 -0.50 -0.70 -0.31
2404401      -0.60 -0.17 -0.50 -0.08 -0.35  0.00 -0.20  0.05
2404402          -0.10   0.08   0.00   0.11
2404500  1  5   0.00  0.00  1.00  0.00
2404600  1  6   0.00  0.00  1.00  0.00
2404700  1  7  -1.00  0.00  0.00  0.00
2404800  1  8  -1.00  0.00  0.00  0.00
*
*  torque difference curves
*
2404900  2  1  0.0  0.0  0.0  0.0
2405000  2  2  0.0  0.0  0.0  0.0
2405100  2  3  0.0  0.0  0.0  0.0
2405200  2  4  0.0  0.0  0.0  0.0
2405300  2  5  0.0  0.0  0.0  0.0
2405400  2  6  0.0  0.0  0.0  0.0
2405500  2  7  0.0  0.0  0.0  0.0
2405600  2  8  0.0  0.0  0.0  0.0
*
****************************************************
2440000      npcolleg     branch
2440001      1            1
2440101      0.0337 0.7348 0.0 0.0 0.0 0.0 4.57e-5 0.207   00
2440200      004     104670.0    320.0    0.00030
2441101      244010000  248000000  0.0337   0.0 0.0    0000
2441201      3.0        0.0          0.0
*
****************************************************
2480000      npcolleg     branch
2480001      1            1
2480101      0.0337 0.9429 0.0 0.0 0.0 0.0 4.57e-5 0.207   00
2480200      004     104670.0    320.0    0.0003
2481101      248010000  252000000  0.0337    0.0 0.0    0000
2481201      3.0      0.0          0.0
*
****************************************************
2520000      npcolleg        pipe
2520001      2
2520101      0.0337           2
2520301      0.9752           2
2520601      0.0              2
```

```
2520701     0.0                2
2520801     4.57e-5   0.207    2
2521001     00                 2
2521101     0000               1
2521201     004    104670.0    320.0    0.0003    0.   0.   1
2521202     004    104670.0    320.0    0.0003    0.   0.   2
2521300     1
2521301     3.0      0.0       0.0        1
*
*****************************************************
*  Secondary side for the broken loop
*****************************************************
*
3000000     npstgdcm      annulus
3000001     5
3000101     0.0           1
3000102     0.0296        4
3000103     0.0           5
3000201     0.0           3
3000202     0.005281      4
3000301     2.8965        1
3000302     2.0980        2
3000303     2.5654        4
3000304     3.4395        5
3000401     0.3228        1
3000402     0.0           4
3000403     0.1302        5
3000501     0.0           5
3000601     -90.0         5
3000701     -2.0223       1
3000702     -2.0980       2
3000703     -2.5654       4
3000704     -2.5464       5
3000801     4.57e-5    0.3689    1
3000802     4.57e-5    0.0971    4
3000803     4.57e-5    0.0801    5
3000901     0.0        0.0       4
3001001     0001000       5
3001101     0000          3
3001102     0100          4
3001201     004     101400.0    310.   1.0   0.   0.   1
3001202     004     101420.0    310.   1.0   0.   0.   2
3001203     004     101450.0    310.   1.0   0.   0.   3
3001204     004     101470.0    310.   1.0   0.   0.   4
3001205     004     101500.0    310.   1.0   0.   0.   5
3001300     1
3001301     0.0     0.0      0.0       1
3001302     0.0     0.0      0.0       2
3001303     0.0     0.0      0.0       3
3001304     0.0     0.0      0.0       4
*
*****************************************************
3010000     npstgdcm      sngljun
3010101     300010000   304000000   0.0   100   100.   0000
3010201     1     0.0       0.0            0.0
*
*****************************************************
3040000     blsteamg      pipe
3040001     5
3040101     0.2293        3
3040102     0.0           5
3040201     0.2293        2
3040202     0.2323        3
3040203     0.3138        4
3040301     2.5464        1
3040302     2.5654        3
3040303     2.0980        4
3040304     2.0223        5
3040401     0.0           3
3040402     0.4951        4
3040403     0.7979        5
3040501     0.0           5
3040601     90.0          5
3040701     2.5464        1
3040702     2.5654        3
3040703     2.0980        4
3040704     2.0223        5
3040801     4.57e-5      0.036      4
3040802     4.57e-5      0.219      5
3040901     1.435        1.435      4
3041001     0001000       5
3041101     0000          3
3041102     0000          4
3041201     004    101500.0    310.0   1.0    0.0    0.0    1
3041202     004    101470.0    310.0   1.0    0.0    0.0    2
3041203     004    101440.0    310.0   1.0    0.0    0.0    3
3041204     004    101420.0    310.0   1.0    0.0    0.0    4
3041205     004    101400.0    310.0   1.0    0.0    0.0    5
3041300     1
3041301     0.0      0.0       0.0       1
3041302     0.0      0.0       0.0       2
3041303     0.0      0.0       0.0       3
3041304     0.0      0.0       0.0       4
3041401     0.036     1.0      1.0      1.0     3
3041402     0.1258    1.0      1.0      1.0     4
*
*****************************************************
3080000     npsepar      separatr
3080001     3    1
3080101     0.0   2.120   0.572    0.0   90.0    2.120    4.57e-5
3080102     0.2134    00
3080200     004    101370.0    310.0     1.0
3081101     308010002   316010001  0.0615   0.0  0.0  0100   0.2
3082101     308010001  300010001  0.03964  100.  100.  0000  0.15
3083101     304050002   308010001   0.1986   0.0  0.0    0000
3081201     0.0         0.0         0.0
3082201     0.0         0.0         0.0
3083201     0.0         0.0         0.0
*
*****************************************************
3120000     npsgspbp      branch
3120001     2             1
3120101     0.0   2.120   0.6288    0.0    90.0   2.120    4.57e-5
3120102     0.1242    00
3120200     004     101370.0    310.0     1.0
3121101     300000000   312000000   0.3164    0.0   0.0   0000
3122101     312010000   316000000   0.0392    1.5   1.5   0000
3121201     0.0         0.0            0.0
```

```
3122201   0.0       0.0       0.0
*
****************************************************
3160000   stmdome   snglvol
3160101   0.0  3.7778  2.0288  0.0  90.0  3.7778   4.57e-5
3160102   0.7696    00
3160200   004  101340.0   310.0  1.0
*
****************************************************
*  blsg steam line
****************************************************
3200000   blstmln1    branch
3200001   2           1
3200101   0.0286   5.286  0.0   0.0   0.0   0.0   4.57e-5
3200102   0.1909   00
3200200   004   101320.0   310.0   1.0
3201101   316010000  320000000  0.0286   0.0  0.0   0100
3202101   320010000  324000000  0.0286   0.0  0.0   0000
3201201   0.0        0.0        0.0
3202201   0.0        0.0        0.0
*
****************************************************
3240000   blstmln2    snglvol
3240101   0.0286   9.9213  0.0   0.0   0.0   0.0   4.57e-5
3240102   0.1909   00
3240200   004   101320.0   310.0    1.0
*
****************************************************
* secondary relief and safety valves, intact loop
****************************************************
*
3690000   blsgrv    valve
3690101   320010000  370000000  2.96e-4  0.0149 0.0 0100
3690201   0         0.0         0.0         0.0
3690300   trpvlv
3690301   501
*
****************************************************
3700000   contain    tmdpvol
3700101   1.0e+8   10.0  0.0  0.0  0.0  0.0  0.0  0.0   00
3700200   004
3700201   0.0   1.01325e+5   305.0     1.0
*
****************************************************
3790000   blsgsv    valve
3790101   324010000 380000000  0.00195 0.00055  0.0   0100
3790201   0          0.0          0.0          0.0
3790300   trpvlv
3790301   501
*
****************************************************
3800000   contain    tmdpvol
3800101   1.0e+8  10.0   0.0  0.0  0.0  0.0  0.0  0.0   00
3800200   004
3800201   0.0    1.01325e+5    305.0     1.0
*
****************************************************
*  Intact Loop with pressurizer
****************************************************
4000000   wphotleg    snglvol
4000101   0.0337 1.3246  0.0  0.0  0.0  0.0  4.57e-5  0.207  00
4000200   004    103650.0     337.0   0.0004
*
****************************************************
4060000   wpl otleg       branch
4060001   3               1
4060101   0.0337 1.3843  0.0  0.0   0.0  0.0  4.57e-5  0.207  00
4060200   004    103690.0    337.0    0.0004
4061101   400010000  406000000   0.0337    0.0   0.0   0000
4062101   406010000  408000000   0.0337    0.0   0.0   0000
4063101   600030002  406010006   0.00352   1.0   0.5   0001
4061201   0.1         0.0         0.0
4062201   0.1         0.0         0.0
4063201   0.0         0.0         0.0
*
****************************************************
4080000   wphotleg        pipe
4080001   2
4080101   0.0337           2
4080301   0.7043           1
4080302   0.5278           2
4080601   0.0              1
4080602   50.0             2
4080701   0.0              1
4080702   0.4043           2
4080801   4.57e-5   0.207  2
4080901   0.05     0.05    1
4081001   0000000           2
4081101   100000            1
4081201   004    103740.0    337.0    0.0004    0.   0.   1
4081202   004    103520.0    337.0    0.1       0.   0.   2
4081300   1
4081301   0.1    0.0    0.0                  1
4081401   0.     0.     0.55     0.785       1
*
****************************************************
4090000   wphotleg      sngljun
4090101   408010000   412000000   0.0337    0.0 0.0   0100
4090201   1           0.0         0.0         0.0
*
****************************************************
4120000   wpsgin        snglvol
4120101   0.0   0.706   0.125   0.0   90.0    0.706    4.57e-5
4120102   0.377     0000000
4120200   004     103520.0     337.0     1.0
*
****************************************************
4130000   wpsgfbj       sngljun
4130101   412010000   416000000   0.2093    0.0 0.0   0000
4130201   1    0.0     0.0     0.0
*
****************************************************
4160000   wpsgfb        snglvol
4160101   0.0   1.1035 0.2323   0.0     90.0   1.1035   4.57e-5
4160102   0.4474    0000000
4160200   004     103510.0    337.0     1.0
*
****************************************************
```

```
4170000    npsgin      sngljun
4170101    416010000   420000000  0.0425  0.0 0.0 100100
4170110    0.    0.    0.725    1.
4170201    1   0.0   0.0   0.0
*
************************************************
4200000    wpsgtube    pipe
4200001    12
4200101    0.0425      12
4200301    0.7181      4
4200302    1.2827      6
4200303    2.5654      7
4200304    2.1728      9
4200305    2.5654      11
4200306    2.8724      12
4200601    90.0        8
4200604    -90.0       12
4200701    0.7181      4
4200702    1.2827      6
4200703    2.5654      7
4200704    2.0980      8
4200705    -2.0980     9
4200706    -2.5654     11
4200707    -2.8724     12
4200801    1.524-6     0.0196      12
4200901    0.0         0.0         7
4200902    0.006       0.0         8
4200903    0.006       0.006       9
4200904    0.0         0.006       10
4200905    0.0         0.0         11
4201001    0000000     12
4201101    0000        11
4201201    004     103500.0   317.0   1.  0.  0.  1
4201202    004     103490.0   317.0   1.  0.  0.  2
4201203    004     103480.0   317.0   1.  0.  0.  3
4201204    004     103480.0   317.0   1.  0.  0.  4
4201205    004     103470.0   317.0   1.  0.  0.  5
4201206    004     103450.0   317.4   1.  0.  0.  6
4201207    004     103430.0   317.3   1.  0.  0.  7
4201208    004     103410.0   317.3   1.  0.  0.  8
4201209    004     103410.0   317.3   1.  0.  0.  9
4201210    004     103430.0   317.4   1.  0.  0.  10
4201211    004     103460.0   317.6   1.  0.  0.  11
4201212    004     103490.0   317.0   1.  0.  0.  12
4201300    1
4201301    0.0    0.0    0.0    1
4201302    0.0    0.0    0.0    2
4201303    0.0    0.0    0.0    3
4201304    0.0    0.0    0.0    4
4201305    0.0    0.0    0.0    5
4201306    0.0    0.0    0.0    6
4201307    0.0    0.0    0.0    7
4201308    0.0    0.0    0.0    8
4201309    0.0    0.0    0.0    9
4201310    0.0    0.0    0.0    10
4201311    0.0    0.0    0.0    11
*
************************************************
4210000    wpsgout     sngljun
```

```
4210101    420010000   424000000   0.0425   0.0   0.0   0100
4210201    1           0.0    0.0     0.0
*
************************************************
4240000    wpsgfbo     snglvol
4240101    0.0  1.1035   0.2323  0.0  -90.0  -1.1035  4.57e-5
4240102    0.4474    0000000
4240200    004    103510.0    320.0    1.0
*
************************************************
4250000    wpsgfbj     sngljun
4250101    424010000   428000000   0.2093  0.0    0.0   0000
4250201    1     0.0    0.0    0.0
*
************************************************
4280000    wpsgout     snglvol
4280101    0.0   0.706   0.125   0.0  -90.0   -0.706   4.57e-5
4280102    0.377    0000000
4280200    004    103520.0    324.0    1.0
*
************************************************
4290000    wpcrsleg    sngljun
4290101    428010000   432000000   0.0222   0.0 0.0    0100
4290201    1       0.0       0.0       0.0
*
************************************************
4320000    wpcrsleg    pipe
4320001    5
4320101    0.0222   5
4320301    0.516    1
4320302    1.2422   4
4320303    1.1919   5
4320601    -50.0    1
4320602    -90.0    4
4320603    0.0      5
4320701    -0.3953  1
4320702    -1.2422  4
4320703    0.0      5
4320801    4.57e-5   0.1682   5
4320901    0.036     0.036    1
4320902    0.0       0.0      3
4320903    0.065     0.065    4
4321001    0000000   5
4321101    0000      4
4321201    004    103760.0    320.0  0.005  0.  0.  1
4321202    003    110140.0    320.0  0.  0.  0.  2
4321203    003    122230.0    320.0  0.  0.  0.  3
4321204    003    134320.0    320.0  0.  0.  0.  4
4321205    003    140390.0    320.0  0.  0.  0.  5
4321300    1
4321301    0.1    0.0     0.0     1
4321302    0.1    0.0     0.0     2
4321303    0.1    0.0     0.0     3
4321304    0.1    0.0     0.0     4
*
************************************************
*
4330000    wpfcv     valve
4330101    432010000   436000000   0.0222    0.0   0.0    0100
```

```
4330201   1        0.0       0.0       0.0
4330300   mtrvlv
4330301   536     537      1.42    1.0     0
*
**************************************************
4360000     wpcrslgu    pipe
4360001     4
4360101     0.0222    4
4360301     1.3202    1
4360302     1.1222    2
4360303     1.1417    3
4360304     1.1222    4
4360601     0.0       1
4360602     90.0      4
4360701     0.0       1
4360702     1.1222    4
4360801     4.57e-5   0.1682    4
4360901     0.065     0.065     1
4360902     0.0       0.0       3
4361001     0000000   4
4361101     0000      3
4361201     003       140410.0     320.6   0.   0.   0.   1
4361202     003       135000.0     320.4   0.   0.   0.   2
4361203     003       124180.0     320.0   0.   0.   0.   3
4361204     003       113320.0     320.0   0.   0.   0.   4
4361300     1
4361301     0.1       0.0       0.0       1
4361302     0.1       0.0       0.0       2
4361303     0.1       0.0       0.0       3
*
**************************************************
4400000     wprcpump    pump
4400101     0.0    0.802    0.0235    0.0    90.0    0.351    0
4400108     436010000    0.0222     0.0       0.0       0000
4400109     444000000    0.0337     0.0525    0.0525    0000
4400200     004       106220.0    320.0     0.00010
4400201     1         0.0       0.0       0.0
4400202     1         0.0       0.0       0.0
4400301     240     240     240     -1      -1     500     0
4400302     188.5   0.0       .054    10.0    55.2
4400303     0.54    750.0   0.0     0.0     0.0    0.0    0.0
*
**************************************************
4440000     wpcolleg    snglvol
4440101     0.0337 1.1211 0.0 0.0 0.0 0.0 4.57e-5 0.207  00
4440200     004    103200.0     319.0    0.0003
*
**************************************************
4480000     wpcolleg     branch
4480001     2        1
4480101     0.0337 1.1945 0.0 0.0 0.0 0.0 4.57e-5 0.207  00
4480200     004    104570.0    320.0    0.0003
4481101     444010000   448000000   0.0337   0.0   0.0   0000
4482101     448010000   452000000   0.0337   0.0   0.0   0000
4481201     0.1       0.0       0.0
4482201     3.0       0.0       0.0
*
**************************************************
4520000     wpcolleg     snglvol
4520101     0.0337 1.3125 0.0 0.0 0.0 0.0 4.57e-5 0.207  00
4520200     004    104560.0    320.0    0.0003
*
**************************************************
*  Secondary Loop for the intact loop
**************************************************
*
5000000     wpstgdcm     annulus
5000001     5
5000101     0.0          1
5000102     0.0296       4
5000103     0.0          5
5000201     0.0          3
5000202     0.005281     4
5000301     2.8965       1
5000302     2.0980       2
5000303     2.5654       4
5000304     3.4395       5
5000401     0.3228       1
5000402     0.0          4
5000403     0.1302       5
5000501     0.0          5
5000601     -90.0        5
5000701     -2.0223      1
5000702     -2.0980      2
5000703     -2.5654      4
5000704     -2.5464      5
5000801     4.57e-5    0.3689    1
5000802     4.57e-5    0.0971    4
5000803     4.57e-5    0.0801    5
5000901     0.0        0.0       4
5001001     0001000      5
5001101     0000         3
5001102     0100         4
5001201     004     101400.0    310.   1.0   0.   0.   1
5001202     004     101420.0    310.   1.0   0.   0.   2
5001203     004     101440.0    310.   1.0   0.   0.   3
5001204     004     101470.0    310.   1.0   0.   0.   4
5001205     004     101500.0    310.   1.0   0.   0.   5
5001300     1
5001301     0.0      0.0       0.0       1
5001302     0.0      0.0       0.0       2
5001303     0.0      0.0       0.0       3
5001304     0.0      0.0       0.0       4
*
**************************************************
5010000     wpstgdcm     sngljun
5010101     500010000   504000000   0.0    100.   100.   0000
5010201     1      0.0       0.0       0.0
*
**************************************************
5040000     wpsteamg     pipe
5040001     5
5040101     0.2293       3
5040102     0.0          5
5040201     0.2293       2
5040202     0.2323       3
5040203     0.3138       4
5040301     2.5464       1
```

```
5040302   2.5654     3
5040303   2.0980     4
5040304   2.0223     5
5040401   0.0        3
5040402   0.4951     4
5040403   0.7979     5
5040501   0.0        5
5040601   90.0       5
5040701   2.5464     1
5040702   2.5654     3
5040703   2.0980     4
5040704   2.0223     5
5040801   4.57e-5    0.036    4
5040802   4.57e-5    0.219    5
5040901   1.435      1.435    4
5041001   0001000    5
5041101   0000       3
5041102   0000       4
5041201   004   101500.0   310.0   1.0   0.0  0.0   1
5041202   004   101470.0   310.0   1.0   0.0  0.0   2
5041203   004   101440.0   310.0   1.0   0.0  0.0   3
5041204   004   101420.0   310.0   1.0   0.0  0.0   4
5041205   004   101400.0   310.0   1.0   0.0  0.0   5
5041300   1
5041301   0.0    0.0    0.0    1
5041302   0.0    0.0    0.0    2
5041303   0.0    0.0    0.0    3
5041304   0.0    0.0    0.0    4
5041401   0.036    1.0   1.0   1.0   3
5041402   0.1258   1.0   1.0   1.0   4
*
*************************************************
5080000   npsepar    separatr
5080001   3   1
5080101   0.0  2.120  0.572  0.0  90.0   2.120   4.57e-5
5080102   0.2134   00
5080200   004   101370.0   310.0   1.0
5081101   508010002 516010001 0.0615  0.0 0.0  0100 0.2
5082101   508010001 500010001 0.03964 100. 100. 0000 0.15
5083101   504050002 508010001 0.1986  0.0  0.0  0000
5081201   0.0    0.0    0.0
5082201   0.0    0.0    0.0
5083201   0.0    0.0    0.0
*
*************************************************
5120000   npsgspbp    branch
5120001   2          1
5120101   0.0  2.120  0.6288   0.0  90.0   2.120  4.57e-5
5120102   0.1242   00
5120200   004   101370.0   310.0   1.0
5121101   500000000  512000000  0.3164  0.0   0.0   0000
5122101   512010000  516000000  0.0392  1.5   1.5   0000
5121201   0.0    0.0    0.0
5122201   0.0    0.0    0.0
*
*************************************************
5160000   stmdome    snglvol
5160101   0.0  3.7778  2.0288  0.0  90.0  3.7778   4.57e-5
5160102   0.7696    00
5160200   004  101340.0   310.0  1.0
*
*************************************************
*   wpsg steam line
*************************************************
5200000   ilstmln1     branch
5200001   2            1
5200101   0.0286   5.286  0.0   0.0   0.0   0.0   4.57e-5
5200102   0.1909   00
5200200   004   101320.0   310.0   1.0
5201101   516010000  520000000  0.0286  0.0  0.0   0100
5202101   520010000  524000000  0.0286  0.0  0.0   0000
5201201   0.0        0.0        0.0
5202201   0.0        0.0        0.0
*
*************************************************
5240000   ilstmln2    snglvol
5240101   0.0286   9.9213  0.0   0.0   0.0   0.0   4.57e-5
5240102   0.1909   00
5240200   004   101320.0   310.0   1.0
*
*************************************************
* secondary relief and safety valves, intact loop
*************************************************
*
5690000   ilsgrv     valve
5690101   520010000  570000000 2.96e-4  0.0149 0.0   0100
5690201   0          0.0        0.0        0.0
5690300   trpvlv
5690301   501
*
*************************************************
5700000   contain    tmdpvol
5700101   1.0e+8 10.0  0.0  0.0  0.0   0.0   0.0   0.0   00
5700200   004
5700201   0.0   1.01325e+5   305.0    1.0
*
*************************************************
5790000   blsgsv     valve
5790101   524010000  580000000  0.00195 0.00055 0.0 0100
5790201   0          0.0        0.0        0.0
5790300   trpvlv
5790301   501
*
*************************************************
5800000   contain    tmdpvol
5800101   1.0e+8  10.0  0.0  0.0  0.0  0.0  0.0   0.0   00
5800200   004
5800201   0.0   1.01325e+5   305.0    1.0
*
*************************************************
* pressurizer
*************************************************
*
6000000    prssurgl    pipe
6000001    3
6000101    3.515e-3    3
6000301    6.7788      1
6000302    9.245       2
```

```
6000303    5.4221      3
6000401    0.0         3
6000601    -90.0       3
6000701    -4.4077     1
6000702    -4.995      2
6000703    -2.5768     3
6000801    4.57e-5    0.0669    3
6001001    0000        3
6001101    0000        2
6001201    004   103350.0    333.0   1.0   0.0   0.0     1
6001202    004   103400.0    336.0   1.0   0.0   0.0     2
6001203    004   103690.0    338.0   1.0   0.0   0.0     3
6001300    1
6001301    0.0    0.0    0.0    1
6001302    0.0    0.0    0.0    2
*
****************************************************
6030000    prssurgl     sngljun
6030101    610010000   600000000  3.515e-3  0.0  0.0  100100
6030201    1    0.0    0.0    0.0
6030110    0.0669    0.0    0.725    1.0
*
****************************************************
6100000    prsrizer     pipe
6100001    8
6100101    0.0          1
6100102    0.2827       6
6100103    0.2731       8
6100201    0.0          7
6100301    0.201        1
6100302    0.470        3
6100303    0.600        4
6100304    0.682        6
6100305    0.5375       8
6100401    0.0325       1
6100402    0.0          8
6100501    0.0          8
6100601    -90.0        8
6100701    -0.201       1
6100702    -0.470       3
6100703    -0.6         4
6100704    -0.682       6
6100705    -0.5375      8
6100801    4.57e-5    0.3187    1
6100802    4.57e-5    0.600     6
6100803    4.57e-5    0.2949    8
6101001      00         8
6101101    0000         7
6101201    004    103290.0    320.0    1.0    0.0    0.0    1
6101202    004    103290.0    321.0    1.0    0.0    0.0    2
6101203    004    103300.0    324.0    1.0    0.0    0.0    3
6101204    004    103300.0    326.0    1.0    0.0    0.0    4
6101205    004    103310.0    327.0    1.0    0.0    0.0    5
6101206    004    103310.0    328.0    1.0    0.0    0.0    6
6101207    004    103320.0    329.0    1.0    0.0    0.0    7
6101208    004    103330.0    330.0    1.0    0.0    0.0    8
6101300    1
6101301    0.0    0.0    0.0    7
*
****************************************************
6190000    spryin      sngljun
6190101    444010003   620010001   0.0   0.0    0.0    10102
6190201    1    0.0    0.0    0.0
*
****************************************************
6200000    prsspryl     pipe
6200001    2
6200101    3.53e-4          2
6200301    22.43            2
6200601    90.0             2
6200701    8.131536         2
6200801    4.57e-5    0.0   2
6201001    00         2
6201101    0000       1
6201201    004    103610.0    320.0    1.0    0.0    0.0    1
6201202    004    103450.0    322.0    1.0    0.0    0.0    2
6201300    1
6201301    0.0   0.0     0.0        1
*
****************************************************
6210000    prsspryl      sngljun
6210101    620010000   610000000   1.0e-6    0.0   0.0   0100
6210201    1    0.0    0.0    0.0
*
*6210000   prsspryl     tmdpjun
*6210101   620010000    610000000       0.0
*6210200   1            524       p     610010000
*6210201   0.0          0.0      0.0      0.0
*6210202   15.68e6      0.0      0.0      0.0
*6210203   16.03e6      0.98     0.0      0.0
*
****************************************************
6500000    porvout      tmdpvol
6500101    1.0e+1    10.0  0.0   0.0   0.0   0.0    0.0   0   00
6500200    004
6500201    0.0        1.01325e+5       300.0       1.0
*
****************************************************
6510000    porv           valve
6510101    610000000   650000000  3.66e-5  0.0251  0.0   0100
6510201    0            0.0          0.0          0.0
6510300    trpvlv
6510301    501
*
****************************************************
6600000    prsfvout       tmdpvol
6600101    1.0e+8   10.0   0.0   0.0   0.0   0.0    0.0   0    00
6600200    004
6600201    0.0        1.01325e+5       300.0       1.0
*
****************************************************
6610000    prsfvalv          valve
6610101    610000000   660000000  1.54e-4  0.2052  0.0   0100
6610201    0            0.0          0.0          0.0
6610300    trpvlv
6610301    500
*
****************************************************
```

```
* rhr system
*****************************************************
7800000    rhrsc1     tmdpvol
7800101    0.  10.  1000.  0.  0.  0.  0.  0.  00000
7800200    3
7800201    0.0   101325.0   337.0
*
7810000    rsuln11    tmdpjun
7810101    200010005     780010001     0.006
7810200    1   0
7810201    0.0      3.0   0.0   0.0
7810202    1000.0   3.0   0.0   0.0
*
7850000    rhrso1     tmdpvol
7850101    0.  10.  1000.  0.  0.  0.  0.  0.  00000
7850200    3
7850201    0.0   101325.0   320.0
*
7860000    rsoln11    tmdpjun
7860101    785010001   244010005     0.006
7860200    1   0
7860201    0.0      3.0   0.0   0.0
7860202    1000.0   3.0   0.0   0.0
*
7400000    rhrsc2     tmdpvol
7400101    0.  10.  1000.  0.  0.  0.  0.  0.  00000
7400200    3
7400201    0.0   101325.0   337.0
*
7410000    rsuln12    tmdpjun
7410101    400010005     740010001     0.006
7410200    1   0
7410201    0.0      3.0   0.0   0.0
7410202    1000.0   3.0   0.0   0.0
*
7450000    rhrso2     tmdpvol
7450101    0.  10.  1000.  0.  0.  0.  0.  0.  00000
7450200    3
7450201    0.0   101325.0   320.0
*
7460000    rsoln12    tmdpjun
7460101    745010001   448010005     0.006
7460200    1   0
7460201    0.0      3.0   0.0   0.0
7460202    1000.0   3.0   0.0   0.0
*
*****************************************************
* containment volume for environmental heat losses
*****************************************************
9000000    envsink     snglvol
9000101    2000.   100.   0.0  0.0  0.0  0.0  0.0   0    10
9000200    004    1.01325e+5   300.15   1.0
*
9030000    dummy       tmdpvol
9030101    0.0    1.0    10.0  0.0  0.0  0.0  0.0  0.0   00
9030200    004
9030201    0.0    1.01325e+5   300.15   1.0
*
9040000    dumjun      sngljun
9040101    900000000   903000000   0.05   0.0  0.0   1100
9040201    1   0.0   0.0   0.0
*
*****************************************************
*  break point  - 5% break area
*****************************************************
9150000    npcolbrv    valve
9150101    610010001 920010001 1.129e-2 0. 0. 00100 1. 1.
9150201    0          0.0         0.0         0.0
9150300    trpvlv
9150301    500
*
*****************************************************
9200000    npcolleg    tmdpvol
9200101    1.0e+8   10.0  0.0  0.0  0.0  0.0  0.0  0   00
9200200    004
9200201    0.0      1.01325e+5      300.15     1.0
*
*****************************************************
*  Reactor Vessel Heat Structures
*****************************************************
* 100-1: vessel wall above nozzles,
*        below upper head flange
*****************************************************
*
11001000    1    7    2    1    0.320
11001100    0      1
11001101    1      0.323
11001102    4      0.476
11001103    1      0.601
11001201    5      1
11001202    6      5
11001203    9      6
11001301    0.0      6
11001400    0
11001401    317.0        7
11001501    100010000     0   101    1    0.823    1
11001601    900010000     0   101    1    0.823    1
11001701    0    0    0    0    1
11001801    0. 10.0   10.0    0.0 0.  0  0. 1.     1
11001901    0. 10.0   10.0    0.0 0.  0  0. 1.     1
*
*****************************************************
*    104-1: reactor vessel wall below nozzles
*****************************************************
*
11041000    12    7    2    1    0.320
11041100    0      1
11041101    1      0.323
11041102    4      0.381
11041103    1      0.506
11041201    5      1
110412[illegible]    6      5
11041[illegible]    9      6
11041[illegible]    0.0    6
11041[illegible]0    0
[illegible]41401    317.0        7
[illegible]    104010000     0   101    1    0.600    1
 1041502    108010000     0   101    1    0.677    2
```

```
11041503    108020000        0   101     1   0.867     3
11041504    108030000    10000   101     1   0.610     9
11041510    108090000        0   101     1   1.2588   10
11041511    112010000        0   101     1   0.445    11
11041512    116010000        0   101     1   0.4762   12
11041601    900010000        0   101     1   0.600     1
11041602    900010000        0   101     1   0.677     2
11041603    900010000        0   101     1   0.867     3
11041604    900010000        0   101     1   0.610     9
11041610    900010000        0   101     1   1.2588   10
11041611    900010000        0   101     1   0.445    11
11041612    900010000        0   101     1   0.4762   12
11041701    0     0     0     0     12
11041801    0. 10.0  10.0    0.0  0. 0. 0. 1.   12
11041901    0. 10.0  10.0    0.0  0. 0. 0. 1.   12
*
****************************************************
* 112-1: vessel bottom and flange
****************************************************
*
11121000    1     7     1     1     0.0
11121100    0     1
11121101    1     0.003
11121102    4     0.724
11121103    1     0.849
11121201    5     1
11121202    6     5
11121203    9     6
11121301    0.0   6
11121400    0
11121401    317.0        7
11121501    112010000      0   101     0    0.686    1
11121601    900010000      0   101     1    0.686    1
11121701    0     0     0     0     1
11121801    0. 10.0  10.0    0.0 0. 0. 0. 1.0     1
11121901    0. 10.0  10.0    0.0 0. 0. 0. 1.0     1
*
****************************************************
* 112-2: heater rods, below heated section
****************************************************
*
11122000    3     4     2     1     0.0
11122100    0     1
11122101    1     0.002
11122102    1     0.00295
11122103    1     0.00375
11122201    3     1
11122202    1     2
11122203    4     3
11122301    0.0   3
11122400    0
11122401    317.0        4
11122501               0       0   0      1   731.2   1
11122502               0       0   0      1   556.2   2
11122503               0       0   0      1  1470.3   3
11122601     112010000         0  101     1   731.2   1
11122602     116010000         0  101     1   556.2   2
11122603     120010000         0  101     1  1470.3   3
11122701     0     0     0     0     3
11122901     0. 10.0     10.0     0.0  0. 0. 0. 1.    3
*
****************************************************
* 120-1: core barrel, channel
****************************************************
*
11201000    18    5     2     1     0.257
11201100    0     1
11201101    4     0.267
11201201    5     4
11201301    0.0   4
11201400    0
11201401    317.0       5
11201501    120010000        0   101     1   1.2588    1
11201502    124010000    10000   101     1   0.305    13
11201503    128010000        0   101     1   0.867    14
11201504    132010000        0   101     1   0.677    15
11201505    136010000        0   101     1   0.600    16
11201506    140010000        0   101     1   0.3674   17
11201507    144010000        0   101     1   0.897    18
11201601    108090000        0   101     1   1.2588    1
11201602    108080000        0   101     1   0.305     2
11201603    108080000        0   101     1   0.305     3
11201604    108070000        0   101     1   0.305     4
11201605    108070000        0   101     1   0.305     5
11201606    108060000        0   101     1   0.305     6
11201607    108060000        0   101     1   0.305     7
11201608    108050000        0   101     1   0.305     8
11201609    108050000        0   101     1   0.305     9
11201610    108040000        0   101     1   0.305    10
11201611    108040000        0   101     1   0.305    11
11201612    108030000        0   101     1   0.305    12
11201613    108030000        0   101     1   0.305    13
11201614    108020000        0   101     1   0.867    14
11201615    108010000        0   101     1   0.677    15
11201616    104010000        0   101     1   0.600    16
11201617    100010000        0   101     1   0.3674   17
11201618    100010000        0   101     1   0.897    18
11201701    0     0     0     0     18
11201801    0. 10.0     10.0     0.0  0.  0.  0.0  1.0    18
11201901    0. 10.0     10.0     0.0  0.  0.  0.0  1.0    18
*
****************************************************
* 124-1: heated section of heater rods in channel
****************************************************
*
11241000    12    9     2     1     0.0
11241100    0     1
11241101    2     0.00200
11241102    2     0.00260
11241103    2     0.00375
11241104    2     0.00475
11241201    7     2
11241202    2     4
11241203    1     6
11241204    4     8
11241301    0.0   2
11241302    1.0   4
11241303    0.0   8
```

```
11241400    0
11241401    317.0        9
11241501            0        0    0    1      162.25      12
11241601    124010000  10000   111  1      162.25      12
11241701    888   0.026284     0.0   0.0   1
11241702    888   0.054904     0.0   0.0   2
11241703    888   0.080266     0.0   0.0   3
11241704    888   0.100800     0.0   0.0   4
11241705    888   0.115238     0.0   0.0   5
11241706    888   0.122688     0.0   0.0   6
11241707    888   0.122688     0.0   0.0   7
11241708    888   0.115238     0.0   0.0   8
11241709    888   0.100800     0.0   0.0   9
11241710    888   0.080266     0.0   0.0   10
11241711    888   0.054904     0.0   0.0   11
11241712    888   0.026284     0.0   0.0   12
11241900    1
11241901    0. 0.1525 3.5075  0. 0. 0. 0. 1.0  3.6 1.1 1.0 1
11241902    0. 0.4575 3.2025  0. 0. 0. 0. 1.0  3.6 1.1 1.0 2
11241903    0. 0.7625 2.8975  0. 0. 0. 0. 1.0  3.6 1.1 1.0 3
11241904    0. 1.0675 2.5925  0. 0. 0. 0. 1.0  3.6 1.1 1.0 4
11241905    0. 1.3725 2.2875  0. 0. 0. 0. 1.0  3.6 1.1 1.0 5
11241906    0. 1.6775 1.9825  0. 0. 0. 0. 1.0  3.6 1.1 1.0 6
11241907    0  1.9825 1.6775  0. 0. 0. 0. 1.0  3.6 1.1 1.0 7
11241908    0. 2.2875 1.3725  0. 0. 0. 0. 1.0  3.6 1.1 1.0 8
11241909    0. 2.5925 1.0675  0. 0. 0. 0. 1.0  3.6 1.1 1.0 9
11241910    0. 2.8975 0.7625  0. 0. 0. 0. 1.0 3.6 1.1 1.0 10
11241911    0. 3.2025 0.4575  0. 0. 0. 0. 1.0 3.6 1.1 1.0 11
11241912    0. 3.5075 0.1525  0. 0. 0. 0. 1.0 3.6 1.1 1.0 12
*
*****************************************************
* 124-2: unheated instrument rods
*****************************************************
*
11242000    12    6     2     1     0.0
11242100    0     1
11242101    3     0.00432
11242102    2     0.00612
11242201    1     2
11242202    5     5
11242301    0.0   5
11242400    0
11242401    317.0        6
11242501    0           0      0      1      31.72       12
11242601    124010000  10000  111   1      31.72       12
11242701    0     0          0          0    12
11242900    1
11242901    0.    10.0  10.0  0. 0. 0. 0. 1. 3.6  1.1  1. 12
*
*****************************************************
* 128-1: upper plenum internals
*****************************************************
*
11281000    1     5     1     1     0.0
11281100    0     1
11281101    4     0.023
11281201    5     4
11281301    0.0   4
11281400    0
11281401    317.0        5
11281501    128010000       0   101      0      0.773      1
11281601    128010000       0   101      0      0.773      1
11281701    0     0     0     0     1
11281801    0. 10.0  10.0 0. 0.0 0. 0. 1.  1
11281901    0. 10.0  10.0 0. 0.0 0. 0. 1.  1
*
*****************************************************
* 132-1: guide tubes
*****************************************************
*
11321000    5     4     2     1     0.04405
11321100    0     1
11321101    3     0.04655
11321201    5     3
11321301    0.0   3
11321400    0
11321401    317.0        4
11321501    156020000       0   101      1      5.406      1
11321502    156020000       0   101      1      4.800      2
11321503    156010000       0   101      1      2.939      3
11321504    156010000       0   101      1      7.176      4
11321505    156010000       0   101      1      5.800      5
11321601    132010000       0   101      1      5.406      1
11321602    136010000       0   101      1      4.800      2
11321603    140010000       0   101      1      2.939      3
11321604    144010000       0   101      1      7.176      4
11321605    148010000       0   101      1      5.800      5
11321701    0      0        0        0     5
11321801    0.    10.0      10.0  0. 0.  0.0 0. 1.   5
11321901    0.    10.0      10.0  0. 0.  0.0 0. 1.   5
*
*****************************************************
* 144-1: upper core support plate
*****************************************************
*
11441000    1     9     1     1     0.0
11441100    0     1
11441101    8     0.304
11441201    5     8
11441301    0.0   8
11441400    0
11441401    317.0        9
11441501    144010000       0   101      0      0.156      1
11441601    140010000       0   101      0      0.156      1
11441701    0     0     0     0     1
11441801    0. 10.0  10.0 0. 0.0 0. 0. 1.  1
11441901    0. 10.0  10.0 0. 0.0 0. 0. 1.  1
*
*****************************************************
* 148-1: reactor vessel wall above upper plenum flange
*****************************************************
*
11481000    1     7     2     1     0.320
11481100    0     1
11481101    1     0.323
11481102    4     0.522
11481103    1     0.647
11481201    5     1
```

```
11481202    6      5
11481203    9      6
11481301    0.0    6
11481400    0
11481401    317.0         7
11481501    148010000       0    101      1      0.404     1
11481601    900010000       0    101      1      0.404     1
11481701    0      0      0      0      1
11481801    0. 10.0   10.0 0. 0.0 0. 0. 1. 1
11481901    0. 10.0   10.0 0. 0.0 0. 0. 1. 1
*
****************************************************
* 152-1; reactor vessel upper head
****************************************************
*
11521000    1      7      3      1      0.320
11521100    0      1
11521101    1      0.324
11521102    4      0.354
11521103    1      0.479
11521201    5      1
11521202    6      5
11521203    9      6
11521301    0.0    6
11521400    0
11521401    317.0         7
11521501    152010000       0    101      1      0.5       1
11521601    900010000       0    101      1      0.5       1
11521701    0      0      0      0      1
11521801    0. 10.0   10.0 0. 0.0 0. 0. 1. 1
11521901    0. 10.0   10.0 0. 0.0 0. 0. 1. 1
*
****************************************************
*        ht str no. 212-1   Loop Heat Structures
****************************************************
*
12121000    2        6      3      1      0.377      0
12121100    0               1
12121101    1               0.380
12121102    2               0.430
12121103    2               0.555
12121201    5               1
12121202    6               3
12121203    9               5
12121301    0.0             5
12121400    0
12121401    317.0        6
12121501    212010000    0    101     1       0.1872      1
12121502    228010000    0    101     1       0.1872      2
12121601    900010000    0    101     1       0.1872      2
12121701    0            0      0      0       2
12121801    0.  10.0     10.0 0.  0.   0.    0.  1.      2
12121901    0.  10.0     10.0 0.  0.   0.    0.  1.      2
*
****************************************************
*        ht str no. 212-2   blsg inlet/outlet plnm walls
****************************************************
12122000    4        6      2      1      0.365      0
12122100    0               1
12122101    1               0.368
12122102    2               0.434
12122103    2               0.559
12122201    5               1
12122202    6               3
12122203    9               5
12122301    0.0             5
12122400    0
12122401    317.0           6
12122501    212010000   0    101     1          0.4237  1
12122502    228010000   0    101     1          0.4237  2
12122503    216010000   0    101     1          1.1035  3
12122504    224010000   0    101     1          1.1035  4
12122601    900010000   0    101     1          0.4237  2
12122602    900010000   0    101     1          1.1035  4
12122701      0          0            0             0     4
12'22801      0.     10.0    10.0   0.  0.    0.  0  1.    4
'' 22901      0.     10.0    10.0   0.  0.    0.  0  1.    4
*
****************************************************
*      ht str no. 220-2   blsg inlet/outlet tube sheet
****************************************************
*
12202000    2        4      2      1      0.0098     0
12202100    0        1
12202101    3        0.0163
12202201    5        3
12202301    0.0      3
12202400    0
12202401    317.0    4
12202501    220010000   0      101       1      45.40      1
12202502    220080000   0      101       1      45.40      2
12202601    0           0      0         1      45.40      2
12202701    0           0          0            0          2
12202801    0.       10.0    10.0  0. 0. 0.     0   1.     2
*
****************************************************
*      ht str no. 220-1 sg in the loop without pressurizer
****************************************************
*
12201000    12      8      2      1      0.00980
12201100    0       1
12201101    7       0.0127
12201201    5       7
12201301    0.0     7
12201400    0
12201401    317.0        8
12201501    220010000   10000    101   1    89.76        4
12201502    220050000   10000    101   1   180.86        6
12201503    220070000       0    101   1   361.72        7
12201504    220080000   10000    101   1   306.36        9
12201505    220100000   10000    101   1   361.72       11
12201506    220120000       0    101   1   359.04       12
12201601    304010000       0    110   1    89.76        4
12201602    304020000       0    110   1   180.86        6
12201603    304030000       0    110   1   361.72        7
12201604    304040000       0    110   1   306.36        9
12201605    304030000  -10000    110   1   361.72       11
12201606    304010000       0    110   1   359.04       12
```

```
12201701    0     0     0     0    12
12201801    0. 10.0 10.0  0.0  0.  0.0  0. 1.      12
12201900    1
12201901    0. 10.0 10.0  0.0 0.  0.0   0. 1. 10.2 1.1 1.0  12
*
****************************************************
* ht str no. 300-1    blsg external dc pipe to environ
****************************************************
13001000    5       5     2     1     0.0486    0
13001100    0        1
13001101    2        0.0572
13001102    2        0.1572
13001201    5        2
13001202    9        4
13001301    0.0      4
13001401    317.0    5
13001501    300010000    0         101     1     9.0016    1
13001502    300020000    0         101     1     8.3920    2
13001503    300030000    10000     101     1     10.2616   4
13001504    300050000    0         101     1     10.2380   5
13001601    900010000    0         101     1     9.0016    1
13001602    900010000    0         101     1     8.3920    2
13001603    900010000    0         101     1     10.2616   4
13001604    900010000    0         101     1     10.2380   5
13001701      0          0          0          0      5
13001801      0.  10.0   10.0    0.  0.    0.   0.  1.  5
13001901      0.  10.0   10.0    0.  0.    0.   0.  1.  5
*
****************************************************
* ht str no. 300-2    blsg upper dc to separator
****************************************************
13002000    2       2     2     1     0.2514    0
13002100    0            1
13002101    1            0.2554
13002201    5            1
13002301    0.0          1
13002400    0
13002401    317.0        2
13002501    304050000    0       101       1    0.6461   1
13002502    308010000    0       101       1    2.120    2
13002601    300010000    0       101       1    0.6461   1
13002602    308010000    0       101       1    2.120    2
13002701      0          0           0          0    2
13002801      0.     10.0   10.0   0.   0.  0.   0.  1.  2
13002901      0.     10.0   10.0   0.   0.  0.   0.  1.  1
13002902      0.     10.0   10.0   0.   0.  0.   0.  1.  2
*
****************************************************
*    ht str no. 300-3    blsg upper sg shell to environ
****************************************************
13003000    4       6     2     1     0.4375    0
13003100        0             1
13003101        1             0.4405
13003102        2             0.4785
13003103        2             0.6035
13003201        5             1
13003202        6             3
13003203        9             5
13003301        0.0           5
13003400        0
13003401        317.0         6
13003501    300010000    0       101       1    0.6461   1
13003502    304050000    0       101       1    1.0104   2
13003503    312010000    0       101       1    2.120    3
13003504    316010000    0       101       1    3.4278   4
13003601    900010000    0       101       1    0.6461   1
13003602    900010000    0       101       1    1.0104   2
13003603    900010000    0       101       1    2.120    3
13003604    900010000    0       101       1    3.4278   4
13003701        0            0           0           0    4
13003801        0.   10.0   10.0    0.   0.   0.  0.  1.  1
13003802        0.   10.0   10.0    0.   0.   0.  0.  1.  2
13003803        0.   10.0   10.0    0.   0.   0.  0.  1.  3
13003804        0.   10.0   10.0    0.   0.   0.  0.  1.  4
13003901        0.   10.0   10.0    0.   0.   0.  0.  1.  4
*
****************************************************
*    ht str no. 300-4    blsg lower sg dc to boiler
****************************************************
13004000    1       2     2     1     0.345     0
13004100    0            1
13004101    1            0.351
13004201    5            1
13004301    0.0          1
13004400    0
13004401    317.0        2
13004501    304010000    0       101       1    1.0637   1
13004601    300050000    0       101       1    1.0637   1
13004701        0            0           0           0    1
13004801        0.   10.0   10.0    0.   0.   0.  0.  1.  1
13004901        0.   10.0   10.0    0.   0.   0.  0.  1.  1
*
****************************************************
*    ht str no. 300-5    blsg lower sg dc wall to environ
****************************************************
13005000    1       6     2     1     0.370     0
13005100        0             1
13005101        1             0.373
13005102        2             0.405
13005103        2             0.530
13005201        5             1
13005202        6             3
13005203        9             5
13005301        0.0           5
13005400        0
13005401        317.0         6
13005501    300050000    0       101       1    1.2637   1
13005601    900010000    0       101       1    1.2637   1
13005701        0            0           0           0    1
13005801        0.   10.0   10.0    0.   0.   0.  0.  1.  1
13005901        0.   10.0   10.0    0.   0.   0.  0.  1.  1
*
****************************************************
*      ht str no. 304-1    blsg boiler wall to environ
****************************************************
13041000    5       6     2     1     0.347     0
13041100        0             1
13041101        1             0.350
```

```
13041102        2            0.380
13041103        2            0.505
13041201        5            1
13041202        6            3
13041203        9            5
13041301        0.0          5
13041400        0
13041401        317.0        6
13041501   304010000   0        101     1     1.2827   1
13041502   304020000   10000    101     1     2.5654   3
13041503   304040000   0        101     1     2.098    4
13041504   304050000   0        101     1     0.3658   5
13041601   900010000   0        101     1     1.2827   1
13041602   900010000   0        101     1     2.5654   3
13041603   900010000   0        101     1     2.098    4
13041604   900010000   0        101     1     0.3658   5
13041701        0            0            0        0    5
13041801        0.   10.0   10.0   0.   0.   0.   0.   1.   4
13041802        0    10.0   10.0   0.   0.   0    0.   1.   5
13041901        0.   10.0   10.0   0.   0.   0.   0.   1.   5
*
*****************************************************
*     ht str no. 312-1    blsg separator to sep bypass
*****************************************************
13121000    1      2     2     1     0.2982     0
13121100        0            1
13121101        1            0.3012
13121201        5            1
13121301        0.0          1
13121400        0
13121401        317.0        2
13121501   308010000   0     101     1     1.7886   1
13121601   312010000   0     101     1     1.7886   1
13121701        0         0          0        0     1
13121801        0.    10.0   10.0   0.   0.   0.   0.   1.   1
13121901        0.    10.0   10.0   0.   0.   0.   0.   1.   1
*
*****************************************************
*    ht str no. 316-1    blsg hemisph top to environ
*****************************************************
13161000    1      6     3     1     0.447     0
13161100        0            1
13161101        1            0.451
13161102        2            0.473
13161103        2            0.598
13161201        5            1
13161202        6            3
13161203        9            5
13161301        0.0          5
13161400        0
13161401        317.0        6
13161501   316010000   0        101      1      0.391    1
13161601   900010000   0        101      1      0.391    1
13161701        0         0          0           0     1
13161801        0.    10.0   10.0   0.   0.   0.   0.   1.   1
13161901        0.    10.0   10.0   0.   0.   0.   0.   1.   1
*
*****************************************************
*      primary loop piping heat structures
```

```
*****************************************************
14001000    6      5     2     1     0.1035     0
14001100        0            1
14001101        2            0.1981
14001102        2            0.3231
14001201        5            2
14001202        9            4
14001301        0.0          4
14001400        0
14001401        317.0        5
14001501   400010000   0     101     1     1.3246   1
14001502   408010000   0     101     1     0.5968   2
14001503   408020000   0     101     1     0.5278   3
14001504   200010000   0     101     1     1.3246   4
14001505   208010000   0     101     1     0.5968   5
14001506   208020000   0     101     1     0.5278   6
14001601   900010000   0     101     1     1.3246   1
14001602   900010000   0     101     1     0.5968   2
14001603   900010000   0     101     1     0.5278   3
14001604   900010000   0     101     1     1.3246   4
14001605   900010000   0     101     1     0.5968   5
14001606   900010000   0     101     1     0.5278   6
14001701        0          0          0          0    6
14001801        0.   10.0   10.0   0.   0.   0.   0.   1.   6
14001901        0.   10.0   10.0   0.   0.   0.   0.   1.   6
*
*****************************************************
*      ht str no. 400-2    il + bl col heat struct
*****************************************************
14002000    18     5     2     1     0.0841     0
14002100        0            1
14002101        2            0.1219
14002102        2            0.2469
14002201        5            2
14002202        9            4
14002301        0.0          4
14002400        0
14002401        317.0        5
14002501   432010000   0       101    1    0.516    1
14002502   432020000   10000   101    1    1.2422   4
14002503   432050000   0       101    1    1.1919   5
14002504   436010000   0       101    1    1.1919   6
14002505   436020000   10000   101    1    1.1222   9
14002506   232010000   0       101    1    0.516    10
14002507   232020000   10000   101    1    1.2422   13
14002508   232050000   0       101    1    1.1919   14
14002509   236010000   0       101    1    1.1919   15
14002510   236020000   10000   101    1    1.1222   18
14002601   900010000   0       101    1    0.516    1
14002602   900010000   0       101    1    1.2422   4
14002603   900010000   0       101    1    1.1919   6
14002604   900010000   0       101    1    1.1222   9
14002605   900010000   0       101    1    0.516    10
14002606   900010000   0       101    1    1.2422   13
14002607   900010000   0       101    1    1.1919   15
14002608   900010000   0       101    1    1.1222   18
14002701        0          0          0          0    18
14002801        0.   10.0   10.0   0.   0.   0.   0.   1.   18
14002901        0.   10.0   10.0   0.   0.   0.   0.   1.   18
```

```
*
***************************************************
*    ht str no. 400-3   il + bl cl heat struct
***************************************************
14003000    7        5      2      1      0.1035      0
14003100       0               1
14003101       2               0.1937
14003102       2               0.3187
14003201       5               2
14003202       9               4
14003301       0.0             4
14003400       0
14003401       317.0           5
14003501    444010000    0        101       1      1.0562   1
14003502    448010000    0        101       1      1.1067   2
14003503    452010000    0        101       1      1.3125   3
14003504    244010000    0        101       1      0.647    4
14003505    248010000    0        101       1      0.878    5
14003506    252010000    10000    101       1      0.9752   7
14003601    900010000    0        101       1      1.0562   1
14003602    900010000    0        101       1      1.1067   2
14003603    900010000    0        101       1      1.3125   3
14003604    900010000    0        101       1      0.647    4
14003605    900010000    0        101       1      0.878    5
14003606    900010000    0        101       1      0.9752   7
14003701       0          0          0          0     7
14003801       0.    10.0   10.0    0.    0.    0.   0.   1.   7
14003901       0.    10.0   10.0    0.    0.    0.   0.   1.   7
*
***************************************************
*  ht str no. 412-1   ilsg inlet/outlet plnm hemisph
***************************************************
14121000    2        6      3      1      0.377       0
14121100       0               1
14121101       1               0.380
14121102       2               0.430
14121103       2               0.555
14121201       5               1
14121202       6               3
14121203       9               5
14121301       0.0             5
14121400       0
14121401       317.0           6
14121501    412010000    0        101       1      0.1872   1
14121502    428010000    0        101       1      0.1872   2
14121601    900010000    0        101       1      0.1872   2
14121701       0          0          0          0     2
14121801       0.    10.0   10.0    0.    0.    0.   0.   1.   2
14121901       0.    10.0   10.0    0.    0.    0.   0.   1.   2
*
***************************************************
*      ht str no. 412-2   ilsg inlet outlet plnm walls
***************************************************
14122000    4        6      2      1      0.365       0
14122100       0               1
14122101       1               0.368
14122102       2               0.434
14122103       2               0.559
14122201       5               1
14122202       6               3
14122203       9               5
14122301       0.0             5
14122400       0
14122401       317.0           6
14122501    412010000    0        101       1      0.4237   1
14122502    428010000    0        101       1      0.4237   2
14122503    416010000    0        101       1      1.1035   3
14122504    424010000    0        101       1      1.1035   4
14122601    900010000    0        101       1      0.4237   2
14122602    900010000    0        101       1      1.1035   4
14122701       0          0          0          0     4
14122801       0.    10.0   10.0    0.    0.    0.   0.   1.   4
14122901       0.    10.0   10.0    0.    0.    0.   0.   1.   4
*
***************************************************
*       ht str no. 420-1 intact loop sg tubes
***************************************************
*
14201000    12       8      2      1      0.00980
14201100    0     1
14201101    7     0.0127
14201201    5     7
14201301    0.0   7
14201400    0
14201401    317.0        8
14201501    420010000   10000    101    1    89.76     4
14201502    420050000   10000    101    1    180.86    6
14201503    420070000   0        101    1    361.72    7
14201504    420080000   10000    101    1    306.36    9
14201505    420100000   10000    101    1    361.72    11
14201506    420120000   0        101    1    359.04    12
14201601    504010000   0        110    1    89.76     4
14201602    504020000   0        110    1    180.86    6
14201603    504030000   0        110    1    361.72    7
14201604    504040000   0        110    1    306.36    9
14201605    504030000   -10000   110    1    361.72    11
14201606    504010000   0        110    1    359.04    12
14201701    0     0     0     0     12
14201801    0.  10.0   10.0   0.0   0.  0.0   0.  1.      12
14201900    1
14201901    0.  10.0  10.0   0.0   0.  0.0   0.  1.  10.2  1.1  1.0  12
*
***************************************************
*     ht str no. 420-2   ilsg inlet/outlet tube sheet
***************************************************
14202000    2        4      2      1      0.0098      0
14202100    0              1
14202101    3              0.0163
14202201    5              3
14202301    0.0            3
14202400    0
14202401    317.0          4
14202501    420010000    0        101       1      45.40   1
14202502    420080000    0        101       1      45.40   2
14202601    0            0        0         1      45.40   2
14202701       0          0          0          0     2
14202801       0.    10.0   10.0    0.    0.    0.   0.   1.   2
***************************************************
```

```
*   ht str no. 500-1   ilsg external dc pipe to environ
*****************************************************
15001000   5      5     2     1     0.0486    0
15001100     0           1
15001101     2           0.0572
15001102     2           0.1572
15001201     5           2
15001202     9           4
15001301     0.0         4
15001401     317.0       5
15001501   500010000   0       101     1     9.0016   1
15001502   500020000   0       101     1     8.3920   2
15001503   500030000   10000   101     1    10.2616   4
15001504   500050000   0       101     1    10.2380   5
15001601   900010000   0       101     1     9.0016   1
15001602   900010000   0       101     1     8.3920   2
15001603   900010000   0       101     1    10.2616   4
15001604   900010000   0       101     1    10.2380   5
15001701     0          0          0          0    5
15001801     0.    10.0    10.0    0.   0.   0.   0.   1.   5
15001901     0.    10.0    10.0    0.   0.   0.   0.   1.   5
*
*****************************************************
*    ht str no. 500-2   ilsg upper dc to separator
*****************************************************
15002000   2      2     2     1     0.2514    0
15002100     0           1
15002101     1           0.2554
15002201     5           1
15002301     0.0         1
15002400     0
15002401     317.0       2
15002501   504050000   0     101     1     0.6461   1
15002502   508010000   0     101     1     2.120    2
15002601   500010000   0     101     1     0.6461   1
15002602   508010000   0     101     1     2.120    2
15002701     0          0          0          0    2
15002801     0.    10.0    10.0    0.   0.   0.  0.   1.   2
15002901     0.    10.0    10.0    0.   0.   0.  0.   1.   1
15002902     0.    10.0    10.0    0.   0.   0.  0.   1.   2
*
*****************************************************
*    ht str no. 500-3   ilsg upper sg shell to environ
*****************************************************
15003000   4      6     2     1     0.4375    0
15003100     0           1
15003101     1           0.4405
15003102     2           0.4785
15003103     2           0.6035
15003201     5           1
15003202     6           3
15003203     9           5
15003301     0.0         5
15003400     0
15003401     317.0       6
15003501   500010000   0     101     1     0.6461   1
15003502   504050000   0     101     1     1.0104   2
15003503   512010000   0     101     1     2.120    3
15003504   516010000   0     101     1     3.4278   4
15003601   900010000   0     101     1     0.6461   1
15003602   900010000   0     101     1     1.0104   2
15003603   900010000   0     101     1     2.120    3
15003604   900010000   0     101     1     3.4278   4
15003701     0          0          0          0    4
15003801     0.    10.0    10.0    0.   0.   0.   0.   1.   1
15003802     0.    10.0    10.0    0.   0.   0.   0.   1.   2
15003803     0.    10.0    10.0    0.   0.   0.   0.   1.   3
15003804     0.    10.0    10.0    0.   0.   0.   0.   1.   4
15003901     0.    10.0    10.0    0.   0.   0.   0.   1.   4
*
*****************************************************
*  ht str no. 500-4   ilsg lower sg dc to boiler
*****************************************************
15004000   1      2     2     1     0.345     0
15004100     0           1
15004101     1           0.351
15004201     5           1
15004301     0.0         1
15004400     0
15004401     317.0       2
15004501   504010000   0     101     1     1.0637   1
15004601   500050000   0     101     1     1.0637   1
15004701     0          0          0          0    1
15004801     0.    10.0    10.0    0.   0.   0.   0.   1.   1
15004901     0.    10.0    10.0    0.   0.   0.   0.   1    1
*
*****************************************************
*  ht str no. 500-5   ilsg lower sg dc wall to environ
*****************************************************
15005000   1      6     2     1     0.370     0
15005100     0           1
15005101     1           0.373
15005102     2           0.405
15005103     2           0.530
15005201     5           1
15005202     6           3
15005203     9           5
15005301     0.0         5
15005400     0
15005401     317.0       6
15005501   500050000   0     101     1     1.2637   1
15005601   900010000   0     101     1     1.2637   1
15005701     0          0          0          0    1
15005801     0.    10.0    10.0    0.   0.   0.   0.   1.   1
15005901     0.    10.0    10.0    0.   0.   0.   0.   1.   1
*
*****************************************************
*     ht str no. 504-1   ilsg boiler wall to environ
*****************************************************
15041000   5      6     2     1     0.347     0
15041100     0           1
15041101     1           0.350
15041102     2           0.380
15041103     2           0.505
15041201     5           1
15041202     6           3
15041203     9           5
15041301     0.0         5
```

```
15041400      0
15041401      317.0        6
15041501   504010000   0      101    1   1.2827   1
15041502   504020000   10000  101    1   2.5654   3
15041503   504040000   0      101    1   2.098    4
15041504   504050000   0      101    1   0.3658   5
15041601   900010000   0      101    1   1.2827   1
15041602   900010000   0      101    1   2.5654   3
15041603   900010000   0      101    1   2.098    4
15041604   900010000   0      101    1   0.3658   5
15041701      0          0          0        0     5
15041801      0.    10.0    10.0   0.  0.  0.  0.  1.   4
15041802      0.    10.0    10.0   0.  0.  0.  0.  1.   5
15041901      0.    10.0    10.0   0.  0.  0.  0.  1.   5
*
*****************************************************
*   ht str no. 512-1   ilsg separator to sep bypass
*****************************************************
15121000   1     2     2    1.    0.2982    0
15121100      0             1
15121101      1             0.3012
15121201      5             1
15121301      0.0           1
15121400      0
15121401      317.0         2
15121501   508010000   0      101    1   1.7886   1
15121601   512010000   0      101    1   1.7886   1
15121701      0          0          0        0     1
15121801      0.    10.0    10.0   0.  0.  0.  0.  1.   1
15121901      0.    10.0    10.0   0.  0.  0.  0.  1.   1
*
*****************************************************
*     ht str no. 516-1   ilsg hemisph top to environ
*****************************************************
15161000   1     6     3    1     0.447     0
15161100      0             1
15161101      1             0.451
15161102      2             0.473
15161103      2             0.598
15161201      5             1
15161202      6             3
15161203      9             5
15161301      0.0           5
15161400      0
15161401      317.0         6
15161501   516010000   0      101    1   0.391   1
15161601   900010000   0      101    1   0.391   1
15161701      0          0          0        0     1
15161801      0.    10.0    10.0   0.  0.  0.  0.  1.   1
15161901      0.    10.0    10.0   0.  0.  0.  0.  1.   1
*
*****************************************************
*     ht str no. 610-1   prizer wall heat struct
*****************************************************
16101000   7     6     2    1     0.300     0
16101100      0             1
16101101      1             0.303
16101102      2             0.360
16101103      2             0.485
16101201      5             1
16101202      6             3
16101203      9             5
16101301      0.0           5
16101400      0
16101401      317.0         6
16101501   610020000   10000  101    1   0.475    2
16101502   610040000   0      101    1   0.600    3
16101503   610050000   10000  101    1   0.682    5
16101504   610070000   10000  101    1   0.5375   7
16101601   900010000   0      101    1   0.475    2
16101602   900010000   0      101    1   0.600    3
16101603   900010000   0      101    1   0.682    5
16101604   900010000   0      101    1   0.5375   7
16101701      0          0          0        0     7
16101801      0.    10.0    10.0   0.  0.  0.  0.  1.   5
16101802      0.    10.0    10.0   0.  0.  0.  0.  1.   7
16101901      0.    10.0    10.0   0.  0.  0.  0.  1.   7
*
*****************************************************
*   ht str no. 610-2   prizer top (hemisph) heat struct
*****************************************************
16102000   1     6     3    1     0.323     0
16102100      0             1
16102101      1             0.326
16102102      2             0.383
16102103      2             0.508
16102201      5             1
16102202      6             3
16102203      9             5
16102301      0.0           5
16102400      0
16102401      317.0         5
16102402      317.0         6
16102501   610010000   0      101    1   0.311   1
16102601   900010000   0      101    1   0.311   1
16102701      0          0          0        0     1
16102801      0.    10.0    10.0   0.  0.  0.  0.  1.   1
16102901      0.    10.0    10.0   0.  0.  0.  0.  1.   1
*
*****************************************************
*   ht str no. 610-3   prizer bot (flange) heat struct
*****************************************************
16103000   1     6     1    1     0.0       0
16103100      0             1
16103101      1             0.003
16103102      2             0.8374
16103103      2             0.9624
16103201      5             1
16103202      6             3
16103203      9             5
16103301      0.0           5
16103400      0
16103401      317.0         6
16103501   610080000   0      101    1   0.2731   1
16103601   900010000   0      101    1   0.2731   1
16103701      0          0          0        0     1
16103801      0.    10.0    10.0   0.  0.  0.  0.  1.   1
16103901      0.    10.0    10.0   0.  0.  0.  0.  1.   1
```

```
*
*****************************************************
*        Thermal Properties
*****************************************************
*
20100100    tbl/fctn    1    1  * mgo
20100200    tbl/fctn    1    1  * nicr
20100300    tbl/fctn    1    1  * copper
20100400    tbl/fctn    1    1  * inconel
20100500    tbl/fctn    1    1  * stainless steel
20100600    c-steel             * carbon steel
20100700    tbl/fctn    1    1  * al2o3
20100900    tbl/fctn    1    1  * rockwool insulation
*
*****************************************************
*            thermal conductivity
*****************************************************
* mgo
*
20100101    293.2   0.814   1273.2   1.047
*
* nicr heater
*
20100201 293.15 8.78 573.15 11.3 773.15 13.81 1073.15 18.83
20100202  1273.15  22.18  1473.15  25.52  10000.0  25.52
*
* copper
*
20100301    300.0   383.0
20100302    373.15  379.  473.15  374.  573.15  369.
20100303    673.15  363.  873.15  353.
*
* inconel 600
*
20100401    200.0    13.0    323.0    14.9
20100402    373.15 15.8 573.15 18.9 873.15 23.8 1173.15 29.3
*
*
* stainless steel
*
20100501    273.15   12.98   1199.82   25.1   10000.0   25.1
*
* aluminum oxide
*
20100701    300.0    28.0
20100702  373.15 25.122 473.15 20.935 573.15 16.748 773.15
          12.561
20100703  1073.15  8.374 1473.15  8.374
*
* rockwool insulation
*
20100901    273.0   0.1192
20100902    311.15  0.1192  422.15  0.1681  533.15  0.2166
20100903    811.15  0.3448
*
*****************************************************
*            volumetric heat capacity
*****************************************************
* mgo
*
20100151    293.15  2.88e6  373.15  3.04e6  473.15  3.15e6
20100152    573.15  3.20e6  673.15  3.25e6  773.15  3.29e6
20100153    873.15  3.34e6  973.15  3.44e6 1073.15  3.53e6
20100154   1173.15  3.63e6
*
* nicr heater
*
20100251    300.0    3.00e+6
20100252    373.15 3.23e+6 573.15 3.62e+6 773.15  4.10e+6
20100253    1073.15 4.61e+6 1173.15 4.73e+6 1273.15 4.95e+6
20100254    1473.15   5.29e+6   10000.0   5.29e+6
*
* copper
*
20100351     3.43e6
*
* inconel 600
*
20100451    300.0    3.50e6    323.0    3.76e6
20100452    373.15 3.94e+6 573.15 4.18e+6  873.15  4.71e+6
20100453    1173.15  5.17e+6
*
* stainless steel
*
20100551  273.15 3.83e+6  366.5  3.83e+6  477.59  4.19e+6
20100552  588.59 4.336e+6 699.82 4.504e+6 810.93 4.639e+6
20100553  922.04 4.773e+6 1144.26 5.076e+6 1366.5 5.376e+6
20100554  1477.59  5.546e+6   10000.0  5.546e+6
*
* aluminum oxide
*
20100751    300.0    [illegible].00e6
20100752    373.15 3.0[illegible]5e+6 473.15 3.482e+6 573.15 3.796e+6
20100753    673.15 3.946e+6 773.15 4.093e+6 873.15 4.239e+6
20100754 973.15 4.384e+6 1073.16 4.373e+6 1173.16 4.529e+6
20100755    1373.16 4.529e+6  1473.16 4.685e+6
*
* rockwool
*
20100951     1.36e+5
*
*****************************************************
* core power
*****************************************************
*
20288800        power        501
20288801          -1.0      0.430e+6
20288802           0.0      0.430e+6
*
*****************************************************
*     Control Systems
*****************************************************
* calculate core collapsed liquid level
*****************************************************
*
20512400   "core lvl"       sum        1.0      3.66     1
20512401       0.0          0.305              voidf   124010000
20512402                    0.305              voidf   124020000
```

```
20512403              0.305       voidf    124030000
20512404              0.305       voidf    124040000
20512405              0.305       voidf    124050000
20512406              0.305       voidf    124060000
20512407              0.305       voidf    124070000
20512408              0.305       voidf    124080000
20512409              0.305       voidf    124090000
20512410              0.305       voidf    124100000
20512411              0.305       voidf    124110000
20512412              0.305       voidf    124120000
*****************************************************
* calculate core collapsed liquid level ---vessel---
*****************************************************
*
20512500  "core lvl"        sum       1.0     5.8027   1
20512501     0.0      0.305       voidf       124010000
20512502              0.305       voidf       124020000
20512503              0.305       voidf       124030000
20512504              0.305       voidf       124040000
20512505              0.305       voidf       124050000
20512506              0.305       voidf       124060000
20512507              0.305       voidf       124070000
20512508              0.305       voidf       124080000
20512509              0.305       voidf       124090000
20512510              0.305       voidf       124100000
20512511              0.305       voidf       124110000
20512512              0.305       voidf       124120000
20512513              0.867       voidf       128010000
20512514              0.6757      voidf       132010000
20512515              0.6         voidf       136010000
*****************************************************
* calculate pressurizer collapsed liquid level
*****************************************************
*
20512600  "pzr lvl"         sum       1.0     0.0      1
20512601     0.0      0.201       voidf       610010000
20512602              0.470       voidf       610020000
20512603              0.470       voidf       610030000
20512604              0.60        voidf       610040000
20512605              0.682       voidf       610050000
20512606              0.682       voidf       610060000
20512607              0.5375      voidf       610070000
20512608              0.5375      voidf       610080000
*
20575100  "dpdoup"          sum       1.0     0.0      1
20575101        0.0         1.0          p    136010000
20575102                   -1.0          p    104010000
*
20575300  "dpe080"          sum       1.0     266000.  1
20575301        0.0         1.0          p    436010000
20575302                   -1.0          p    436040000
*
20575700  "dpe220"          sum       1.0     266000.  1
20575701        0.0         1.0          p    236010000
20575702                   -1.0          p    236040000
*
20575400  "updp"            sum       1.0     0.0      1
20575401        0.0         1.0          p    124010000
20575402                   -1.0          p    136010000
*
20575500  "ildown"          sum          1.0     0.0      1
20575501         0.0        -1.0           p    432010000
20575502                     1.0           p    432050000
*
20575600  "bldown"          sum          1.0     0.0      1
20575601         0.0        -1.0           p    232010000
20575602                     1.0           p    232050000
*
20576000  "dpe290"          sum          1.0     1200.    1
20576001         0.0         1.0           p    120010000
20576002                    -1.0           p    124010000
*
20576100  "dpe300"          sum          1.0     32000.   1
20576101         0.0         1.0           p    124010000
20576102                    -1.0           p    128010000
*
20576300  "dpe320"          sum          1.0     13000.   1
20576301         0.0         1.0           p    128010000
20576302                    -1.0           p    140010000
*
*****************************************************
* calculate wide range sg liquid levels
*****************************************************
*
20531200  "blsglwde"     sum      1.0      8.9221049 1
20531201  0.0    2.5464  voidf    304010000
20531202         2.5654  voidf    304020000
20531203         2.5654  voidf    304030000
20531204         2.0980  voidf    304040000
20531205         2.0223  voidf    304050000
20531206         2.1200  voidf    308010000
20531207         3.7778  voidf    316010000
*
20551200  "ilsglwde"     sum      1.0      8.8904978 1
20551201  0.0    2.5464  voidf    504010000
20551202         2.5654  voidf    504020000
20551203         2.5654  voidf    504030000
20551204         2.0980  voidf    504040000
20551205         2.0223  voidf    504050000
20551206         2.1200  voidf    508010000
20551207         3.7778  voidf    516010000
*
*****************************************************
* calculate the noncondensable mass in primary
* system-broken loop
*****************************************************
*
20561100  "v-200"      mult     1.0       0.1      1
20561101  tmassv       200010000
20561102  quals        200010000
20561103  quala        200010000
*
20561200  "v-206"      mult     1.0       0.1      1
20561201  tmassv       206010000
20561202  quals        206010000
20561203  quala        206010000
*
20561300  "v-208-1"    mult     1.0       0.1      1
```

```
20561301  tmassv     208010000
20561302  quals      208010000
20561303  quala      208010000
20561400  "v-208-2"  mult      1.0      0.1    1
20561401  tmassv     208020000
20561402  quals      208020000
20561403  quala      208020000
*
20562000  "hl-b-nc"  sum       1.0      0.1    1
20562001  0.0        1.0    cntrlvar   611
20562002             1.0    cntrlvar   612
20562003             1.0    cntrlvar   613
20562004             1.0    cntrlvar   614
***
20562100  "v-212"    mult      1.0      0.1    1
20562101  tmassv     212010000
20562102  quals      212010000
20562103  quala      212010000
*
20562200  "v-216"    mult      1.0      0.1    1
20562201  tmassv     216010000
20562202  quals      216010000
20562203  quala      216010000
*
20562300  "v-220-1"  mult      1.0      0.1    1
20562301  tmassv     220010000
20562302  quals      220010000
20562303  quala      220010000
20562400  "v-220-2"  mult      1.0      0.1    1
20562401  tmassv     220020000
20562402  quals      220020000
20562403  quala      220020000
20562500  "v-220-3"  mult      1.0      0.1    1
20562501  tmassv     220030000
20562502  quals      220030000
20562503  quala      220030000
20562600  "v-220-4"  mult      1.0      0.1    1
20562601  tmassv     220040000
20562602  quals      220040000
20562603  quala      220040000
20562700  "v-220-5"  mult      1.0      0.1    1
20562701  tmassv     220050000
20562702  quals      220050000
20562703  quala      220050000
20562800  "v-220-6"  mult      1.0      0.1    1
20562801  tmassv     220060000
20562802  quals      220060000
20562803  quala      220060000
20562900  "v-220-7"  mult      1.0      0.1    1
20562901  tmassv     220070000
20562902  quals      220070000
20562903  quala      220070000
20563000  "v-220-8"  mult      1.0      0.1    1
20563001  tmassv     220080000
20563002  quals      220080000
20563003  quala      220080000
20563100  "v-220-9"  mult      1.0      0.1    1
20563101  tmassv     220090000
20563102  quals      220090000
20563103  quala      220090000
20563200  "v-220-10"  mult     1.0      0.1    1
20563201  tmassv     220100000
20563202  quals      220100000
20563203  quala      220100000
20563300  "v-220-11"  mult     1.0      0.1    1
20563301  tmassv     220110000
20563302  quals      220110000
20563303  quala      220110000
20563400  "v-220-12"  mult     1.0      0.1    1
20563401  tmassv     220120000
20563402  quals      220120000
20563403  quala      220120000
*
20563500  "v-224"    mult      1.0      0.1    1
20563501  tmassv     224010000
20563502  quals      224010000
20563503  quala      224010000
*
20563600  "v-228"    mult      1.0      0.1    1
20563601  tmassv     228010000
20563602  quals      228010000
20563603  quala      228010000
*
20563900  "sg-b-t"   sum       1.0      0.1    1
20563901  0.0        1.0    cntrlvar   623
20563902             1.0    cntrlvar   624
20563903             1.0    cntrlvar   625
20563904             1.0    cntrlvar   626
20563905             1.0    cntrlvar   627
20563906             1.0    cntrlvar   628
20563907             1.0    cntrlvar   629
20563908             1.0    cntrlvar   630
20563909             1.0    cntrlvar   631
20563910             1.0    cntrlvar   632
20563911             1.0    cntrlvar   633
20563912             1.0    cntrlvar   634
*
20564000  "sg-b-nc"  sum       1.0      0.1    1
20564001  0.0        1.0    cntrlvar   621
20564002             1.0    cntrlvar   622
20564003             1.0    cntrlvar   639
20564004             1.0    cntrlvar   635
20564005             1.0    cntrlvar   636
***
20564100  "v-232-1"  mult      1.0      0.1    1
20564101  tmassv     232010000
20564102  quals      232010000
20564103  quala      232010000
20564200  "v-232-2"  mult      1.0      0.1    1
20564201  tmassv     232020000
20564202  quals      232020000
20564203  quala      232020000
20564300  "v-232-3"  mult      1.0      0.1    1
20564301  tmassv     232030000
20564302  quals      232030000
20564303  quala      232030000
20564400  "v-232-4"  mult      1.0      0.1    1
20564401  tmassv     232040000
```

```
20564402    quals      232040000
20564403    quala      232040000
20564500    "v-232-5"  mult     1.0      0.1     1
20564501    tmassv     232050000
20564502    quals      232050000
20564503    quala      232050000
*
20564600    "v-236-1"  mult     1.0      0.1     1
20564601    tmassv     236010000
20564602    quals      236010000
20564603    quala      236010000
20564700    "v-236-2"  mult     1.0      0.1     1
20564701    tmassv     236020000
20564702    quals      236020000
20564703    quala      236020000
20564800    "v-236-3"  mult     1.0      0.1     1
20564801    tmassv     236030000
20564802    quals      236030000
20564803    quala      236030000
20564900    "v-236-4"  mult     1.0      0.1     1
20564901    tmassv     236040000
20564902    quals      236040000
20564903    quala      236040000
*
20565000    "ol-b-nc"  sum      1.0      0.1     1
20565001    0.0     1.0    cntrlvar   641
20565002            1.0    cntrlvar   642
20565003            1.0    cntrlvar   643
20565004            1.0    cntrlvar   644
20565005            1.0    cntrlvar   645
20565006            1.0    cntrlvar   646
20565007            1.0    cntrlvar   647
20565008            1.0    cntrlvar   648
20565009            1.0    cntrlvar   649
***
20565100    "v-240"    mult     1.0      0.1     1
20565101    tmassv     240010000
20565102    quals      240010000
20565103    quala      240010000
*
20565200    "v-244"    mult     1.0      0.1     1
20565201    tmassv     244010000
20565202    quals      244010000
20565203    quala      244010000
*
20565300    "v-248"    mult     1.0      0.1     1
20565301    tmassv     248010000
20565302    quals      248010000
20565303    quala      248010000
*
20565400    "v-252-1"  mult     1.0      0.1     1
20565401    tmassv     252010000
20565402    quals      252010000
20565403    quala      252010000
20565500    "v-252-2"  mult     1.0      0.1     1
20565501    tmassv     252020000
20565502    quals      252020000
20565503    quala      252020000
*
20566000    "cl-b-nc"  sum      1.0      0.1     1
20566001    0.0     1.0    cntrlvar   651
20566002            1.0    cntrlvar   652
20566003            1.0    cntrlvar   653
20566004            1.0    cntrlvar   654
20566005            1.0    cntrlvar   655
*
**************************************************
* calculate the noncondensable mass in primary
* system-Intact loop
**************************************************
*
20581100    "v-400"    mult     1.0      0.1     1
20581101    tmassv     400010000
20581102    quals      400010000
20581103    quala      400010000
*
20581200    "v-406"    mult     1.0      0.1     1
20581201    tmassv     406010000
20581202    quals      406010000
20581203    quala      406010000
*
20581300    "v-408-1"  mult     1.0      0.1     1
20581301    tmassv     408010000
20581302    quals      408010000
20581303    quala      408010000
20581400    "v-408-2"  mult     1.0      0.1     1
20581401    tmassv     408020000
20581402    quals      408020000
20581403    quala      408020000
*
20582000    "hl-i-nc"  sum      1.0      0.1     1
20582001    0.0     1.0    cntrlvar   811
20582002            1.0    cntrlvar   812
20582003            1.0    cntrlvar   813
20582004            1.0    cntrlvar   814
***
20582100    "v-412"    mult     1.0      0.1     1
20582101    tmassv     412010000
20582102    quals      412010000
20582103    quala      412010000
*
20582200    "v-416"    mult     1.0      0.1     1
20582201    tmassv     416010000
20582202    quals      416010000
20582203    quala      416010000
*
20582300    "v-420-1"  mult     1.0      0.1     1
20582301    tmassv     420010000
20582302    quals      420010000
20582303    quala      420010000
20582400    "v-420-2"  mult     1.0      0.1     1
20582401    tmassv     420020000
20582402    quals      420020000
20582403    quala      420020000
20582500    "v-420-3"  mult     1.0      0.1     1
20582501    tmassv     420030000
20582502    quals      420030000
20582503    quala      420030000
```

```
20582600   "v-420-4"    mult      1.0      0.1     1
20582601     tmassv     420040000
20582602     quals      420040000
20582603     quala      420040000
20582700   "v-420-5"    mult      1.0      0.1     1
20582701     tmassv     420050000
20582702     quals      420050000
20582703     quala      420050000
20582800   "v-420-6"    mult      1.0      0.1     1
20582801     tmassv     420060000
20582802     quals      420060000
20582803     quala      420060000
20582900   "v-420-7"    mult      1.0      0.1     1
20582901     tmassv     420070000
20582902     quals      420070000
20582903     quala      420070000
20583000   "v-420-8"    mult      1.0      0.1     1
20583001     tmassv     420080000
20583002     quals      420080000
20583003     quala      420080000
20583100   "v-420-9"    mult      1.0      0.1     1
20583101     tmassv     420090000
20583102     quals      420090000
20583103     quala      420090000
20583200   "v-420-10"   mult      1.0      0.1     1
20583201     tmassv     420100000
20583202     quals      420100000
20583203     quala      420100000
20583300   "v-420-11"   mult      1.0      0.1     1
20583301     tmassv     420110000
20583302     quals      420110000
20583303     quala      420110000
20583400   "v-420-12"   mult      1.0      0.1     1
20583401     tmassv     420120000
20583402     quals      420120000
20583403     quala      420120000
*
20583500   "v-424"      mult      1.0      0.1     1
20583501     tmassv     424010000
20583502     quals      424010000
20583503     quala      424010000
*
20583600   "v-428"      mult      1.0      0.1     1
20583601     tmassv     428010000
20583602     quals      428010000
20583603     quala      428010000
*
20583900   "sg-b-tb"    sum       1.0      0.1     1
20583901   0.0        1.0     cntrlvar    823
20583902              1.0     cntrlvar    824
20583903              1.0     cntrlvar    825
20583904              1.0     cntrlvar    826
20583905              1.0     cntrlvar    827
20583906              1.0     cntrlvar    828
20583907              1.0     cntrlvar    829
20583908              1.0     cntrlvar    830
20583909              1.0     cntrlvar    831
20583910              1.0     cntrlvar    832
20583911              1.0     cntrlvar    833
20583912              1.0     cntrlvar    834
*
20584000   "sg-i-nc"    sum       1.0      0.1     1
20584001   0.0        1.0     cntrlvar    821
20584002              1.0     cntrlvar    822
20584003              1.0     cntrlvar    839
20584004              1.0     cntrlvar    835
20584005              1.0     cntrlvar    836
***
20584100   "v-432-1"    mult      1.0      0.1     1
20584101     tmassv     432010000
20584102     quals      432010000
20584103     quala      432010000
20584200   "v-432-2"    mult      1.0      0.1     1
20584201     tmassv     432020000
20584202     quals      432020000
20584203     quala      432020000
20584300   "v-432-3"    mult      1.0      0.1     1
20584301     tmassv     432030000
20584302     quals      432030000
20584303     quala      432030000
20584400   "v-432-4"    mult      1.0      0.1     1
20584401     tmassv     432040000
20584402     quals      432040000
20584403     quala      432040000
20584500   "v-432-5"    mult      1.0      0.1     1
20584501     tmassv     432050000
20584502     quals      432050000
20584503     quala      432050000
*
20584600   "v-436-1"    mult      1.0      0.1     1
20584601     tmassv     436010000
20584602     quals      436010000
20584603     quala      436010000
20584700   "v-436-2"    mult      1.0      0.1     1
20584701     tmassv     436020000
20584702     quals      436020000
20584703     quala      436020000
20584800   "v-436-3"    mult      1.0      0.1     1
20584801     tmassv     436030000
20584802     quals      436030000
20584803     quala      436030000
20584900   "v-436-4"    mult      1.0      0.1     1
20584901     tmassv     436040000
20584902     quals      436040000
20584903     quala      436040000
*
20585000   "ol-i-nc"    sum       1.0      0.1     1
20585001   0.0        1.0     cntrlvar    841
20585002              1.0     cntrlvar    842
20585003              1.0     cntrlvar    843
20585004              1.0     cntrlvar    844
20585005              1.0     cntrlvar    845
20585006              1.0     cntrlvar    846
20585007              1.0     cntrlvar    847
20585008              1.0     cntrlvar    848
20585009              1.0     cntrlvar    849
***
20585100   "v-440"      mult      1.0      0.1     1
```

```
20585101    tmassv     440010000
20585102    quals      440010000
20585103    quala      440010000
*
20585200    "v-444"    mult    1.0       0.1     1
20585201    tmassv     444010000
20585202    quals      444010000
20585203    quala      444010000
*
20585300    "v-448"    mult    1.0       0.1     1
20585301    tmassv     448010000
20585302    quals      448010000
20585303    quala      448010000
*
20585400    "v-452"    mult    1.0       0.1     1
20585401    tmassv     452010000
20585402    quals      452010000
20585403    quala      452010000
*
20586000    "cl-i-nc"  sum     1.0       0.1     1
20586001    0.0     1.0    cntrlvar    851
20586002            1.0    cntrlvar    852
20586003            1.0    cntrlvar    853
20586004            1.0    cntrlvar    854
*
*************************************************
* calculate the noncondensable mass in primary
* system-pressurizer
*************************************************
*
20566100    "v-600-1"  mult    1.0       0.1     1
20566101    tmassv     600010000
20566102    quals      600010000
20566103    quala      600010000
20566200    "v-600-2"  mult    1.0       0.1     1
20566201    tmassv     600020000
20566202    quals      600020000
20566203    quala      600020000
20566300    "v-600-3"  mult    1.0       0.1     1
20566301    tmassv     600030000
20566302    quals      600030000
20566303    quala      600030000
*
20566600    "v-610-1"  mult    1.0       0.1     1
20566601    tmassv     610010000
20566602    quals      610010000
20566603    quala      610010000
20566700    "v-610-2"  mult    1.0       0.1     1
20566701    tmassv     610020000
20566702    quals      610020000
20566703    quala      610020000
20566800    "v-610-3"  mult    1.0       0.1     1
20566801    tmassv     610030000
20566802    quals      610030000
20566803    quala      610030000
20566900    "v-610-4"  mult    1.0       0.1     1
20566901    tmassv     610040000
20566902    quals      610040000
20566903    quala      610040000
20567000    "v-610-5"  mult    1.0       0.1     1
20567001    tmassv     610050000
20567002    quals      610050000
20567003    quala      610050000
20567100    "v-610-6"  mult    1.0       0.1     1
20567101    tmassv     610060000
20567102    quals      610060000
20567103    quala      610060000
20567200    "v-610-7"  mult    1.0       0.1     1
20567201    tmassv     610070000
20567202    quals      610070000
20567203    quala      610070000
20567300    "v-610-8"  mult    1.0       0.1     1
20567301    tmassv     610080000
20567302    quals      610080000
20567303    quala      610080000
*
20567400    "v-620-1"  mult    1.0       0.1     1
20567401    tmassv     620010000
20567402    quals      620010000
20567403    quala      620010000
20567500    "v-620-2"  mult    1.0       0.1     1
20567501    tmassv     620020000
20567502    quals      620020000
20567503    quala      620020000
*
20567900    "pzr-nc"   sum     1.0       0.1     1
20567901    0.0     1.0    cntrlvar    666
20567902            1.0    cntrlvar    667
20567903            1.0    cntrlvar    668
20567904            1.0    cntrlvar    669
20567905            1.0    cntrlvar    670
20567906            1.0    cntrlvar    671
20567907            1.0    cntrlvar    672
20567908            1.0    cntrlvar    673
*
20568000    "pzrsp-nc"  sum    1.0       0.1     1
20568001    0.0     1.0    cntrlvar    661
20568002            1.0    cntrlvar    662
20568003            1.0    cntrlvar    663
20568002            1.0    cntrlvar    679
20568003            1.0    cntrlvar    674
20568004            1.0    cntrlvar    675
*
*************************************************
* calculate the noncondensable mass in primary
* system-reactor vessel
*************************************************
*
20586100    "v-100"    mult    1.0       0.1     1
20586101    tmassv     100010000
20586102    quals      100010000
20586103    quala      100010000
*
20586200    "v-104"    mult    1.0       0.1     1
20586201    tmassv     104010000
20586202    quals      104010000
20586203    quala      104010000
*
```

```
20586300    "v-108-1"    mult    1.0    0.1    1
20586301    tmassv    108010000
20586302    quals     108010000
20586303    quala     108010000
*
20586400    "v-128"    mult    1.0    0.1    1
20586401    tmassv    128010000
20586402    quals     128010000
20586403    quala     128010000
*
20586600    "v-132"    mult    1.0    0.1    1
20586601    tmassv    132010000
20586602    quals     132010000
20586603    quala     132010000
*
20586800    "v-136"    mult    1.0    0.1    1
20586801    tmassv    136010000
20586802    quals     136010000
20586803    quala     136010000
*
20586900    "v-140"    mult    1.0    0.1    1
20586901    tmassv    140010000
20586902    quals     140010000
20586903    quala     140010000
*
20587000    "v-144"    mult    1.0    0.1    1
20587001    tmassv    144010000
20587002    quals     144010000
20587003    quala     144010000
*
20587100    "v-148"    mult    1.0    0.1    1
20587101    tmassv    148010000
20587102    quals     148010000
20587103    quala     148010000
*
20587200    "v-152"    mult    1.0    0.1    1
20587201    tmassv    152010000
20587202    quals     152010000
20587203    quala     152010000
*
20587300    "v-156-1"    mult    1.0    0.1    1
20587301    tmassv    156010000
20587302    quals     156010000
20587303    quala     156010000
20587400    "v-156-2"    mult    1.0    0.1    1
20587401    tmassv    156020000
20587402    quals     156020000
20587403    quala     156020000
*
20588000    "vesel-nc"    sum    1.0    0.1    1
20588001    0.0    1.0    cntrlvar    861
20588002           1.0    cntrlvar    862
20588003           1.0    cntrlvar    863
20588004           1.0    cntrlvar    864
20588005           1.0    cntrlvar    866
20588006           1.0    cntrlvar    868
20588007           1.0    cntrlvar    869
20588008           1.0    cntrlvar    870
20588009           1.0    cntrlvar    871
20588010           1.0    cntrlvar    872
20588011           1.0    cntrlvar    873
20588012           1.0    cntrlvar    874
*
****************************************************
* total noncondeasable mass in primary system
****************************************************
*
20593000    "t-nocd-m"    sum    1.0    0.1    1
20593001    0.0    1.0    cntrlvar    620
20593002           1.0    cntrlvar    640
20593003           1.0    cntrlvar    650
20593004           1.0    cntrlvar    660
20593005           1.0    cntrlvar    680
20593006           1.0    cntrlvar    820
20593007           1.0    cntrlvar    840
20593008           1.0    cntrlvar    850
20593009           1.0    cntrlvar    860
20593010           1.0    cntrlvar    880
*
20592900    "u-tubes"    sum    1.0    0.1    1
20592901    0.0    1.0    cntrlvar    639
20592902           1.0    cntrlvar    839
*
****************************************************
* core power
****************************************************
*
20588800    "core pow"    function    1.0    0.43e-6    1
20588801    time    0    888
*
****************************************************
* calculate time-integrated break mass flow
****************************************************
*
20591500    "int bflo"    integral    1.0    0.00    1
20591501    mflowj    915000000
*
. zzz
```

```
**************************************************
*                                                *
*    LSTF Mid-loop : Transient  Input Deck       *
*                    for relap5/mod3.2 Assessment *
*                                                *
*    Pressurizer Manway Opening Case             *
**************************************************
*
100      restart    transnt
101      run
102      si     si
103      10033
105      5.0    10.0
*
201      9000.0  1.0e-12   0.1   3   100   10000   10000
*
20800001   dt         0.0
20800002   dtcrnt     0.0
20800003   systms     1
20800004   sysmer     1
20800005   pps        610020000
20800006   pps        152010000
20800007   pps        136010000
20800008   pps        420010000
20800009   pps        220010000
20800010   gammaw     420010000
20800011   gammaw     220010000
20800012   gammaw     100010000
20800013   gammaw     610040000
*
**************************************************
*    minor edits
**************************************************
*
301  p         610010000   * pzr pressure
302  p         516010000   * sg-i steam dome pres.
303  p         316010000   * sg-b steam dome pres.
304  p         452010000   * cold leg-i
305  p         252010000   * cold leg-b
306  p         400010000   * hot leg-i
307  p         200010000   * hot leg-b
308  p         248010000   * cold leg-b
309  p         448010000   * cold leg-b
310  p         124010000   * mid-core pressure
311  p         124020000   *
312  p         124030000   *
313  p         124040000   *
314  p         124050000   *
315  mflowj    108040000   * core downcomer flowrate
316  mflowj    124030000   * core flowrate
317  mflowj    136010000   * upper plenum to hl-b
318  mflowj    136020000   * upper plenum to hl-i
319  mflowj    136030000   * upper plenum to up-132
322  mflowj    208010000   * sg-b inlet flowrate
323  mflowj    252010000   * cold leg-b flowrate
324  mflowj    408010000   * sg-i inlet flowrate
325  mflowj    651000000   * prz. porv flowrate
326  mflowj    915000000   * break flowrate
327  tempf     124010000   *
328  tempf     124020000   *
329  tempf     124030000   * core water temperature
330  tempf     124040000   *
331  tempf     124050000   *
332  sattemp   124060000   * core saturation temp.
333  voidg     124010000   *
334  voidg     124020000   *
335  voidg     124030000   *
336  voidg     124040000   * core void
337  voidg     124050000   *
338  voidg     124060000   *
339  voidf     104010000   * vessel inlet
340  voidf     136010000   * vessel outlet
341  voidf     200010000   * hot leg-b
342  voidf     206010000   *
343  voidf     208010000   *
344  voidf     212010000   * sg-b inlet
345  voidf     228010000   * sg-b outlet
346  voidf     232010000   * cross leg
347  voidf     232050000   *
348  voidf     236040000   * rcp suction
349  voidf     244010000   * rcp discharge
350  voidf     248010000   *
351  voidf     252010000   * cold leg-b
352  voidf     400010000   * hot leg-i
353  voidf     406010000   *
354  voidf     408010000   *
355  voidf     412010000   * sg-i inlet
356  voidf     428010000   * sg-i outlet
357  voidf     432010000   * cross leg
358  voidf     432050000   *
359  voidf     436040000   * rcp suction
360  voidf     444010000   * rcp discharge
361  voidf     448010000   *
362  voidf     452010000   * cold leg-i
363  cputime   0
364  systms    1           * primary system mass
365  sysmer    1           * estimated mass error
*
**************************************************
*    variable trips
**************************************************
*
500  time   0   lt   null  0    0.0     n   * false
501  time   0   ge   null  0    0.0     n   * true
536  time   0   ge   null  0    0.0     l   * true
537  time   0   lt   null  0    0.0     l   * false
555  time   0   ge   null  0   10000.   l  * eccs injection
570  time   0   ge   null  0   1000.    l  * rhr flow
*
**************************************************
*  hydrodynamic components
**************************************************
*
3690000    blsgsv      valve
3690101    320010000 37[illegible]00000   2.96e-4 0.0149 0.0   0100
3690201    0           0.0          0.0          0.0
3690300    trpvlv
3690301    501
```

```
*
3790000    blsgsv    valve
3790101    324010000  380000000 0.00195 0.00055 0.0 0100
3790201    0          0.0       0.0     0.0
3790300    trpvlv
3790301    500
****************************************************
*
5690000    ilsgsv    valve
5690101    520010000  570000000 2.96e-4 0.0149 0.0  0100
5690201    0          0.0       0.0     0.0
5690300    trpvlv
5690301    501
*
5790000    blsgsv    valve
5790101    524010000  580000000 0.00195 0.00055 0.0  0100
5790201    0          0.0       0.0     0.0
5790300    trpvlv
5790301    500
****************************************************
*
6510000    porv          valve
6510101    610000000 650000000 3.66e-5  0.0251 0.0  0100
6510201    0     0.0    0.0      0.0
6510300    ' pvlv
6510301      )
*
6610000      fvalv          valve
6610101     .0000000 660000000 1.54e-4  0.2052 0.0 0100
6610201            0.0    0.0      0.0
6610300     pvlv
6610301     500
*
6210000    prsspryl          delete
*
****************************************************
* ecc system
****************************************************
*
7410000    rhrou-i      tmdpjun
7410101    400010005    740010001       0.006
7410200    1     570
7410201     0.0     3.0   0.0   0.0
7410202    10.0     1.5   0.0   0.0
7410203    20.0     0.0   0.0   0.0
*
7810000    rhrou-b      tmdpjun
7810101    200010005    780010001       0.006
7810200    1     570
7810201     0.0     3.0   0.0   0.0
7810202    10.0     1.5   0.0   0.0
7810203    20.0     0.0   0.0   0.0
*
7460000    rhrin-i      tmdpjun
7460101    745010001    448010005       0.006
7460200    1     570
7460201     0.0     3.0   0.0   0.0
7460202    10.0     1.5   0.0   0.0
7460203    20.0     0.0   0.0   0.0
*
7860000    rhrin-b      tmdpjur
7860101    785010001    24401??05       0.006
7860200    1     570
7860201     0.0     3.0   0.0   0.0
7860202    10.0     1.5   0.0   0.0
7860203    20.0     0.0   0.0   0.0
*
****************************************************
*  break point  - pzr. top manway 33.5% break area
****************************************************
9150000    npcolbrv    sngljun
9150101    610010001 920010001 1.129e-2 0. 0. 00100 1. 1.
9150201    0          0.0        0.0        0.0
*
9200000    npcolleg     tmdpvol
9200101    1.0e+8   10.0  0.0  0.0   0.0  0.0   0.0  0  00
9200200    004
9200201    0.0   1.01325e+5    300.15   1.0
*
****************************************************
*
. zzz
```

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S. Smith, NRC Project Manager

11. ABSTRACT *(200 words or less)*

The potential for the RELAP5/MOD3.2 code was assessed for the loss of residual heat removal (RHR) event during the mid-loop operation. The predictability of major thermal hydraulic phenomena was evaluated for the long term transient. The results of two typical cases, cold leg opening (CLO) case with water-filled steam generators (SGs) and pressurizer opening (PRO) case with emptied SGs were compared with experimental data conducted at ROSA-IV/LSTF in Japan.

It was found that the code was capable of simulating the system responses to the loss-of-RHR event during the reduced inventory operation. The thermal hydraulic transport process including noncondensable gas behavior was reasonably predicted with an appropriate time setup and CPU time. Overall, the code well predicted the major thermal hydraulic phenomena during the transient.

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